



***PRIMUS*RS**

# OPERATOR'S MANUAL



Original Instructions

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This manual supports the BTE PrimusRS™  
Instructions for use and technical description are included.

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# SYMBOLS AND WARNING

## Marking on the Equipment

Manufacturer



Authorized Representative in the European Community



Catalogue Number  
(Product and Model Number)



Serial Number



Medical Device



Temperature Limit



Humidity Limitation



Atmospheric Pressure Limitation



Where applicable:  
CE Conformity Marking



Electromagnetic Field



Follow Instructions for Use



Emergency Stop



General Warning Sign



Type B Applied Part



Tipping Hazard





Product certification



Alternating Current



“ON” (Power)



“OFF” (Power)



Protective Earth (Ground)



Do Not Forklift



Do Not Stack



Do Not Modify  
Equipment

**WARNING:** Do not modify this equipment without authorization of the manufacturer.

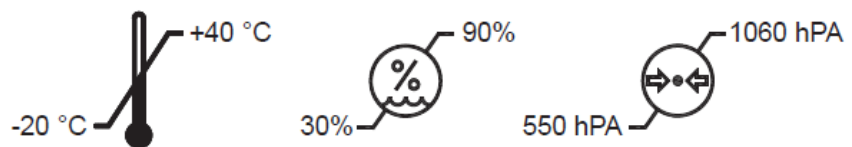
Multiple-Socket  
Outlet Warning

**WARNING:** Only Primus control module, printer, and monitor may be safely attached to multiple-socket outlet

Grounding  
Integrity

Grounding integrity depends on connection to a grounded, hospital grade receptacle

Permissible  
Environmental  
Conditions for  
Transport and  
Storage



# CAUTION



This equipment contains an electromagnet and produces a strong magnetic field.

The magnetic field can interfere with the function of implanted pacemakers and defibrillators. Patients and operators with medical implants should take care to maintain a 6" (15cm) distance between the implant and the workhead shaft.

If you have any questions, please contact BTE at 800-331-8845.

## Important Information for Safety

### Transport Position

The Primus can be only transported with the Exercise Head moved down on the column below the 26 mark and the shaft facing downward (position 9). No tools can be attached to the head and the PRO Package rack must be removed. Casters can be engaged once these actions are completed. Forklift cannot be used unless the system is inside a crate designed for use with forklifts.

Adjustable Positioning Chair and PRO Package must be transported separate from the unit unless all components are crated. Tools and attachment should be removed from the tool racks on the Primus base unless the unit is transported for a very short distance, for example across the room.

### Dedicated Circuit

For domestic markets, the following instructions are included: "This equipment requires a dedicated circuit. Supply voltage must be between 110 and 120VAC. MEASURE supply voltage before proceeding with on-site assembly. Call BTE if the supply voltage is out of range or if there are any problems with the product. 1-800-331-8845" The voltage listed varies to meet the standard of the country to where the Primus is being shipped and will be in use.

### **WARNING**

To avoid risk of electrical shock, this equipment must only be connected to supply mains with protective earth.

DO NOT plug the power supply into an ungrounded outlet. Voltages over 125 can result in error messages. Even if you have a dedicated outlet for your Primus, have a technician check the outlet with a voltmeter to ensure that the wall voltage meets the requirements for the following nominal voltage: 100V, 115 V, 200V, or 230 V. If your wall voltage exceeds the required voltage for your country, call BTE immediately.

Multiple-socket outlet located inside the Primus base or inside the computer cart is used to connect the system computer, printer, and monitor. The multiple-socket outlet shall only be used for supplying power to the intended electrical equipment that is part of the medical electrical system. If other electrical equipment is connected, electrical current drawn by the system could exceed the maximum allowed current tripping the circuit breaker. If this occurred while patient was applying force to a tool, the patient could lose balance and fall. There is also a possibility that as the result of the sudden loss of power, a tool would drop on the patient what could result in bruises and skin cuts.

**WARNING**

Only Primus control module, printer, and monitor may be safely attached to the multiple-socket outlet.

**WARNING**

Connect to the multiple-socket outlet only the specified Primus equipment

**WARNING**

Connecting electrical equipment to the multiple-socket outlet effectively leads to creating a medical electrical system and the result can be a reduced level of safety.

**WARNING**

An additional multiple-socket outlet or extension cord shall not be connected to the Primus system.

Only factory installed devices are to be used with the control module supplied with the Primus, with the exception of the USB ports on the front of the control module. The USB ports on the front of the control module are to be used with USB Flash drives **only** and **only** when instructed to do so by BTE. The devices that are connected to the control module as part of the standard installation are as follows.

Port	Devices
USB	Keyboard
	Touch Screen USB Interface
	Printer
	USB Powered Speakers
Audio Out	USB Powered Speakers
DVI	Touchscreen Monitor
Serial Port	PrimusRS Base

**WARNING**

The Primus is not intended to be connected to a network, do not do so unless instructed by BTE.

**CAUTION**

This product may contain natural rubber latex which may cause allergic reactions

Do not connect or disconnect the two exercise head cables while power is connected to your PrimusRS. This will cause serious, irreparable damage to the electronics.

In the event that the PrimusRS motor needs to be stopped immediately, use the slap-switch at the end of the white cable (Figure 5gg). This switch can be squeezed by hand or stepped on like a pedal. Ensure that it is easily accessible by the patient prior to beginning any CPM treatment. After stopping Primus with the slap-switch, you must restart the entire system with the “RESET” switch on the right side panel of the machine (page 523).

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the Evaluation screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. You must click “OK” in order to proceed to the next test. This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation, page 417).

The use of extension cords is not recommended. If an extension cord cannot be avoided, use no less than 14 gauge wire. Keep the cord as short as possible, and use only hospital approved plugs where applicable. The extension cord MUST complete the ground from the PRIMUS RS power supply cord to the wall outlet.

Advise your subject to stop the test immediately if he or she experiences any unusual pain or discomfort (page 419).

Ensure that the Exercise Head locking lever is locked into one of the preset positions before proceeding with an exercise (page 802).

A “RECOMMENDED” safe lift may not be the same as a subject’s “MAXIMUM” lift capability. If the subject does not voluntarily discontinue testing, it is up to the evaluator to determine the limit at which the subject is capable of safely lifting. This limit may be based on observations made by the evaluator, such as fatigue or use of improper lifting techniques. The safe maximum lift capability may not necessarily be based on what the subject says he/she is capable of doing. (pages 769-770).

### **Permissible Environmental Operating Conditions**

Ambient temperature: +10°C to +40°C

Relative humidity: 30% to 75%

Atmospheric pressure: 700 hPa to 1060 hPa

The Primus sound pressure level does not exceed 70dbA at the workstation.

### **Electromagnetic Interference**

The equipment needs to be placed into service according to electromagnetic compliance information provided in the manual Appendix.

### **WARNING**

Do not modify this equipment without the authorization of the manufacturer

## IMPORTANT NOTES:

The control module that was shipped with your Primus is the brain of the system. Adding other software to this control module will lead to errors in your Primus operating system.

**DO NOT** install any software applications, utilities, or modify the existing software and operating system configurations. Doing so, will void your BTE warranty.

Your Primus was shipped with an initial default password enabled. You will not be able to access a patient record without first entering the password.

The initial password is: **rs**

If you wish to change the password, select **Utilities**, then **Password**.

## **Primus Description and Intended Use**

Product: Primus

Models: PrimusRS (Abbreviated as PRRS) and Primus+ (Abbreviated as PR30)

### **Short Description**

A very versatile rehabilitation device for upper extremity and lower extremity strength testing and exercise. The dynamometer offers isometric, isotonic, isokinetic, eccentric, concentric, and continuous passive motion modes, as well as many adapters for isolated joint and compound motions.

### **General Description**

The Primus is a comprehensive rehabilitation system. The system provides active and passive torque resistance to patient motion. The equipment captures and reports real time objective data in Isotonic, Isometric, Continuous Passive Motion (CPM), and Isokinetic resistance modes from initial patient evaluation through rehabilitation and return to function. The system includes a dynamometer, electronics, adapters for various applications, and a system control module for user interface and storing patient data.

Depending on the configuration ordered by the customer, the Primus may contain the following components:

- Set of tools used for patient strength testing and exercising
- Base providing the structural support where transformer, electronics, control module, other components and tools are stored
- Exercise Head that incorporates an interface for tools as well as motor, brake, and clutch
- Column on which the Exercise Head is mounted allowing it to travel up and down
- Adjustable arm with touch screen and keyboard attached
- Adjustable Positioning Chair (optional)
- Additional set of tools and accessories called PRO Package (optional)

Note: In the Primus+ model, the control module, monitor, keyboard and printer are located on the computer cart.

## **Intended Use (Intended Purpose)**

### **Summary**

The Primus is intended to be used for musculoskeletal strength testing and exercise. Applications include physical rehabilitation and sports therapy. The system is intended to measure strength, increase muscle strength and endurance, and track patient progress through the process. It may be used for upper extremity, lower extremity, and trunk muscle weakness.

### **Detailed**

The Primus is an exercise and strength measurement device that is intended for use in physical rehabilitation, inclusive of, but not limited to, physical therapy, occupational therapy, and athletic training. The system provides isometric and dynamic resistance for the physical rehabilitation of patients with injuries that affect the hand, wrist, elbow, shoulder, torso, hip, knee, or ankle. The system is used to improve the muscle strength and endurance of selected body segments and improve the range of motions at effected joints.

In addition to isolated joint and strength testing and exercise, the Primus may also be used for integrated, functional movements where the patient is allowed to perform compound motions, which are intended to simulate the motions of real-life tasks. Examples of these movements are pushing a load, reaching overhead, pulling a handle, and swinging a baseball bat. The intent of exercising in this manner is to improve the patient's general strength, endurance, and coordination for performing such movements.

The system measures torque/force, position, velocity, and time in imperial or metric units. From these four variables, work (force x distance), power (work/time) can be calculated. These calculations are then used to determine strength and progress in exercise programs. These measures may be obtained with isometric, isotonic, or isokinetic resistances.

The information gathered by the computerized data collection systems on the device is used:

- In the documentation of patient progress from one treatment session to the next
- As visual performance feedback
- To measure and compare the strength, work output and power output of the right extremity to the left or one muscle group to the other (agonist vs antagonist)



**Intended Medical Indication**

The Primus is an exercise and strength testing device that is intended for use in physical rehabilitation. The system is used to improve the muscle strength and endurance of selected body segments.

**Contraindications**

Contraindications for use include conditions where tensile strength of tissues and/or structures is involved, i.e., healing bone fractures and tendon, ligament, and muscle repairs. Clinical judgment is required to determine whether subject should perform assessments and/or exercise.

**Intended Patient Population**

General Population: Anyone who needs rehabilitation and whose muscle strength, range of motion, or overall capacity needs to be measured. There are no age, weight, or height restrictions for the use of the Primus, with the exception of the chair that allows its use up to adults 6'5" weighing 135 kg (300 lbs.).

**Intended Anatomical Applicability**

Strength testing and exercise of the musculoskeletal system

**Intended User Profile**

Medical healthcare professionals

**Intended Conditions of Use**

Office or clinic setting

**Frequency of Use**

There is no frequency of use restrictions for this device.

**Use of Energy Source**

An electric power source is required to provide power to the equipment.

## **Essential Functions**

### **Primus Essential Functions**

- Accuracy of Treatment including correct torque, speed, distance, direction, and response to user control
- Availability of Isotonic, Isometric, Continuous Passive Motion (CPM), and Isokinetic resistance modes
- In the CPM mode, tool travel is limited to the range set by the user.
- Exercise Head can travel up and down on the column and can be tilted to allow Adjustable Positioning required for measurement or exercise.
- The application provides feedback on torque applied by the user, speed applied by the user, and range of motion.
- Accuracy of output such as reports that must provide graphs and numeric measurements. Display of real time activity must reflect activity of system and database must accurately store data.
- Recovery in that the system must be able to shut down in case patient needs to stop the exercise
- The system must not apply excessive forces when in failure mode.

Optional Equipment:

### **Adjustable Positioning Chair Essential Functions**

- Support the patient in various sitting positions as well as prone and supine positions for exercising on the Primus system
- Immobilize the patient and/or patient's extremities for exercising on the Primus system
- Connect to the Primus system to stabilize the patient during exercises

### **PRO Package Essential Functions**

- Allow a range of functional movements, such as, but not limited to:
  - Golf, tennis, baseball, and cricket swing
  - Tennis, baseball, cricket, football, softball, and soccer ball throw
  - Push, pull, lunge, proprioceptive neuromuscular facilitation movements

## **Frequently Used Functions**

All device functions are used on a regular basis.

The four modes for testing or exercise – isometric, isotonic, isokinetic, and continuous passive motion (CPM). One of the modes is static – isometric, and three of the modes are dynamic – isotonic, isokinetic, and CPM are used regularly. The isotonic mode is most frequently used.

The tools that interface with the exercise head are used regularly since any one of the tools is attached for each test or exercise.

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## **Applied Parts**

Applied parts include tools, attachments, emergency stop, and the Adjustable Positioning Chair

## **Essential Performance**

The device does not have any essential performance characteristics.

## **Primus Performance Characteristics**

- Measures torque, position, velocity, and time
  - Measures speeds up to 4500 degrees/second, Tolerance = +/- 1%
- Range of motion (ROM) setting
  - Mechanical stops are provided to be used to stop tools at 800 in/lbs with a length greater than 5 inches.
  - Allows the Operator to set ROM [between 15 and 360 degrees in 15 degree intervals]
- Isometric mode
  - The maximum resistance is at least 1,800 inch-lb
- Isokinetic mode
  - Resistance range in Con/Con mode for the concentric part of the exercise is 40 inch-lb to 1,260 inch-lb at 240 degrees/second
    - Minimum of 40 in.lb – tolerance = +/- 4
    - Maximum of 1,260 in.lb = +/-20 at 240 degrees/second.
  - Resistance range in Con/Ecc mode for the eccentric part of the exercise is 40 inch-lb to 1,260 inch-lb at 240 degree/second
    - Minimum of 3 in.lb – tolerance = +/- 4
    - Maximum of 1,260 in.lb = +/-20 at 240 degrees/second.
  - Rotation speed range is 5 degrees/sec to 240 degrees/second.
    - Tolerance of minimum 5 degrees/sec = +/-1
    - Tolerance of maximum 240 degrees/sec = +2 /-2
- Isotonic mode
  - Resistance range in Con/Con mode for the concentric part of the exercise is 3 inch-lb to 1,260 inch-lb.
    - Minimum of 3 in.lb – tolerance = + 12 /-3
    - Maximum of 1,260 in.lb = +/-14
  - Resistance range in Con/Ecc mode for the eccentric part of the exercise is 3 inch-lb to 1,260 inch-lb.
    - Minimum of 3 in.lb – tolerance = + 12 /-3
    - Maximum of 1,260 in.lb = +/-14

- Continuous Passive Motion (CPM)
  - Resistance range is 3 inch-lb to 900inch-lb
    - Minimum of 3 in.lb – tolerance = + 12 / -3
    - Maximum of 900 in.lb = +/-15 at 50 degrees/second.
  - Rotation speed range is 5 degrees/sec to 240 degrees/sec.
    - Tolerance of minimum 5 degrees/sec = +/-1
    - Tolerance of maximum 240 degrees/sec = +2 / -2
- Availability of various exercise attachments
- Calibration
  - Takes  $\leq$  10 minutes
- Performance characteristics – Allows user to:
  - Select exercise category (evaluation or treatment)
  - Select exercise type (concentric, eccentric, or concentric/eccentric)
  - Select resistance type (isokinetic, isometric, or isotonic)
  - Select CPM
  - Select exercise direction (clockwise, counterclockwise, both)
  - Start exercise
  - Stop exercise
  - Select exercise speed for Isokinetic and CPM.
  - Select range of motion.
- Column
  - Allows exercise head to travel up and down on the column in the specified range
    - Maximum height is 90 inches
    - The minimum height is less than or equal to 19 inches.
- Exercise Head
  - Exercise head rotation is +90 degrees to -90 degrees (from horizontal).
  - Exercise head locks in horizontal position and four positions above and below in 22.5 degree increments

## Preventative Inspection

At the beginning of each work shift when Tool 191 is utilized, verify that the cable is not damaged or worn out.

## Maintenance

Calibration should be performed by the operator every two weeks.

The operator should verify that the Velcro on the straps are not worn out.

No components shall be serviced while in use with a client.

### Control Module Maintenance

The Primus software runs in the Microsoft Windows environment (See Section 2.2 for details).

Windows is an extremely reliable and secure operating system, but extended use calls for some degree of system maintenance.

Several simple steps should be taken to ensure that your Primus control module continues to perform at maximum efficiency. Some of these are outlined below.

- Do Not Install Any Additional Software on the Control Module

Your BTE Primus is in constant communication with the control module. Maintaining a "clean", dedicated control module is crucial to the integrity of this communication stream.

**Installation of third party software will likely interfere with your ability to print reports.**

- Shut Down the Control Module Every Week

The control module must be properly shut down at least once a week. The equipment shut down instruction are included below.

- Shut Down Your Control Module Properly

To avoid possibly damaging your system, do not shut down your control module by simply flipping the power switch.

Step 1. When you are ready to close down your Primus, click on the **Windows icon** at the bottom left corner of the screen.

Step 2. Click on the **Power icon**.

Step 3. Select the "**Shut Down**" option.

Step 4. Once Windows has shut down, flip the switch on the right Primus tool panel to "**Off**".

- Clean Patient Database Every Month

At least once a month remove from patient database information that is no longer needed. A large patient database can slow down the software. Data management instructions are included in Section 7.

### **Equipment Shut Down**

Shut down the control module before turning the system off; reference instructions above.

### **Components Designated as Repairable by Service Personnel**

There are no components on which preventative inspection and maintenance shall be performed by service personnel. Components will be replaced if needed in accordance with BTE service policy. In addition, documentation and instructions for any in-field repairs to be conducted by service personnel will be provided.

### **Environmental Protection**

At the end of the equipment service life, dispose the device components in accordance with all local, state and federal laws for electronics recycling.



***PRIMUS*RS**

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- 02 – General Operation**
- 03 – Patient Records**
- 04 – Evaluation**
- 05 – Treatment**
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## Section 1 – Installation and Setup

### 1.1 Introduction

The functionality of the PrimusRS and Primus+ models is the same. Unless otherwise stated, all text referencing the PrimusRS also applies to the Primus+.

This section will guide you through the steps necessary to get your Primus ready to use.

The Primus system is shipped with re-usable shipping braces and casters (wheels). These parts are designed to provide maximum protection in transit and ease of installation. The caster assemblies provide adjustable ground clearance. The system is shipped in the highest position to clear ramps, curbs, and thresholds. The system can be lowered to pass under low doorways.

Special packing materials are sent with the unit for return of the braces and casters. **These parts must be returned to BTE after installation (Figure 1a). If they are not returned, you will be charged for these parts.** If the system ever needs to be moved, BTE will lend you braces and casters.

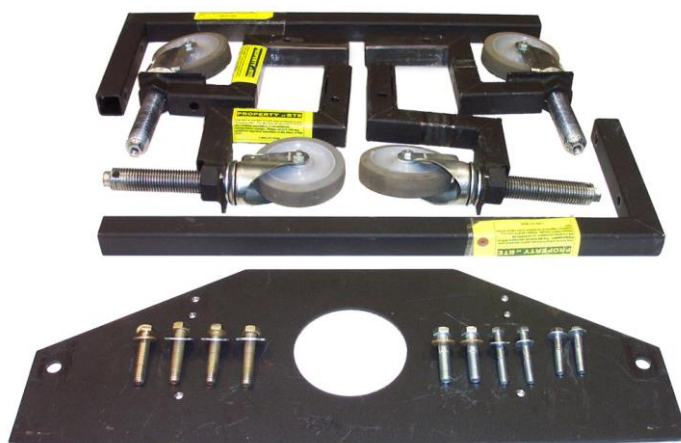


Figure 1a

### 1.2 BTE Primus Assembly Instructions

Please inspect all parts for any visible damage from shipping. Notify BTE upon discovery of any damage.

The following tools will be required for assembly of the equipment:

#### Tools required:

1/8"	Allen Wrench
5/32"	Allen Wrench
9/16"	Socket Wrench
3/4"	Socket Wrench
1/4"	Flathead Screwdriver

## 1.2.1 Positioning the System and Placing it onto the Floor

- Step 1. First unwrap the unit, removing all protective packaging. Examine your Primus (see diagram, Section 1.3).
- Step 2. Position the system where it is to be installed. If the system is to be installed against a wall, position the system one foot away from the wall to start. When positioning the Primus allow enough access to the power inlet so that it may be disconnected without moving the Primus.
- Step 3. Adjust all of the wheel assemblies (Figure 1b) to lower the Primus system so that there is 1" of floor clearance under the unit (use a  $\frac{3}{4}$ " wrench).
- Step 4. Place a piece of cardboard or masonite under each of the back left and right corners of the unit. Adjust the rear wheel assemblies to lower the unit onto the cardboard.
- Step 5. Remove the rear caster assemblies with the  $\frac{3}{4}$ " wrench (Figure 1c). Push on the vertical shipping braces at the front of the machine to slide the unit into the final position.
- Step 6. Adjust one of the front wheel assemblies to raise one side of the machine. Raise the system until there is about  $\frac{1}{2}$ " of clearance under the back corner of the machine.
- Step 7. Remove the cardboard on that side and replace it with one of the rubber isolation pads provided with the machine. Place another rubber pad under the front corner on the same side.
- Step 8. Lower the system onto the rubber pads.
- Step 9. Repeat on the other side.
- Step 10. Connect the two main cables to the exercise head. Be sure to seat them properly, and place them in the strain relief. (Figures 1d and 1e.)



Figure 1b



Figure 1c



Figure 1d

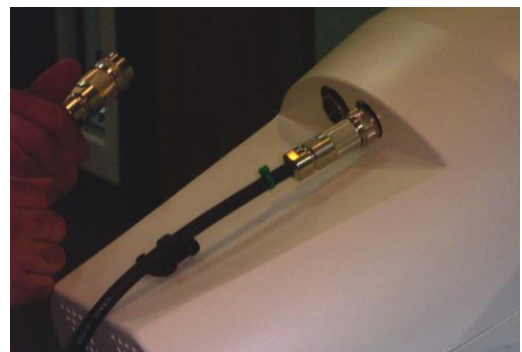


Figure 1e

**IMPORTANT**

**Do not connect or disconnect the two exercise head cables (Figure 1d, Figure 1e) while power is connected to your Primus. This will cause serious, irreparable damage to the electronics.**

- Step 11. Connect the main power cord from the lower right hand side of the Primus to a standard grounded AC outlet for nominal voltage 100 V, 115 V (domestic), 215 V or 230 V.

**IMPORTANT**

The Primus **MUST** be operated on a **DEDICATED 15 amp (domestic) or 10 amp (international) circuit**. If other equipment is operated on the same circuit, you may encounter problems during use of the Primus and, over time, damage to the Primus electronics. **DO NOT** plug the power supply into an ungrounded outlet.

Voltages over 125 (domestic) or 250 (international) can result in error messages. Even if you have a dedicated outlet for your Primus, have a technician check the outlet with a voltmeter to ensure that the wall voltage does NOT exceed the limit.

**If your wall voltage exceeds the limit, call BTE immediately.**

**The use of extension cords is not recommended.** If an extension cord cannot be avoided, use no less than 14 gauge wire. Keep the cord as short as possible, and use only hospital approved plugs. The extension cord **MUST** complete the ground from the Primus power supply cord to the wall outlet.

- Step 12. Move the switch on the right side of the unit (Figure 1f) to the "On" (up) position.



Figure 1f

- Step 13. Use the "Up/Down" switch at the end of the long black cable on the side of the vertical column to move the exercise head to a height of 41" (104 cm)' (Figure 1g).

- Step 14. The front shipping braces and caster assembly can now be removed from the machine and disassembled.

**Place the braces and four casters into the package provided and return the parts to BTE.**



Figure 1g

- Step 15. Release the exercise head's locking lever (on the right side) and rotate the head to the number 5 position so that the cables hang through the yoke.
- Step 16. Unpack the tool attachments and place them on their designated holder on the Primus base as indicated by the outlines and attachment numbers on the tool boards.

## 1.2.2 Connecting the Electronics

### 1.2.2.1 PrimusRS

You will find that the PrimusRS is practically ready to use straight out of the box.

- Step 1. Unpack the printer from the box and place the printer on the back of the unit. (See diagram - Figure 1)
- Step 2. Remove the vented cover from the left side of the shelf that the printer sits on.
- Step 3. Route the printer power cable and USB cable through the hole in the back of the shelf.
- Step 4. Plug the USB cable into one of the available USB ports on the printer.
- Step 5. Route the print power cable through the large rectangular cut-out under the control module.
- Step 6. Open the PrimusRS base by turning the two latches on the left panel counterclockwise and then swinging open the panel.

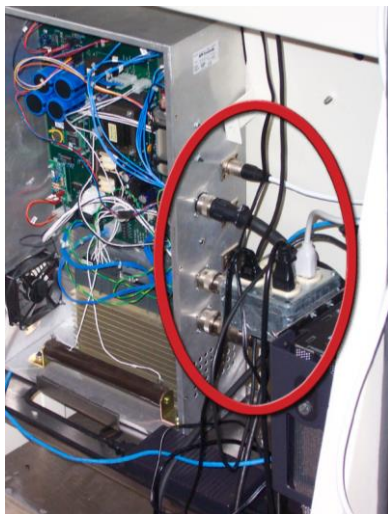


Figure 1h

- Step 7. Inside you will find an outlet box powering all of the peripherals (e.g. control module and monitor).
- Step 8. Plug the printer's power cable into the outlet box. (Figure 1h).

**This completes the PrimusRS assembly.  
Your system is ready for use!**

### 1.2.2.2 Primus+

In the Primus+ model, the control module, monitor, keyboard and printer are located on the control module cart.

#### Control Module Cart Setup

- Step 1. Remove cart from its shipping carton.
- Step 2. Attach the stainless steel handle to the front of the top shelf using the included screws.
- Step 3. Place the control module (CPU) horizontally on the bottom shelf of the cart.
- Step 4. Place the printer on the middle stationary shelf above the control module.
- Step 5. Place the monitor and keyboard on the top shelf. The monitor must be secured to the top shelf with the provided hardware.
- Step 6. Slide the adjustable tray under the top shelf. As an option, the keyboard may be placed on the tray.
- Step 7. Connect each cable end to its proper receptacle. The cart is shipped pre-wired with the cables in the proper position and ready for use.
- Step 8. Connect the long cable extending from the back of the cart to its mating connector on the electronics drawer inside the Primus base. Be sure the connector is firmly secured.

**This completes the Primus+ assembly.  
Your system is ready for use!**



## 1.3 PrimusRS Components

Your system consists of these main components:



Figure 1i

**Note** - The "Slap" Switch may be referred to as an Emergency Stop or Shutoff Switch

## 1.4 Using the Ergotron® (Movable Arm for the Monitor)

The PrimusRS is equipped with a unique swing-arm keyboard and monitor holder. This system allows you to quickly and easily move the touch-screen monitor to the most convenient position for any given exercise. This section applies only to the PrimusRS model.

### 1.4.1 Correct Positioning of the Ergotron®

The Ergotron® ships folded in line with the column. It is essential that you unfold it properly. **Incorrect positioning of the arm will inflict undue strain on the keyboard and monitor cables, damaging them over time.** Follow the steps shown in the following photographs:



Figure 1j



Figure 1k

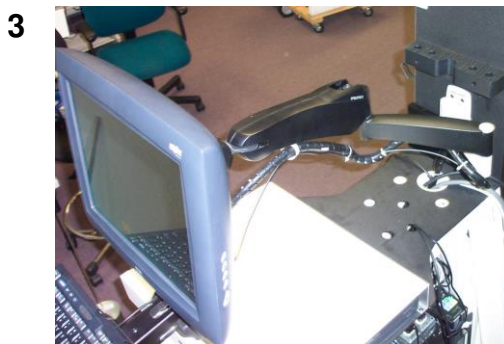


Figure 1l



Figure 1m



Figure 1n

Once the Ergotron® is correctly unfolded, simply grasp either the monitor or one of the three swing-arm sections to move the position of the entire arm.



**IMPORTANT**

Every time you move the monitor from one side of the PrimusRS to the other, **ensure that the cables do *not* wrap around the arm (Figure 1).** This will prolong the life of the cables.

**CORRECT**

Figure 1o

**INCORRECT**

Figure 1p

### 1.4.2 Precise Tension Adjustment

The Ergotron® can be finely tuned through precise adjustments of the tension on each joint.

**If you need to alter the spring tension in the arms, follow this procedure:**

- Step 1. Locate the screw at the top of the joint you wish to adjust (Figure 1).
- Step 2. Use an Allen wrench to turn the screw in either the “+” or the - direction to either tighten or loosen the joint.



Figure 1q

**If you need to adjust the tension of the swiveling monitor bracket:**

- Step 1. Snap off the two plastic protective caps located on either side of the joint (Figure 1).
- Step 2. Slip a hex wrench (supplied with Primus) over the nut on the left side of hinge to hold the screw into place.
- Step 3. With the second hex wrench, turn the nut on the right side to loosen the hinge.
- Step 4. Move the monitor to the new angle.
- Step 5. Use the two wrenches to tighten the nut.
- Step 6. Replace the plastic caps.



Figure 1r

**1.4.3 Cleaning the Touchscreen**

Any standard glass cleaner can be used to clean the touchscreen when it becomes dirty, but avoid products containing ammonia. Always spray the glass cleaner on the cloth or towel and clean the screen with the moistened cloth. **Glass cleaner sprayed directly on the monitor could possibly leak inside a non-sealed unit and cause damage.**

**1.5 Calibration Kit**

Calibration is essential in order for Primus RS to record accurate exercise results and to maintain a smooth, consistent feel of resistance. This is a quick and easy process documented in Section 7 – Utilities of this manual.

The calibration kit (Figure 1i) for the BTE PrimusRS consists of:

- calibration bar
- 40 lb weight attached to hooked rod

**Make sure to calibrate your PrimusRS every two weeks.**



Figure 1i

## 1.6 Strongly Recommended Additional Purchases

In addition to the equipment shipped to you from BTE, the purchase of the following items from a local supplier is strongly recommended for adequate protection of your patient data:

- **USB “jump/thumb” drive or portable HDD** for backing up and archiving copies of patient data
- **An Uninterruptible Power Supply (UPS)** unit providing at least 14 amps as a safeguard against the permanent loss of patient information due to power surge or electrical power failure.

### IMPORTANT

In case of accident or malfunction, your control module can be repaired or replaced, but **your valuable patient data can only be restored from copies kept on “backup” CDs** (See Section 7, “Utilities”).

## 1.7 Control Module Care

### 1.7.1 Control Module Handling

A control module's hard disk is vulnerable to loss of data and "corruption" of data (may not function correctly when you attempt to retrieve patient information) from a sudden change in the level of electrical power. In the event of a power failure, the UPS battery will generate electricity long enough to allow you to shut down the system without damage to your patient data. The UPS unit also protects from a sudden power surge or "spike" since all power for the control module comes through the UPS battery where power levels are constantly regulated.

Since control modules are sensitive to extremes of temperature, do not place equipment close to a direct source of heat or cold (for example, in direct sunlight, next to a radiator or an air conditioner).

### IMPORTANT

The Primus is not intended to be connected to a network, do not do so unless instructed by BTE.

### IMPORTANT

**Handle your control module with extreme care.** A drop or a bump, even from a height of 3-4 inches, may cause serious damage which is not covered by warranty.

## 1.7.2 Check Control Module Cables

Check that all cables are connected. Just about every cable connector is made in such a way that it will only attach in its appropriate location. Be sure to secure all cables and tighten them into place with the thumbscrews or with a screwdriver. The power cables for the CPU, monitor, and printer **MUST** be plugged into the power outlets located inside the PrimusRS body.

### **IMPORTANT**

**Check that all cables are firmly secured to the control module and the work head,** or the interruption of data transmission can occur, resulting in error messages.

## 1.7.3 Environment Requirements

The BTE Primus is designed to operate within the following environmental conditions:

<b>Ambient Temperature:</b>	+10°C to +40°C
<b>Relative Humidity:</b>	30% to 75%
<b>Atmospheric Pressure:</b>	700 hPa to 1060 hPa
<b>Voltage Supply:</b>	110-120 VAC (International voltages differ)

# PRIMUSRS

## Section 2 – General Operation

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## Section 2 – General Operation

### 2.1 Getting Started

Ensure that you have carefully read Section 1 of this manual prior to starting up your PrimusRS.

#### IMPORTANT

Voltages over 125 (domestic) or 250 (international) can result in eventual damage to the Primus electronics and produce frequent error messages. Even if you have a dedicated outlet for your Primus, have a technician check the outlet with a voltmeter to insure that the wall voltage does NOT exceed 125/250 volts. If your wall voltage exceeds the limit, call BTE immediately.

**Damage to your PrimusRS resulting from wall voltages exceeding the limit is not covered by your warranty.**

The PrimusRS power switch is located in the panel on the right tool rack (see Figure 2a).

Step 1. Turn the power switch to “On.”

This will automatically turn on the printer, the monitor, the CPU and the PrimusRS machine itself.



Figure 2a

Step 2. Once the system is booted and Primus is ready to use, open the software by double-clicking the PrimusRS icon visible on the “desktop” of the computer monitor.

## 2.2 Basic Software Navigation

The BTE PrimusRS is controlled through its own unique software. Use this section as both an initial primer and a to-the-point, “quick reference” guide to your PrimusRS software.

### 2.2.1 The Windows XP and Windows 7 Environment

PrimusRS brings you its innovative features by harnessing the power of Windows XP or Windows 7. As a new user of PrimusRS, it is important for you to first acclimate yourself to the Microsoft Windows XP or Windows 7 operating system.

Familiarize yourself with these basic functions:

**Desktop** – Once Windows loads up, the entire screen is taken up by the ‘desktop.’ Double-clicking the Primus ‘shortcut’ icon launches the PrimusRS software.

**Minimize** – Clicking this button ‘hides’ the open program and reduces it to a button on the start bar (Figure 2b).

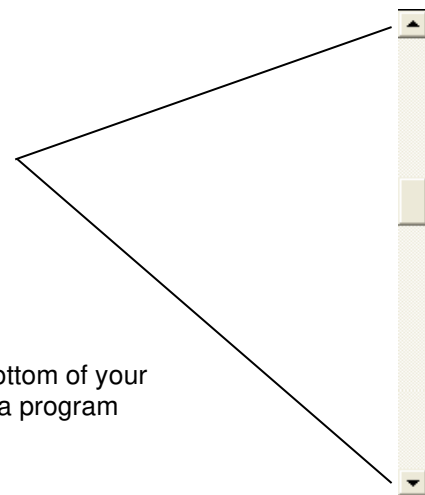
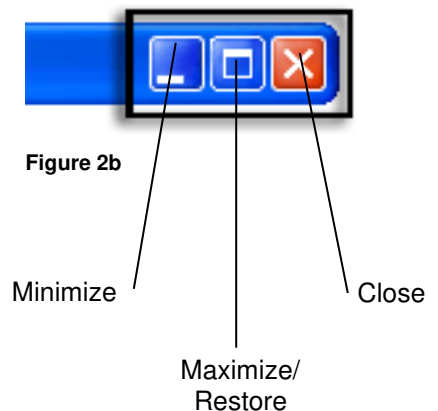
**Maximize/Restore** – expands program window to fit the size of the entire screen. If the program is already expanded, clicking here will shrink the screen to a smaller window (Figure 2b).

**Close** – closes the active program window (Figure 2b).

**Scrollbars** – Click the small black “up” and “down” arrows on the bar at the right of a given window to scroll up and down in screens (Figure 2c).

**Start bar** - This horizontal bar (Figure 2d) located at the bottom of your screen displays a button of every open program. Clicking a program name here switches you to that program.

**Start button** – This button is used to launch nearly every program and function of Microsoft Windows.



### 2.2.2 Using the PrimusRS Software

Once you are comfortable with Windows XP or Windows 7, take some time to familiarize yourself with the general layout and functioning of the PrimusRS software. Doing this now will maximize your efficiency down the line.

The following elements are used throughout the software:

**Title bar** – This narrow blue strip at the top of your screen displays the name of the current patient and the template currently in use.

**Tabs** – These divide and organize the overall structure of the Primus software. Analogous to a tab on a rolodex, clicking one of these allows you to quickly switch from one screen to another. Active tabs are denoted by the color blue.

**Menu bar** – Clicking “File,” “Utilities,” or “Help” at the top left of your screen will open a menu.

**Menu items** – Within each menu, click on a menu item to perform an operation or to specify a setting. Clicking “Notes,” “Save Options” or “Delete Options” causes a check to appear next to the word, indicating that the function is switched on. Open the Utilities menu and click on the word again to turn the feature off.

**Text fields** – Text and numerical values are entered into “fields.” To enter text or an integer into a field, touch or click the field. A blinking black “cursor” will indicate that the field is active. Type the required information.

**Must-enter fields** – Many fields in Primus are optional. There are, however, several which must be entered. These are denoted with bold white fields and black characters.

**Radio buttons** - Radio buttons are used to select an option from a finite set. Only one option in the set can be selected at a time (for example – specifying a goal of time, distance, or force).

**Check boxes** – A checkbox is like a switch – touch one to activate a setting. Click it again to deactivate it. You do not have to directly hit the checkbox – touching any part of the word labeling it will suffice.

**Lists** – Click or touch an item in a list once to select it.

## 2.3 Home (Startup) Screen

The first active screen you will see – *Home* – is highlighted in blue (Figure 2e). *Home* is the first of a series of section titles which appear on the top of the screen. On the right side of the screen is the Control Panel (Figure 2f). This panel is present when in any test- or exercise-related tab as it enables you to alter exercise settings (such as resistance).

The *Home* screen is designed for general feedback, and for performing basic trial exercises without having to first create a patient record. This screen offers quick, easy use without the need to go any further in the software for simple isotonic exercises. Since no patient is named, data is **NOT** stored; however it can be printed.



### 2.3.1 The Home Screen

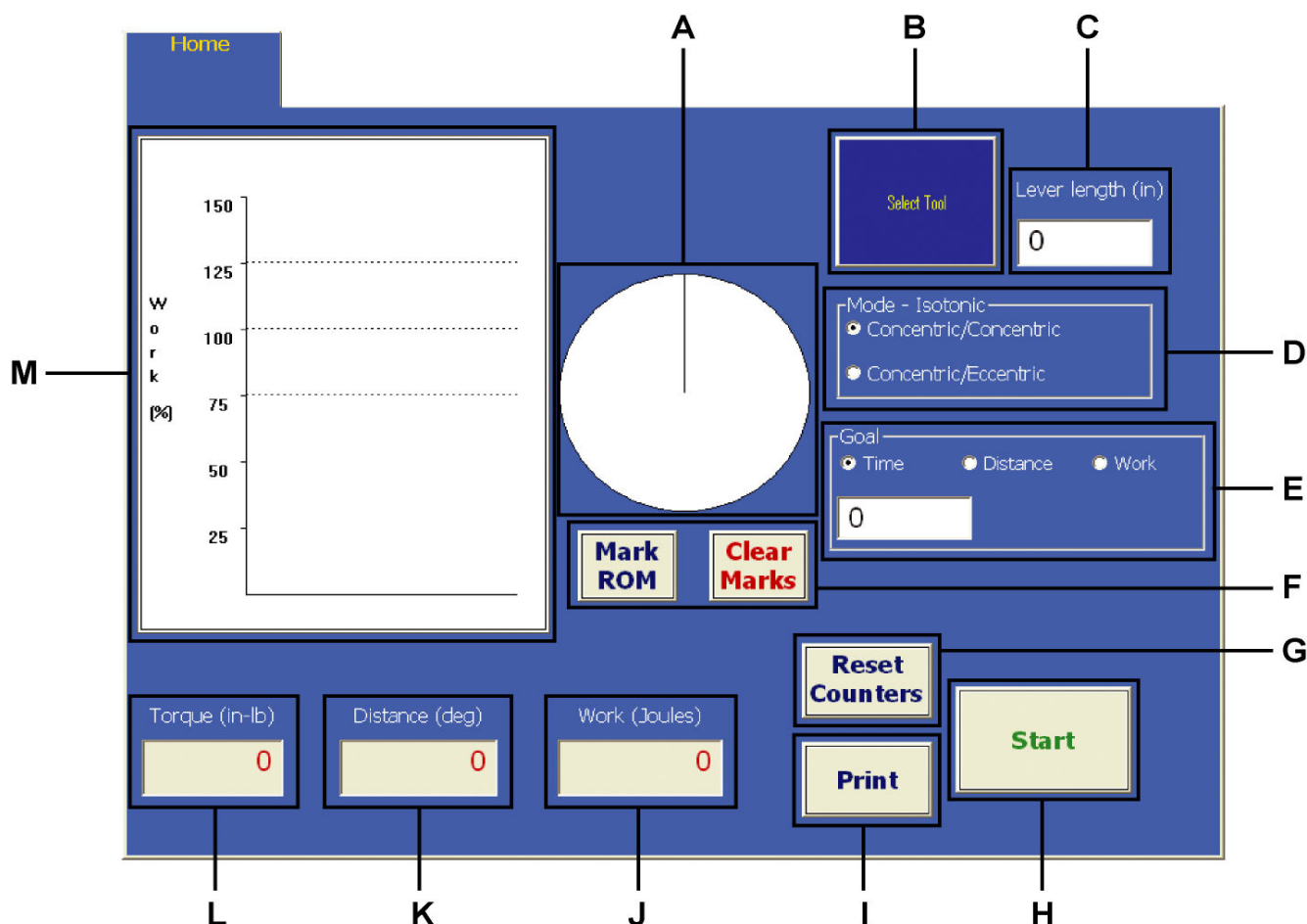


Figure 2e

- A. Range of Motion Indicator** – display ROM in degrees as a pie slice. The pie slice changes color every 5 revolutions, making it easy to count reps visually.
- B. Tool Selection** – click to select tool for exercise
- C. Lever Length** – entering lever length of the tool in use enables PrimusRS to convert inch-pounds of torque into pounds of force.
- D. Mode** – this setting allows selection between Concentric/Concentric (CON/CON) and Concentric/Eccentric (CON/ECC) operation.
- E. Goal** – enables the therapist to set a goal in units of Time, Distance, or Work
- F. Mark ROM / Clear ROM** – Click “Mark ROM” when the patient reaches each extreme of his/her range of motion. Hit “Clear Marks” to reset the marked range.
- G. Reset Counters** – clears Torque, Distance, and Work counters to prepare for another trial.
- H. Start/Stop Button** – begins and ends trial exercises on the PrimusRS
- I. Print** – this button prints data to hard copy without saving it onto the computer
- J. Work** – displays amount of work exerted in Joules
- K. Distance** – display field for distance achieved (in degrees)
- L. Torque** – displays force exerted in inch-pounds
- M. Work Graph** – bar graphs displaying amount of work performed in 5 second intervals. Target area is designated based on work done during first 5 seconds.

## 2.4 Control Panel

The Control Panel – located at the right of the screen at all times - is used in the *Home*, *Evaluation*, and *Treatment* screens. Though its primary function is to control resistance settings, it has several other features (described below).

- A. Exit** – hit this button to exit Primus software
- B. Timer** – displays elapsed time of current exercise
- C. Maximum Force** – displays maximum force available
- D. Lock/Unlock** - this button turns the resistance on and off, locking and unlocking the shaft. It can be used to position a tool (attachment).
- E. CCW/CW** – means “Counterclockwise” and “Clockwise”, describing the direction of rotation of the tool. You can set different forces *in each direction*.

**Note:** If you select “Concentric/Eccentric” operation (Figure 2e - D), the CCW and CW become “CON” and “ECC” respectively.

**F. Resistance Settings –**

- a. The “±10” buttons permit quick force adjustments in increments of 10.
- b. The “7” windows show the current force set in each direction.
- c. The arrow buttons permit small incremental force adjustments during exercise.

**Note:** You can click the cursor in the force window and use the keyboard to type in any force.

- G. Synch Switch** – clicking this synchronizing option equates the resistance in both directions

**Note:** When Concentric/Eccentric (CON/ECC) is selected, resistance is automatically synchronized, and the “synch” switch becomes inactive. If you desire to set unequal CON/ECC forces, see procedure below (see section 2.4.2).

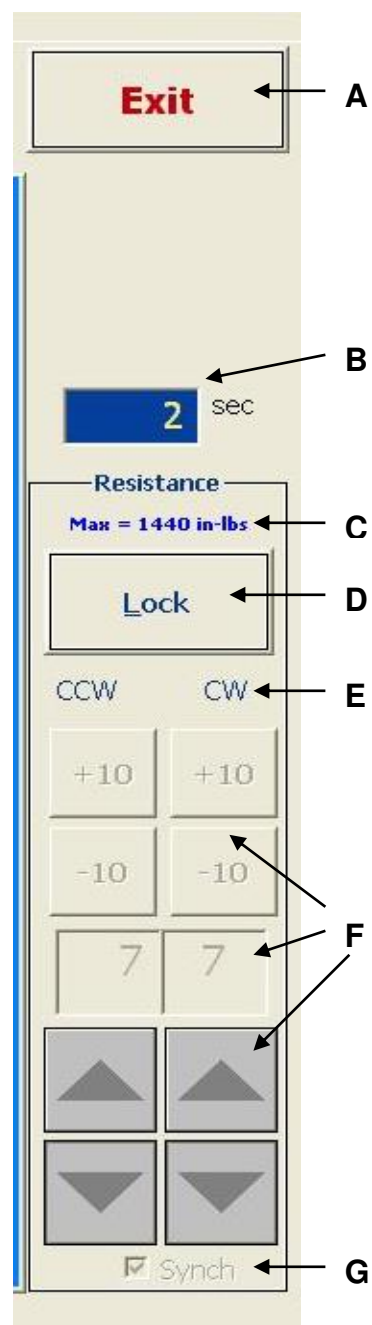


Figure 2f

### 2.4.1 Resistance Modes

The PrimusRS has the capability of offering two (2) modes of operation: concentric/concentric (CON/CON) and concentric/eccentric (CON/ECC). If you want concentric resistance in both directions, choose CON/CON. CON/ECC provides you with concentric resistance one direction and eccentric resistance in the return direction.

In CON/ECC mode, when you click start, a screen will pop up prompting you to unlock the tool. (This unlock feature allows you to position the tool appropriately.) To perform an exercise, click the “Ready” button in this window. The eccentrics are only operational after you click “Ready” and for safety purposes, the eccentrics are turned off as soon as you click “Stop.”

After hitting “Start,” use the Control Panel to manipulate resistance in real time.

### 2.4.1 Setting Unequal forces

No matter which mode you choose, there is the ability to set a different resistance level in each direction. In CON/CON mode, this can be useful in exercising agonist and antagonist muscles at their appropriate resistance level within the same exercise. To change a resistance setting in CON/CON mode, simply place the cursor in the field you wish to change, delete the current setting and then input the new number via the keyboard. Or, if you want resistance in only one direction, insert zero in the opposite field.

For safety reasons, the Primus will not let you select unequal CON/ECC forces without using a special procedure. This way, the patients cannot accidentally activate this option on their own.

To set unequal CON/ECC forces:

- Step 1. Start the exercise, as described in Section 2.3.1. At this point, DO NOT click the resistance controls (Figure 2f– F).
  - Step 2. Press the “CTRL” button on your keyboard and hold it down.
  - Step 3. Still holding “CTRL,” click or touch the force display window (the field showing a numerical value in (Figure 2f – F).
- Note:** If you click or touch any area on the screen first, you will have to stop and restart the exercise to set unequal CON/ECC forces.
- Step 4. Having performed Step 3 correctly, you will notice that the “Synch” checkbox at the bottom of the Control Panel is now activated (Figure 2f - G).
  - Step 5. Click “Synch” (Figure 2f - G) to remove the checkmark from the small box. This will enable you to set unequal forces in each direction.
  - Step 6. Use any of the resistance controls in Figure 2f – F to freely change forces now.

## 2.5 Workhead Release

In the course of an exercise, components inside the PrimusRS exercise head apply resistance to the central shaft. This process creates the resistance the patient feels when moving a tool attachment. In Isometric exercises, the workhead applies maximum resistance, effectively “locking” the central shaft. There are two situations when the head must be “unlocked”.

### 2.5.1 Unlocking Due to Prolonged Inactivity on the PrimusRS

Even when a test or exercise is completed, the workhead continues to hold the attachment in place so that it does not swing freely. This is a very important PrimusRS safety feature, because if a tool with a long lever length were released abruptly, it could swing and injure a patient.

The mechanical components inside the exercise head actively hold the tool in place. Keeping the shaft locked for long periods of time when the Primus is not in use can be likened to leaving one's car engine running in neutral in the parking lot before walking into work for an eight hour shift. Doing such a thing would cause unnecessary wear on the car engine, just as leaving the PrimusRS exercise head locked and leaving it for hours would cause unnecessary wear on the mechanical components inside.

Putting the car into “park” is second-nature to us, but in the midst of treating patients in a clinic, remembering to hit the “Unlock” button after evaluations and treatments is easy to forget. For this reason, PrimusRS unlocks its exercise shaft for you after detecting 7 minutes of inactivity.

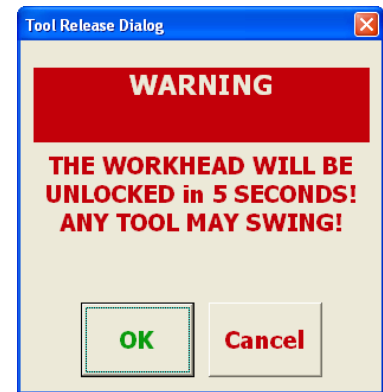


Figure 2g

You will be clearly alerted that the workhead is about to be released with a distinct beeping noise and a flashing dialog box (Figure 2g). **Ensure that the patient is not in close proximity to the tool attachment when the workhead unlocks.** If you want to keep the tool locked and do not want it released, press “Cancel” within five seconds of the box appearing. Otherwise, Primus will proceed to unlock the exercise head if you do nothing or touch “OK” in the dialog box.

## 2.5.2 Unlocking the Workhead When Switching Modes

Switching between tests or exercises conducted in different modes – Isometric, Isotonic, Isokinetic, CPM – **requires** the workhead to unlock. This is because the mechanical components inside the head must switch to exert the different type of resistance used by the new mode.

Most often, you will conduct a series of tests and exercises of differing resistance modes. If your Evaluation or Treatment Template (Sections 4.3, 5.3) contains a variety of different tests and exercises, clicking “Previous/Next Trial” or “Previous/Next Trial Exercise” in the *Evaluation* (Section 4) and *Treatment* (Section 5) screens will initiate the workhead release alert (Figure 2g).

**You must click “OK” in this dialog box in order to perform the next exercise in a different resistance mode.**

Ensure that the patient is a safe distance away from the attachment when the workhead is unlocked.

# PRIMUSRS

## Section 3 – Patient Records

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## Section 3 – Patient Records

### 3.1 Introduction

A Patient Record is required for each patient you wish to evaluate or treat using the PrimusRS. This record will contain a patient's profile, including occupation, type of injury and other details relevant to treatment.

**The *Evaluation, Treatment, and Review/Reports* screens are inaccessible until you have created and loaded a Patient Record.**

#### 3.1.1 Passwords and Security

##### Note

For HIPAA Compliance and its confidentiality requirements, Patient Records are password protected.

The default database password is “rs” – Enter “rs” in the text field and click “OK” whenever this screen appears.

This password can be changed by selecting “Password” from the *Utilities* pull-down menu (See Section 7).

**The password is case-sensitive. To avoid confusion, consider using only lowercase letters.**

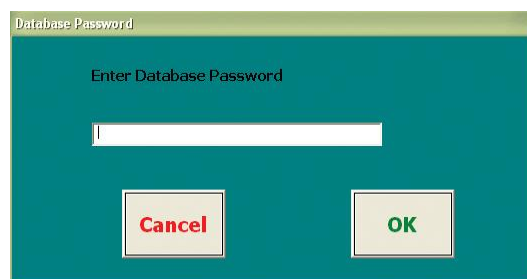


Figure 3a

**If Primus does not seem to accept your password, try pressing “CAPS LOCK” on the keyboard and re-typing your password.**

For HIPAA Compliance, whenever the *Home* tab is clicked, the currently selected patient name will disappear. When this occurs, the password must be re-entered to re-load the patient's record in order to again access *Evaluation, Treatment, and Review/Reports* screens.

### 3.2 Creating a New Patient Record

Step 1. Click the *Patient Record* tab at the top left of the screen (outlined in black in Figure 3b).

When you click the tab, a dialog box will appear with several options.

Step 2. Click “New Patient” at the bottom of the window (the other options are not used until you have a series of patients already entered into the database).

Step 3. Enter the password as described in Section 3.1. Proceed to Section 3.2.1.

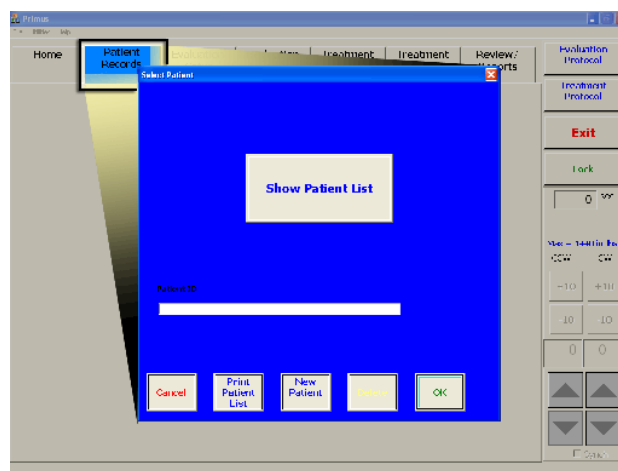


Figure 3b

### 3.2.1 The “Patient” Screen

The screenshot shows the 'Patient Records' application with the 'Patient' tab selected. The form contains the following fields and controls:

- Patient ID:** Text field with value '303'.
- Last Name:** Text field with value 'Jones'.
- First Name:** Text field with value 'Beatrice'.
- Height:** Text field with value '0'.
- Weight:** Text field with value '0'.
- Date of Birth:** Text field with value '1/1/1978'.
- Sex:** Radio buttons for 'Male' (selected) and 'Female'.
- Dominant Side:** Radio buttons for 'Left' (selected), 'Right', and 'Amb.'.
- Involved Side:** Radio buttons for 'Left', 'Right', 'Both', and 'N/A' (selected).
- Sort 1, Sort 2, Sort 3:** Three empty dropdown menus.
- Buttons:** A row of seven buttons at the bottom: 'Next', 'Previous', 'Save', 'Cancel', 'New', 'Modify', and 'Delete'.

Figure 3c

Step 1. Enter information into the first three fields shown in Figure 3c to create a patient record. Use the Tab key to move to the next field.

- **Patient ID (*must enter field*)** – a unique identification code composed of any combination of up to fifteen (15) characters (letters, numbers, spaces, or symbols).
- **Last Name (*must enter field*)** – allows up to twenty-five (25) characters.
- **First Name (*must enter field*)** – allows up to twenty-five (25) characters.

The following fields are optional:

- **Height** – three (3) digit maximum. Enter whole inches or centimeters (0 – 120).
- **Weight** – three (3) digit maximum. Enter a number between 0 and 999.
- **Date of Birth** – enter dates in format “mm/dd/yyyy” For example, March 03, 1903 would be 03/03/1903.
- **Sex** – select male or female.
- **Dominant Side** – select Left, Right, or Amb. if patient is ambidextrous.
- **Involved Side** – specify which side of the patient has been injured – Left, Right, Both, or N/A if it is not appropriate to label any particular side as injured.

Step 2. Click the tabs labeled “Insurance” and “Injury” if you wish to enter insurance information, referral source, and details about the patient’s injury or condition and medical history.

Step 3. Once you have entered this information, touch the “Save” button at the bottom of the screen.

## 3.3 Editing and Deleting Patient Records

### 3.3.1 Editing a Patient Record

Step 1. Click the *Patient Records* section title (next to the *Home* tab) on the top of your screen.

Step 2. Click the “Show Patient List” button (visible in Figure 3b) and enter your password.

A list of all the patients whose records are saved in the PrimusRS database will be displayed.

You can re-sort patients by clicking the column titles labeled:

**Patient ID**

**Last Name**

**First Name**

**Date Selected**

**Date Entered**

Patient ID	Last Name	First Name	Date Selected	Date Entered
bubba	bubba	jones	07-22-03	07-22-03
111	Campbell	Dave	07-11-03	06-13-03
445	Contreras	Jose	06-16-03	06-13-03
1092	dddadf	aasdfedade	07-03-03	07-03-03
202	Einstein	Albert	07-22-03	06-05-03
101	Franklin	Benjamin	06-17-03	06-05-03
9090	Franklin	Harris	07-23-03	07-10-03
4901	Halladay	Jack	07-10-03	07-09-03
4445678	Johnson	Joe	07-10-03	07-03-03
10987	Maloney	Don	07-22-03	06-16-03
007	new	guy	07-22-03	07-22-03
303	Spiff	Spaceman	07-22-03	07-02-03

Patient ID

Cancel Print Patient List New Patient OK

Figure 3d

Step 3. Click on a patient's name and touch the “OK” button. You will be taken to the Patient Screen (Figure 3c)

Step 4. Touch the “Modify” button on the bottom of the Patient Screen and enter changes in the text fields.

Step 5. Click “Save” to store modifications to the Patient Record.

### 3.3.2 Deleting a Patient Record

#### IMPORTANT

When a record is deleted ALL test and treatment data for that subject is also **permanently** deleted.

Patient Records can be deleted in two different screens. From the “Select Patient” screen, you can type in a patient's ID number and touch “OK”. This will display the first tab of the patient's information section. Press the “Delete” button at the bottom of the Patient Screen (Figure 3c). A dialog box will pop up asking if you are sure you want to delete the patient. Click OK and you have deleted this file from the program.

A patient's file can also be removed from the Patient List Screen (Figure 3d). From the “Select Patient” screen, touch the “Show Patient List” box. Enter the system password, displaying the list. Highlight the



appropriate patient's name and click the "Delete" box at the bottom of the box. That file has now been deleted from the database.



# PRIMUSRS

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## Section 4 – Evaluation

### 4.1 Contraindications

This section contains suggestions for use of the BTE PrimusRS in muscle performance testing. It is the responsibility of the clinician to determine the appropriateness of the patient for testing on this equipment. A complete examination of the patient should precede the decision to test the patient on the Primus. Below is a list of possible contraindications for testing on the PrimusRS:

- unstable joint or bone healing
- severe pain
- acute strain or sprain
- severe open wounds or sores
- deep laceration surrounding joint

### 4.2 Introduction

Precede testing with a warm-up exercise or practice to familiarize the patient with the test motion and equipment, and to warm up the muscle before maximal effort is exerted. The *Home* screen (Section 2) is useful for this.

Numerous methods of evaluation are available for use on the BTE PrimusRS. The type of evaluation procedure you choose for each subject will be dependent on your objective for doing the evaluation. The following list is representative of these options with their associated objectives.

☐ **Standard Testing Template**

- measures maximum strength, power and endurance
- provides comparison of right to left side for percentage of deficit
- identifies baseline of performance
- assesses progress and provides clinician with information to determine appropriateness of continuation of skilled intervention or discharge
- measures patient's/client's job task performance level

☐ **Maximum Lift/Push/Pull**

- measures maximum lifting ability (or pushing/pulling)
- identifies repetitive lifting ability (or pushing/pulling)

☐ **Consistency of Effort Test or Maximum Voluntary Effort**

- provides coefficient of variation analysis
- assists in determining if the patient is trying his/her best

☐ **Agonist/Antagonist Ratio**

- measures maximum strength, power and endurance
- provides agonist/antagonist ratio

These protocols have been used clinically for many years and are supported in published research. They are among the most frequently used tests administered on this type of device and are effective for general strength testing as well as for identification of muscle performance deficits. The clinical applications of these tests are discussed in great detail in the second part of this manual (turn to the #3 red tab).

### 4.2.1 Suggestions for Successful Evaluations

- Repeat tests periodically to determine how well the patient is progressing.
- It is important to record the height and angle of the Exercise Head so that it is returned to exactly the same position each time that particular patient is tested. Even small variations may cause changes in test results.
- Subjects who might experience edema should have volumetric or other edema measurements taken before and after testing.
- The subject should be tested in an identical way at each session. The sequence of attachments used, amount of rest periods, hand placement, body positioning, instructions, and even time of day should be duplicated as much as possible.
- The monitor display screens should not be visible to the patient (except for the endurance testing).
- Test results should not be discussed with the patient until all testing is completed.

#### Note

Press the “**F10**” key on the top row of your keyboard (**Error! Reference source not found.**) to launch **Primal Pictures – Interactive Functional Anatomy (IFA)**. IFA is a vast interactive resource of 3-dimensional models and detailed descriptions of every major bone, tendon, ligament, and muscle group in the body. This innovative software has been integrated into PrimusRS so that hitting F10 takes you directly to the interactive informational section relating to the tool and muscle movement set for the current test.

For instance, if you select an evaluation with the 701 tool and you choose “Elbow Flexion/Extension” from the functional descriptions list, hitting F10 launches the IFA Elbow Flexion/Extension video.

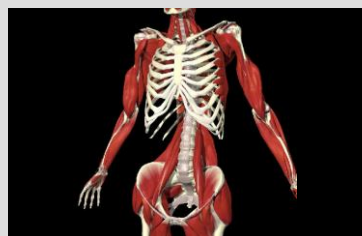


Figure 4a

Before any test can be conducted, a Template must be established as outlined in Section 4.3.

## 4.3 Evaluation Templates

Templates are the backbone of both evaluation and treatment on the PrimusRS. They serve as guides in the set-up of evaluations and treatment. You can opt to use the templates as defined, modify existing templates or create you own. This section gives a thorough tutorial on using Templates.

### 4.3.1 General vs. Patient-Specific Templates

PrimusRS affords you great flexibility in evaluating your patients. To get the most out of your Primus, it is imperative to fully grasp the difference between a General Template and a Patient-Specific Template. Using the right kind of template for a particular application will maximize your efficiency.

A General Evaluation Template is a set of tests which are saved into the database in a way that makes it available for use with **any** patient. **It is the basis for creation of a Patient-Specific Evaluation.** Your PrimusRS already contains several General Templates designed to evaluate particular muscle groups or functional tasks.

If **no patient is selected** (as indicated in the title bar of the software) you can:

- a. **Create a new General Template based on the pre-defined tests in an existing General Template.** In this case, the pre-defined template serves as a true 'template.' This operation allows you to customize your new 'duplicate' of the template at will while leaving the original unmodified.
- b. **Create a new General Template from scratch.** *Any particularly versatile set of tests which you anticipate using with more than one patient should be saved into a General Template.*
- c. **Edit a General Template directly.** This modifies the BTE-made preset template. If you choose to edit in this way, you will be unable to revert to the original version of the template.

A Patient-Specific Template is a set of tests unique to a particular patient. Again, PrimusRS offers you great flexibility in creating and editing these. With a patient record loaded (the patient's name will appear on the title bar of the software), you have the option to:

- a. **Use a General Template as the basis for a Patient-Specific Template.** This allows you to customize the test set to fit your patient's needs while leaving the original intact.
- b. **Create a Patient-Specific Template from scratch.**
- c. **Edit an existing Patient-Specific Template.**
- d. **Save a Patient-Specific Template you have created as a General Template.** If you create a template for a particular patient and realize that it will be useful for another patient, you can save it as a General Template as well.

The following sections will guide you through all of these different options.

### 4.3.2 Creating and Modifying a General Template

Step 1. Click the *Home* tab to ensure that no patient name is selected. The title bar at the top of the screen will read "No Patient Selected" (See Section 2.2 for basic software navigation).

Step 2. Click the *Evaluation Setup* tab (Figure 4b).

Step 3. At this point, you have three options:

- create a new General Template based on the pre-defined tests in an existing General Template,
- create a General Template from scratch, or
- edit a General Template directly.



Figure 4b

#### 4.3.2.1 To create a new General Template based on the pre-defined tests in an existing General Template:

- Click the “New” button at the bottom center of your screen (Figure 4c).
- Choose “New Template” from the dialog box and touch “OK.”
- Choose a pre-defined template from the list in the “Select General Evaluation Template” box (Figure 4d). Click “OK.”

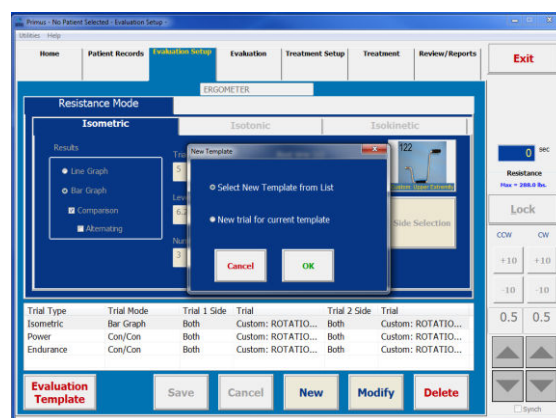


Figure 4c

- You will be prompted to enter a unique name for your new template. Bear in mind that this is essentially a ‘clone’ of the pre-defined template. To avoid confusion, consider giving the new template a name different but related to that of the original. For example if you choose Grip Strength you might want to enter a name like “New Hand Protocol”.

**Note:** This name can be edited at any time by clicking the “Modify” button at the bottom of the screen and placing the cursor in the white text field at the top just underneath the *Evaluation* Tab (Figure 4e).

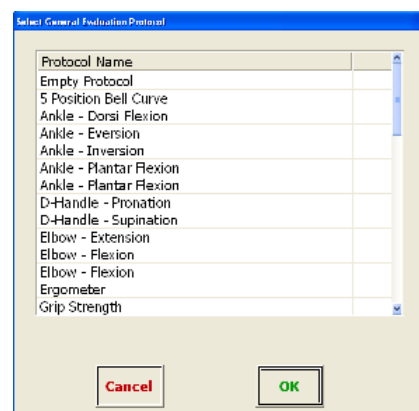


Figure 4d

Clear undesired text using the delete/backspace keys on your keyboard and type in your new name.

- Click the “Save” button at the bottom of the screen.

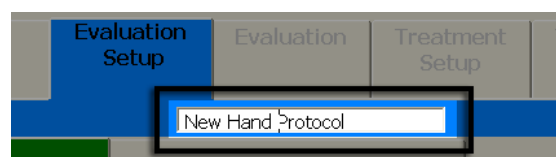


Figure 4e

Now Proceed to Section 4.5 to create/edit individual tests.

#### 4.3.2.2 To create a new General Template from scratch:

- Perform steps **a** and **b** as described above.
- Select “Empty Template” from the General Evaluation Template list (Figure 4d). Click “OK.”
- Enter a unique template name when prompted and click “OK” in the dialog box to return to *Evaluation Setup* (Figure 4f).

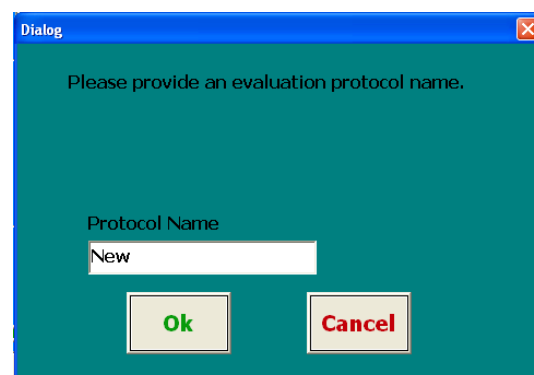


Figure 4f



The template name is now displayed directly beneath the *Evaluation* tab and in the title bar at the uppermost portion of the screen (Figure 4g).

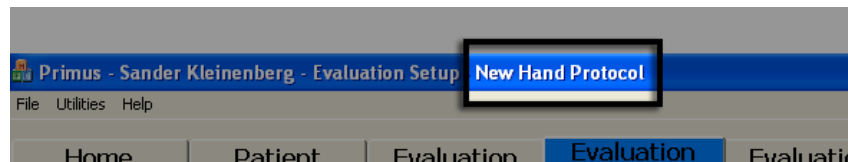


Figure 4g

- d. Proceed to Section 4.5 to create/edit individual tests.

#### 4.3.2.3 To edit a General Template directly:

- a. Click the “Evaluation Templates” button at the bottom left of your screen.
- b. Touch the name of an existing template to select (Figure 4d). Click “OK” at the bottom of the dialog box to return to Evaluation Setup.
- c. Notice that the template name is displayed in the text field directly underneath the *Evaluation* tab.
- d. To rename the template, hit the “Modify” button at the bottom of your screen.
- e. This will make all fields active, including the template name text field (Figure 4e). If you want to rename the template, click inside the white text field to place your cursor.

Clear undesired text using the delete/backspace keys on your keyboard and type in your new name.

Hit “Save” at the bottom of the screen to apply your changes

- f. Proceed to Section 4.5 to create/edit individual tests.

### 4.3.3 Creating and Modifying a Patient-Specific Template

- Step 1. Click the *Patient Records* tab at the top left of the screen.
- Step 2. A new window will appear (Figure 4h). If you have not yet defined a patient, go to Section 3.2 of this manual. Touch “Show Patient List” or enter a Patient ID in the “Enter ID” field.
- Step 3. If you touched “Show Patient List,” you will be prompted to enter your password.
- Step 4. Type in the password and hit “Enter” on the keyboard—the default password is “rs” (See Section 07 – “Utilities” to learn more about password settings).

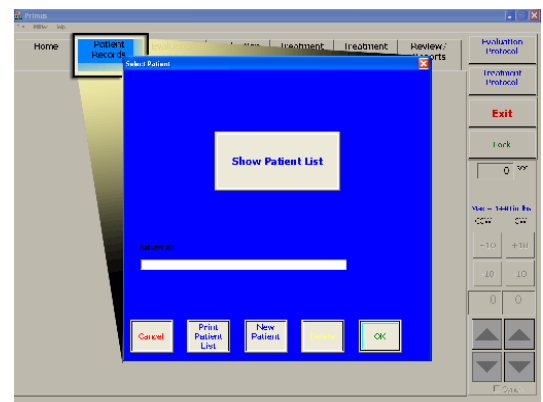


Figure 4h

- Step 5. Select your patient from the list and click “OK” (Figure 4i).

His/her name will now appear in the PrimusRS title bar (uppermost left of main software window – (Figure 4j).

**Note:** Do not go to the Home screen once you have loaded your patient’s record. To protect your patient’s data from being viewed by unauthorized persons, his or her software record will be deactivated every time you click the *Home* tab. You will have to re-enter *Patient Records*, type the password again, and reload the patient record.



Figure 4i

- Step 6. Touch the *Evaluation Setup* tab on the upper region of your screen (Figure 4b).

You now have several options:

#### 4.3.3.1 Using a General Template as the basis for a Patient-Specific Template

- Click the “New” button at the bottom center of your screen (Figure 4c).
- Choose “New Template” from the dialog box and touch “OK.”
- Choose a pre-defined template from the list in the “Select General Evaluation Template” box (Figure 4d). Click “OK.”

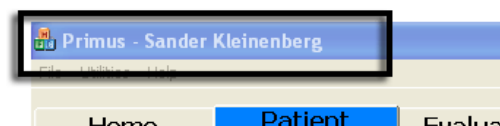


Figure 4j

This will copy the pre-defined General Template into the current Patient’s own template list. By default, the name of the ‘cloned’ template stays the same.

- To change the name of the new patient template, hit the “Modify” button at the bottom of your screen.

This will make all fields active, including the template name text field (Figure 4e). If you want to rename the template, click inside the white text field to place your cursor. Clear undesired text using the delete/backspace keys on your keyboard and type in your new name.

Hit “Save” at the bottom of your screen to apply your changes.

- Proceed to Section 4.5 to create/edit individual tests

#### 4.3.3.2 Creating a Patient-Specific Template from scratch

- Do steps **a** and **b** as described above.
- Select “Empty Template” from the general Evaluation Template List (Figure 4d). Click “OK.”

- c. Enter a unique name for the template you are creating and click “OK” in the dialog box (Figure 4f).

The template name is now displayed directly underneath the *Evaluation* tab and in the title bar (Figure 4g) at the uppermost portion of your screen

- d. Proceed now to Section 4.5 and create/edit individual tests.

#### 4.3.3.3 Editing an existing Patient-Specific Template

- a. Click the “Evaluation Templates” button at the bottom left of your screen.
- b. Select an existing template. Click on the template and touch “OK” (Figure 4d). Notice that the template name is displayed in the text field directly underneath the *Evaluation* tab.
- c. To rename the template, hit the “Modify” button at the bottom of your screen.
- d. This will make all fields active, including the template name text field (Figure 4e). If you want to rename the template, click inside the white text field to place your cursor. Clear undesired text using the delete/backspace keys on your keyboard and type in a new name.
- e. Hit “Save” at the bottom of the screen to apply your changes.
- f. To add and edit individual tests, proceed to Section 4.5.

#### 4.3.3.4 Saving a Patient-Specific Template you have created as a General Template

You may find yourself wanting to use an evaluation crafted for a specific patient with another patient. Instead of creating a new General Template and manually replicating each test, use this time saving function:

- a. Follow up to step **c** in 4.4.3.3.
- b. You will notice that the “Save” button is active.
- c. Click the “Utilities” menu in the menu bar at the top left of your screen (Figure 4k).
- d. Move your pointer over “Save Options” in the Utilities menu.

The menu will expand, showing a sub-menu with the option to turn Save Options “On” or “Off.”

Click “On.”

- e. Now - back in the *Evaluation Setup* screen - click the “Save” button at the bottom of your screen.

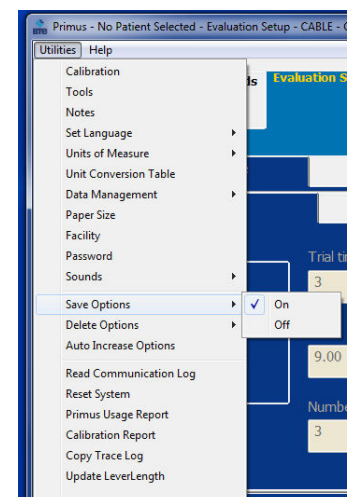


Figure 10k

A dialog box will pop up giving you three “Save Options:”

#### Save to General Template List Only

(this option is not available if no tests have yet been saved into the current patient template).

### Save to Patient Template List Only

### Save to BOTH Patient and General Template Lists

Select the function of your choice and click “OK.”

*If you do not want the Save Options dialog box to appear every time you hit “Save,” repeat Step d but click “Off” this time.*

- Step 6. Now that you have loaded the appropriate Template, proceed to Section 4.5 to create/edit individual tests.

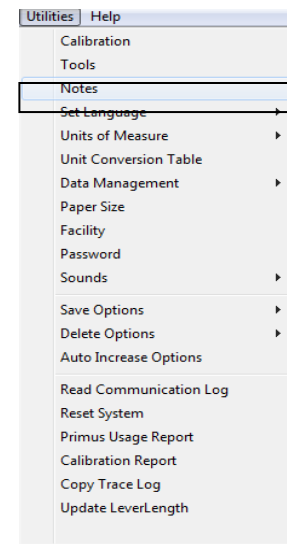


Figure 4l

## 4.3.4 Entering Setup/Print Notes

PrimusRS includes a built-in note-taking option. Notes are activated and deactivated via the Utilities menu at the top left of the screen.

To turn on Notes, click “Utilities” and move your cursor down to click “Notes” (Figure 4l). A check mark indicates that Notes are activated.

This will bring up the “Notes” window (Figure 4m).

You can now enter any necessary information.

There are two types of notes:

### Setup Notes (*Evaluation Setup* screen):

Enter information such as the height of the exercise head, location of range of motion stops (when applicable), and the patient’s position. Use of this feature allows you to accurately and consistently repeat tests.

Setup Notes are entered only in the *Evaluation Setup* screen. They are not printable – they are solely for the purpose of helping you set up evaluations.

### Print Notes (*In Evaluation* screen):

After performing an Evaluation, enter any information you want to be able to print in this field. This may include observations of the patient’s performance during an evaluation.

Click “OK/Save” to save your notes. At this point, the “Notes” window will be “minimized” (reduced to a small

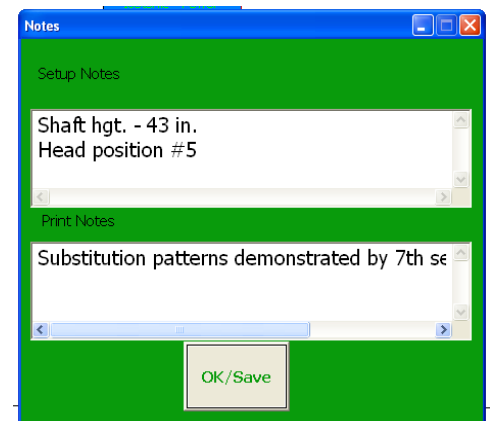


Figure 4m

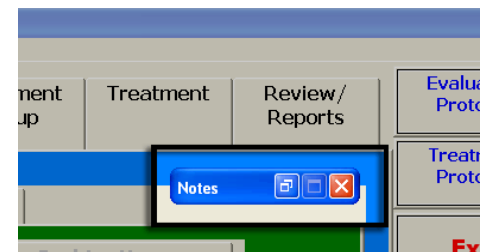


Figure 4n

rectangle). This minimized box will lodge itself at the top right of your screen (Figure 4n) by default.

You can move the minimized notes box to any area of your screen by pressing it on the monitor and dragging your finger to a new position.

If you wish to enter more notes later, click the “Restore” button in the small box to restore the screen (Figure 4o).


To reduce Notes back to the minimized bar, click the minimize button at the top right of the notes screen. (Figure 4p).



Figure 4o



Figure 10p

To hide notes altogether, click  or go into the “Utilities” menu and uncheck “Notes” (Figure 4l).

## 4.4 The Evaluation Setup Screen

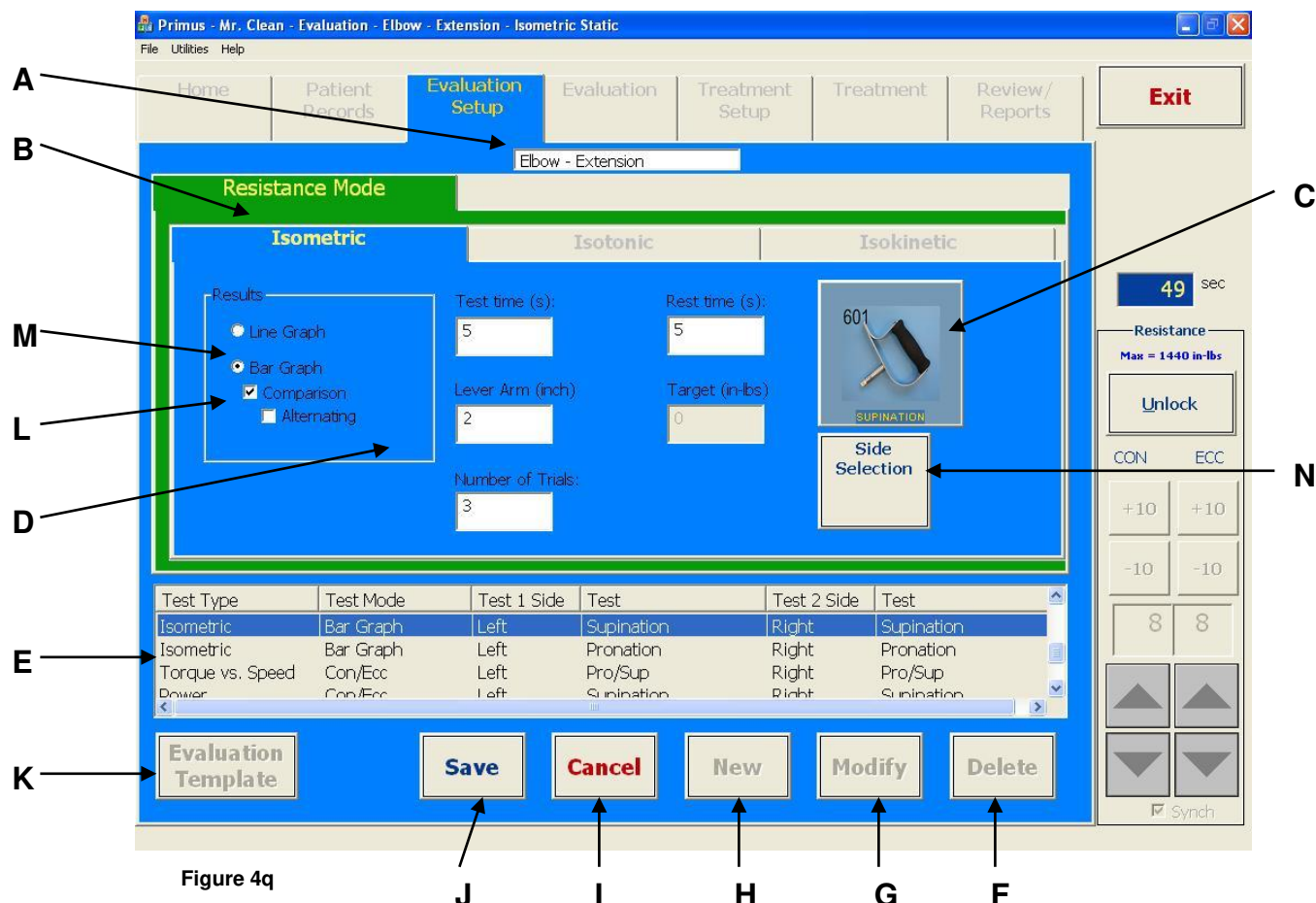


Figure 4q

- A. Evaluation Template Name** – field displaying currently loaded template (editable by clicking the “Modify” button (G) at the bottom right of the screen)
- B. Modes of Operation** – Isometric, Isotonic, and Isokinetic evaluations are configured by clicking the appropriate tabs.
- C. Tool Selection** – click to select tool for exercise
- D. Test Parameters** – enter parameters of test here
- E. Test Descriptions** – lists all exercises which have been entered into the selected template
- F. Delete** – deletes selected test. If Delete Options (Section 7 – Utilities) are on – this button can be used to delete an entire template as well.
- G. Modify** – allows changing parameters of the selected test or renaming the current template (in field A).
- H. New** – creates new templates and new tests
- I. Cancel** – cancels current operation
- J. Save** – saves changes to test or template
- K. Evaluation Templates** – used for navigation between templates
- L. (Available only when Bar Graph is selected in M)**
  - Comparison** – compares involved side with uninvolved sides
  - Alternating** – a variation on traditional comparison testing – when selected, the patient alternates right and left extremities
- M. Results** – selects display configuration (*Line Graph* or *Bar Graph*)
- N. Side Selection** – clicking this tab enables you to set parameters for each side being tested (involved and uninvolved)

## 4.5 Adding and Editing Tests in an Evaluation Template

PrimusRS *Evaluation Setup* screen (Figure 4q) is used to set up tests in a General or a Patient-Specific Evaluation Template.

### Note

If you intend to set up tests for a specific patient, ensure that you have loaded a patient record (See Section 4.3.3).

If you wish to set up tests which are to be available to ANY patient, you must ensure that no patient record is loaded (See Section 4.3.2).

This section outlines the basic universal procedure for setting up any test. *Evaluation Setup* will vary depending upon which test mode is chosen: Isometric, Isotonic, or Isokinetic. Each mode has different parameters.

Use the diagram on the preceding page to help you in locating and understanding the buttons on your screen. If you have general questions regarding the layout and the logic of the software, refer to Section 2.2 – “Basic Software Navigation.”

### 4.5.1 Creating New Tests

- Step 1. Click “New” at the bottom of the screen (Figure 4q - H). This will bring up a dialog box.
- Step 2. Select “New Trial for Current Template” from the dialog box and click “OK.” This will activate the screen and allow you to set parameters for each individual exercise.
- Step 3. *Evaluation Setup* defaults to the Isometric mode setup screen. An Isotonic or Isokinetic evaluation can be set up by clicking the appropriately labeled tab now. (Figure 4q - B). If an agonist/antagonist or left and right side comparison is desired, click the “Comparison” box at this time.
- Step 4. Click the “Select Tool” button (Figure q - C).
- Step 5. Select the body part to be tested.  
  
Click the image of the attachment you intend to use for the test (Figure r).  
  
Click “OK.”
- Step 6. Click the “Side Selection” button (Figure 4q – N) and choose side and side 2 test options from the list box.  
  
Click “OK.”

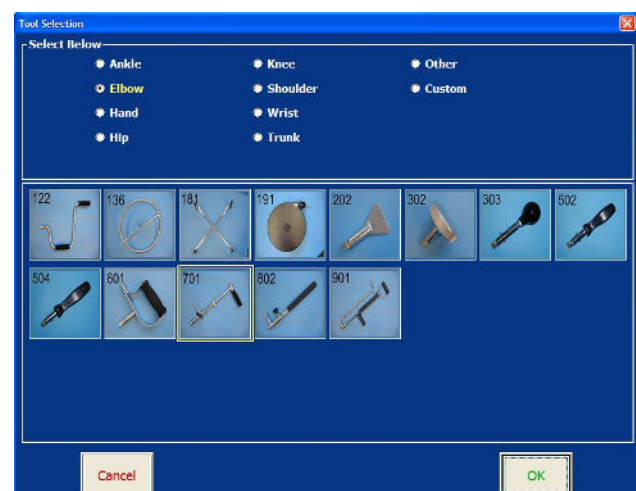


Figure 4r

Note that for most attachments, the tool's lever length now automatically appears in the "Lever Length" field (Figure 4q– D). This allows PrimusRS to display force in pounds.

- Step 7. If you selected the 701 or the 802 tool, loosen the tightening knob on the attachment and adjust its length to fit your patient for the current evaluation. Make sure to tighten the knob after such an adjustment. Depending on the exercise, you may also wish to release the 701 tool's handle (by pressing the button on the attaching pin) in order to reposition it.

Now locate the etched number which corresponds to the attachment's current lever length (this number reflects the distance from the tool's axis of rotation to the center of the patient's hand).

Enter this value in the Lever Length field of the software (Figure – D).

- Step 8. Check the necessary boxes, click the appropriate radio buttons, and fill in the test parameter fields shown in Figure - D. Selection of set-up parameters will be discussed for each test later in this Section.

Some fields are optional in certain tests. You must, however, fill in each "Must-Enter" field labeled with yellow text.

- Step 9. Once the parameters are set, click "Save" at the bottom of the screen (Figure 4q – J).

## 4.5.2 Editing Existing Tests

PrimusRS gives you the capability to edit the parameters of tests saved into a Template. You may edit a test at any time. Refer to the diagram in Section 4.4 if you have trouble locating buttons on the screen. Consult Section 2.2 – "Basic Software Navigation" to answer general questions on how to use the software.

- Step 1. Click the test you wish to edit in the Test Descriptions List (Figure - E). This will highlight the selected test in the list and test settings will display in the *Evaluation Setup* screen.
- Step 2. Click the "Modify" button to activate the test settings (Figure - G).
- Step 3. Change the desired parameters.
- Step 4. Click "Save" to store your changes (Figure – J).

## 4.5.3 Changing the Sequence of Tests

When you start an evaluation, the tests in the template will be performed in the order in which they are listed in the *Evaluation Setup* screen. If you wish to change their sequence:

- Step 1. Click on the test you wish to move in the Test Descriptions List (Figure ).
- Step 2. Hit the "CTRL" key on your keyboard and hold it down.
- Step 3. Still holding "CTRL," tap the "up" or "down" arrow on your keyboard to change the test's position.

Exercise Type	Exercise Mode	Exercise Side	Exercise
Isotonic	Con/Ecc	Left	SHOULDER EXT. ROTAT.
Isotonic	Con/Ecc	Left	SHOULDER INT. ROTAT.
Isotonic	Con/Ecc	Left	PNF DIAGONAL FLEXION
Isotonic	Con/Ecc	Left	PNF DIAGONAL EXTENSION

Next Previous Save Cancel New

Figure 4s



## 4.6 Deleting Individual Tests and Entire Templates

### 4.6.1 Deleting a Single Test

If you find that a particular test is no longer needed, you can easily delete it. This will remove the test entirely from the Primus software. **Deletion is permanent - once deleted, a test cannot be recovered.**

- Step 1. Go into the *Evaluation Setup* screen.
- Step 2. Select the test from the Test Type list (Figure – E) by touching or clicking it.
- Step 3. Hit the large “Delete” button at the bottom right of the screen (Figure – F).
- Step 4. Click “Yes” in the dialog box to confirm deletion of the test.

### 4.6.2 Deleting an Entire Evaluation Template

PrimusRS gives you the capability to delete an entire Template in one operation.

**Deletion of a template is permanent – tests in a deleted template are removed from the computer and cannot be recovered.**

#### 4.6.1.1 To Delete a General Evaluation Template

- a. Touch the *Home* tab to ensure that no patient name is selected. The title bar at the top of the screen will read “No Patient Selected”
- b. Click the *Evaluation Setup* tab (Figure 4b).
- c. Click the “Evaluation Templates” button at the bottom left of the screen.
- d. Select the General Evaluation Template you wish to delete (Figure ). Click “OK.”
- e. Click “Utilities” in the menu bar at the upper left of the screen and move your pointer down to “Delete Options.”

The menu will expand (Figure ).

- f. Touch “On” in the menu to activate the Delete Options feature.
- g. Now touch the “Delete” button at the bottom right of the screen (Figure - F).

The Delete Options dialog box will appear on your screen.

- h. Select the “Delete all Tests AND Template” option and click “OK.”

Your template is now removed.

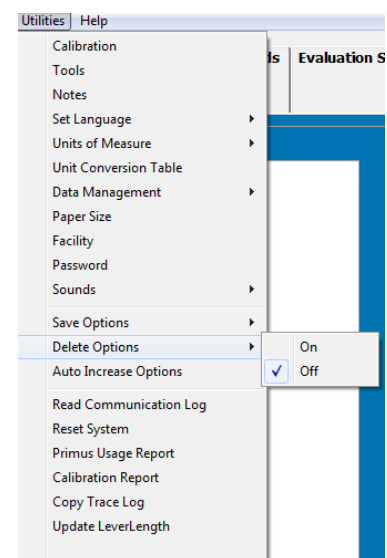
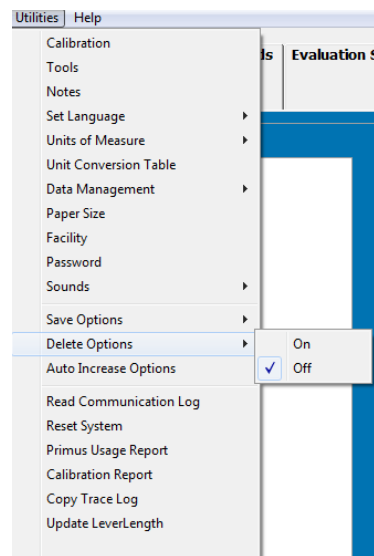


Figure 4t

*If you do not want the Delete Options dialog box to appear every time you hit “Delete,” repeat e. Click “Off” in the expanded menu.*

#### 4.6.1.2 To Delete a Patient-Specific Evaluation Template

- a. Select/load the patient at the *Patient Records* tab.
- b. Click the *Evaluation Setup* tab (Figure 4b).
- c. Click the “Evaluation Templates” button at the bottom left of the screen.
- d. Select the General Evaluation Template you wish to delete (Figure ). Click “OK.”
- e. Click “Utilities” in the menu bar at the upper left of the screen and move your pointer down to “Delete Options.” The menu will expand (Figure ).
- f. Touch “On” in the menu to activate the Delete Options feature.
- g. Now touch the “Delete” button at the bottom right of the screen (Figure - F). The Delete Options dialog box will appear on your screen.
- h. Select the “Delete all Tests AND Template” option and click “OK.”



**Figure 4u**

## 4.7 Evaluating Your Patient Using PrimusRS Templates

PrimusRS includes useful General Evaluation Templates designed to evaluate many of the injured muscle groups most commonly encountered by therapists. The majority of these include the following established tests:

- Isometric Maximum Strength
- Isometric Consistency of Effort Testing (See Clinical Applications portion of this manual, Section 3)
- Isotonic Dynamic Power
- Isotonic Dynamic Endurance
- Isotonic Torque vs. Speed

Additionally, General Evaluation Templates are available for Lift Testing:

- Maximum Lift/Push/Pull
- Repetitive Lift/Push/Pull

The following sections will guide you through conducting each of these evaluations.

**Note**

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



## 4.8 Isometric Maximum Strength Test

The first step in strength testing is obtaining a measure of the subject's maximum strength capability. This is accomplished through isometric testing. The PrimusRS offers a variety of tests that can be used to collect this information; Maximum Strength Test (a comparison test), Consistency of Effort Test, 5 Position Bell Curve Test, and Rapid Exchange Test to name several. The first to be discussed is the Isometric Maximum Strength Test.

This test gathers that information and displays it in bar graph format. The subject is normally given three trials. The peak isometric force achieved is presented for each trial and then averaged. Additionally, consistency of effort is quantified by a Coefficient of Variation (CV) score (refer to Section 9 for detailed definition and explanation). Since this number is derived using the mean force exerted during an evaluation, *a minimum of three trials must be completed in order for Primus to compute and display CV*. A high CV indicates significant disparity between the forces generated from trial to trial. A low coefficient of variation, therefore, indicates strong consistency of effort. ("It should be possible in a physical capability test to achieve a coefficient of variation of less than 15%". *Work Practices Guide for Manual Lifting* - NIOSH pub. no. 81-122).

### 4.8.1 Setting Up an Isometric Maximum Strength Test

- Step 1. Follow the procedure outlined in Section 4.3.3 which deals with General vs. Patient Specific Templates.
- Step 2. Continue through Section 4.3.3.1, selecting a Template in Step **c** which corresponds to the muscle group or functional activity you intend to evaluate.
- Step 3. Click on “Isometric Bar Graph” in the Test Descriptions List (Figure – E).
- Step 4. Click “Modify” to activate test parameters (Figure – G). Remember that white fields represent active parameters.

Notice that the parameter fields are already filled in with suggested values or defaults (See Section 4.4 for a detailed diagram with descriptions of each parameter).

- Step 5. Edit appropriate parameters by clicking inside a labeled field. Drag your finger over the numerical value entered and type a new one in on the keyboard. You can also clear the field using the “backspace” or “delete” buttons located on your keyboard.

Note that setting “Number of Trials” to less than 3 will prevent PrimusRS from computing a Coefficient of Variation (CV). For this reason, BTE recommends performing at least 3 trials.

“Comparison” is checked in the Evaluation Setup screen in order for PrimusRS to compute the percent deficit of the involved side as compared to the uninvolved side (Figure – L).

- Step 6. Check that the correct tool attachment is selected. If you wish to use a different attachment, click the image of the tool at the right of the screen (Figure – C).

In the Tool Selection window, click the tool you intend to use, select the appropriate functional description, and click “OK” (Figure ).

Note that for most attachments, the tool’s lever length now automatically appears in the “Lever Length” field (Figure - D). This allows PrimusRS to compute force readings in pounds.

**Note:**

If you selected the 701 or the 802 tool, loosen the tightening knob on the attachment and adjust its length to fit your patient for the current evaluation. Tighten the knob and locate the etched number which corresponds to the new length of the tool (this number reflects the distance from the tool’s axis of rotation to the center of the patient’s hand). Enter this value into the Lever Length field in the software (Figure - D).

- Step 7. Click the box labeled “Side Selection” (Figure - N). Tap on the “Side 1” tab and specify which side/extremity you wish to test first. Set “Side 2” to the second side you will test. Also select the type of muscle motion (for each side) which reflects the test you are performing. If action is not listed or a specific task is being tested, a description may be typed into designated field.
- Step 8. When you are satisfied with all test parameters, click “Save” (Figure – J).
- Step 9. To enter setup Notes, open the **Notes** window (Section 4.3.4).

*If you wish to set up the remaining tests in this template before beginning your evaluation, go to Section 4.10 – Isotonic Power Test and Section 4.11 – Isotonic Endurance Test. Return to 4.8.2 when you are ready to run the evaluation.*

## 4.8.2 Conducting an Isometric Maximum Strength Test

- Step 1. Click the “Evaluation” tab at the top of your screen to conduct a static strength test (Figure ).

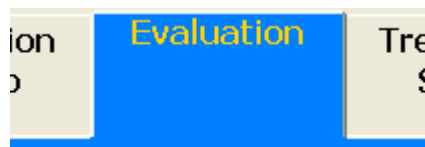


Figure 4v

- Step 2. Attach the appropriate tool to the exercise head. Touch the “Unlock” button in the Control Panel at the right so that you can rotate the attachment to the appropriate position for the test (Figure ). Press “Lock” to lock the tool in place.



Figure 4w

- Step 3. Position the patient in such a way that there will be no muscle substitution, allowing you to isolate the appropriate muscle group.
- Step 4. In order for the patient to get used to the test, hit “Start” at the bottom right of the screen to begin a practice trial. Have patient perform a sub-maximal effort.
- Step 5. A vertical bar will appear showing the amount of force exerted (Figure ). The trial will automatically stop when the defined test time is reached or the force drops to less than 10% of the maximum. You may also hit “Stop” to end the trial.

- Step 6. Hit **"Clear"** to delete the practice trial(s). The patient should now be ready for his or her evaluation.

If you selected a comparison evaluation, the screen will display two rectangles labeled "left" and "right" (Figure ).

Notice that the left one is selected by default – it is filled with yellow.

The patient's uninvolved or dominant side should be tested first.

(If you wish to begin the evaluation with the other side, simply touch the white graph region to select it. In the course of the evaluation, you can manually switch between graphs in this manner.)

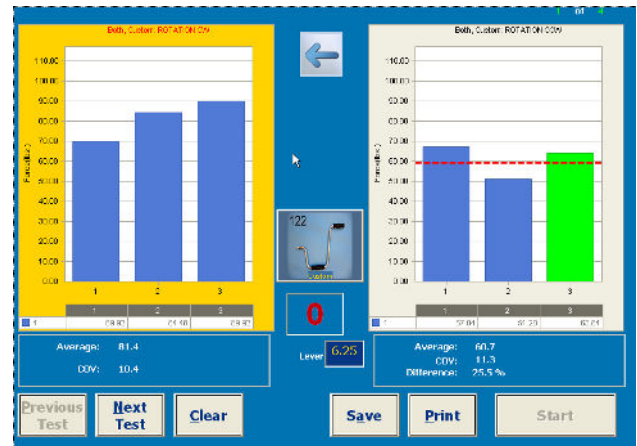


Figure 4x

- Step 7. Instruct the patient to exert maximum effort. Prompt the patient "Ready ... Go."

Press **"Start."** PrimusRS will graph the maximum force exerted.

**Advise your subject to stop the test immediately if he or she experiences any unusual pain or discomfort.**

**Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

- Step 8. Again, the test will automatically stop after the Test Time set in *Evaluation Setup* has elapsed. If you did not set a Test Time, you must touch the **"Stop"** button at the bottom of the screen to end the trial.

Maximum effort should be reached within 2 to 3 seconds which may be indicated by a physiological tremor. That is the rationale behind the three (3) second test time default.

Once the trial has concluded, tell the subject to relax but to NOT change hand or body position. Allow the patient to rest for approximately 5 seconds between trials.

If a Rest Time was set in *Evaluation Setup*, the red counter in the center of the screen will flash and beep once the specified rest time elapses (Figure ).



Figure 4y

- Step 9. Ensure that the patient is correctly positioned for the next trial.

**Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may significantly alter data due to a change in leverage.**

- Step 10. Press **"Start"** to begin the next trial. Proceed through the balance of the trials in the way described above.  
At the conclusion of the three trials, the average force and coefficient of variation are displayed at the bottom of the graphs. The CV should be less than 15% for an acceptable test.

Step 11. If you are conducting a standard comparison evaluation, touch the second white graph box after trials are completed on the first side.

Reposition the subject for testing of the non-dominant or involved side. It is extremely important that the patient be positioned as before. Repeat Steps 7 - 10 with the other side until all trials are complete.

Step 12. If a trial is not satisfactory, press "Clear" and the selected (green colored) bar will disappear.

Hitting "**Start**" will allow you to redo the deleted trial. A results bar can be selected at any time for deletion by directly clicking on the bar of the trial you wish to delete.

Step 13. To enter your observations of the evaluation, open the **Notes** window (Section 4.3.4).

Step 14. Press "**Save**" to store the evaluation results. Saved notes and test results are available for on-screen viewing and printing in the "Reviews/Reports" tab (See Section 6 of this manual).

Step 15. If you want an instant hardcopy of your evaluation results, hit "Print" now.

*(To proceed with the standard testing protocol, go to Section 4.10 – Isotonic Power Test.)*

## 4.9 Isometric Consistency of Effort Testing

Isometric tests measure the peak (maximum) force a patient can exert in a specific position, with a specific attachment or a specific muscle group. Isometric testing is also an ideal tool to look at consistency between trials because you are controlling all variables except effort exerted by the patient.

PrimusRS offers three different Isometric feedback formats to choose from: Static Line Graph, Static Bar Graph (Single-Sided), and Static Bar Graph (Comparison). This combination of settings enables you to perform several general types of testing:

**Isometric Line Graph Test** is a timed test which graphs real time torque curves. It displays peak force, average force for seconds 3 to 5, and average force for the entire trial (3 or more tests).

**Bar Graph / Comparison Test** (Section 4.9.3) is a test for quantifying maximum voluntary effort. It calculates the coefficient of variation of multiple trials, alternating between clockwise and counter-clockwise directions or left and right sides.

### 4.9.1 Setting up an Isometric Line Graph Test

A key feature of this test is the presentation of test results in line graph overlays. Real time torque curves are displayed as the patient is instructed to exert a maximum isometric effort. Test time (duration of each trial) defaults to six seconds, as recommended by Chaffin (1975), and up to three trials may be overlaid per test. The graphs display peak force, average force from seconds 3 to 5, and average force for the entire 6 seconds.

As this test is also frequently used for treatment purposes, you do have the option of changing the test time to up to 60 seconds and setting a target torque as a goal for the patient to reach during an isometric exercise. If a target torque is set, the results will also include the percentage of time the patient is able to maintain his or her effort within the target torque window (target torque plus or minus 10%).

Step 1. Follow the procedure outlined in Section 4.3.3 regarding choice of templates.

Step 2. If you want to use an existing template:

Continue through Section 4.3.3.1, selecting a template in Step **c** which corresponds to the muscle group you intend to evaluate.

If you wish to create a new template, follow the steps in Section 4.3.3.2.

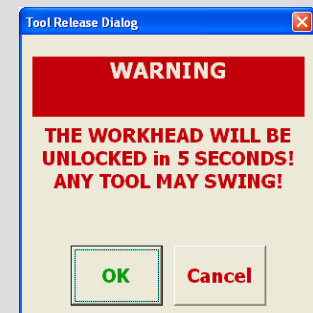
- Step 3. Complete Steps 1-6 in Section 4.5.1, selecting an “Isometric” evaluation.
- Step 4. Click inside the radio box labeled “Line Graph” at the left of your screen (Figure - M).
- Step 5. Enter the “Number of Trials” to be conducted in the evaluation. A minimum of 3 trials is required for PrimusRS to compute a Coefficient of Variation (CV).
- Step 6. Touch the “Test Time” field. A six second trial is the most common setting. You can, however, increase the duration of each trial to up to 60 seconds. This is very useful in conjunction with the target setting for engaging the subject in a controlled isometric exercise.  
  
Please note that the coefficient of variation (CV) is still based on the time from the beginning of the third second to the end of the fifth second.
- Step 7. Enter a Rest Time in between trials (BTE recommends 15 seconds).
- Step 8. Click the “Side Selection” tab near the top of the screen (Figure – N). Specify the “Side” of the trial – “Left,” “Right,” or “Both” (if using two hands at the same time for the test). Select the appropriate description of the muscle movement to be tested in the evaluation.
- Step 9. Touch the “Save” button at the bottom of the screen to save your exercise.
- Step 10. Enter Setup Notes (see Section 4.3.4 for details).

## 4.9.2 Conducting an Isometric Line Graph Test

### Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



- Step 1. Click the “*Evaluation*” tab to conduct a static strength test.
- Step 2. Position the patient in such a way that there will be no muscle substitution, allowing you to isolate the appropriate muscle group.

- Hit “Unlock” to move the tool to the desired position.
- Step 3. In order for the patient to get used to the test, hit “**Start**” at the bottom right of the screen to begin a practice trial.
- Step 4. Instruct him or her to exert sub-maximum effort on the attachment. PrimusRS will start recording force and graphing it on the screen (Figure 4z)
- Step 5. Hit “**Stop**” to halt the practice trial. Touch the “**Clear**” button to delete practice trial(s).
- Step 6. If the patient has no questions, hit “**Start**” to begin the evaluation. Instruct your patient to exert maximum effort against the attachment without jerking, and to discontinue at any sign of discomfort. It is recommended that the subject not be allowed to view the screen while testing. Do not coach the subject during the data collection, as that may affect the results.

As soon as effort is exerted on the attachment, the force will begin recording and a line graph will appear. Vertical dotted lines delineate the 2-5 second region used for data collection. Each trial's individual force in this three second period is displayed in the box beneath the graph. The peak force for each individual trial is displayed in the same box, and marked on the graph with a cross.

After three trials, the cumulative average force exerted in the 2-5 second region is displayed directly beneath the line graphs. The Coefficient of Variation is also calculated. (The CV should be less than 15% for an acceptable test.) Finally, the cumulative average peak force is calculated and displayed to the right of the CV. If you wish to view the details of a single trial, click on that line item in the list below the graph. Click the “View all Trials” button to once again view all of the data. (Figure 4aa)

- Step 7. PrimusRS will stop graphing when the test time elapses.
- Allow the patient to rest for approximately 15 seconds between trials.
- If a Rest Time was set in *Evaluation Setup*, the red counter in the center of the screen will flash and beep once the specified rest time elapses (Figure bb).

Hit “**Start**” to run the next trial. Continue this process until all the trials are finished (Figure z).



Figure 10z

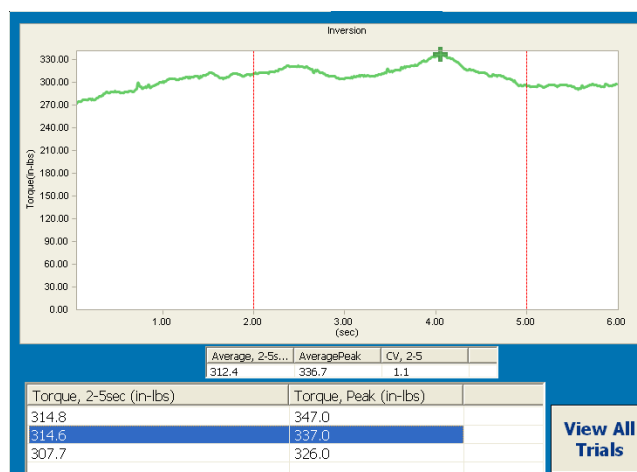


Figure 4aa



Figure 4bb



- Step 8. If you find a trial to be unsatisfactory, select it by clicking the desired trial in the list below the graph (Figure 4aa). (A test is selected when it is the only visible line on the graph). Hit "Clear" to delete the selected trial.
- Step 9. Record your observations with the "Notes" utility (Section 4.3.4).
- Step 10. Once you are satisfied with the set of trials, touch "Save" to save your graphs. Saved notes and test results are available for on-screen viewing and printing in the "Reviews/Reports" tab (Described in Section 6 of this manual).
- Step 11. If you want an instant hardcopy of your evaluation results, hit "Print" now.

### 4.9.3 Isometric Bar Graph / Comparison Tests

PrimusRS is designed to perform an unlimited amount of customizable Isometric Evaluations. There are three additional isometric tests that have yet been discussed. These are pre-set consistency of effort templates that are based on specific test procedures published in the literature. These include:

- **Maximum Voluntary Effort Test** - based on Dr. Leonard Matheson's testing technique (using a series of different attachments).
- **Five Position Bell Curve Test** - uses five grip positions (typically performed with a hand dynamometer).
- **Rapid Exchange Test** - compares right to left hand strength (4 to 5 trials for each hand) through analysis of the coefficient of variation (also typically performed with a hand dynamometer).

To conduct any of these tests, follow these general instructions.

- Step 1. Load a Patient Record as outlined in Section 4.3.3 regarding choice of templates. Continue through Section 4.3.3.1, selecting the Evaluation Template desired; 5 Position Bell Curve, Grip – Rapid Alternating, or Maximum Voluntary Effort.
- Highlight your choice and click "OK."
- Step 2. Test parameters for each of these trials have been pre-set to suggested values and modification is discouraged. You may, however, edit them as you feel necessary. To do so, click the "Modify" button at the bottom of your screen. This will activate all editable parameters.
- Click the "Side Selection" tab (Figure q – N) to set the side of the patient being tested in Test 1 and Test 2. The un-involved or dominant side should be tested first. Adjust the functional description to fit the muscle group you intend to test.
  - Make sure to enter lever length in order for results to be displayed in pounds instead of inch-pounds. Lever length is the distance from the tool's axis of rotation to the end of the tool. If you are using the 701 or the 802, adjust this value to match the accurate length etched onto the adjustable attachment.
  - Remember that at least 3 trials must be run in order for PrimusRS to compute CV (Coefficient of Variation).
- Step 3. Enter Setup Notes (See Section 4.3.4).
- Step 4. Click "Save" to commit the changes you have made.

Proceed now to the section that is specific to the test you have chosen. If you selected the Maximum Voluntary Effort Test, go to Section 4.9.4. Choose Section 4.9.5 if you intend to conduct the 5-Position Bell Curve or Section 4.9.6 for the Rapid Exchange Test.

#### 4.9.4 Maximum Voluntary Effort Test

The Maximum Voluntary Effort Evaluation contains several separate tests, each utilizing its own attachment. The design of this test is based on a study conducted by Niemeyer, Matheson, et al ("Testing consistency of effort: BTE Work Simulator." Industrial Rehab Quarterly 2(1): 5-32, 1989). The attachments used in this study include:

302 Three Inch Diameter Knurled Knob  
 502 Small Screwdriver  
 504 Large Screwdriver  
 601 D-Handle  
 701 Small Variable-Length Lever

Four tests are performed with each attachment, totaling 20 tests. As a result, twenty CV's are obtained from this procedure. Hence, it is a valuable tool in establishing reliability of the patient's efforts.

Step 1. If you wish to customize this evaluation, you must edit every test in the Test Type list individually. Therefore, edit each test with the procedure outlined in Section 4.9.3, steps 2-5.

**Note: If you change any parameters of this test protocol, you will not be able to compare your results to the data of this published study. This includes the sequence in which the attachments were used.**

Step 2. In *Evaluation Setup*, click on the first test which utilizes attachment #302. You may choose to test with another attachment first; simply click on that test.  
*(Consult Section 4.5.3 if you desire to change the order in which the tests are to be conducted.)*

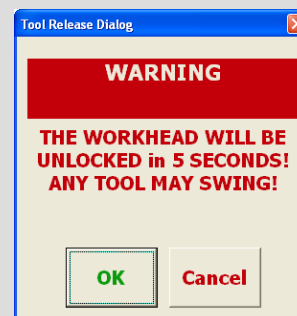
Attach the tool pictured in your selected setup to the PrimusRS exercise head.

Step 3. Click the "Evaluation" tab (Figure ).

##### Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click "OK" in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click "OK" in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



Step 4. Position your patient in such a way that there will be no muscle substitution, allowing you to isolate the appropriate muscle group.

Step 5. In order for the patient to get used to the test, hit "Start" at the bottom right of the screen to begin a practice trial.

- Step 6. A vertical bar will appear for each trial showing the amount of force exerted (as shown in Figure 4cc). A trial will stop automatically after the “Test Time” entered in *Evaluation Setup* elapses or when the force drops to under 10% of the maximum.
- Step 7. Hit “**Stop**” and “**Clear**” to delete practice trials. The patient should now be ready for his or her evaluation.

The screen displays two white rectangles with labels corresponding to the sides and functions you entered for “Side 1” and for “Side 2” in *Evaluation Setup*.

Notice that the left one is selected by default – it is filled in yellow. The uninjured or dominant side should be tested first. Make sure that the uninjured side graph is selected (filled in yellow). If the wrong side is selected, touch the other white graphing area – the selection fill will move to this graph.

Continue testing in this manner until all the trials are finished (Figure 4cc) for the first side.

If a trial is not satisfactory, press “Clear” and the selected (green colored) bar will disappear. A test result bar can be selected at any time for deletion by directly clicking on the desired bar on the graph.

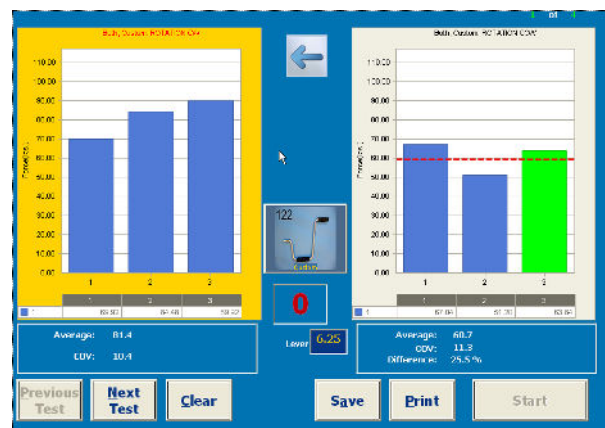


Figure 10cc

- Step 8. Touch the second graphing area (when applicable) and repeat Steps 8-9 with the involved extremity.
- Step 9. To enter your observations of the evaluation, open the **Notes** window (Section 4.3.4).
- Step 10. Prompt the patient: “Ready... Go!”

Instruct your patient to exert maximum effort against the attachment without jerking, and to discontinue at any sign of discomfort.

Touch the “**Start**” button to run the first trial.

It is recommended that the subject not be allowed to view the screen while testing. Do not coach the subject during the data collection, as that may affect the results.

- Step 11. PrimusRS will graph the force exerted until the Test Time elapses (if test time was set in *Evaluation Setup*). Hit “**Stop**” to halt the trial manually.

Allow the patient to rest for approximately 5 seconds between trials.

If a Rest Time was set in *Evaluation Setup*, the red counter in the center of the screen will flash and beep once the specified rest time elapses (Figure bb).

After three trials, the average force exerted and the Coefficient of Variation are displayed at the bottom of the graphs. The CV should be less than 15% for an acceptable test.

Step 12. Press **“Save”** to store the evaluation results. Saved notes and test results are available for on-screen viewing and for printing in the “Reviews/Reports” tab.

Step 13. If you want an instant hardcopy of your evaluation results, hit **“Print”** now.

Step 14. The Maximum Voluntary Effort Template includes several tests. Use the “Next/Previous Test” buttons to perform the remaining tests in the Evaluation Template (Figure dd).



Figure 4dd

#### 4.9.5 Five Position Bell Curve Test

Choose this test if you want to assess a patient’s isometric strength abilities across the five positions of the grip attachment. This will provide you with information related to the “bell shaped curve” that is referred to in the literature. Numerous articles have been published related to studies of the five-rung test.

Step 1. Click the **“Evaluation Setup”** tab (Figure 4b). Choose the 5 Position Bell Curve Test from the template list.

Step 2. The default parameters include ten (10) test trials, two (2) second trial duration, and a five (5) second rest break. You may choose to edit any of these defaults by touching the **“Modify”** button and typing in changes. **“Save”** any changes and then click on the **“Evaluation”** tab.

Step 3. Insert tool number 162 and set it in position I.

Step 4. Position the patient at the workhead and adjust the height so that the upper arm is relaxed by his/her side, elbow is flexed at 90 degree angle and the forearm is in neutral.

Step 5. In order for the patient to get used to the test, hit **“Start”** at the bottom right of the screen to begin a practice trial.

Step 6. The screen displays two rectangles with labels corresponding to the sides and functions you entered for **“Side 1”** and for **“Side 2”** in *Evaluation Setup*. Notice that the graph corresponding to the side to be tested is filled in yellow.

The dominant or uninvolved extremity should be tested first.

To test the other side (Side 2), touch the right white text area – the yellow fill will move to this graph.



Figure 4ee

A vertical bar will appear for each trial showing the amount of force exerted (Figure ee). Each trial will halt after the **“Test Time”** entered in *Evaluation Setup* elapses or when the force drops to under 10% of the maximum.

Step 7. Hit **“Stop”** and **“Clear”** to delete practice trials. The patient should now be ready for his or her evaluation.

Step 8. Prompt the patient **“Ready ... Go.”**

Touch the **“Start”** button to run the first trial. Instruct your patient to exert maximum effort against the attachment without jerking, and to discontinue at any sign of discomfort.

It is recommended that the subject not be allowed to view the screen while testing. Do not coach the subject during the data collection, as that may affect the results.

- Step 9. PrimusRS will graph the force exerted until the Test Time elapses (as was set in *Evaluation Setup*). Hit **“Stop”** to halt the trial manually.

Touch the second graphing area (when applicable) while instructing the patient to switch hands. Repeat Steps 8-9 with the involved extremity.

- Step 10. After completion of trials with the tool set in position I, it will be necessary to adjust tool to position II through V. Patient will perform 1 trial per hand in each position.

At the conclusion of the test, average force and CV's for each hand as well as percent difference between the two hands will be calculated.

- Step 11. To enter your observations of the evaluation, open the **Notes** window (Section 4.3.4).

- Step 12. Press **“Save”** to store the evaluation results. Saved notes and test results are available for on-screen viewing and for printing in the “Reviews/Reports” tab.

- Step 13. If you want an instant hardcopy of your evaluation results, hit “Print” now.

#### 4.9.6 Grip - Rapid Alternating Test

This grip test is another commonly used assessment tool particularly in the hand rehabilitation arena. It was developed to detect patients exerting insincere effort. The literature reveals numerous studies related to the value of this particular test. Some question whether it is sensitive and specific enough to effectively detect sincerity of effort and others cite issues related to standardization of the test.

- Step 1. Click the *“Evaluation Setup”* tab. Select the “Rapid Exchange Test” from the template list.

- Step 2. Choose “Modify” to edit any test parameters. The default settings of a two (2) second trial time and one (1) second rest time allow for smooth operation of the test through 10 trials each hand. Touch “Save” to capture any changes.

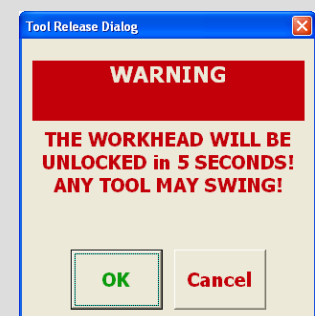
- Step 3. Click the *“Evaluation”* tab to advance to the test screen.

- Step 4. Insert the #162 tool into the exercise head. Position the patient at the workhead and adjust the height so that the upper arm is relaxed by his/her side, elbow is flexed at 90 degree angle and the forearm is in neutral.

##### Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



- Step 5. In order for the patient to get used to the test, touch **“Start”** at the bottom right of the screen to begin a practice trial. Instruct them to exert force on the tool for about one second, allowing for the remaining trial and rest time (2 seconds) to be used to release tool from one hand, switch, and then grasp with the opposite hand.
- Step 6. The screen displays two rectangles with labels corresponding to the sides and functions you entered for “Side 1” and for “Side 2” in the “Side Selection” tab of *Evaluation Setup*.

A vertical bar will appear for each trial showing the amount of force exerted (as shown in Figure 4ff). A trial will halt after the “Test Time” entered in *Evaluation Setup* elapses or when the force drops to under 10% of the maximum.

The Rapid Exchange Test is set to “Alternating,” so after every trial (2 seconds by default), PrimusRS automatically switches from graphing “Side 1” to “Side 2,” and vice versa. The patient must switch hands on the attachment and perform the correct alternating movements quickly.



Figure 4ff

- Step 7. Click **“Stop”** and **“Clear”** to delete practice trials. The patient should now be ready for his or her evaluation.
- Step 8. Prompt the patient: “Ready... Go!” Touch the **“Start”** button to run the first trial. Instruct your patient to exert maximum effort against the attachment.

It is recommended that the subject not be allowed to view the screen while testing. Do not coach the subject during the data collection, as that may affect the results.

At second 2 of the trial, instruct the patient to stop and switch hands. If a Rest Time was set in *Evaluation Setup*, the red counter in the center of the screen will flash and beep once the specified rest time elapses.

Continue the test in this manner until all 10 trials are completed. PrimusRS will graph the force exerted and label the peak force for each trial.

On completion of all trials, the average force exerted, coefficient of variation and percentage difference between sides are displayed at the bottom of the graphs. The CV should be less than 15% for an acceptable test.

- Step 9. If a trial is not satisfactory, press “Clear” and the selected (green colored) bar will disappear. A test result bar can be selected at any time for deletion by clicking the bar of the desired trial on the graph.
- Step 10. To enter your observations of the evaluation, open the **Notes** window (Section 4.3.4).
- Step 11. Press **“Save”** to store the evaluation results. Saved notes and test results are available for on-screen viewing and for printing in the “Reviews/Reports” tab.
- Step 12. If you want an instant hardcopy of your evaluation results, hit “Print” now.

## 4.10 Isotonic Power Test

The Isotonic Power Test is the second step in the standard testing protocol and is a means of quantifying efficiency of performance. It is a way of measuring the patient's ability to repeatedly perform a specific task/exercise in a defined period of time. The test results can be used to determine a patient's ability to perform a specific work task or daily activity as well as to serve as an indicator of progress when compared over time.

### 4.10.1 Isotonic Power Test Setup

Step 1. Follow the general procedure outlined in Section 4.8.1, with a few exceptions:

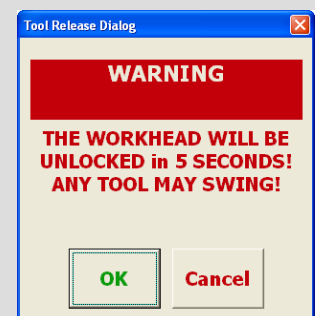
- In 4.8.1, Step 3 – select the **“Power”** test from the Test Type list.
- The exercise parameters are pre-set to suggested values:
  - The resistance level is automatically set to 50% of the patient's average peak strength in the Isometric Maximum Strength Test. If you did not perform the Isometric Maximum Strength Test, you can enter and adjust the resistance for each of the patient's two extremities using the resistance *Control Panel* (use either the +/- or arrow keys on the screen or input via the keyboard).
  - Duration of trials need not exceed 10 seconds as a study has shown that a person begins to fatigue at approximately 8 seconds when working at half his or her maximum. Therefore, one (1) trial is standard but multiple trials can be designated.
  - Use the same attachment(s) as in the Isometric Maximum Strength Test.

### 4.10.2 Conducting the Isotonic Power Test

#### Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



Step 1. Touch the *Evaluation* Tab at the top of your screen.

Step 2. Check the resistance in the *Control Panel* (see Section 2.4). The test force should be set to 50% of the average force recorded in the Isometric Maximum Strength test. (You can adjust it during the course of the exercise by touching the arrow buttons in the *Control Panel*, but this is not recommended during testing.)



**Note:**

With most attachments, the Dynamic Power Test is performed best with either the Clockwise (CW) or Counter Clockwise (CCW) resistance (Section 2.4) to zero.

**Test the dominant or uninvolved side first.**

- Step 3. Position the patient in such a way that there will be no muscle substitution, allowing you to isolate the appropriate muscle group.
- Step 4. Instruct the patient to perform as many reps as possible as quickly as he or she can when you say “Go.” Remind them to move the attachment through the full range of motion.

Allow two or three practice trials by clicking “**Start**” at the bottom right of your screen. This lets the patient get a feel for the resistance level before the actual test begins.

Observe the subject for correct movement patterns as he or she completes practice trials.

**Do NOT allow your subject to use substitution patterns.**

The test will automatically stop after the Test Time entered in *Evaluation Setup* elapses. Touch the “**Stop**” button if you wish to stop a test manually.



Figure 4gg

- Step 5. Hit “**Stop**” and “**Clear**” to delete these practice tests when you are ready to conduct the actual evaluation.
- Step 6. Click “**Start**” and instruct the patient to perform the test.

**Remind the subject to stop the test immediately if he or she experiences any unusual pain or discomfort.**

**Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

PrimusRS will graph the power output of the patient during the evaluation (Figure gg).

- Step 7. Each trial will automatically stop after the Test Time you specified in *Evaluation Setup* has elapsed. If you did not set a Test Time, you must touch the “**Stop**” button at the bottom of the screen to halt the trial.

**Note:**

PrimusRS will automatically stop the trial if the power drops to under 10% of the maximum.

If a Rest Time was set in Evaluation Setup, the red counter in the center of the screen will flash and beep once the prescribed rest time elapses (Figure hh).



Figure 4hh

- Step 8. If multiple trials were chosen, ensure that the patient is correctly positioned



for the next trial. Repeat Step 6.

Each bar shown in Figure gg represents the average power of a single trial.

- Step 9. Reposition the patient for the non-dominant or involved side if you are doing a comparison test.
- Step 10. Touch the other labeled white graphing area box to select the other side.
- Step 11. Instruct the patient to repeat the testing process with his or her other side (see Steps 6 - 8).
- Step 12. If a trial is not satisfactory, press “Clear” and the selected (green) bar will disappear.
- Touching “**Start**” again will allow you to redo the deleted trial. Any results bar can be selected at any time for deletion by clicking the bar of the desired trial on the graph.
- Once the test is completed, the average power and CV’s will be displayed if multiple trials were performed. In a comparison test, Percent Difference will be calculated and displayed. The comparison is always based on the side with lesser average power and stated in terms of “less than.”
- When a test is repeated week after week, it is helpful to look at the change in percent difference between the injured and non-injured extremity when determining how well the patient is progressing.)
- Step 13. Record your observations with the PrimusRS “Notes” feature (see Section 4.3.4).
- Step 14. Press “**Save**” to store the evaluation results. Saved notes and test results are available for on-screen viewing and printing in the “Reviews/Reports” tab.
- Step 15. Hit “Print” now for an instant hardcopy of your evaluation results.

## 4.11 Isotonic Endurance Test

The endurance test is designed to determine dynamic stamina (or fatigue) of a specific muscle or group of muscles. It is the third part of the standard test protocol. Endurance is quantified by the amount of work performed when the force and the rate of performance are held constant. In this test, a metronome is provided which can be set to allow 1 to 60 reps per minute. “Real Time” graphics provide visual feedback to help the patient maintain the selected pace.

### 4.11.1 Isotonic Endurance Test Setup

Follow the same general procedure outlined in Section 4.8.1, with a few exceptions:

- In 4.8.1, Step 3 – select “**Endurance**” from the Test Type list (Figure q – E).
- The exercise parameters are pre-set to suggested values:
  - The torque is automatically set to that used for the Isotonic Power Test of the *weaker* extremity. The same resistance level (1/2 the average peak isometric strength of the weaker extremity) must be used with both sides so that the testing procedure is exactly the same for both sides.
- Enter the “**Pace**” parameter in reps/minute. Unless pacing is dictated by a specific work task, recommendations for pace are detailed below.

- You must test the non-injured extremity first; so in the “Side Selection” tab (Figure q – N), “Side 1” is assigned to the uninvolved or dominant side and “Side 2” to the involved or non-dominant extremity.
- Use the same attachment(s) as in the previous test.

### 4.11.2 Conducting the Isotonic Endurance Test

To gauge a person's endurance, it is important that you control the rate of speed at which the person works and be sure that he or she works at the same speed with each extremity. To help control the patient's speed, a timing cycle is displayed on the screen. The subject performs one complete repetition for each cycle. It was found that for motions involving up to 90 degrees of shaft rotation, a good pace is 60 cycles (repetitions) per minute. With motions involving greater than 90 degrees, acceptable paces range from 45 to 30 cycles (repetitions) per minute. You could also use a cycle rate that duplicates a specific job task. What is most important is that the pacing be the same for each extremity and each re-test of the same subject.

#### Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



- Step 1. Click the *Evaluation* tab.
- Step 2. Ensure that the resistance in the Control Panel is set to **30%** of the average force recorded for the weaker side in the Isometric Strength Test.  
  
*With most attachments, the Dynamic Endurance Test is best performed with either the Clockwise (CW) or Counter-Clockwise (CCW) resistance (see Section 2.4) to zero.*
- Step 3. Position the patient, and allow two or three practice trials by clicking “**Start**”. Show them the monitor screen and explain that the object is for him or her to match the pace of the red horizontal “pacing bar” and to keep the work rate the same for the duration of the test.
- Step 4. Hit “**Stop**” and “**Clear**” to delete these practice trials when you are ready to conduct the actual evaluation.
- Step 5. Begin with the uninjured extremity. Click “**Start**” and instruct the patient to do reps in synch with the horizontal pacing bar (one rep per bar).

As the test progresses, vertical bars representing power (as shown in Figure ii) appear every five seconds to indicate how efficiently the patient is working.

The ideal rate is achieved when the vertical bars continue to appear at or near the horizontal 100% guide line.

It is recommended that you hit **“Stop”** to end the test if the patient records two consecutive cycles where the power bar is below the 75% line (bottom line of the three horizontal lines). This is an indication that the patient has reached his or her fatigue point. PrimusRS will notify you if power falls below 50%. (The lines are further explained below.)

- Step 6. Once the uninvolved side is tested, reposition the patient to test the other side.
- Step 7. Touch the other white graphing box to select the injured side in the software.
- Step 8. Repeat the testing process with the patient's involved side.

The results will appear as shown in Figure ii.

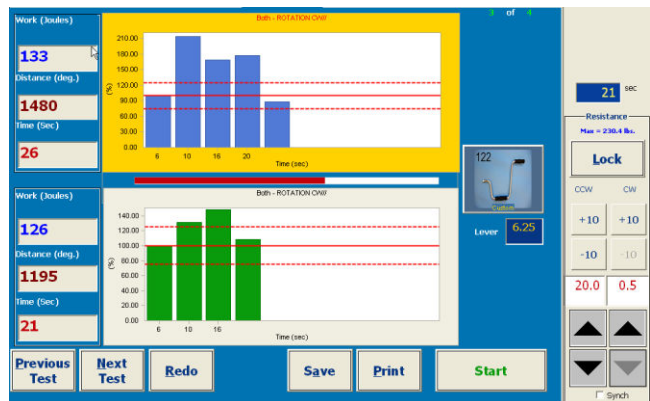


Figure 4ii

Interpret the horizontal lines as follows:

100% (middle of the three lines) is the amount of power generated during the first five seconds of the test. Every five seconds after that, another bar is displayed. This is useful feedback for maintaining a proper pace.

The object is to keep the power bar for each cycle time (five seconds) time between 125% (top line) and 75% (bottom line) of the first cycle. If this is accomplished, then the patient is working at the proper pace.

In a comparison test, Percent Difference will be calculated and displayed. The comparison is always based on the side with lesser average power and stated in terms of “less than.” The three counters at the left of the screen display:

- **Time** – total elapsed time for the test
- **Distance** – total number of degrees of rotation
- **Work** – calculated by multiplying the average force times the total distance moved during the test.

- Step 9. If a trial is not satisfactory, press “Redo” to repeat the test. A sufficient rest break would be needed to allow the muscle(s) to recover from fatigue.
- Step 10. Record your observations with the PrimusRS “Print Notes” feature (see Section 4.3.4).
- Step 11. Press **“Save”** to store the evaluation results. Saved notes and test results are available for on-screen viewing and printing in the “Reviews/Reports” tab.
- Step 12. If you want an instant hardcopy of your evaluation results, hit “Print” now.

## 4.12 Torque vs. Speed Test

The Torque vs. Speed test quantifies a subject's maximum power output. It measures the speed at which he or she can move at a given resistance level and plots the output results on a graph. As the torque is increased, it is expected that the subject's speed will decrease. In sports medicine applications, it may be desirable to measure a subject's peak performance. For some athletic activities (such as running, jumping and cycling) power output is important to the athlete's success. This test gives you a way to quantify peak power output and document changes in performance levels over time.

### 4.12.1 Torque vs. Speed Setup

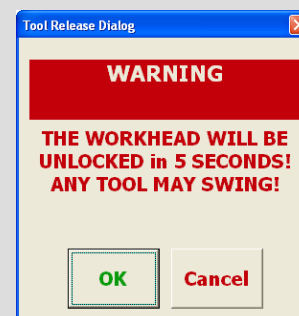
Step 1. Follow the same general procedure outlined in Section 4.8.1, with a few exceptions:

- In 4.8.1, Step 3 – select **“Torque vs. Speed”** from the Test Type list (Figure q – E).
- Grayed out settings are ‘inactive’ – they are not applicable to this test.
- Remember to fill out the parameters under the “Side Selection” tab (Figure q – N). Select the patient’s non-injured or dominant extremity in the “Side 1” tab.
- Use the same attachment as in the previous tests

#### Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



### 4.12.2 Conducting the Torque vs. Speed Test

Step 1. Click the *Evaluation* Tab.

You will notice that the screen is split horizontally (Figure jj).

If you checked “Comparison” in *Evaluation Setup*, the labels on the two white graphing areas reflect your settings for “Side 1.” You can toggle to the “Side 2” evaluation by clicking the “Test 2” button located at the lower right of your screen.

Step 2. Check the amount of torque for each set. Unless you changed the parameter in *Evaluation Setup*, this test will run in CON/ECC mode.

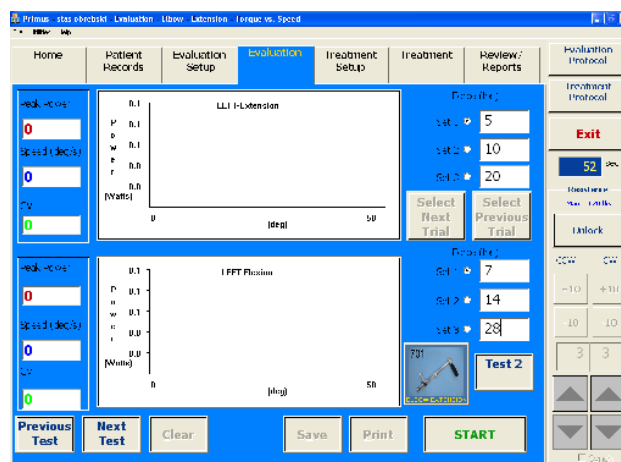


Figure 4jj

If you have completed the Isometric Maximum Strength Test, the torque or force values will automatically be entered for each set as a percentage of the subject's maximum isometric effort. These standard settings are based on years of clinical trials and are as follows:

- Torque for the first set will be 25% of the patient's maximum isometric strength value.
- Torque for the second set will be 50% higher than the torque for the first set (or 37.5% of patient's maximum isometric strength value).
- Torque for the third set will be 50% higher than that of the second set (or 56.2% of the patient's maximum isometric strength value).

If you elected not to perform the Isometric Maximum Strength Test first, touch the first "Force" field now ("Set 1"). Hit "backspace" to clear the "0" and type in your desired force setting.

To move your cursor to the next setting, hit the "Tab" key on the keyboard and type over the existing value. Alternatively, click inside the field you wish to clear, hit "Delete" or "Backspace" on your keyboard and type in the new setting. Repeat this process to set all six test forces.

- Step 3. Position the patient for two to three test trials first. Hit the **"Start"** button at the bottom right of your screen.
- Step 4. Hit "Unlock Tool" in the dialog box and have the patient move the tool to the starting position.
- Step 5. Click the **"Ready"** button and instruct the patient to move the tool through his or her range of motion in a controlled manner. Hit **"Start"** to perform subsequent trials. Since resistance increases with every set, allow the patient to complete "Set 1."

Touch the **"Set 2"** radio button in order to move to the next set. Click **"Start"** to begin the second set. This is an important step so that your patient knows what to expect from the actual evaluation.

Click the radio button next to a set you completed and hit **"Clear"** to delete these practice tests one at a time.

- Step 6. Touch the **"Set 1"** radio box at the top right of the screen.
- Step 7. Click the **"Start"** button to commence the evaluation. Instruct your patient to move the tool through their range of motion in a controlled manner.

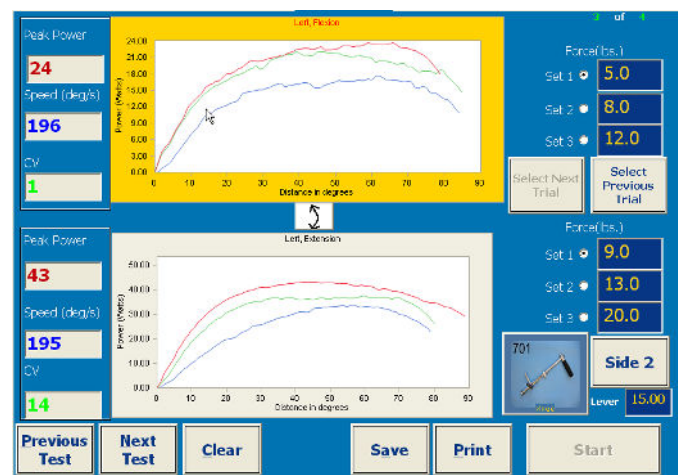


Figure 4kk

The subject's goal for this test is to perform each repetition as quickly as possible. Power output is graphed in relation to the angle of movement for that rep (Figure kk). Peak power and speed for every rep are displayed in the counters at the left of the screen. After three sets, coefficient of variation is computed and displayed in the "CV" field.

Touch **"Start"** again to perform remaining trials in the set.

The evaluation will pause upon completion of the first set of reps (three by default).

- Step 8. Click “**Set 2**” and touch “**Start**” to run the second set in the same way. Repeat the process for the third set. Primus will notify you once each set is finished.
- Step 9. If you wish to delete an unsatisfactory trial, select it using the “Select Next/Previous Trial” buttons (You will know that a trial is selected when the graph is highlighted in red). Hit “Clear.” Touch the “Start” button to redo a trial.
- Step 10. Now click the bottom white graphing area to select the opposite muscle function. Explain to the patient that for the next three sets, he or she will feel resistance in the opposite direction. Repeat Steps 6-9 in this direction.
- Step 11. If you selected “Comparison” (switched ON by default), click the “Test 2” button and repeat Steps 3-10 with the patient’s other extremity.
- Step 12. Enter your observations on the patient’s performance through the Setup Notes feature (Section 4.3.4).
- Step 13. Once you are satisfied with your trials, touch “**Save**” to save the evaluation results. Saved notes and test results are available for on-screen viewing and printing in the “Reviews/Reports” tab (Section 6).
- Step 14. If you want an instant hardcopy of your evaluation results, hit “**Print**” now.

## 4.13 Maximum Lift/Push/Pull Test

This test is designed for determining a subject’s maximum weight handling ability using attachment 191 (See Clinical Applications – Section 5). It provides a means for selecting a range through which the test must be performed, and then produces “real time” velocity graphs of individual repetitions per lift. The results are displayed in actual pounds of weight and can be used for measuring lifting, pushing, or pulling ability.

**Note:** Only attachment 191 can be used with this test.

### 4.13.1 Maximum Lift/Push/Pull Test Setup

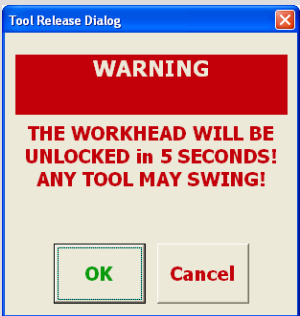
- Step 1. Load a Patient Record as outlined in Section 4.3.3.  
  
Proceed to Section 4.3.3.1 and load the “Maximum Lift/Push/Pull” General Evaluation Template.
- Step 2. Click the “Modify” button at the bottom of your screen. This will activate all editable parameters.
- Step 3. If you are attaching a custom, non-BTE-made handle (like a crate) to the 191, enter the weight of the piece in the “Handle” field.
- Step 4. Enter Setup Notes (see Section 4.3.4).
- Step 5. Click the “Save” button at the bottom of your screen (Figure q – J).

4.13.2 Conducting a Maximum Lift/Push/Pull Test

Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



Step 1. Click the *Evaluation* tab at the top of your screen.

It is recommended that this test be started with the weight at its lowest level (approximately 5 lbs). The weight is displayed as a red number in the white field to the right of the white test area (Figure II).

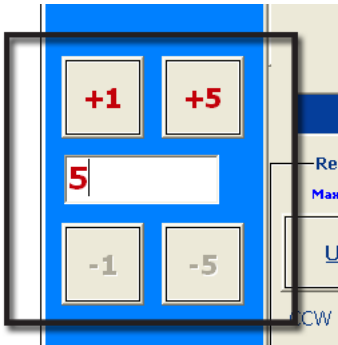


Figure 4II

Step 1. Attach the 191 attachment to the exercise head (as described in Section 8.3).

Step 2. Mount the cable and pulley system (described in Section 8.4).

Step 3. Hook the desired handle to the clip at the end of the 191 cable.

Step 4. Instruct the patient to grasp the handle. Place him or her into the proper position for the evaluation.

Turn the 191 disc manually to remove slack in the cable.

Step 5. Click “**Start.**” This will initiate the “Range Setup” screen (Figure mm). Before beginning the test you must set the range (distance) of the lift/push/pull excursion.

Step 6. Touch “**Set BOR.**” Have your subject move the handle to the beginning of the desired range and hold it in place while you click “OK.”

Step 7. Now touch “**Set EOR.**” Instruct your patient to move the handle to the full excursion (end of range) and hold it in place. Hit “OK.”

The range is now set.

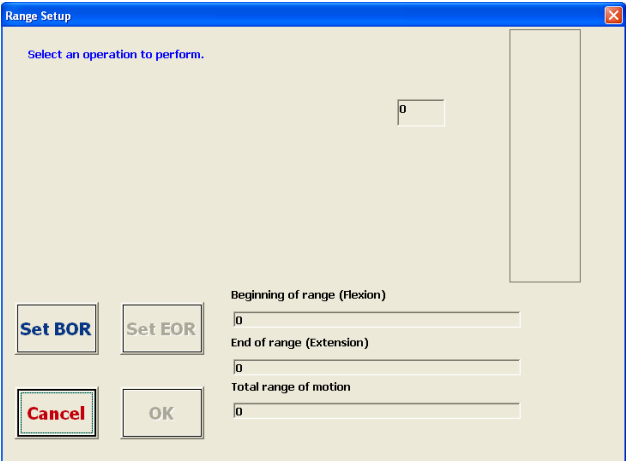


Figure 4mm

Step 8. The test will now automatically start. Your patient should start the test at a nominal pace.

A line will graph the velocity of each repetition vs. distance. As each rep is completed, the weight (pounds or kilograms) and power are displayed beneath the graph (Figure nn).

*In the Maximum Lift/Push/Pull Evaluation, the full range must be completed for a rep to be counted. An audible beep will indicate the beginning and the completion of each rep.*

You should increase the resistance *in between* reps in 1 lb. or 5 lb. increments using the “+1” and “+5” buttons (Figure II). Use the “-1” and “-5” buttons to decrease weight if it becomes necessary. Sufficient rest period should be allowed between each rep (generally 15-30 seconds).

The “Power” number indicates the amount of power generated during a lift, push, or pull. This number should increase at a predictable rate if the weight increases and the subject’s technique remains constant.

If the number decreases dramatically, the subject may be lifting differently (substituting, using poor body mechanics, jerking the handle, etc...), and he or she may have exceeded the maximum safe force.

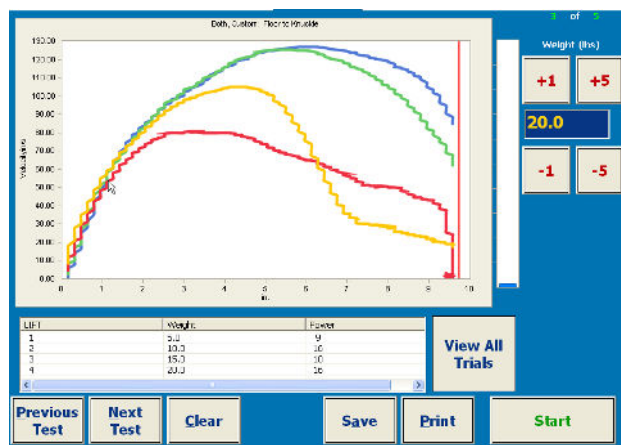


Figure 4nn

Step 9. Touch “**Stop**” on the screen when the data is sufficient or when the patient becomes fatigued.

Step 10. To delete an unsatisfactory trial, select it by clicking the desired trial in the list below the graph. The trial is selected when it’s the only line on the graph and the item in the list is highlighted in blue. Hit “Clear” to remove the bad trial. If you wish to view all of the trials again, click the “View all Trials” button.

Step 11. Enter your observations on the patient’s performance through the notes feature (Section 4.3.4).

Step 12. Touch “**Save**” to save the evaluation results. Saved notes and test results are available anytime for on-screen viewing and printing in the “Reviews/Reports” tab.

Step 13. If you want an instant hardcopy of your evaluation results, hit “Print” now.

#### Note

Using the floor pulley adapter will add 2 (two) pounds to the set weight. This is due to the extra drag caused by the pulley. To compensate, add two pounds to the result when the evaluation is completed.



## 4.14 Repetitive Lift/Push/Pull Test

### 4.14.1 Setting Up a Repetitive Lift/Push/Pull Test

The Repetitive Lift/Push/Pull Test is used to document how many times a patient can perform a lift. It is used most frequently in assessing a job-specific requirement. It is an excellent way to document the fatigue rate of the subject (See Clinical Applications – Section 5). As he or she begins to fatigue, the power per lift will drop.

Set-up of this test is similar to that of Maximum Lift/Push/Pull.

**Note:** Only attachment 191 can be used with this test.

Step 1. Load a Patient Record as outlined in Section 4.3.3.

Proceed to Section 4.3.3.1 and load the “Repetitive Lift/Push/Pull” General Evaluation Template.

Step 2. Click the “Modify” button at the bottom of your screen (Figure q – G). This will activate all editable parameters. These include handle weight and pace as the length of the lever arm defaults to the #191 attachment.

Handle weight - defaults to 1lb. which is the weight of the standard handle. If you are attaching a custom, non-BTE-made handle (like a crate) to the 191, weigh it and then enter that weight into the “Handle” field.

Pace – defaults to zero and therefore requires you to input a desired pace. Use a work requirement if available; otherwise, a pace of 1 lift every 10 seconds is reasonable.

Step 3. Enter Setup Notes (see Section 4.3.4).

Step 4. Click the “Save” button at the bottom of your screen.

### 4.14.2 Conducting a Repetitive Lift/Push/Pull Test

Step 1. Click the *Evaluation* tab at the top of your screen.

#### Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



Step 2. Attach the 191 attachment to the exercise head (as described in Section 8.3).

- Step 3. Mount the cable and pulley system (described in Section 8.4).
- Step 4. Hook the desired handle to the clip at the end of the 191 cable.
- Step 5. Set the desired weight to be lifted.
- Step 6. Instruct the patient to grasp the handle. Place him or her into the proper position for the evaluation.
- Turn the 191 disc manually to remove slack in the cable.
- Step 7. Click **“Start.”** This will initiate the “Range Setup” screen (Figure mm). Before beginning the test you must set the range (distance) of the lift/push/pull excursion.
- Step 8. Touch **“Set BOR.”** Have your subject move the handle to the beginning of the desired range and hold it in place while you click **“OK.”**
- Step 9. Now touch **“Set EOR.”** Instruct your patient to move the handle to the full excursion (end of range). Hit **“OK.”**

The range is now set. Move the handle to the beginning of the range.

- Step 10. The test will now automatically start. Your patient should start the test at a nominal pace.

The blue bars which appear in the test area indicate the power per repetition (based on the second rep. equaling 100%). As the patient fatigues, subsequent bars will shorten. (Figure 400.)

*The full range of motion **does NOT** have to be completed for a rep to be counted. Reps which do not pass through the full range of motion, however, will be displayed in green.*

The total amount of “Work” and total “Time” are updated underneath the graph in real time.

- Step 11. Touch **“Stop”** on the screen when you the data is sufficient or the patient becomes fatigued.
- Step 12. Enter your observations on the patient’s performance through the notes feature (Section 4.3.4).
- Step 13. Once you are satisfied with your trials, touch **“Save”** to save the evaluation results. Saved notes and test results are available for on-screen viewing and printing in the Reviews/Reports” tab.

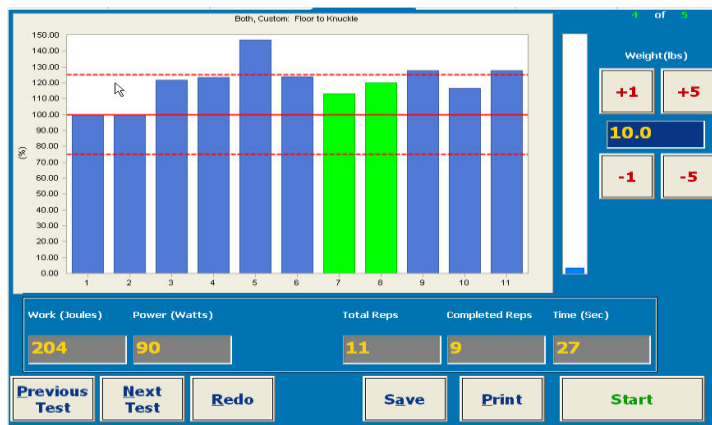


Figure 400

- Step 14. If you want an instant hardcopy of your evaluation results, hit **“Print”** now.

**Note**

Using the floor pulley adapter will add 2 (two) pounds to the set weight. This is due to the extra drag caused by the pulley. To compensate, add two pounds to the result when the evaluation is completed.

## 4.15 Isokinetic Evaluation

The PrimusRS Isokinetic Evaluation allows you to set up a test for a single side or a comparison test where both sides are tested separately and compared. You can use pre-set templates to evaluate a patient or create your own template from scratch. Any test may be redone at a later date to look for changes over time. You may also elect to retest only the involved side for re-evaluation.

### 4.15.1 Isokinetic Evaluation Setup

Isokinetic Evaluations are configured in much the same way as the Isotonic and Isometric evaluations described up to this point.

- Step 1. Load a Patient Record as described in Section 4.3.3.
- Step 2. Create a New Patient Template (Section 4.3.3.2).
- Step 3. Click “New” at the bottom of the screen. This will bring up a dialog box.
- Step 4. Select “New Trial for Current Template” from the dialog box and click “OK”. This will activate the screen and allow you to set parameters for each individual exercise.
- Step 5. *Evaluation Setup* defaults to the Isometric mode setup screen. Click the “Isokinetic” tab. (Figure q – B).
- Step 6. Select resistance mode:  
  
CON/CON – concentric resistance in both direction  
  
CON/ECC – concentric resistance in the starting direction and eccentric in the opposite direction.  
  
Based on the resistance mode, if an agonist/antagonist or left and right side comparison is desired, click the “Comparison” box at this time.
- Step 7. Click the “Select Tool” button (Figure q - C).
- Step 8. Select the body part to be tested and click the image of the attachment you intend to use for the test (Figure r).  
  
Click “OK.”
- Step 9. If you are using the variable-length 701 or 802 tool, adjust the lever length of the attachment in order for PrimusRS to automatically convert force measurements to pounds.  
  
Lever length is the distance from the tool’s axis of rotation to the end of the tool. Enter the accurate number etched onto the tool.

If lever length is not entered, force will be displayed in inch-pounds

- Step 10. Select “Set/Edit Sets and Speeds” icon as shown (Figure )
- Step 11. Touch the “Insert” button and a new pop-up “Isokinetic Exercise Speed and Reps Entry” appears as shown (Figure pp).

- Step 12. Click “Insert” and create a new set. Enter a speed for the set in degrees/second. It is generally accepted that speeds of 60 degrees per second and multiples thereof be used.

Touch “Insert” again to enter subsequent sets and speeds (BTE recommends setting at least three sets).

- Step 13. Press “OK” to save speeds and return to *Evaluation Setup*. Your new speed settings will appear in the middle of the screen.

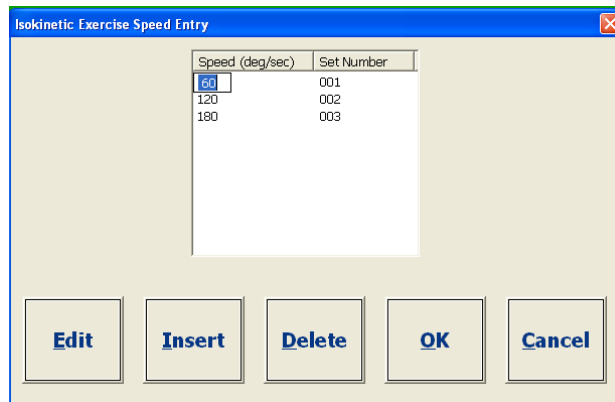


Figure 4pp

To edit speeds:

Press the “Set/Edit Sets and Speeds” button again. In the Sets and Speeds dialog box, touch the speed you want to modify and click the “Edit” button. You may now type in a new speed. Press “OK” to confirm your change and return to *Evaluation Setup*. “Cancel” returns you to *Evaluation Setup* but discards your most recent set and speed changes

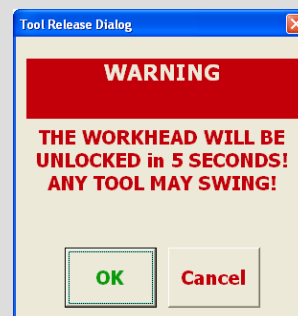
- Step 14. Touch the “Side Selection” box (Figure q – N). The uninvolved or dominant extremity should be tested first. Enter this side under the “Side 1” tab as well as the muscle function being tested. If you checked “Comparison” in *Evaluation Setup* to compare one extremity to the other, specify the involved, non-dominant extremity in the Side 2 tab.
- Step 15. Enter Setup Notes (see Section 4.3.4 for details).
- Step 16. Press the “Save” button.

## 4.15.2 Conducting an Isokinetic Evaluation

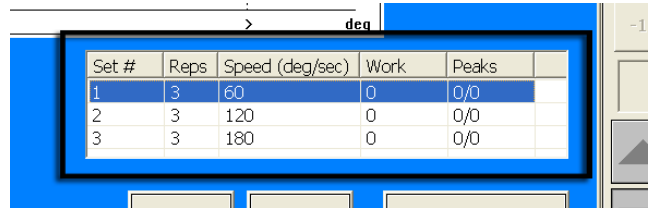
### Note

If your Evaluation Template includes tests with differing resistance modes (Isometric, Isotonic, Isokinetic), you will be prompted to unlock the exercise head when switching from one test to another in the *Evaluation* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



- Step 1. Click the “*Evaluation*” tab.
- Step 2. Position the patient in such a way that there will be no muscle substitution, allowing you to isolate the appropriate muscle group.
- Step 3. If you selected CON/ECC in *Evaluation Setup*: remember that the first direction the patient moves will be met with concentric resistance. The second direction will be eccentric. For this reason, tell the patient in which direction to begin moving the attachment.



Set #	Reps	Speed (deg/sec)	Work	Peaks
1	3	60	0	0/0
2	3	120	0	0/0
3	3	180	0	0/0

Figure 10qq

The top white region is labeled with the muscle movement to be tested first. Should you want to start with the opposite movement (currently the bottom white graph box), click the arrowed button between the two graphs (Figure 4).



Figure 10rr

- Step 4. Click or touch the first set to be performed in the Set/Speed List Box in the lower right corner of your screen (Figure 4).
- Step 5. In order for the patient to get used to the test, hit “**Start**” at the bottom right of the screen to begin a practice trial.
- Step 6. The Set/Edit ROM dialog box will appear because Isokinetic mode requires that range of motion is specified. Click “**Set BOR**” and instruct your patient to move the tool to the beginning of the desired range. Click “**OK**” to save that position.
- Next, touch the “**Set EOR**” button and have the subject to be tested move the tool to the end of range. Click “**OK**” to save this position. Instruct your patient to remove his or her hand from the attachment – it will be moved back into the starting position.
- Step 7. The test will now start. Explain to the subject that the attachment must be moved through the entire range of motion to be counted as a valid rep.

Force exerted by the patient is graphed as a colored line between the two vertical black dotted lines (Figure ). These vertical dotted lines indicate the boundaries of the range of motion set for the test. The white graphing areas are labeled according to the side and function you entered for “Side 1” and for “Side 2” in *Evaluation Setup*.

Each set will stop when all reps are completed.

(If you are doing a comparison evaluation and want to give the patient a practice test using his or her other extremity, touch the “Test 2” button, have the patient grasp the attachment with the other extremity and



Figure 4ss

repeat Steps 5-7.)

Step 8. Now that the patient is used to the test, hit **“Stop”** and **“Clear”** to delete these practice trials.

You are ready to begin the evaluation.

Step 9. Follow the same procedure outlined in Steps 5-7.

Once the patient finishes the first set, select the second one by clicking the set name in the Set/Speed List Box (Figure 4). Repeat this procedure until each set is completed.

Step 10. If a trial is not satisfactory, press “Clear” and the selected (red colored) bar will disappear. A test result bar can be selected at any time for deletion using the “Select Next/Previous Trial” buttons.

Step 11. Touch the “Test 2” button to evaluate the other side if you set up a comparison evaluation. Repeat the testing process with the other extremity.

Step 12. The amount of work done (in joules) is displayed in the Set/Speed List Box.

Peak torque in either direction appears next to the work total:

The first number under “peaks” refers to the top graph.

The second number under peaks (after the slash) refers to the bottom graph.

Step 13. To enter your observations of the evaluation, open the Setup Notes window (Section 4.3.4).

Step 14. Press **“Save”** to store the evaluation results. Saved notes and test results are available for on-screen viewing and for printing in the “Reviews/Reports” tab.

Step 15. If you want an instant hardcopy of your evaluation results, hit “Print” now.

# PRIMUSRS

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## Section 5 – Treatment

### 5.1 Contraindications

This section contains suggestions for use of the BTE PrimusRS in muscle performance training. It is the responsibility of the clinician to determine the appropriateness of the patient for treatment on this equipment. A complete examination of the patient should precede the decision to treat the patient on the PrimusRS. Below is a list of possible contraindications for testing on the PrimusRS:

- unstable joint or bone healing
- severe pain
- acute strain or sprain
- severe open wounds or sores
- deep laceration surrounding joint

### 5.2 Developing a Treatment Plan

Following a comprehensive examination of the subject's current medical condition to determine appropriateness for exercise on the PrimusRS, and before you begin initial treatment on the Primus, we recommend that you take a few minutes to plan a treatment program. This involves first assessing the patient's physical impairment and then, doing a *task analysis* to determine what daily functions and/or work activities may be affected by this impairment. Both of these steps can be accomplished during an initial interview period with the patient.

#### 5.2.1 Getting Started

The first step is a traditional interview and evaluation to establish diagnosis and cause of injury. You must determine current range of motion, sensation, and pain status. This is not unlike anything you are probably already doing. This procedure is intended to gather general observations about the patient's condition. More specific information will be documented once use of the PrimusRS begins.

#### 5.2.2 Task Analysis (located in Section 10 - Appendix)

The second step is a task analysis. Regardless of whether you are dealing with a work related injury, are trying to improve the patient's sports or ADL functioning, or planning specific joint and muscle group conditioning, a task analysis will be a very helpful aid in developing the most appropriate functional rehab program.

With the aid of the Task Analysis form (provided in Section 10 – Appendix), any task can be broken down into its individual functions. Much information can be obtained from the patient during a 15 to 20 minute interview process. "Occupation Title" is the starting point if the patient has a job. Once you have established the patient's occupation, ask him/her to state a list of daily activities. The column entitled "Task" is a broad heading for a group of functions which may form one activity or job duty. As each activity is named, interrupt the patient and ask him to explain what type of equipment is used, what tools are needed, how much weight is involved, and what motions are required. Write down all specific information in the second column. When one task is completely explored, proceed on to the next.

A completed Task Analysis form will have several complete tasks and numerous individual functions listed. All ADL functions can be listed in a similar manner. You can also use this form to identify the isolated muscle groups and/or joints you would like to focus your treatment plan on. The third column, "Tool No.," is reserved for relating all individual functions to PrimusRS attachments, once the interview is over.



Use the PrimusRS *Master Chart* (located in Section 10 – Appendix) to then summarize the exercise program you intend to implement and to create a reference guide as a reminder for the patient.

### 5.2.3 Beginning Treatment

Once you have evaluated the patient and decided which attachments will be used, you may proceed with treatment. Depending on the ability of the patient and his or her state of recovery, you may or may not be able to begin using all the chosen attachments on the first day. Consider a warm-up exercise on the PrimusRS *Home* screen (Section 2.3) using attachment 181 or 122 prior to any vigorous exercise on the first day (this data is not saved). Do not attempt to push the patient beyond a level of exercise that he/she can comfortably perform. You, as a clinician, must determine when your patient has reached the fatigue point or has worked to a level that is appropriate for the injury/condition. Signs/symptoms to watch for include increased edema, altered sensation, substitution patterns, slowing of work rate, or inability to complete desired range of motion.

## 5.3 Treatment Templates

Once you have completed the **Task Analysis** and **PrimusRS Master Chart** forms (Section 10 – Appendix), you are ready to start a new patient on a daily treatment program. This program will constitute the template for that patient. Resistance modes available include isometric, isotonic, isokinetic and continuous passive motion (CPM). Isotonic mode is most frequently utilized for treatment. CON/CON and CON/ECC are available in the isotonic and isokinetic modes. If you want to include lifting activities in the treatment program, go to the evaluation section and choose maximum or repetitive lifting tests (Sections 4.13 or 4.14).

### 5.3.1 General vs. Patient-Specific Templates

PrimusRS affords you great flexibility in treating your patients. To get the most out of your Primus, it is imperative to fully grasp the difference between a General Template and a Patient-Specific Template. Using the right kind of template for a particular application will maximize your efficiency.

A General Treatment Template is set of exercises which is saved into the database in a way that makes it available for use with **any** patient. **It is the basis for creation of a Patient-Specific Treatment regimen.** Your PrimusRS already contains several General Templates designed to exercise particular muscle groups.

If **no patient is selected** (as indicated in the title bar of the software) you can:

- a. **Create a new General Template based on the pre-defined exercises in an existing General Template.** In this case, the pre-defined template serves as a true 'template.' This operation allows you to customize your new 'duplicate' of the template at will while leaving the original unmodified.
- b. **Create a new General Template from scratch.** *Any particularly versatile set of exercises which you anticipate using with more than one patient should be saved into a General Template.*
- c. **Edit a General Template directly.** This modifies the BTE-made preset template. If you choose to edit in this way, you will be unable to revert to the original version of the template.

A Patient-Specific Template is a set of exercises unique to a particular patient. Again, PrimusRS offers you great flexibility in creating and editing these. With a patient-record loaded (the patient's name will appear on the title bar of the software), you have the option to:

- Use a General Template as the basis for a Patient-Specific Template.** This allows you to customize the exercise set to fit your patient's needs while leaving the original intact.
- Create a Patient-Specific Template from scratch.**
- Edit an existing Patient-Specific Template.**
- Save a Patient-Specific Template you have created as a General Template.** If you create a template for a particular patient and realize that it will be useful for another patient, you can save it as a General Template as well.

The following sections will guide you through all of these different options.

### 5.3.2 Creating and Modifying a General Template

Step 1. Click the *Home* tab to ensure that no patient name is selected. The title bar at the top of the screen will read "No Patient Selected" (See Section 2.2 for basic software navigation).

Step 2. Click the *Treatment Setup* tab (Figure 5a).

Step 3. At this point, you have three options.



Figure 5a

#### 5.3.2.1 To create a new General Template based on the pre-defined exercises in an existing General Template:

- Click the "New" button at the bottom center of your screen (Figure 5b).
- Choose "New Template" from the dialog box and touch "OK."
- Choose a pre-defined template from the list in the "Select General Treatment Template" box (Figure 5c). Click "OK."
- You will be prompted to enter a unique name for your new template. Bear in mind that this is essentially a 'clone' of the pre-defined template. Therefore, consider avoiding confusion by giving the new template a name related to that of the original. For example if you chose Hand Strengthening you might want to enter a name like "Hand Strengthening Setup 1."

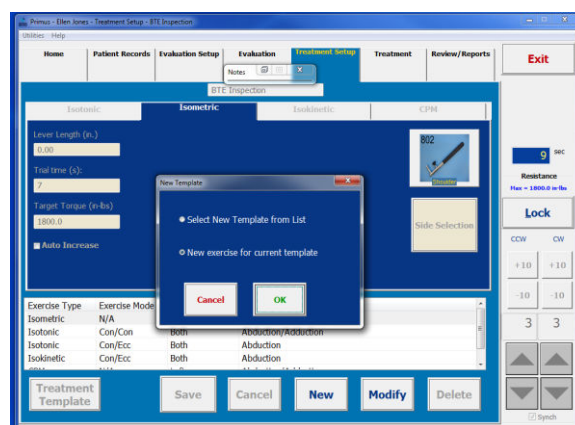


Figure 5b

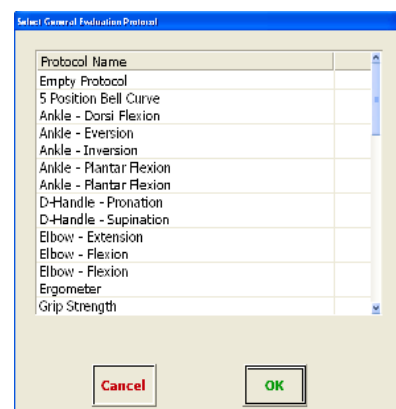


Figure 5c

**Note:** This name can be edited at any time by touching the “Modify” button (Figure 5d) and placing the cursor in the white text field at the top just underneath the *Treatment Setup* tab (Figure 5e). Use the keyboard to change the template name and hit “Save.”



Figure 5d

Clear undesired text using the delete/backspace keys on your keyboard and type in your new name.

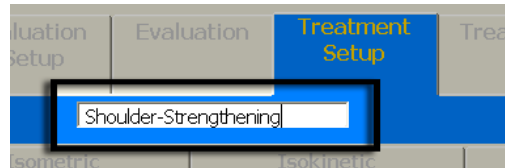


Figure 5e

- e. Click the “Save” button at the bottom of the screen.

Now Proceed to Section 5.4 to create/edit individual tests.

#### 5.3.2.2 To create a new General Template from scratch:

- a. Perform steps **a** and **b** as described above.
- b. Select “Empty Template” from the General Treatment Template list (Figure 5c). Click “OK.”
- c. Enter a unique template name when prompted and click “OK” in the dialog box to return to *Treatment Setup* (Figure 5f).

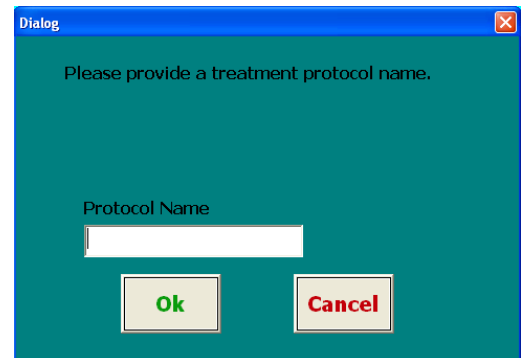


Figure 5f

The template name is now displayed directly beneath the *Treatment Setup* tab and in the title bar at the uppermost portion of the screen (Figure 5g).



Figure 5g

- d. Proceed now to Section 5.4 and add exercises to your new template.

#### 5.3.2.3 To edit a General Template directly:

- a. Click the “Treatment Templates” button at the bottom left of your screen.
- b. Touch the name of an existing template to select (Figure 5c). Click “OK” at the bottom of the dialog box to return to *Treatment Setup*.

- c. Notice that the template name is displayed in the text field directly underneath the *Treatment Setup* tab (Figure 5e).
- d. To rename the template, hit the “Modify” button at the bottom of your screen (Figure 5d).
- e. This will make all fields active, including the template name text field (Figure 5e). If you want to rename the template, click inside the white text field to place your cursor.

Clear undesired text using the delete/backspace keys on your keyboard and type in your new name.

Hit “Save” to apply your changes.

- f. Proceed to Section 5.4 to create/edit individual exercises.

### 5.3.3 Creating and Modifying a Patient-Specific Template

- Step 1. Click the *Patient Records* tab at the top left of the screen.
- Step 2. A new window will appear (Figure 5h). *If you have not yet defined a patient, go to Section 3.2 of this manual.* Touch “Show Patient List” or enter a Patient ID in the “Enter ID” field.
- Step 3. If you touched “Show Patient List,” you will be prompted to enter your password.

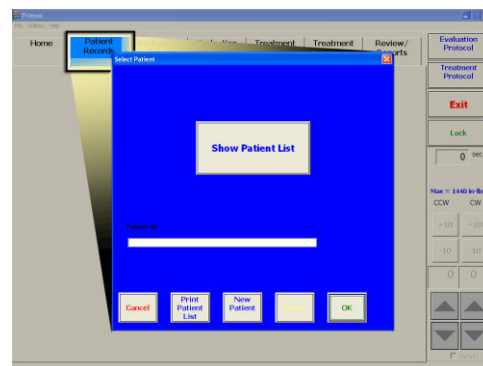
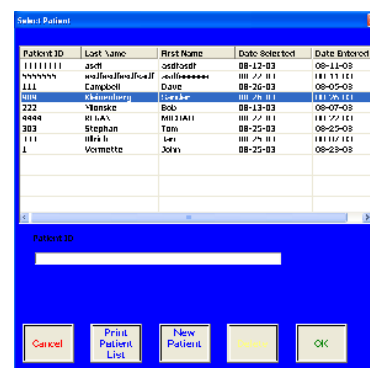


Figure 5h

Enter the password –the default password is “rs” (See Section 7 – “Utilities” to learn more about password settings).

- Step 4. Select your patient from the list and click “OK” (Figure 5i).

His/her name will now appear in the PrimusRS title bar (uppermost left of main software window – Figure 5j).



**Note:** Do not go to the *Home* screen once you have loaded your patient’s record. To protect your patient’s data from being viewed by unauthorized persons, his or her software record will be deactivated every time you click the *Home* tab. You will have to re-enter *Patient Records*, type the password again, and reload the patient record.

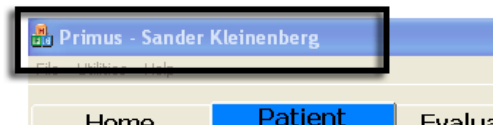


Figure 5j

- Step 5. Touch the *Treatment Setup* tab on the upper region of your screen (Figure 5a).

You are now presented with several options:

#### **5.3.3.1 Using a General Template as the basis for a Patient-Specific Template**

- a. Click the “New” button at the bottom center of your screen (Figure 5b).
- b. Choose “New Template” from the dialog box and touch “OK.”
- c. Choose a pre-defined template from the list in the “Select General Treatment Template” box (Figure 5c). Click “OK.”

This will copy the pre-defined General Template into the current Patient’s own template list. By default, the name of the ‘cloned’ template stays the same.

- d. To change the name of the new patient template, hit the “Modify” button at the bottom of your screen (Figure 5d).

This will make all fields active, including the template name text field (Figure 5e). If you want to rename the template, click inside the white text field to place your cursor. Clear undesired text using the delete/backspace keys on your keyboard and type in your new name.

Hit “Save” to apply your changes.

- e. Proceed to Section 5.4 to create/edit individual tests.

#### **5.3.3.2 Creating a Patient-Specific Template from scratch**

- a. Do steps **a** and **b** as described above.
- b. Select “Empty Template” from the general Treatment Template List (Figure 5c). Click “OK.”
- c. Enter a unique name for the template you are creating and click “OK” in the dialog box (Figure 5f).

The template name is now displayed directly underneath the *Treatment Setup* tab and in the title bar (Figure 5j) at the uppermost portion of your screen.

- d. Proceed now to Section 5.4 and add exercises to your new template.

#### **5.3.3.3 Editing an existing Patient-Specific Template**

- a. Click the “Treatment Templates” button at the bottom left of your screen.
- b. Select an existing template. Click on the template and touch “OK” (Figure 5c). Notice that the template name is displayed in the text field directly underneath the Treatment Setup tab.
- c. To rename the template, hit the “Modify” button at the bottom of your screen (Figure 5d).
- d. This will make all fields active, including the template name text field (Figure 5e). If you want to rename the template, click inside the white text field to place your

cursor. Clear undesired text using the delete/backspace keys on your keyboard and type in a new name.

- e. Hit “Save” to apply your changes.
- f. To add and edit individual tests, proceed to Section 5.4.

#### 5.3.3.4 Saving a Patient-Specific Template you have created as a General Template

You may find yourself wanting to use an exercise regimen crafted for a specific patient with another patient. Instead of creating a new General Template and manually replicating each exercise, use this time saving function:

- a. Follow up to step **c** in 5.3.3.3.
- b. You will notice that the “Save” button is active.
- c. Click the “Utilities” menu in the menu bar at the top left of your screen (Figure 5k).
- d. Move your pointer over “Save Options” in the Utilities menu.

The menu will expand, showing a sub-menu with the option to turn Save Options “On” or “Off.”

Click “On.”

- e. Now - back in the *Treatment Setup* screen - click the “Save” button at the bottom of your screen.

A dialog box will pop up giving you three “Save Options.”

**Save to General Template List Only**  
(this option is not available if no exercises have yet been saved into the current patient template).

**Save to Patient Template List Only**

**Save to BOTH Patient and General Template Lists**

Choose the function you need and click “OK.”

*If you do not want the Save Options dialog box to appear every time you hit “Save,” repeat Step d but click “Off” this time.*

- Step 6. Now that you have loaded the appropriate General Template, proceed to Section 5.4 to create/edit individual exercises.

### 5.3.4 Entering Setup/Print Notes

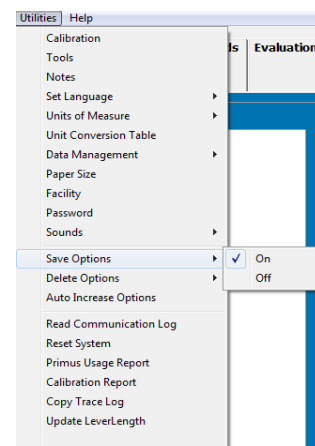


Figure 5k

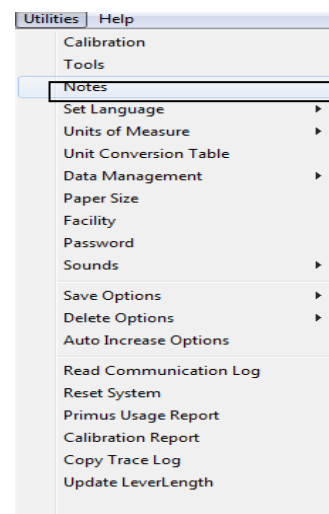


Figure 5l

PrimusRS includes a built-in note-taking option. Notes are activated and deactivated via the “Utilities” menu at the top left of the screen.

To turn on Notes, click “Utilities,” and move your cursor down to click “Notes” (Figure 5l). A check mark indicates that Notes are activated.

This will bring up the “Notes” window (Figure 5m).

You can now enter any necessary information.

There are two types of notes:

**Setup Notes (*Treatment Setup* screen):**

Enter information such as the height of the exercise head, location of range of motion stops (when applicable), and the patient’s position. Use of this feature allows you to accurately and consistently repeat exercises.

Setup Notes are entered only in the *Treatment Setup* screen. They are not printable – they are solely for the purpose of helping you set up treatments.

**Print Notes (*Treatment* screen):**

After performing a Treatment, enter any information you want to be able to print in this field. This may include observations of the patient’s performance during a treatment.

Click “OK/Save” to save your notes. At this point, the “Notes” window will be “minimized” (reduced to a small rectangle). This minimized box will lodge itself at the top right of your screen (Figure 5n) by default.

You can move the minimized notes box to any area of your screen by pressing it on the monitor and dragging your finger to a new position.

If you wish to enter more notes later, click the “Restore” button in the small box to restore the screen (Figure 5o)

To reduce Notes back to the minimized bar, click the minimize button at the top right of the notes screen. (Figure 5p).

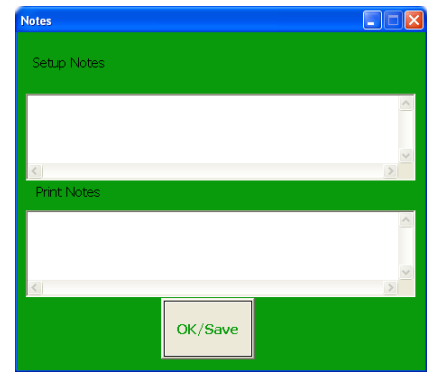


Figure 5m

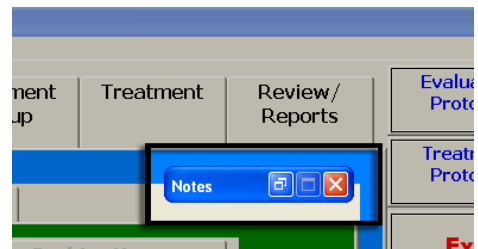



Figure 5n



Figure 5o



Figure 5p

To hide notes altogether, click  or go into the “Utilities” menu and uncheck “Notes.”

## 5.4 The Treatment Setup Screen

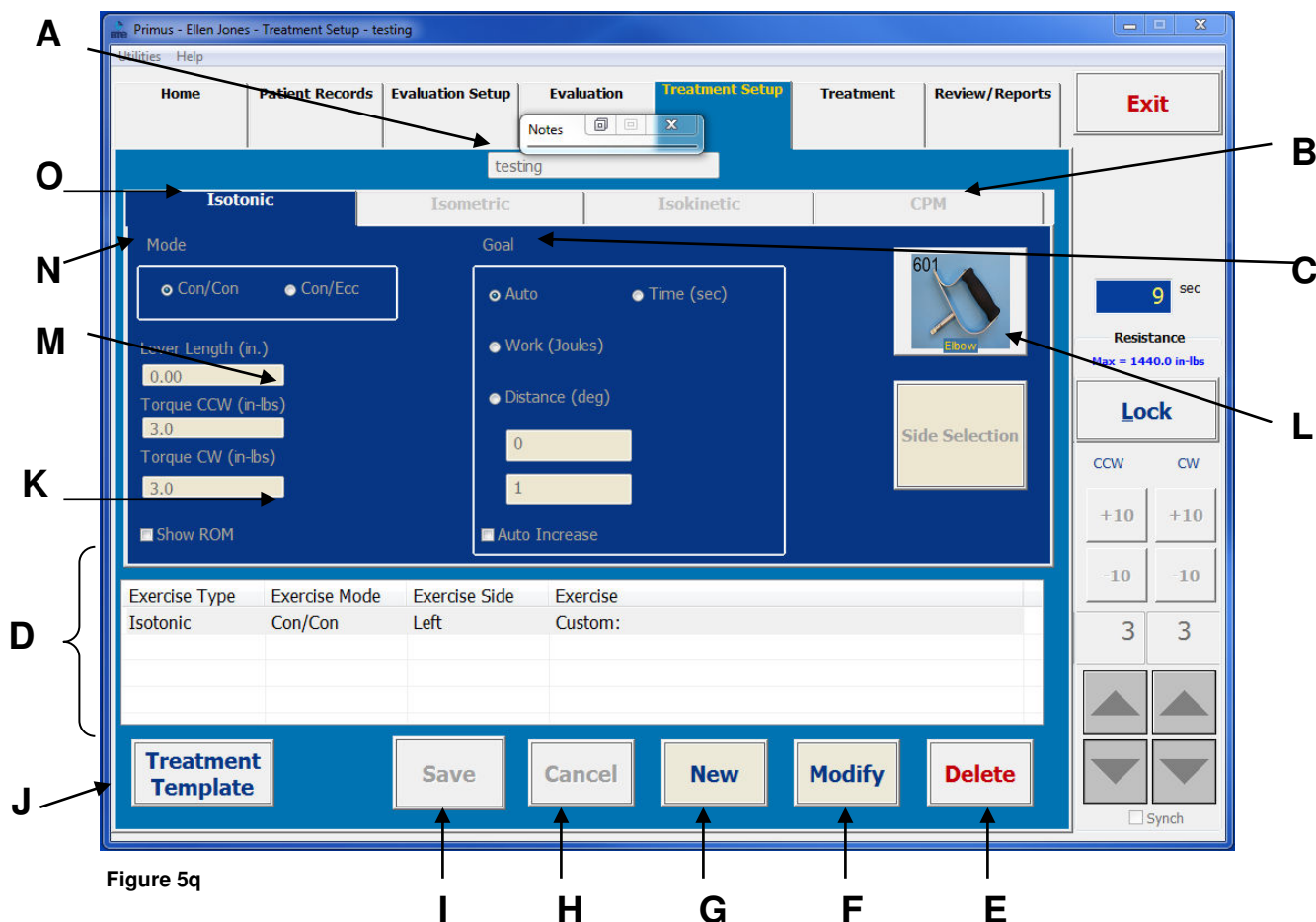


Figure 5q

- A. Treatment Template Name** – field displaying currently loaded template (editable by clicking the “Modify” button (F) at the bottom right of the screen)
- B. CPM** – Continuous Passive Motion
- C. Goal** – allows you to set a goal in one of these categories; “Auto” (unspecified goal dynamically regulated by therapist); “Time” (in seconds); Work (in-lbs-degs); Distance (degs)
- D. Exercise Descriptions** – lists exercises in the selected template
- E. Delete** – used to delete the selected exercise. If Delete Options (Section 7 – Utilities) are on – this button can be used to delete an entire template as well.
- F. Modify** – allows changing parameters of the selected exercise or renaming the template
- G. New** – allows creation of new template and new exercise
- H. Cancel** – cancels current operation
- I. Save** – saves changes to exercise and template
- J. Treatment Templates** – used for navigation between templates
- K. Force Settings** – set force in CW and CCW directions.
- L. Tool Selection** – Select attachment to be used
- M. Lever Length** – fill in this field to view results in lbs
- N. Muscle Mode** – select the muscle contractions for the exercise (CON/CON or CON/ECC).
- O. Exercise Mode** - there are three different modes available for selection, each with its own blue tab.



## 5.5 Adding and Editing Exercises in a Treatment Template

The PrimusRS *Treatment Setup* screen (Figure 5q) is used to create and edit parameters for each exercise in a template. Now that you have created a Treatment Template, use information entered into the **Task Analysis** and **Master Chart** (Section 10 – Appendix) to begin defining exercises. Primus enables you to establish specific exercise goals for each patient within *Treatment Setup*.

**Note**

If you intend to set up exercises for a specific patient, ensure that you have loaded a patient record! (See Section 5.3.3)

If you wish to set up exercises which are to be available to ANY patient, you must ensure that no patient record is loaded. (See Section 5.3.2)

*Treatment Setup* will vary depending upon which exercise mode is chosen: Isotonic, Isometric, Isokinetic, or CPM. Each mode has different treatment parameters.

Use the diagram on the preceding page to help you in locating and understanding the buttons on your screen. If you have general questions regarding the layout and the logic of the software, refer to Section 2.2 – “Basic Software Navigation.”

### 5.5.1 Creating New Exercises

- Step 1. Click “New” at the bottom of the screen (Figure 5q - G). This will bring up a dialog box.
- Step 2. Select “New Exercise for Current Template” from the dialog box. This will activate the screen and allow you to set parameters for each individual exercise.
- Step 3. *Treatment Setup* defaults to the Isotonic mode setup screen. An Isometric, Isokinetic, or CPM treatment can be set up by clicking the appropriately labeled tab now. (Figure 5q – O, B).
- Step 4. Click the “Select Tool” button (Figure 5q - L).
- Step 5. Select the body part to receive treatment. Click the image of the attachment you intend to use for the exercise (Figure 5r).  
  
Click “OK.”  
  
Note that for most attachments, the tool’s lever length now automatically appears in the “Lever Length” field (Figure 5q - M).
- Step 6. If you are using the 701 or the 802, adjust the lever length of the attachment in order

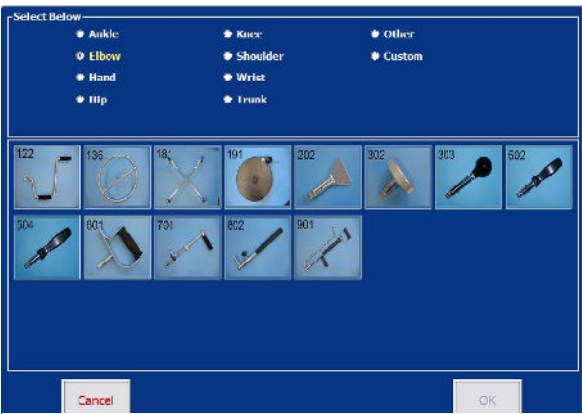


Figure 5r

for Primus to be able to convert force measurements to pounds. Lever length is the distance from the tool's axis of rotation to the end of the tool. If lever length is not entered, force will be displayed in inch-pounds

- Step 7. Check the necessary boxes, click the appropriate radio buttons, and fill in the exercise parameter fields shown in (Figure 5q – C, K, N, P).

Some fields are optional in certain exercises. You must, however, fill in each “Must-Enter” field labeled with yellow text.

- Step 8. Once the parameters are set, click “Save” at the bottom of the screen (Figure 5q - I).

### 5.5.2 Editing Existing Exercises

PrimusRS gives you the capability to edit the parameters of exercises saved into a Template. You may edit an exercise at any time. Refer to the diagram in Section 5.4 if you have trouble locating buttons on the screen. Consult Section 2.2 – “Basic Software Navigation” to answer general questions on how to use the software.

- Step 1. Click the exercise you wish to edit in the Exercise Descriptions List (Figure 5q - D).

This will highlight the selected exercise in the list and exercise settings will display in the *Treatment Setup* screen.

- Step 2. Click the “Modify” button to activate the exercise settings (Figure 5q - F).

- Step 3. Change the desired parameters.

- Step 4. Click “Save” to store your changes (Figure 5q - I).

### 5.5.3 Changing the Sequence of Exercises

When you start a treatment, the exercises in the template will be performed in the order in which they are listed in the *Treatment Setup* screen. If you wish to change their sequence:

- Step 1. Click on the exercise you wish to move in the Exercise Descriptions List (Figure 5s).
- Step 2. Hit the “CTRL” key on your keyboard and hold it down.
- Step 3. Still holding “CTRL,” tap the “up” or “down” arrow on your keyboard to change the exercise's position.

Exercise Type	Exercise Mode	Exercise Side	Exercise
Isotonic	Con/Ecc	Left	SHOULDER EXT. ROTAT.
Isotonic	Con/Ecc	Left	SHOULDER INT. ROTAT.
Isotonic	Con/Ecc	Left	PNF DIAGONAL FLEXION
Isotonic	Con/Ecc	Left	PNF DIAGONAL EXTENSION

Next Previous Save Cancel New

Figure 5s

## 5.6 Deleting Individual Exercises and Entire Templates

### 5.6.1 Deleting a Single Exercise

If you find that a particular exercise is no longer needed, you can easily delete it. This will remove the exercise entirely from the Primus software. **Deletion is permanent - once deleted, an exercise cannot be recovered.**

- Step 1. Go into the *Treatment Setup* screen.
- Step 2. Select the exercise from the Exercise Descriptions List (Figure 5q - D) by touching or clicking it.
- Step 3. Hit the large “Delete” button at the bottom right of the screen (Figure 5q - E).
- Step 4. Click “Yes” in the dialog box to confirm deletion of the exercise.

### 5.6.2 Deleting an Entire Treatment Template

PrimusRS gives you the capability to delete an entire Template in one operation.

**Deletion of a template is permanent – exercises in a deleted template are removed from the computer and cannot be recovered. Data saved on hard drive is retained.**

#### 5.6.2.1 To Delete a General Treatment Template

- a. Touch the *Home* tab to ensure that no patient name is selected. The title bar at the top of the screen will read “No Patient Selected”
- b. Click the *Treatment Setup* tab (Figure 5a).
- c. Click the “Treatment Templates” button at the bottom left of the screen (Figure 5q - J).
- d. Select the General Treatment Template you wish to delete. Click “OK.”
- e. Click “Utilities” in the menu bar at the upper left of the screen and move your pointer down to “Delete Options.”

(The menu will expand Figure 5t).

- f. Touch “On” in the menu to activate the Delete Options feature.
- g. Now touch the “Delete” button at the bottom right of the screen (Figure 5q - E).

The Delete Options dialog box will appear on your screen.

- h. Select the “Delete all Exercises AND Template” option and click “OK.”

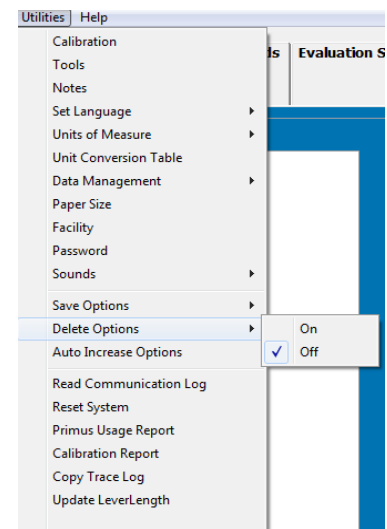


Figure 5t

Your template is now removed.

*If you do not want the Delete Options dialog box to appear every time you hit "Delete," repeat Step 5. Click "Off" in the expanded menu.*

### 5.6.2.2 To Delete a Patient-Specific Treatment Template

- a. Perform Steps 1-5 in Section 5.3.3.
- b. Perform Steps **c** - **h** in Section 5.6.2.1 (above).

## 5.7 Isotonic Treatment

### Note

Press the "**F10**" key on the top row of your keyboard (Figure 5u) to launch **Primal Pictures – Interactive Functional Anatomy** (IFA). IFA is a vast interactive resource of 3-dimensional models and detailed descriptions of every major bone, tendon, ligament, and muscle group in the body. This innovative software has been integrated into PrimusRS so that hitting F10 takes you directly to the interactive informational section relating to the tool and muscle movement set for the current exercise.

For instance, if you select a treatment with the 701 tool and you choose "Elbow Flexion/Extension" from the functional descriptions list, hitting F10 launches the IFA Elbow Flexion/Extension video.



Figure 5u

### 5.7.1 Isotonic Treatment Setup

Step 1. Load a patient record into the software - perform Steps 1-5 in Section 5.3.3.

Step 2. Now you must load a template.

- If you wish to use a BTE pre-set template, perform the procedure described in 5.3.3.1.
- To create a customized template from scratch, follow the steps in 5.3.3.2.
- To edit an existing patient-specific template, see 5.3.3.3.

Step 3. If you loaded a pre-set template, you will see a series of exercises in the horizontal Exercise Descriptions box toward the bottom of your screen (Figure 5q - D). To edit one of these, click on it (it will become highlighted) and touch the "Modify" button at the bottom of your screen. Proceed directly to Step 5.

Step 4. To create a new exercise, follow the procedure outlined in Section 5.5.1. Click the "Isotonic" tab in Step 3.

Set these parameters (diagrammed in Figure 5q – Treatment Setup):

**Mode (N):** CON/CON – provides concentric resistance in both directions

CON/ECC – provides concentric resistance in the first direction and eccentric resistance in the returning direction

**Side (P):** specify side of patient to be treated

**Torque CW/CCW (K):** click in these fields and enter the amount of torque in either the clockwise (CW) or counterclockwise (CCW) direction.

To establish appropriate force settings, it is recommended that you first begin at a low force level with each attachment. (Note that the terms force, resistance and torque are used interchangeably in this manual.)

Step 5. Set a **Goal** (Figure 5q - C):

**Goals** may be set in Time (sec), in Work (in-lbs), or in Distance (degrees). The exercise will stop once this goal is reached. If you wish to set a goal, click on the radio box next to one of these options and enter a numeric value in the text box.

Selection of “Auto” bypasses the goal setting. When “Auto” is selected, PrimusRS will not stop the exercise until you click the “Stop” button.

The setting of Work or Distance goals is normally best accomplished after the patient completes the exercise for the first time. Then you can return to this set-up screen and enter a Work or Distance goal based on the amount which the patient has just performed. Setting Work or Distance goals *after* the first exercise session takes the guess-work out of setting those goals.

**Note:**

Check “Auto Increase” if you want to be able to update the goals of multiple exercises at once. This unique feature of PrimusRS is explained in Section 7 – Utilities.

Step 6. When you are satisfied with all the exercise parameters, click “Save.”

Step 7. As you insert the appropriate attachment, set the proper height for the exercise head. This is done by pressing the switch that will raise or lower the head. You should choose the height that is either comfortable for the patient or appropriate for the desired exercise or simulation. It is important that you note the shaft height with each attachment and then return to that setting each session. Record the shaft height using the Setup Notes feature (Section 5.3.4) Maintaining the appropriate height is essential if you wish to duplicate the same exercise day after day.

Since the exercise head can be tilted to various positions, it is also important to note which position is chosen for each attachment. Look at the position decal on the side of the exercise head and record this number in Setup Notes also (Section 5.3.4)

## 5.7.2 Conducting an Isotonic Treatment

Patient treatment with the PrimusRS means *immediate* visual feedback for the patient and convenient record keeping from the daily treatment chart. The system charts each daily treatment session and plots treatment progress.

**Note**

If your Treatment Template includes exercises with differing resistance modes (Isometric, Isotonic, Isokinetic, CPM), you will be prompted to unlock the exercise head when switching from one exercise to another in the *Treatment* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next exercise.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



- Step 1. Having created or edited an isotonic exercise in *Treatment Setup*, click the “*Treatment*” tab at the top of your screen.
- Step 2. An image of the tool with a functional description is located on this screen. If you wish to select a different exercise from the template, click the “Previous/Next Exercises” buttons on the bottom left of your screen.

BTE recommends starting every patient's first treatment with a Static Test in order to gauge his/her maximum effort of the involved side. By default, treatments are set to start at 30% of this maximum.

**\*If you do *not* wish to run a Static Trial, proceed to Step 9 and enter the amount of resistance you feel is appropriate\***

To perform a Static Trial, click the “Static Trial” button. The Static Test screen, shown here, will pop up to record trials (Figure 5v).

- Step 3. Position the patient in such a way that there will be no muscle substitution, allowing you to isolate the appropriate muscle group.
- Step 4. Instruct the patient to exert as much force as he/she comfortably can.
- Step 5. If you want PrimusRS to provide a different force in clockwise vs. counterclockwise directions (i.e. flexion vs. extension), have the patient exert effort in one direction, pause, and exert effort in the opposite directions.
- Step 6. For the most consistent assessment, have the patient exert effort twice in each direction, letting the results accumulate before hitting “OK.”
- Step 7. The system defaults to the recommended level of 30% of maximum but you have the option of changing this percentage to whatever amount you choose.

 A screenshot of the 'Static Test' dialog box. It has a blue background. At the top, it says 'Force'. Below this, there are two columns: 'Counter Clockwise' and 'Clockwise'. Each column has three input fields: 'Current', 'Maximum', and '% of max'. The 'Current' field for both directions is 0. The 'Maximum' field for Counter Clockwise is 24 and for Clockwise is 16. The '% of max' field for Counter Clockwise is 7.2 and for Clockwise is 4.8. To the right of these fields is the unit 'lbs'. At the bottom, there are two radio buttons: 'CCW as CD' (selected) and 'CW as CD'. At the very bottom are 'OK' and 'Cancel' buttons.

Figure 5v

Simply place your cursor in the small box and type in a different value if you wish.

- Step 8. When you are satisfied with the trials and the percent of max setting, click "OK." This will take you back to the *Treatment* screen.
- Step 9. At this point, the resistance (shown in the Control Panel see Section 2.4) will automatically set itself to the percentage of maximum effort specified by the therapist in the *Static Trial* screen.

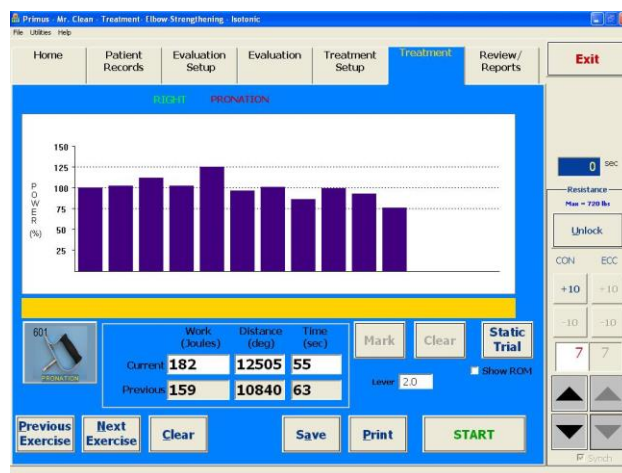


Figure 5w

If you wish, you may alter the amount of resistance at any time during the exercise.

### Note

By default, CW and CCW are "Synched." To un-synch them and alter the resistance in each direction independently, click or touch the "Synch" box underneath the Control Panel's resistance settings (Section 2.4).

Click the "Show ROM" checkbox if you want to activate a visual range of motion display. You do have the ability to designate or "mark" a range of motion as well as "clear" the marks.

- Step 10. Hit "**Start**" at the bottom right of the screen to begin the exercise.

If you have opted not to use a percentage of maximum, begin the exercise at a fairly easy force level. While the patient is exercising, slowly increase the resistance by repeatedly touching the increase force arrows in the Control Panel at the right of the screen (Section 2.4). The objective is to find a level that is challenging for the patient, but not painful. It is important to monitor the patient's reactions and allow his/her input during this process. Once you reach the appropriate level, have him/her exercise until s/he begins to fatigue. When you sense the patient has reached the fatigue point, stop the exercise. **Don't overdo it!** It may take several sessions for the patient to become accustomed to his/her new exercise protocol, and starting at an easy level is less likely to aggravate the injury.

A vertical bar will appear every five seconds showing the power generated by the patient (Figure 5w). The power generated in the first five seconds will equal 100% and power produced in subsequent bars will be compared to this first one.

The red horizontal bar will stretch across the screen as the patient nears his or her goal.

The counters at the bottom display the amount of work generated, the elapsed time, and the distance achieved during the exercise. If you entered a goal, a horizontal bar will simultaneously appear showing progress toward reaching the goal.

If a goal was set, Primus will inform you when the goal is reached and the exercise will stop.

- Step 11. If you selected "Auto" in *Treatment Setup*, the exercise will keep going until you touch the "**Stop**" button.
- Step 12. Touch the "Clear" button to delete an unsatisfactory treatment. Otherwise, touch "Save."

Click “Print” for an instant hardcopy of the patient’s treatment graph and data.

If you save the results of a treatment, every time you conduct it after that point, a “Treatment Progress” graph will appear (Figure 5x). This feature illustrates the difference in the patient’s power capabilities between each of his or her treatment sessions.

- Step 13. Record your observations on the patient’s performance in Print Notes (Section 5.3.4).

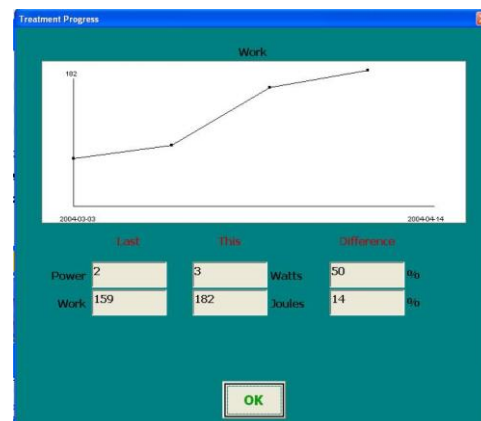


Figure 5x

#### Note:

As your patient progresses, you will increase his or her exercise goals. You can do this manually by modifying each individual exercise (Section 5.5.2) or you may elect to use the PrimusRS “Auto Increase” feature. This allows you to automatically increase any combination of Time, Work, and Distance goals for every exercise in the entire patient template in one operation.

If you checked “Auto Increase” in *Treatment Setup*, you can click the Utilities menu now (at the top left of your screen) and touch “Auto Increase” to perform a goal increase. (See Section 7 – Utilities for more information on this feature).

## 5.8 Isometric Treatment

#### Note

Press the “**F10**” key on the top row of your keyboard (Figure 5u) to launch **Primal Pictures – Interactive Functional Anatomy** (IFA). IFA is a vast interactive resource of 3-dimensional models and detailed descriptions of every major bone, tendon, ligament, and muscle group in the body. This innovative software has been integrated into PrimusRS so that hitting F10 takes you directly to the interactive informational section relating to the tool and muscle movement set for the current exercise.

For instance, if you select a treatment with the 701 tool and you choose “Elbow Flexion/Extension” from the functional descriptions list, hitting F10 launches the IFA Elbow Flexion/Extension video.



Figure 5y



### 5.8.1 Isometric Exercise Setup

- Step 1. Load a patient record into the software - perform Steps 1-5 in Section 5.3.3.
- Step 2. Now you must load a template.
- If you wish to use a BTE pre-set template, perform the procedure described in 5.3.3.1.
  - To create a customized template from scratch, follow the steps in 5.3.3.2.
  - To edit an existing patient-specific template, see 5.3.3.3.
- Step 3. If you loaded a pre-set template, you will see a series of exercises in the horizontal Exercise Descriptions box toward the bottom of your screen (Figure 5q - D). To edit one of these, click on it (it will become highlighted) and touch the “Modify” button at the bottom of your screen. Proceed directly to Step 5.
- Step 4. To create a new exercise, follow the procedure outlined in Section 5.5.1. Click the “Isometric” tab in Step 3.

Set these parameters (shown in Figure 5z):

- **Side** – specify which sides are to be tested.
- **Test Time** – enter the duration of exercise in seconds. 10 seconds is a good starting point. Gradually increase the time in subsequent exercise sessions as the patient is able to tolerate longer contractions.
- **Lever Length** – enter length from the center of the hand to the center of shaft. This will enable PrimusRS to convert inch-pounds of torque into pounds of torque.
- **Target Torque** – enter the amount of force the patient should exert. It is suggested that you set a torque which is 75% of the patient's maximum strength.

- Step 5. Enter Setup Notes (outlined in Section 5.3.4).
- Step 6. Touch “Save” to store changes, or “Cancel” to discard them. When you are satisfied with the settings, click “OK.”

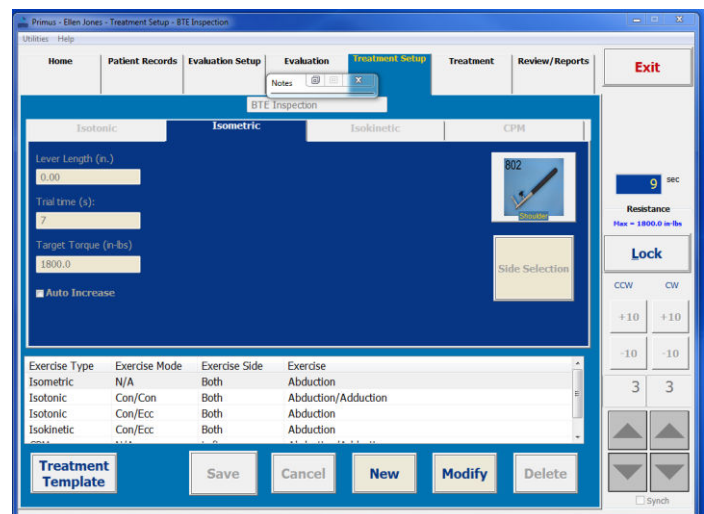


Figure 5z

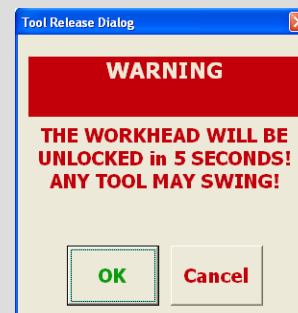
### 5.8.2 Conducting an Isometric

## Treatment

### Note

If your Treatment Template includes exercises with differing resistance modes (Isometric, Isotonic, Isokinetic, CPM), you will be prompted to unlock the exercise head when switching from one exercise to another in the *Treatment* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



Step 1. Having selected an isometric exercise, click the *Treatment* tab on the top of the screen.

- To the right of the screen you will see an image of the tool defined for the currently selected exercise. (If you wish to select a different exercise from the template, simply click the “Previous/Next Exercises” buttons on the bottom left of your screen.)

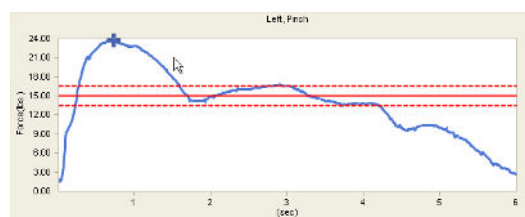


Figure 5aa

- You may edit any exercise or add a new exercise to the template back in the *Treatment Setup* tab.

Step 2. If you entered a Target Torque in *Treatment Setup*, you will notice that the white graphing area contains three horizontal dotted lines (Figure 5aa).

Step 3. The center line represents the target torque. Instruct the patient apply enough force during the exercise to keep the colored graphed lines between these dotted lines. Graphs falling in this region are considered “On Target.”

Step 4. Press “Start” to begin the exercise.

As the patient performs the exercise, a line graph will be drawn, indicating the amount of force exerted (Figure 5bb). Force is plotted against seconds in a line graph. The highest amount of force achieved is marked by an “x” on the graph.



Figure 5bb

The exercise will stop when the Test Time elapses. Press the “Stop” button to stop the machine manually.

If you are unsatisfied with the results of an exercise, hit the “Clear” button.

Repeat the exercise by hitting “Start” again.

- Step 5. When you are satisfied with the results, hit the “Save” button. This will make them available for review in the “Review/Reports” section.

If you save results for a treatment, every time you conduct it after that point, a “Treatment Progress” graph will appear (Figure 5x). This feature illustrates the difference in the patient’s strength between each of his or her treatment sessions.

- Step 6. Record your observations through the “Notes” feature (Section 5.3.4)

Touch “Print” for an instant hardcopy.

## 5.9 CPM – Continuous Passive Motion

In the CPM mode (Continuous Passive Motion), the PrimusRS will move the attachment continuously back and forth through the pre-set range of motion. The patient can relax and allow the attachment to passively move through the range, or the patient can be instructed to apply some resistance against the moving attachment for a passive-assist strengthening exercise.

It is the responsibility of the clinician to determine the appropriateness of the patient for exercises in the CPM mode. A complete examination of the patient should precede any decision to perform such exercise. Below is a list with contraindications for CPM exercise on the PrimusRS:

- unstable joint or bone healing
- severe pain
- septic tenosynovitis
- diffuse cellulitis
- severe open wounds or sores
- deep laceration surrounding joint

It is important to orient the patient to the PrimusRS before beginning an exercise. Explain the purpose of the exercise and how it is to be performed. **Explain the safety features of the system, especially the remote shut-off (Slap Switch – see Section 5.9.2 – Step 5).**

### Note

Press the “F10” key on the top row of your keyboard (Figure 5u) to launch **Primal Pictures – Interactive Functional Anatomy** (IFA). IFA is a vast interactive resource of 3-dimensional models and detailed descriptions of every major bone, tendon, ligament, and muscle group in the body. This innovative software has been integrated into PrimusRS so that hitting F10 takes you directly to the interactive informational section relating to the tool and muscle movement set for the current exercise.

For instance, if you select a treatment with the 701 tool and you choose “Elbow Flexion/Extension” from the functional descriptions list, hitting F10 launches the IFA Elbow Flexion/Extension video.

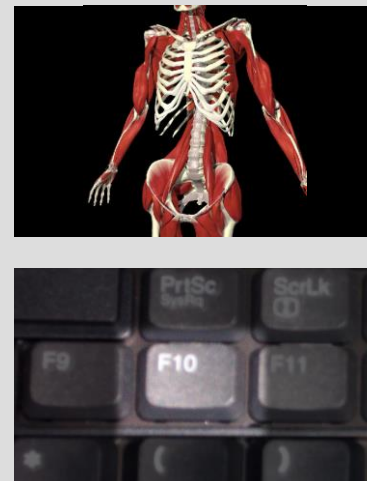


Figure 5cc

## 5.9.1 CPM Setup

Step 1. Load a patient record into the software - perform Steps 1-5 in Section 5.3.3.

Step 2. Now you must load a template.

- If you wish to use a BTE pre-set template, perform the procedure described in 5.3.3.1.
- To create a customized template from scratch, follow the steps in 5.3.3.2.
- To edit an existing patient-specific template, see 5.3.3.3.

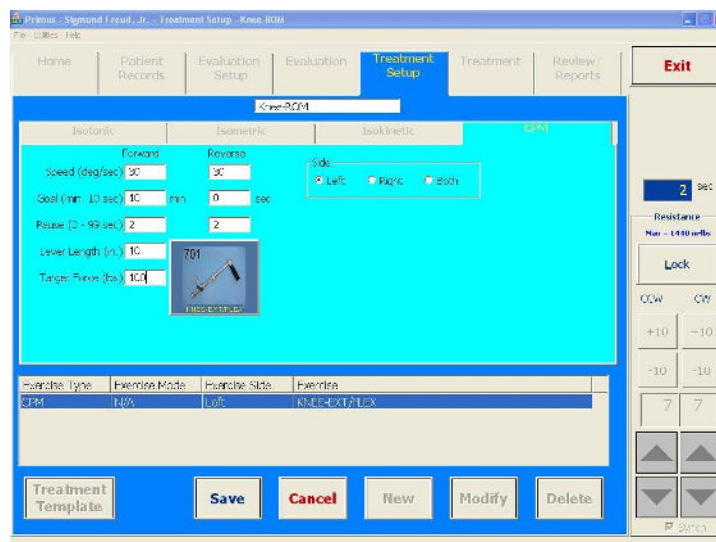


Figure 5dd

Step 3. If you loaded a pre-set template, you will see a series of exercises in the horizontal Exercise Descriptions box toward the bottom of your screen (Figure 5q - D). To edit one of these, click on it (it will become highlighted) and touch the “Modify” button at the bottom of your screen. Proceed directly to Step 5.

Step 4. To create a new exercise, follow the procedure outlined in Section 5.5.1. Click the “CPM” tab in Step 3. Make sure to set these important parameters (shown in Figure 5dd):

- Speed** – set the degrees per second the attachment will move  
(20 degrees/second is a good starting value).
- Goal** – enter a time for the exercise  
(BTE recommends a 20 minute goal time)
- Pause** – specify a rest time in between motions  
(2 seconds is usually sufficient)
- Torque** – set a target force for the patient to exert on the moving attachment  
(75% of the patient's maximum strength is usually appropriate. If you set the torque too low, the weight of the patient's extremity will stall the motor.)

Step 5. Enter Setup Notes (outlined in Section 5.3.4).

Step 6. Touch “Save” to store your new settings, or “Cancel” to discard them.

## 5.9.2 Conducting CPM Treatment

- Step 1. Having set up a CPM exercise in *Treatment Setup*, now click the *Treatment* tab.
- Step 2. Touch the “Start” button at the bottom right of the screen. This will initiate the “CPM Range Setup” screen (Figure 5ee).
- Step 3. Touch the “Set Midpoint” button. Instruct your patient to move the attachment to the midpoint of the range of motion.

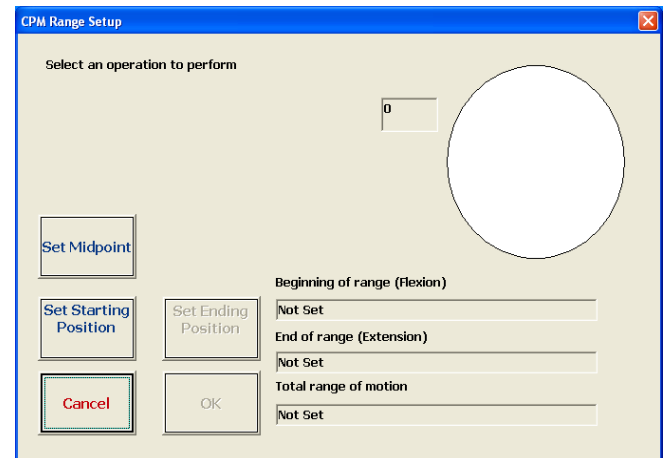


Figure 5ee

Click “OK.”

- Step 4. Hit the “Set Starting Position” button. Have the patient move tool to the desired position and click “OK.”
- Step 5. Click “Set Ending Position.” Again, instruct your patient to move the attachment to the appropriate ending position, and click “OK.” Have the patient release the attachment and press “OK” again. The machine will move it back to the starting position allowing you to begin the treatment.

### IMPORTANT

**In the event that the PrimusRS motor needs to be stopped *immediately*, use the slap-switch at the end of the white cable (Figure 5gg). This switch can be squeezed by hand or stepped on like a pedal. Ensure that it is easily accessible by the patient prior to beginning any CPM treatment.**

After stopping Primus with the slap-switch, you must **restart the entire system** with the orange “OFF/ON” switch on the right side panel of the machine.

- Step 6. Press “OK” to begin treatment. If you desire to switch the order of the two movements, click the double-headed arrow button (Figure 5ff).

Tell your patient to relax and let the machine move his/her limb at a constant speed through the set range of motion.



Figure 5ff

If you entered a Target Torque, position the computer monitor so that the patient can see it. Instruct him or her to exert enough force on the attachment so that the graphing line stays between the horizontal dotted lines.)



Figure 5gg

- Step 7. At any time, you or the patient may touch the “Stop” button or press the remote stop switch (Figure 5gg) to shut the motor off and stop movement.

In addition to using the pause time to maximize the stretching effect of this ROM exercise, you may also increase or decrease the total ROM while the exercise is in progress. As the patient's joint structures and soft tissues becomes relaxed and limber, you may touch the “+” button to add to the total ROM, one degree per touch. You may also decrease the total ROM by touching the “-” box if the original range was too much. The change in ROM will be made in the direction you selected.

As the patient progresses, you may want to set a target torque (Figure 5dd) to begin some low-level strength training. In this case, tell the patient to push in the same direction that the attachment is moving for a concentric exercise, or gently resist as the attachment pushes the limb for an eccentric exercise.

If you set a target torque, the color of the feedback line will indicate which direction the patient is applying force.

- A green line indicates that the patient is exerting force in the direction of the moving attachment (concentric contraction).
- A red line indicates that the patient is applying force against the moving attachment as if trying to stop it (eccentric contraction).

In addition, an “On Target %” will be displayed showing the percentage of time the patient was able to stay in the target force range.

As the exercise progresses and many lines are graphed, the oldest line will be cleared and replaced by the newest one. This “one in – one out” process will continue until the end of the entire exercise.

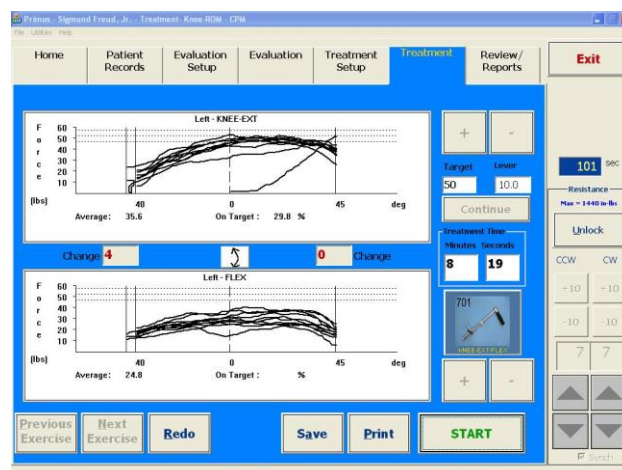
- Step 8. When test time elapses, the exercise will stop. Press “Redo” if the exercise was not satisfactory.

Otherwise, press “Continue” to perform another repetition of the exercise.

- Step 9. When you are finished with CPM Treatment, press “Save” at the bottom of the screen. (The graphs and results are now available for review and for printing in the “Reviews/Reports” screen).

- Step 10. Touch the “Print” button at the bottom of your screen for an instant hardcopy of the treatment results.

Note that any increases/decreases made in ROM are recorded graphically as well as numerically in the boxes between the graphs.





## 5.10 Isokinetic Treatment

### Note

Press the “**F10**” key on the top row of your keyboard (Figure 5hhFigure 5u) to launch **Primal Pictures – Interactive Functional Anatomy** (IFA). IFA is a vast interactive resource of 3-dimensional models and detailed descriptions of every major bone, tendon, ligament, and muscle group in the body. This innovative software has been integrated into PrimusRS so that hitting F10 takes you directly to the interactive informational section relating to the tool and muscle movement set for the current exercise.

For instance, if you select a treatment with the 701 tool and you choose “Elbow Flexion/Extension” from the functional descriptions list, hitting F10 launches the IFA Elbow Flexion/Extension video.



Figure 5hh

### 5.10.1 Isokinetic Treatment Setup

- Step 1. Load a patient record into the software - perform Steps 1-5 in Section 5.3.3.
- Step 2. Now you must load a template.
  - If you wish to use a BTE pre-set template, perform the procedure described in 5.3.3.1.
  - To create a customized template from scratch, follow the steps in 5.3.3.2.
  - To edit an existing patient-specific template, see 5.3.3.3.
- Step 3. If you loaded a pre-set template, you will see a series of exercises in the horizontal Exercise Descriptions box toward the bottom of your screen (Figure 5q - D). To edit one of these, click on it (it will become highlighted) and touch the “Modify” button at the bottom of your screen. Proceed directly to Step 5.
- Step 4. To create a new exercise, follow the procedure outlined in Section 5.5.1. Click the “Isokinetic” tab in Step 3. Choose the attachment to be used for the exercise by tapping the “Select Tool” box and highlighting the tool and proposed use.
- Step 5. Additionally, be sure to set these important parameters (shown in Figure 5ii):

**Mode** – Select the resistance you wish to use; CON/CON or CON/ECC.

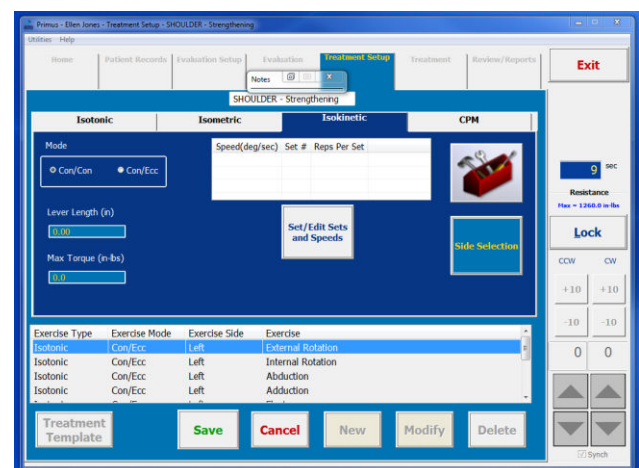


Figure 5ii

**Side** – Specify which side is to be treated.

**Lever Length** – Enter length from the end of the attachment to the center of shaft. This will enable PrimusRS to convert inch-pounds of torque into pounds of torque.

**Max Torque** – Enter the maximum torque allowed in the exercise.

**Reps/Set** – Enter the number of repetitions to be performed per set, and the number of sets.

Step 6. Touch the “Set Speeds” button. The “Isokinetic Exercise Speed Entry” dialog box will appear as shown Figure 5jj.

Step 7. Press “Insert” and enter the speed in degrees/second. “Press OK” to save. A typical speed range for three sets might be 60, 120, 180 deg/sec.

Step 8. Enter Setup Notes (outlined in Section 5.3.4).

Step 9. Touch “Save” to store your new settings, or “Cancel” to discard them.



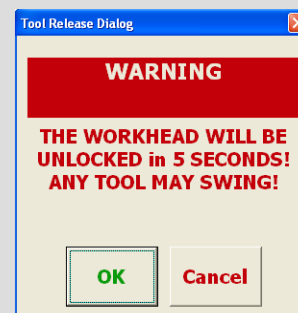
Figure 5jj

## 5.10.2 Conducting an Isokinetic Treatment

### Note

If your Treatment Template includes exercises with differing resistance modes (Isometric, Isotonic, Isokinetic, CPM), you will be prompted to unlock the exercise head when switching from one exercise to another in the *Treatment* screen. Ensure that the patient is a safe distance away from the attachment, and click “OK” in the flashing, beeping dialog box. The workhead will unlock and the tool will swing down freely. **You must click “OK” in order to proceed to the next test.**

This same dialog box will appear after 7 minutes of inactivity on the PrimusRS (See Section 2.5 for detailed explanation).



Step 1. Click the *Treatment* tab at the top of your screen.

Step 2. Position the patient in such a way that there will be no muscle substitution, allowing you to isolate the appropriate muscle group.

Step 3. If you selected CON/ECC in *Treatment Setup*: remember that the first direction the patient moves will be met with concentric resistance. The second direction will be eccentric. For this reason, tell the patient in which direction to begin moving the attachment.

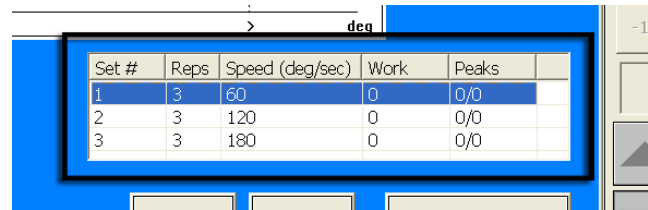


Figure 5kk

The top white region is labeled with the muscle movement to be exercised first. If you want to start with the opposite movement (currently the lower white graph box), click the arrow button (Figure 5kk).



- Step 4. Click or touch the first set to be performed in the Set/Speed List Box in the lower right corner of your screen (Figure 5II).



Set #	Reps	Speed (deg/sec)	Work	Peaks
1	3	60	0	0/0
2	3	120	0	0/0
3	3	180	0	0/0

Figure 5II

- Step 5. Hit **“Start”** at the bottom right of the screen.

The “Set Range” dialog box will appear because Isokinetic mode requires that range of motion is specified.

- Step 6. Click **“Set BOR”** and instruct your patient to move the tool to the beginning of the desired range. Click **“OK”** to save that position

Next, touch the **“Set EOR”** button and have the subject to be tested move the tool to the end of range. Click **“OK”** to save this position.

Instruct your patient to remove his or her hand from the attachment and press **“OK”** again – it will be moved back to the starting position.

- Step 7. The test will now start. Explain to the subject that the attachment must be moved through the entire range of motion to be counted as a valid rep.

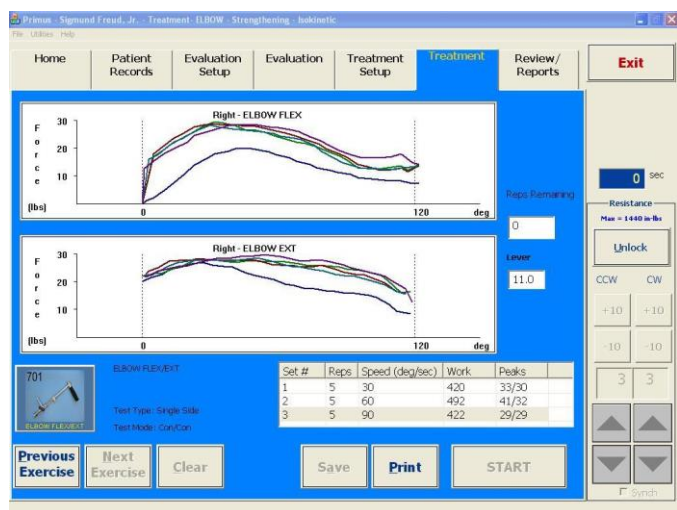


Figure 5mm

Force exerted by the patient is graphed as a colored line between the two vertical black dotted lines (Figure 5mm). These vertical dotted lines indicate the boundaries of the range of motion set for the test. The white graphing areas are labeled according to the side and function you entered for “Side 1” and for “Side 2” in *Treatment Setup*.

Each set will stop when all reps are completed.

Once the patient finishes the first set, select the second one by clicking the set name in the Set/Speed List Box (Figure 5II). Repeat this procedure until each set is completed.

- Step 8. If a rep is not satisfactory, press **“Clear”** and the most recently graphed line will disappear.

The amount of work done (in joules) is displayed in the Set/Speed List Box. Peak torque in either direction appears next to the work total:

The first number under “peaks” refers to the top graph.

The second number under peaks (after the slash) refers to the bottom graph.

- Step 9. To enter your observations of the treatment, open the **“Notes”** window (Section 5.3.4).

- Step 10. Press **“Save”** to store the treatment results. Saved notes and test results are available for on-screen viewing and for printing in the **“Reviews/Reports”** tab.

If you save results for a treatment, every time you conduct it after that point, a “Treatment Progress” graph will appear. This feature illustrates the difference in the patient's strength between each of his or her treatment sessions.

Step 11. If you want an instant hardcopy of your treatment results, click “Print” now.



Section 6 – Reviews and Reports

6.1    Evaluation ..... 602

6.2    Treatment ..... 603



## Section 6 – Reviews/Reports

All data saved in the system can be easily retrieved through the *Reviews/Reports* screen. Results can be viewed as individual treatment and evaluation reports and graphs, or as overall progress graphs.

The *Reviews/Reports* screen is divided into an *Evaluations* and a *Treatments* tab (Figure 6a).

Figure 30a

### 6.1 Evaluations

Step 1. To access test data, click the “Evaluations” tab.

Data are grouped by test type as below:

**Isometric**

**Isotonic Power**

**Isotonic Endurance**

**Lifting**

**Isokinetic**

**Torque vs Speed**

Tests listed under each test type are categorized by tool number, test function, and date and time of each test.

Step 2. To review a specific test, move your cursor to the appropriate test type and double click on the test name. This action will display a full-color graph of that particular test (Figure 6b).

You may print a graph by pressing “Print” at this time, or click “Back” at the bottom of this graph screen to return to *Reviews/Reports*.

If you wish to review a series of evaluations without having to go back to the *Reviews/Reports* screen to double click each one individually, proceed to Step 3.

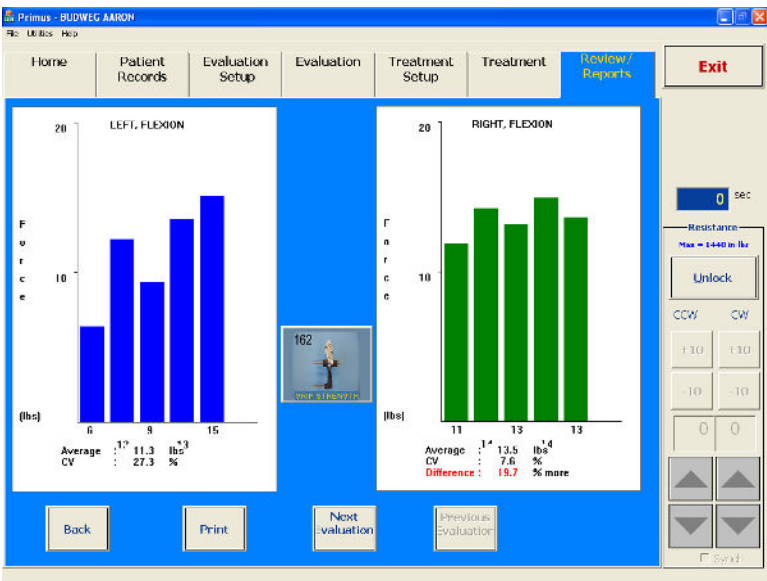


Figure 30b

Step 3. Select the tests you are interested in by checking the small box to the left of each evaluation name (Figure 6c).

Now click “Review” and you will see a full-color graph of the first test you selected at the *Review/Reports* screen. Use “Next” and “Previous” buttons to switch from one test to another.

Tool Description	Date & Ti...	C.	Lin...	Nu...
<input checked="" type="checkbox"/> 162 - GRIP STR...	11/06/03 ...	Y	N	1
<input checked="" type="checkbox"/> 701 - WRIST S...	11/06/03 ...	Y	N	1
<input checked="" type="checkbox"/> 701 - ELBOW E...	11/06/03 ...	N	Y	1
<input checked="" type="checkbox"/> 701 - ELBOW E...	11/06/03 ...	N	Y	1

Figure 30c

If you want to review all tests, click on the “Select All” button. All boxes will now be checked.

Performing steps 1 through 3 and printing the test screens, produces a “BTE PrimusRS Results Report”. A Results Report will provide you with graphic representation of the test specified within a particular test type. Additionally, a text box is provided which contains numeric data.

Step 4. If a hardcopy of comparative data is desired, PrimusRS offers you the “BTE PrimusRS Evaluation Report”. This report provides graphic displays and a text box of numeric data of test results from the first and most recent test dates of all test types. This numeric data provides percent difference calculations that indicate progress or lack thereof. Progress is also displayed in graph format; test results are plotted by date.

To obtain this report, simply select the evaluations you wish to print by checking the box next to each one, and click “Print” directly in the *Reviews/Reports* screen.

6.2 Treatment

The “Treatment Reports” tab is divided into four categories:

- Isometric
- Isotonic
- Isokinetic
- CPM

*Treatment Reports* are selected, viewed, and printed in exactly the same manner as *Evaluation Reports* (Steps 2-4).



# PRIMUSRS

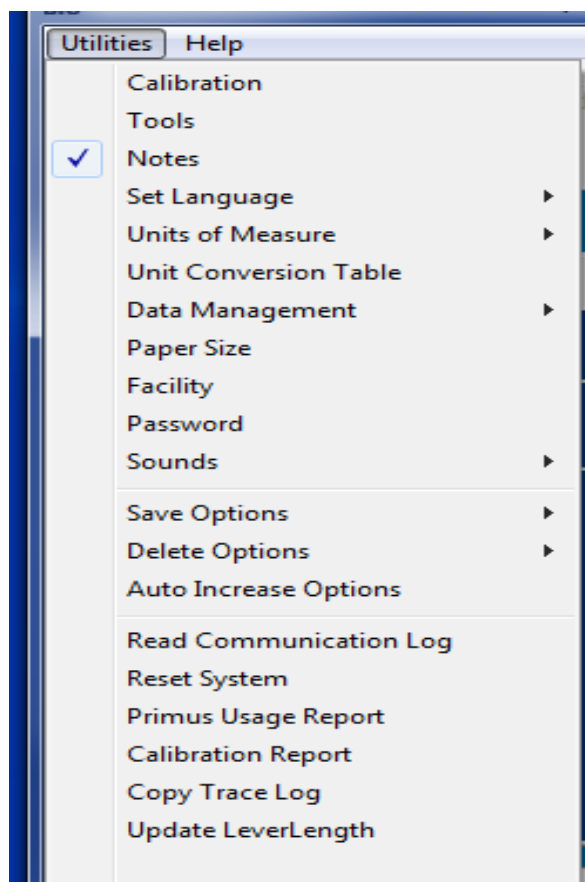
## Section 7 – Utilities, Maintenance, and Diagnostics

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## Section 7 – Utilities, Maintenance, and Diagnostics

Clicking “Utilities” at the uppermost left of the screen displays a menu containing the essential calibration function plus many useful options for adjusting software settings, maintaining your database, and managing individual patient data.



### 7.1 Calibration

Calibration ensures that the PrimusRS is measuring torque accurately. The Primus has been calibrated in the factory before it was shipped, so out-of-the-box adjustment is rarely necessary.

It is, however, important to conduct the calibration procedure once every month and document each calibration on a permanent written record. You will be prompted by the software to enter information such as the time, the date, and your signature every time you initiate the calibration process.

Calibration is based on a comparison of what the PrimusRS is measuring to a known weight. This is accomplished by attaching the Calibration Kit included with your Primus.

Recalibrate PrimusRS using this utility. Simply click and proceed to follow the on-screen instructions. Fill out each of the “Calibration Log” fields.

**If you have any difficulty or questions regarding calibration of the BTE PrimusRS, please do not hesitate to call us for assistance! Our toll-free phone number is 1-800-331-8845.**



## 7.2 Tools

PrimusRS includes a pictorial display of the tools and a list of functional descriptions for each which corresponds with that tool's most common applications. You must select a tool and one of these functional descriptions for every test and exercise. It is possible to edit and add descriptions. Choose "Utilities" and move your cursor to click on "Tools".

To edit a description, click on a tool and highlight the particular exercise you wish to edit from the list. Then, touch the "Edit" button which overlays an additional window containing the tool description and lever length. Place the cursor into the appropriate field and type in any changes you wish to make. Touch "OK" button to save and exit that window.

If you want to add a new description, simply click on the tool, then the "New Description" button. Another window will appear where you will type in the functional description you wish to add. Touch "OK" to exit that window.

## 7.3 Notes

PrimusRS includes a built-in note-taking option. Notes are activated and deactivated via the Utilities menu at the top left of the screen.

To turn on Notes, click "Utilities," and move your cursor down to click "Notes." A check mark indicates that Notes are activated.

This will bring up the "Notes" window (Figure 7b). You are now able to enter any necessary information.

There are two types of notes:

### 7.3.1 Setup Notes

Enter information such as the height of the exercise head and the patient's position. Use of this feature allows you to accurately and consistently repeat tests and exercises.

Setup Notes are not printable – they are solely for the purpose of helping you set up evaluations and treatments.

### 7.3.2 Print Notes

Enter any information you want to be able to print in this field. This may include observations of the patient's performance during an evaluation or treatment.

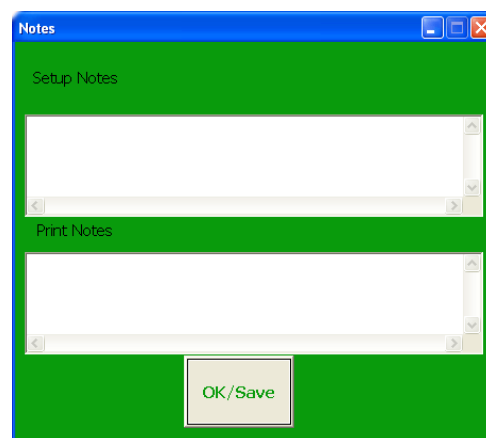


Figure 7b

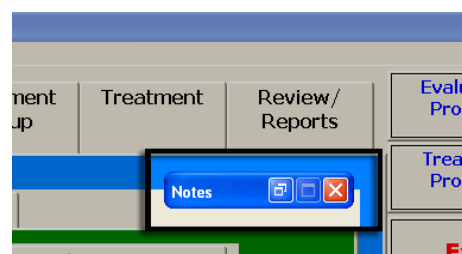


Figure 7c

Click "OK/Save" to save your notes. At this point, the "Notes" window will be "minimized" (reduced to a small rectangle). This minimized box will lodge itself at the top right of your screen (Figure 7d) by default.

You can move the minimized notes box to any area of your screen by pressing it on the monitor and dragging your finger to a new position.




Figure 7d

If you wish to enter more notes later, click the “Restore” button in the small box to restore the screen (Figure 7d)

To reduce Notes back to the minimized bar, click the minimize button at the top right of the notes screen (Figure 7e).



Figure 7e

To hide notes completely, click  or go into the “Utilities” menu and uncheck “Notes” (Figure 7a).

## 7.4 Set Language

(This feature to be added in future version.)

This option allows you to select the language of the software. English, German, French and Spanish are offered.

The default is English.

## 7.5 Units of Measure

From the “Utilities” menu, click on “Units of Measure”. Select English or Metric units for the Primus software. Changing Units from one system to another will convert all existing data values.

The default setting is English units of measure.

## 7.6 Unit Conversion Table

This feature functions as a handy calculator for converting measurements from one unit to another. Force, torque, work, distance, and weight measures may be converted to/from English and metric units. Simply delete zero from the appropriate field, type in measurement, and hit “ENTER” on keyboard. The conversion is instantaneously calculated.

## 7.7 Data Management

Various options are available for patient data management including backup, archive, and restore. This utility also provides you with the ability to format CDRW's within the software program and to select the location/media for storage if other than CDRW.

### 7.7.1 Backup

Copies ALL the information in the database to a safe location from which the data can be retrieved in the case of database corruption

**IMPORTANT:**

It is strongly recommended that a Backup to CD be performed at least once a week (at the end of every day is preferable). If you fail to make a Backup, and your computer malfunctions, you risk losing all patient data).

**7.7.2 Archive/Unarchive**

Archiving a Patient Record places **all** of his/her data on a backup drive and removes it from the main database (*Use once a patient's treatment is discharged and it becomes unnecessary to store his or her information in the main Primus Database*)

Unarchiving retrieves a Patient Record from backup media and copies the data back into the Primus software database.

**7.7.3 Format**

Formats a CDRW for use as backup media (enables PrimusRS to write data to the disc)

**7.7.4 Select Media**

Choose the destination of your backup files – you may decide to store your backup on a CD, hard drive, network, etc. Use of a CDRW is recommended.

**7.7.5 Restore - *Call BTE for advice before using this option.***

“Restore” replaces the information in the database on the hard drive with the data in a backup file. This should **only** be used if the main database becomes corrupted.

**7.8 Paper Size**

Set the paper size for data printouts. Letter size is normal, A4 is for European use.

**7.9 Facility**

This utility allows you to enter the name, address and telephone number of your facility as this information appears on the header of reports. Simply click on “Facility” and type in the information for each field. Touch “Save” to exit the screen.

**7.10 Password**

Patient Records are password-protected. You can change the password from the default (“rs”) here. Click “Password” to activate window, then complete the designated fields. “OK” will allow you to save the information and exit this utility.

**7.11 Sounds**

This option allows you to adjust of the volume of sound feedback. Choose from “Full, Semi, or Off” by clicking on the appropriate word.

## 7.12 Save Options

Switching Save Options on activates a dialog box which will appear every time you save a new test or exercise. With every save operation you will be presented with these options:

### 7.12.1 Save to General Template *only* .....

Selecting this option saves a test into the currently selected General Template (Template name is displayed in the white text field at the top of the Setup screen and in the software’s title bar.)

### 7.12.2 Save to Patient Template *only* .....

Selecting this option saves a test into the currently selected Patient Template (Template name is displayed in the white text field at the top of the Setup screen and in the software’s title bar.)

### 7.12.3 Save to *both* Patient and General Templates .....

Selecting this option saves a test into *both* the currently selected Patient’s Template and to a General Template with the same name (Template name is displayed in the white text field at the top of the Setup screen and in the software’s title bar.)

If Save Options are turned off, when you click “Save,” the current test or exercise will automatically go into the currently selected template (General or Patient).

## 7.13 Delete Options

Turning on Delete Options enables a dialog box which appears at every “Delete” operation in the *Evaluation* and *Treatment Setup* screens. This gives you the option to either delete tests and exercises one at a time or to delete the entire Template.

## 7.14 Auto Increase Options

Over the course of treatment, a patient’s strength should increase. Instead of manually increasing goals for each individual Isotonic exercise in a patient’s template, you may use the Auto Increase option to increase all goals by a certain percentage.

First, you must set each Isotonic exercise to use this feature in *Treatment Setup*:

1. Enter a goal of Time, Work, or Distance.
2. Tick the “Auto Increase” checkbox at the bottom right of the screen. The goal in this exercise is now updateable via the “Auto Increase” feature.
3. Tick “Auto Increase” on any other Isotonic exercises you wish to be able to update automatically.

Now you may update all goals at once whenever you feel it is appropriate.

Clicking “Auto Increase” calls up a window allowing you to specify a percentage of increase in Time, Distance, and/or Work for each of the exercises in the entire patient template.

For example, entering a Time increase of 15%, a Distance increase of 50% and a Work increase of 0% will apply an increase of 15% to every exercise with a Time goal, 50% to every exercise with a Distance goal, and leave exercises with Work goals unchanged.

To help keep track of goal changes, this window will display the last time a patient’s goal was increased.

You do not have to be in *Treatment Setup* to use this feature. Auto Increase can be applied any time the patient’s name is displayed in the title bar at the top of the screen.

## **7.15 Read Communication Log**

Choosing this option translates the Comm.log from codes to understandable actions. It gives an example of the log file before and after the function is run.

## **7.16 Reset System**

If it becomes necessary to abort a test or exercise using the Slap Switch, the system must be reset. First you must press the flashing “Reset” button located on the right side tool panel of the PrimusRS body. Then, click this “Reset System” function. The system should now function.

The reset option is also helpful if some sort of electrical interference in the clinic causes loss of communication between the PrimusRS computer and the Primus electronics. Clicking “Reset” can eliminate the need to shutdown the Primus and start over.

## **7.17 Primus Usage Report**

This feature prints a report containing statistics on a particular patient’s usage of Primus. Included in the report are the dates and times of every test and exercise conducted.

To access this report, select “Primus Usage Report” from the “Utilities” menu. The “Select Patient” screen will appear where you can retrieve the patient’s file by typing in his/her ID number or by selecting from the list of all patients (“Show Patient List”). The default date range is first to last dates of PrimusRS use; although a specific date range can be designated.

## **7.18 Calibration Report**

Choosing this option prints out all calibration data for the machine.

## **7.19 Copy Trace Log**

This option provides an error log which automatically downloads on to a disk. The purpose of this utility is diagnostic; should certain problems occur, BTE engineers can read the data from your disk.

## **7.20 Update Lever Length**

This option when chosen will automatically populate the protocols where lever length is specified in the evaluation and treatment tabs.



# PRIMUSRS

## Section 8 –Tool Attachments and Patient Positioning

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## Section 8 –Tool Attachments and Patient Positioning

### 8.1 Exercise Head

The exercise head is the mechanism that creates the resistance in the PrimusRS. It has two adjustments to put the shaft in the desired position for an exercise – up/down and tilt.

The entire head may be raised or lowered by pushing the up-down switch, which is attached to the unit with a long black cable.

On the right side of the exercise head you will find a large lever. Pulling this lever out will release a locking clamp. The head can now be swiveled to any one of several positions from straight up, to straight down. Push the lever back down to lock the exercise head into the best position for a given exercise.

#### **IMPORTANT:**

Ensure that the Exercise Head locking lever is locked into one of the preset positions before proceeding with an exercise.

#### 8.1.1 Inserting Attachments

The shaft in the exercise head has a large locking knob with a center hole for inserting the PrimusRS attachments. Inside is a square hole which matches the square end found on all attachments. When an attachment is inserted, the squares **must** be aligned before the attachment can be completely seated. The hole is designed to fit very tightly around the square end of each attachment, so they must be inserted at a precise 90 degree angle to the face of the shaft.

Once an attachment is seated, hold it in place, pull out the large knob on the exercise head, turn it clockwise until it stops (it will only turn about 1/8 of a turn), and then release. If properly inserted, the attachment will be locked into the shaft. To make sure it is locked in securely, try to pull it out. When the attachment is properly installed, it will not be possible to pull it out without first turning the locking knob back 1/8 turn in the counterclockwise direction.

When removing an attachment, hold the attachment with one hand while pulling on the locking knob. Once pulled out, the knob should rotate about 1/8 turn in the counterclockwise direction. Release the knob at that point and the attachment should be free to pull out.

#### 8.1.2 Exercise Head Temperatures

It is a normal mechanical process for heat to build up whenever the exercise head is in heavy use or is left turned on for an extended period. This heat will **not** harm your PrimusRS. The heat of the exercise head is internal (it is not actually a very high temperature) and you may occasionally sense external temperature change on the surface of the exercise head.

#### **Note:**

Whenever the PrimusRS is not in use, it is recommended that you reset the program back to the *Home* screen (See Section 2). This will turn the exercise head off, so that it is not on needlessly when not in use. Turning the exercise head off will reduce your electrical power usage and reduce wear.

## 8.2 Tool (Attachment) Description and Uses

The unique attachments designed for the PrimusRS are interchangeably referred to by practitioners as “tools” or “attachments.” Evaluation and Treatment screens in the PrimusRS software feature a button marked “Select Tool”. Click or touch this button to choose the appropriate attachment for any specific test or exercise.

Clicking this button will initiate the “Tool Selection” screen seen below.



You will notice that each attachment is identified by a three digit number. This standard numbering is a handy reference when discussing the various uses for each attachment. It is also useful in recording and documenting patient exercises and evaluations.

A sample of uses for each attachment is given in this section. Keep in mind that the examples stated are but a few applications for each attachment. *The actual total number of applications is limited only by your creativity.* We suggest that you experiment on your own, with each attachment used in as many different positions as you can come up with (i.e., tilt the exercise head through all positions and raise and lower the telescope for an assortment of heights - also try sitting in a chair).

## 102 One Inch Diameter Knurled Knob

*Fine finger manipulation (rotational)*

**To simulate:**

twist top bottles  
machine adjustments

**Uses:**

fingertip desensitization  
pinch strengthening



## 103 Bolt Head

*3/4" bolt head with screwdriver slot*

**To simulate:**

turning bolts

**Uses:**

with 3/4" wrench  
with 3/4" socket wrench  
with straight blade screwdriver



## 202 Key Shape

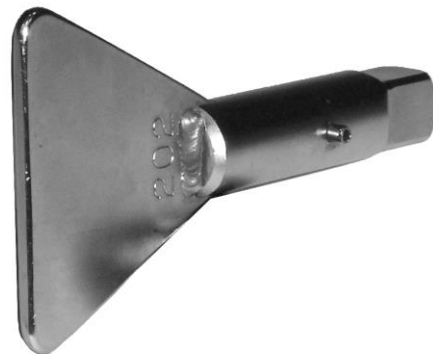
*Finger pinch (rotational)*

**To simulate:**

keys of all types

**Uses:**

fingertip desensitization  
lateral pinch strengthening  
pulp to pulp pinch strengthening  
supination/pronation (with finger pinch)



## 302 Three Inch Diameter Knurled Knob

### *Flat knob grasp*

#### To simulate:

jar lids  
machine adjustments  
small valves

#### Uses:

rotational grip strengthening (static grip while turning)  
fingertip and palmar desensitization  
radial/ulnar wrist deviation



## 303 Round Knob

### *Spherical grasp (rotational) knob*

#### To simulate:

door knobs

#### Uses:

spherical grasp strengthening  
palmar desensitization  
supination/pronation



## 502/504 – 502 Medium Screwdriver Handle

### 504 Large Screwdriver Handle

#### *Cylindrical Hand Grasp (Rotational)*

#### To simulate:

screwdrivers of various sizes  
pipes

#### Uses:

wrist curls  
supination/pronation  
(with ulnar wrist deviation)  
wrist flexion/extension  
palmar desensitization  
grip strengthening  
increase of finger flexion



## 601 D- Handle

*Hand grasp for supination/pronation*

**Uses:**

supination/pronation  
radial and ulnar deviation



## 701 Small Lever (variable length handle)

**To simulate:**

machine control  
car window crank  
lever bar

**Uses:**

wrist flexion/extension  
(with arm support)  
pushing/pulling  
total upper extremity ROM  
intern/extern shoulder rotation  
elbow flexion/extension  
knee flexion/extension  
hip flexion/extension  
ankle exercises



## 802 Large Lever (variable lever length handle)

**To simulate:**

lifting (from various positions)  
crowbar  
drill press  
wrenches, etc.

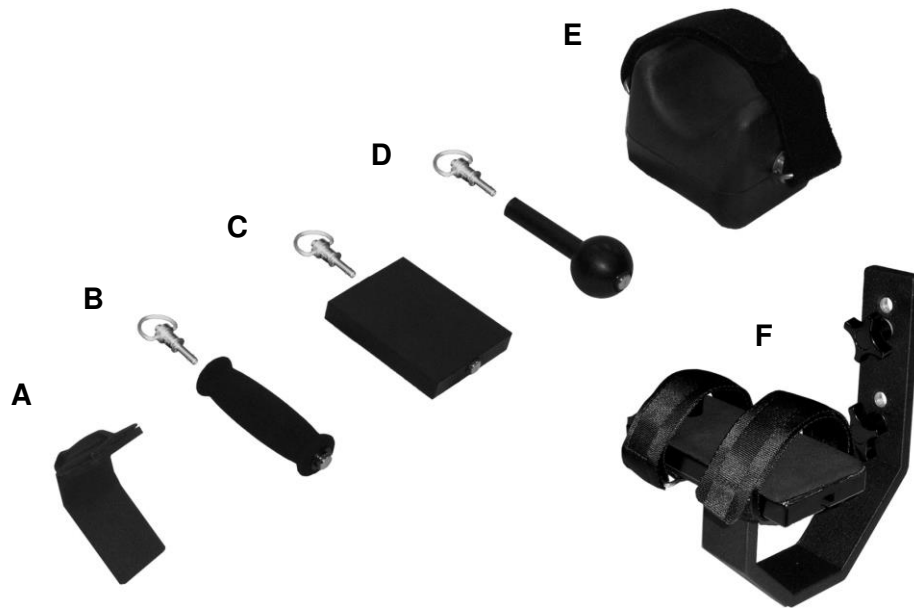
**Uses:**

shoulder abduction/adduction  
shoulder flexion/extension  
pushing/pulling (overhead or horizontal)  
hip exercises



## Changeable Handles and Accessories for 701 and 802

- A. V-Arm rest
- B. Standard Handle
- C. Pedal
- D. Ball Handle
- E. Arm/Leg pad
- F. Arm Support for Wrist Flexion/Extension



### 901 End/Side Handle with Articulating Joint (18.0 in. / 45.8 cm. lever length)

*One or two handed grasp (linear motion)*

**To simulate:**

saw  
shovel  
broom  
hammer

**Uses:**

pushing/pulling  
bilateral upper torso motion  
linear motion



### 136 Steering Wheel (18" Diameter) (9.0 in. / 22.9 cm. lever length)

**To simulate:**

driving  
valve wheels  
machine controls

**Uses:**

bilateral ROM  
driver training  
stroke and paraplegic rehabilitation  
prosthetic and amputee training  
trunk lateral bending  
trunk rotation



### 151 Pinch Tool (6.8 in. / 17.2 cm. lever length)

**To simulate:**

pinching small parts

**Uses:**

three point pinch  
lateral pinch  
tip to tip pinch  
fingertip desensitization



### 162 Grip Tool (4.2 in. / 17.2 cm. lever length)

**To simulate:**

pliers, grip tools  
scissors/shears  
pistol grip with trigger  
stapler  
car door handle, etc  
pistol grip with trigger

**Uses:**

grip strengthening



## 181 Multiple Handle Crossbar (16.0 in. / 40.6 cm. lever length)

*Thirty-two inch diameter crossbar with four handles and ropes*

**To simulate:**

climbing ladders  
pulling ropes

**Uses:**

total upper body conditioning  
cardiac and pulmonary stress testing  
elbow and shoulder ROM  
pushing/pulling overhead  
grip strengthening by pulling ropes  
palmar and fingertip desensitization



## 191 Three Dimensional Motion Attachment (9.0 in. / 22.9 cm. lever length)

*Cable and pulley with interchangeable handles*

**To simulate:**

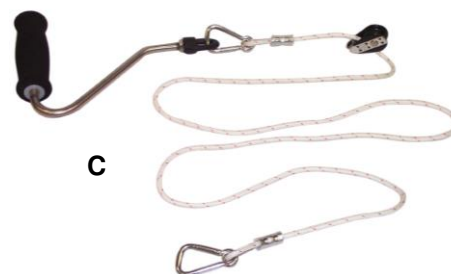
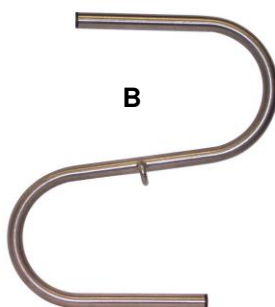
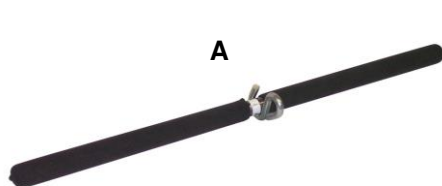
lifting  
rowing  
bowling  
baseball bat  
tennis racket, etc.

**Uses:**

unlimited uses and positioning  
total body exercising  
lift, push, pull in any direction  
PNF patterns  
use as a wall pulley system



### Changeable Handles and Accessories for 191



- A. Bar
- B. S-Handle
- C. Cable with L-handle



## 122 Upper Extremity Ergometer (6.25 in. / 15.88 cm. lever length)

*Two handled crank*

To simulate:

brace hand drill

Uses:

cardiopulmonary conditioning  
cardiovascular conditioning  
upper body strengthening



## 001 Range-Of-Motion Limiters (2)

*Firm rubber posts which screw into threaded holes in the mounting ring on the face of the exercise head*

For use with attachments 601, 701, 802, 901 and during the calibration procedure

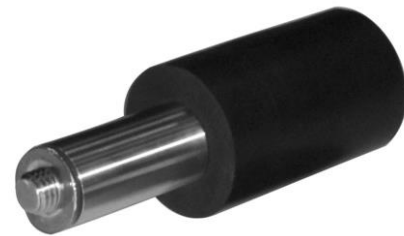


Figure 0a

Range of Motion Limiters in use with the 601 D-Handle attachment (Figure 0a).

## 002 Arm Rest /Stabilizer

*For use with 701 and 802*

### Arm Rest Mounting:

For left hand - screw the mounting bolts into threaded holes 17 and 20 (Figure 0c).

For right hand - screw the mounting bolts into threaded holes 5 and 8 (Figure 0b).



Figure 0c

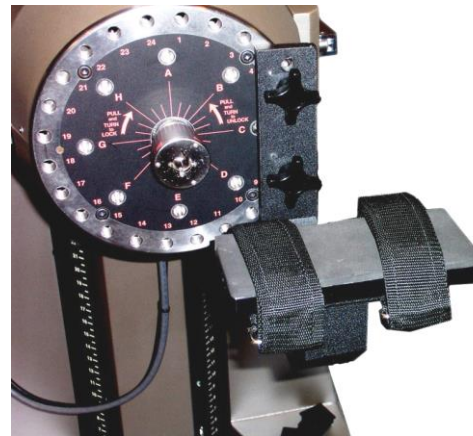


Figure 0b

## Chair Connection Bar

*For use with Patient Positioning Chair*

This tool connects the Patient Positioning Chair to the Exercise Head. This prevents the chair from drifting when a large amount of force is applied on an attachment (usually in a lower extremity exercise).



## 8.3 Attachment 191 Instructions

Attachment 191 is the most versatile attachment for the PrimusRS. It has some very unique applications and learning how to use it properly will greatly enhance your clinic.

This tool must be used in Concentric/Eccentric (CON/ECC) operating mode.

### 8.3.1 Attaching the 191 to Exercise Head

Step 1. Adjust the height so that the base of the yoke is at approximately 41".

Step 2. It is easiest to attach the 191 tool when there is no resistance set, so first ensure that the shaft is unlocked in the software.

When the shaft is unlocked, the button in the Control Panel (Section 2.4) to the right of the screen will read "Lock" (Figure 0d).

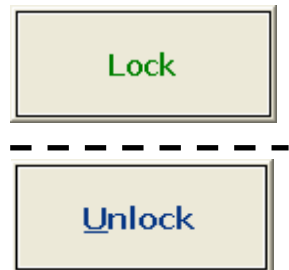


Figure 0d

Step 3. Pull the locking lever on the right of the exercise head and rotate the head to point straight up. Re-lock the lever.

**Note:**

*Unlike other PrimusRS attachments, it is not necessary to lock the 191's central shaft into the exercise head by turning the locking nut.*

Step 4. Align the central attachment shaft with the opening in the locking knob, the same way all other attachments are inserted.

Holding the 191 disc level, align the black stabilizer shaft over the range of motion hole that suits the test or exercise you are planning to conduct (Figure 0e).

Step 5. Align the threaded shaft with the corresponding threaded faceplate hole.

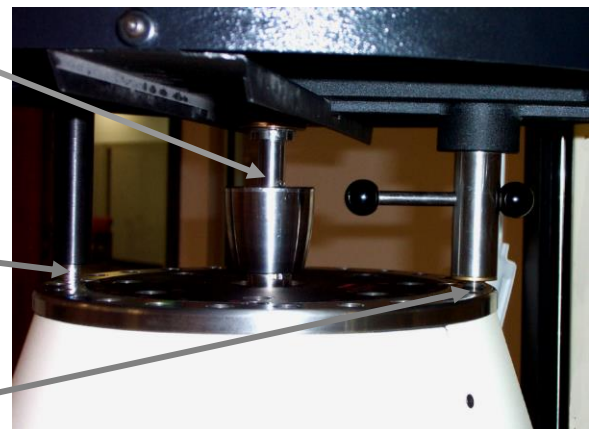


Figure 0e

Taking care to keep all three attachment shafts aligned; rotate the locking knob until the central attachment square shaft extension pops into the square hole in the exercise head locking knob (Figure 0f).

**Figure 0f****Figure 0g**

Step 6. Once the squared center shaft drops into place, turn the threaded shaft clockwise, tightening it into the range of motion hole (Figure 0g).

### 8.3.2 Using Attachment 191 Properly

Always select the range of motion hole that gives you the best position for the movement you are going to do, making sure that the cable is in minimum contact with the black rollers (see Figure 0h – Overhead view of cord feed roller guides).

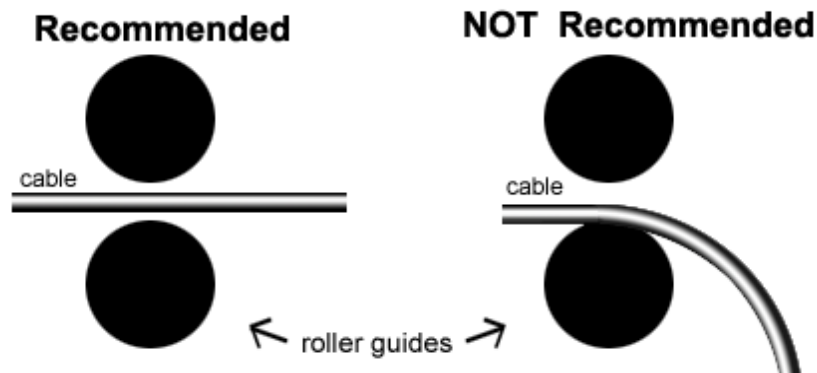


Figure 0h – Overhead view of cord feed roller guides

Some contact between the cable and the rollers is acceptable, but bear in mind that the added drag can add up to 4 pounds to the set force level. For this reason, avoid pulling at an angle greater than 45 degrees. Furthermore, the friction created by pulling the cord at sharp angles will needlessly wear it down and shorten its life.

If you need to retract the 8 foot cord at any time, press the “Unlock” button on the computer screen (Figure 0d), then manually turn the large black knob on top of the disc.

When you are finished using attachment 191, set the exercise head to position 5 for easy removal. The attachment is easier to remove when it is perpendicular to the floor (Figure 0i).

The 191 is easiest to remove if you first touch the “Unlock” button (Figure 0d) in the Control Panel (Section 2.4) of the PrimusRS computer screen.

Simply unscrew the threaded stabilizing shaft to release the attachment from the workhead.

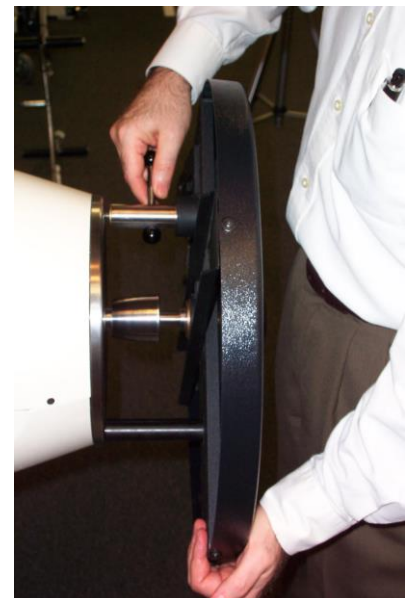


Figure 0i

### 8.3.3 Using the 191 Floor Pulley Adapter

This 191 adapter allows lifting with a starting handle height of approximately 8 inches off the floor.

#### A. Installing the 191 Pulley Bracket

1. Insert the black “U” bracket into the front left leg of the PrimusRS base. Make sure the short side of the bracket goes on the inside of the base and the longer side is on the outside of the base (Figure 0j).
2. Insert the bolt through the bracket and PrimusRS base. Tighten securely.

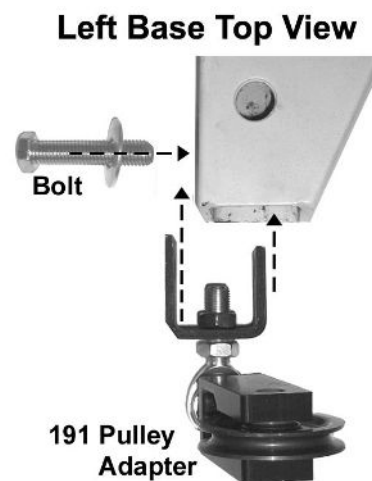


Figure 0j

#### B. Feeding the 191 Cable through Pulley

1. Attach the 191 tool to as described above in Section 8.3.1. Position it so that the black stabilizing shaft is over hole 2 on the outer ring of the faceplate.
2. Rotate the exercise head to the number 9 position (pointing straight down). Lower the head all the way down to the lowest position on the vertical column.
3. Feed the end of the 191 cable through the gap in the pulley bracket (circled in Figure 0k).
4. When set up correctly the cable and pulley should appear as below (Figure 0l).
5. Manually rotate the 191 disk to take up the slack in the cable. Attach the handle of your choice to the clip on the end of the 191 cable. Select a test or exercise and continue with the on-screen instructions.



Figure 0k

#### Cleaning the Attachments

Should it become necessary to clean or disinfect the attachments, use an alcohol based solution. Dampen a cloth with the solution and wipe down the attachments. The metal is stainless steel and should be unaffected by cleaning solution. The plastic and padded handles will also be unharmed.



Figure 0l

## 8.4 Standard Lever Lengths/Radii of PrimusRS Attachments

Tool #	Attachment Name	Inches	Centimeters
122	Upper Extremity Ergometer	6.3	16
136	Steering Wheel	9.0	22.9
151	Pinch Tool	6.8	17.2
162	Grip Tool	4.2	10.7
181	Multi-Handle Crossbar	16.0	40.6
191	3D Motion Attachment	9.0	22.9
701	Small Adjustable Lever	Refer to the scale on the tool, or use a tape measure for actual values.	
802	Large Adjustable Lever		
901	Handle with Articulating Joint	18.0	45.8
103	Bolt Head	Measure the lever length of the tool you are using with this attachment.	

The following attachments provide rotational movement; no conversion is needed for most tests and exercises.

Tool #	Attachment Name	Inches	Centimeters
102	Small Knurled Knob	0.6 (0.7 with cover)	1.6 (1.8 with cover)
302	Large Knurled Knob	1.5 (1.6 with cover)	3.8 (4.0 with cover)
202	Key Shape	0.7	1.8
303	Round Knob	0.9	2.2
502	Medium Screwdriver	0.6	1.6
504	Large Screwdriver	0.7	1.8
601	Cylindrical Handle	Measure from center of attachment to edge of hand.	

## 8.5 PRO Package Tool Descriptions and Uses

The PRO Package allows you to expand your evaluation, treatment, and performance enhancement options. This is achieved through greater specificity of testing and training, resulting in optimal outcomes. The package includes five balls that connect to several different attachments, four different sport assemblies, two ankle attachments, a chop lift bar, balance pad, chest harness, and five different straps. Many of these tools are used in conjunction with the 191 – three dimensional motion attachment.

### Baseball (or Cricket Ball) and Softball with Short Cord Assembly

Used in conjunction with 191 – three dimensional attachment

**To simulate:**

Baseball, softball, (cricket ball) throw/pitch

**Uses include:**

Upper extremity PNF patterns  
Triceps extension  
Scapular retraction/adduction  
Functional grip strength



### Baseballs (or Cricket Balls) with Handles

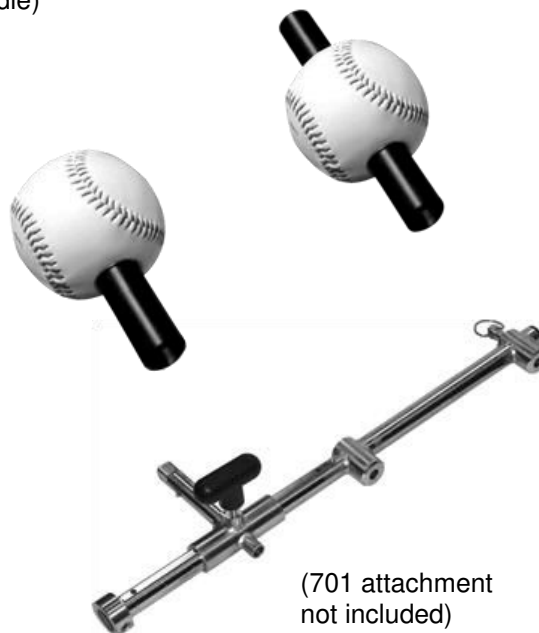
Used in conjunction with 701 – Small Lever (variable length handle)

**To simulate:**

Baseball (cricket ball) grasp  
Stick shift of vehicle

**Uses include:**

Shoulder internal/external rotation  
Elbow flexion/extension  
Wrist flexion/extension  
Functional grip strength  
Closed chain upper extremity activities



(701 attachment  
not included)



## Baseball (or cricket ball) Attachment

**To simulate:**

Baseball (cricket ball) grasp

**Uses include:**

Forearm supination/pronation  
Wrist radial/ulnar deviation  
Wrist flexion/extension  
Functional grip strength



## Baseball (or Cricket Ball) with Cable

Used in conjunction with 191 – three dimensional attachment

**Uses include:**

Shoulder internal/external rotation  
Scapular adduction  
Upper extremity PNF patterns  
90/90 rhythmic stabilization  
Serratus anterior press  
Diagonal lifts



## Swing Tools

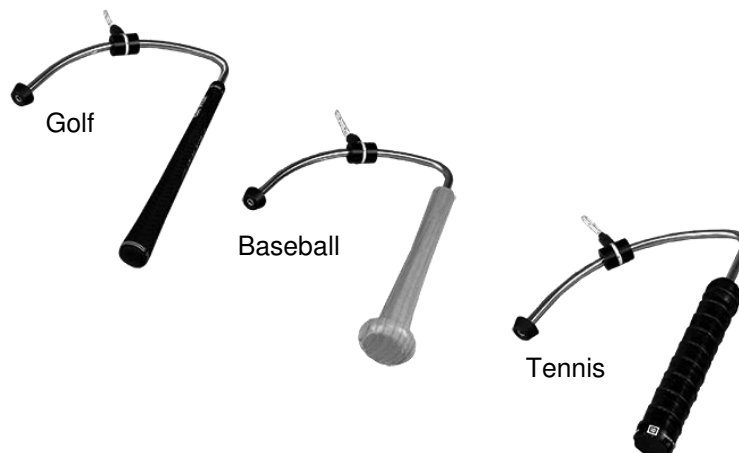
Used in conjunction with 191 – three dimensional attachment

**To simulate:**

Golf swing  
Baseball bat swing  
Tennis racket swings

**Uses include:**

Trunk rotation  
Lumbar stabilization  
Integrated upper extremity motions



## Chop / Lift Bar

Used in conjunction with 191 – three dimensional attachment

**To simulate:**

Chop and lift motions  
Pushing and pulling tasks

**Uses include:**

improving muscle balance  
dynamic trunk stability/control



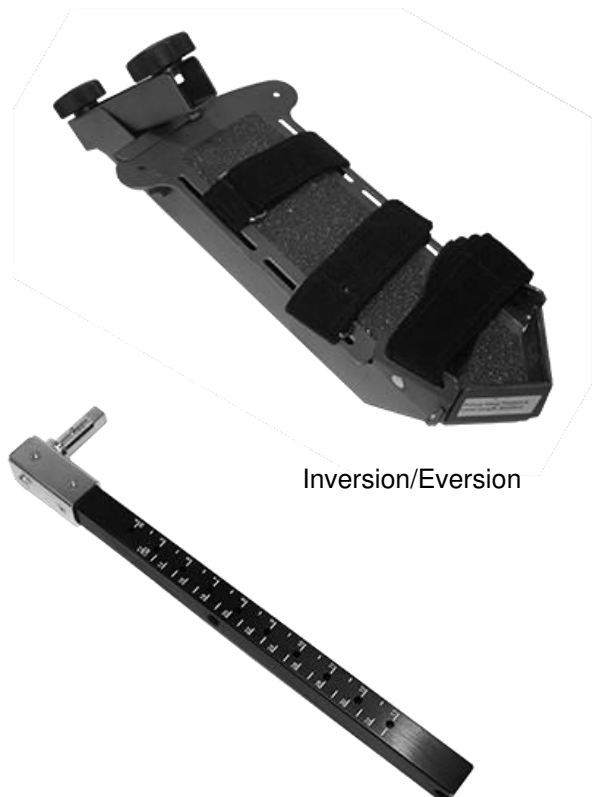
## Ankle Attachments with Universal Tool

**Uses include:**

Isolated Range of motion  
Strengthening  
Endurance  
Stability



Plantarflexion/Dorsiflexion



Inversion/Eversion

## Padded Straps and Harness

Used in conjunction with 191 – three dimensional attachment

### Ankle Cinch Strap



**To simulate:**

- Open chain activities
- Kicking motions

**Uses include:**

- Hip abductor / adductor work
- Knee flexion / extension
- Long lever hip strengthening
- Lower extremity PNF patterns
- Lower abdominal stability
- Balance and gait training

### Thigh Cinch Strap



**To simulate:**

- Climbing stairs

**Uses include:**

- Hip flexor strengthening
- Hamstring and quadriceps strengthening
- Resisted terminal knee extension
- Gluteal strengthening
- Resisted gait training

### Wrist Cinch Straps (Medium and Large)



**To simulate:**

- Throwing motions
- Swimming motions
- Football toss with release

**Uses include:**

- Shoulder stability
- Scapular stabilization
- Upper extremity PNF patterns
- Integrated upper extremity strengthening

## Waist Belt Cinch Strap



### Uses include:

- Assisted sit to stand training
- Resisted gait training
- Resisted side stepping
- Hip turn
- Resisted lunges

## Chest Harness



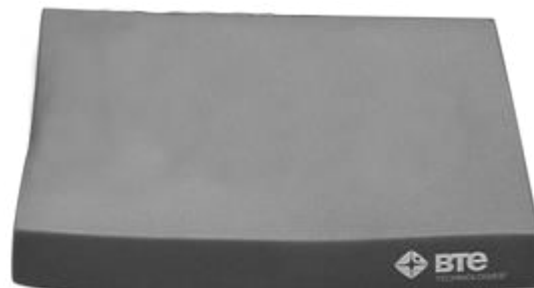
### Uses include:

- Resisted squat to stand
- Single leg dead lift
- Front and side lunges
- Resisted trunk extension / flexion
- Resisted trunk rotation
- Core stability

## Balance Pad

### Uses include:

- Proprioceptive and balance training
- Core strengthening
- Stability
- Gait training



## 8.6 Adjustable Positioning Chair

Determine which positioning chair is in use. Chair versions can be distinguished by the chair's base, see images below. This section documents the version with pneumatic chair base, if chair with mechanical chair base is in use, see appendix for further instructions.



**Mechanical Chair Base**



**Pneumatic Chair Base**

BTE offers an Adjustable Positioning Chair as an option to PrimusRS users. Especially helpful for assessment and treatment of the lower extremities, the chair is designed for multiple positions. This versatility allows its use for children patients up to adults 6'5" weighing 385 pounds.

From a seated position the chair opens 180° to form a horizontal surface. This can be used for treating a patient in the prone position or as an actual treatment table itself.

**WARNING:** Sitting on the end of the chair back cushion when the chair is in the horizontal position is prohibited. Doing so could result in injury.



**Figure 8m**

### 8.6.1 Chair Adjustments

The Adjustable Positioning Chair features several devices for adjusting the seat and the back to accommodate any patient. Adjusting the angle of the chair helps isolate the muscle group to be tested by reducing a patient's ability for substitution.

- The seat angle adjustment lever is located on both sides of the seat bottom (Figure 8m).
- The large black knobs on either side (Figure 8n) allow you to change the depth of the chair.
- Figure 8o shows the pinch adjustment on the back of the chair. This is used to adjust the angle of the chair back.



**Figure 8n**



Figure 8o

### 8.6.2 Chair Positioning

The larger pedal on either side of the chair (figure 8p) are for transport. Actuate the pedal 3-10 times in order to lift the chair onto the casters and allow transport.

Once you have positioned the chair to fit your patient for his or her treatment, actuate the brake pedal to lower the chair and lock it in place (Figure 8z).



Figure 8p



Figure 8z

**WARNING:** Do not perform the chair exercises while chair is in transport mode, must be lowered prior to exercises.

*For lower extremity exercises conducted at high forces, do not lock the chair until you have set up the Chair Connection Bar (Section 8.3.2).*



### 8.6.3 Chair Connection Bar

A special connection bar secures the chair to the exercise head. This should be used to prevent chair movement and exercise head vibration, in order to increase stability of the system (Figure 8q).

Insert the round arm of the connection bar into the tube beneath the seat of the chair (Figure 8r) and push it in as far as it will go (Figure 8s).

With the chair raised, move the chair to a position within 90 degrees of the exercise head.



Figure 8q



Figure 8s



Figure 8r

Grasp the large black knob on the connection bar, and raise it so that the threaded bolt aligns with one of the lower holes on the mounting ring of the exercise head (Figure 8t). Turn the black knob until the connection bar is attached firmly to the exercise head. If necessary, lower or raise the exercise head to meet the threaded bar bolt.

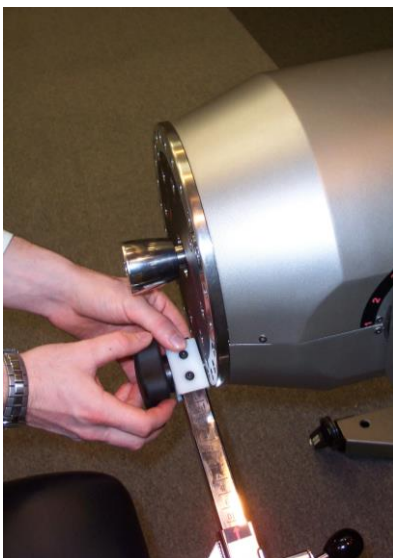


Figure 8t

If the bar does not reach, adjust its length with the spring-loaded pin (Figure 8u).

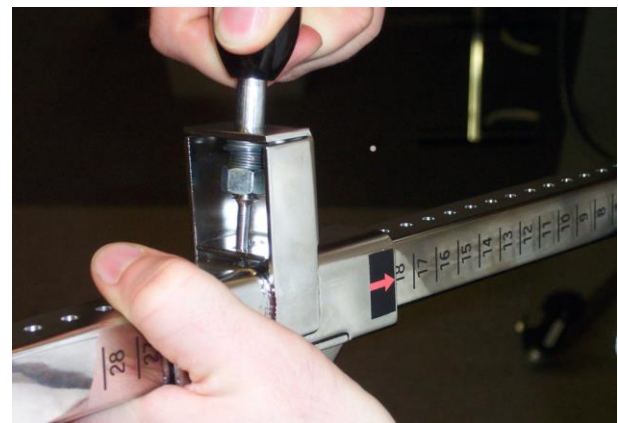


Figure 8u

Pull the pin and tilt it to the left (Figure 8w). Push or pull the chair to the appropriate position, and tilt the pin back (Figure 8v). It will snap into the closest hole and lock the bar to that length.

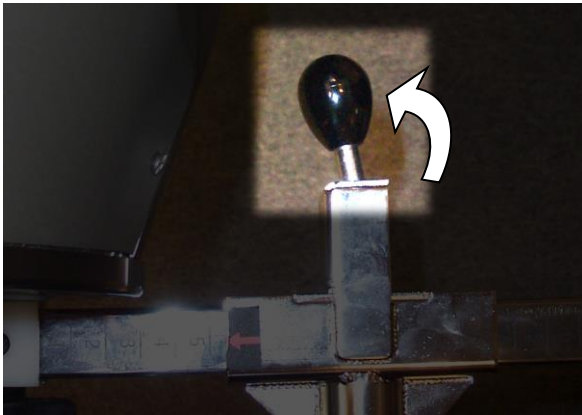


Figure 8w

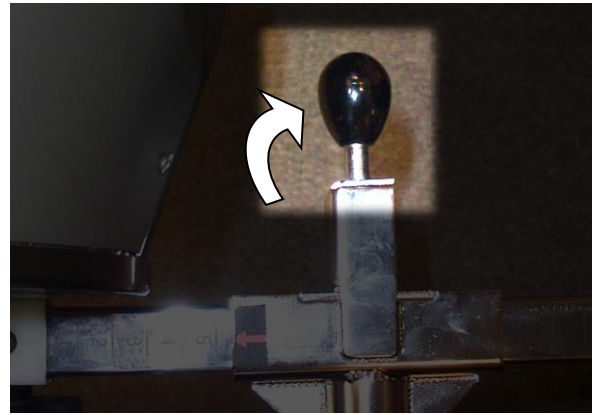


Figure 8v

Finally, lock the chair by stepping on the brake pedal (Figure 8z).

Once fully adjusted and attached, the chair will appear as shown in Figure 8x.



Figure 8x

**NOTE:** For safety purposes, always check that the locking mechanism is engaged prior to patient sitting on the chair and prior to starting a test or exercise.



## 8.6.4 Patient Positioning Guidelines

Following are examples and suggestions for positioning a patient for performing isolated joint test and exercises. These are suggestions only and do not limit you from experimenting with and using your own configurations.

For all isolated setups, please keep in mind the following points and suggestions:

- Position patients so they are comfortable.
- Make sure the axis of rotation of the joint is aligned with the axis of rotation off the PrimusRS exercise head shaft.
- When using the Patient Positioning Chair, lock the casters before beginning the test or exercise.
- To ensure consistent patient positioning in subsequent treatment sessions, many therapists utilize tape on the floor for positioning reference (as shown in Figure 0m). This is a good practice to assure repeatability.
- As Velcro becomes worn, it loses its holding strength. If Arm/Leg Pad or Arm Rest Velcro straps become worn, call BTE to purchase replacements.
- In CON/ECC mode, it is usually not necessary to use straps.
- Observe all patient limitations and contraindications.

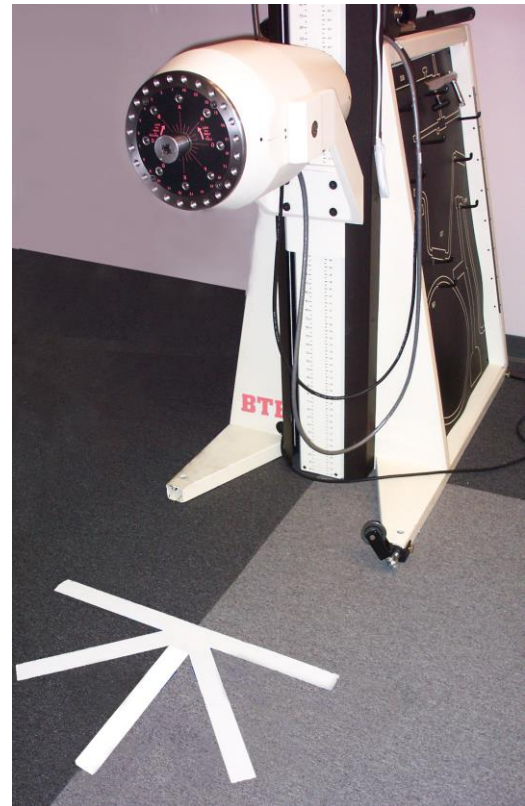
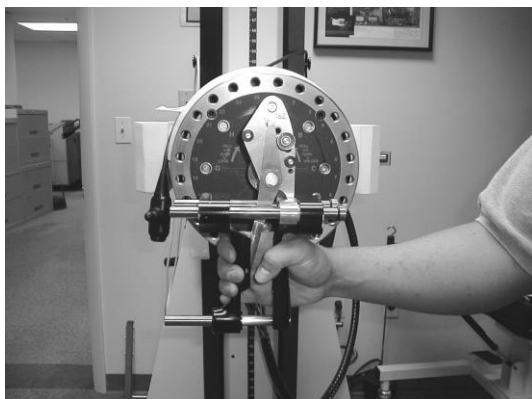


Figure 0m

## 8.7 Upper Extremity Positioning

### 8.7.1 Grip



**Exercise Head:** Number five position

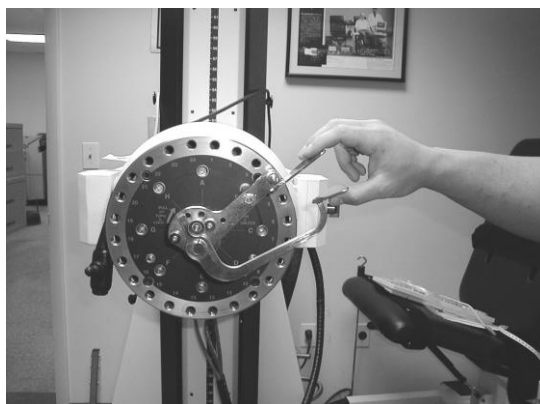
**Attachment:** 162

**Tool Setup:** Place stabilization pin in hole A. Adjust grip opening to appropriate size. Position 2 is the most common for Isometric tests. Position 4 is most common for dynamic use.

**Patient Positioning Chair setup:** Not needed.

**Patient:** Place patient on right side of the PrimusRS with patient's right side facing the Primus. Test right and left from the same side.

### 8.7.2 Pinch - Three Jaw Chuck



**Exercise Head:** Number five position

**Attachment:** 151

**Tool Setup:** Place stabilization pin in hole B. Adjust pinch opening to appropriate size.

**Patient Positioning Chair Setup:** Not needed.

**Patient:** Place patient on right side of the PrimusRS with patient's right side facing the Primus. Test right and left from the same side.

### 8.7.3 Pinch - Lateral



**Exercise Head:** Number five position

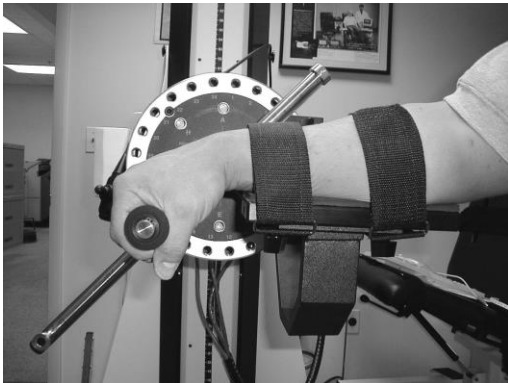
**Attachment:** 151

**Tool Setup:** Place stabilization pin in hole C. Adjust pinch opening to appropriate size.

**Patient Positioning Chair Setup:** Not needed.

**Patient:** Place patient on right side of the PrimusRS with patient's right side facing the Primus. Test right and left from the same side.

### 8.7.4 Wrist Flexion/Extension



**Exercise Head:** Number five position

**Attachment:** 701, and 002 (Arm Rest)

**Tool Setup:**

701 - Use foam or plastic cylinder. Place handle in the A position. Adjust tool length to accommodate patient hand length (normally 3 inches).

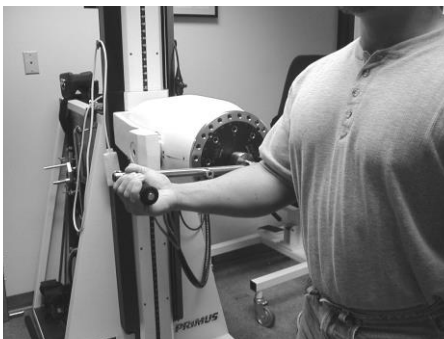
002 - Attach to exercise head using the outer ring holes 5 and 8 on the right, or 17 and 20 on the left.

**Patient Positioning Chair Setup:** Not needed.

**Patient:** Place patients forearm on the platform and use the Velcro straps to secure in place.

Right and left can be tested from the same side.

### 8.7.5 Elbow Flexion/Extension



**Exercise Head:** Number five position

**Attachment:** 701

**Tool Setup:** 701 - Use foam or plastic cylinder. Place handle in the B position. Adjust tool length to accommodate patient forearm length. (Alternate: use padded block)

**Patient Positioning Chair Setup:** Not needed.

**Patient:** Place patient in front of the PrimusRS, aligned with the center shaft.

### 8.7.6 Shoulder Internal/External Rotation



**Exercise Head:** Number three position

**Attachment:** 701

**Tool Setup:** 701 - Use foam or plastic cylinder. Place handle in the B position. Adjust tool length to accommodate patient forearm length. (Alternate: use padded block) Place V-block in hole on the 701 tool over point of rotation.



**Patient Positioning Chair Setup:** Not needed.

**Patient:** Place patient in front of the PrimusRS facing the side. Make sure the humerus is aligned with the axis of rotation of the exercise head shaft.

### 8.7.7 Shoulder Flexion/Extension

The following pictures show shoulder flexion. For shoulder extension, place the pad behind the arm.



**Exercise Head:** Number five position

**Attachment:** 701

**Tool Setup:** Use padded block. Place block in the B position. Adjust tool length to place pressure point above or below the elbow

**Patient Positioning Chair Setup:** Not needed.

**Patient:** Place patient in front of the PrimusRS facing the side.

### 8.7.8 Shoulder Abduction/Adduction

The following pictures show shoulder abduction. For shoulder adduction, place the pad beneath the arm.



**Exercise Head:** Number five position

**Attachment:** 701

**Tool Setup:** Use padded block. Place block in the B position. Adjust tool length to place pressure point above or below the elbow.

**Patient Positioning Chair Setup:** Not needed.

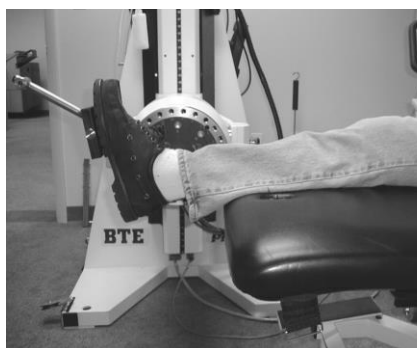
**Patient:** Place patient in front of the PrimusRS facing away from the machine.



## 8.8 Lower Extremity Positioning

### 8.8.1 Ankle Dorsi/Plantar Flexion

The following pictures show plantar flexion. For dorsi flexion, place the block against the top of the foot.



**Exercise Head:** Number five position

**Attachment:** 701

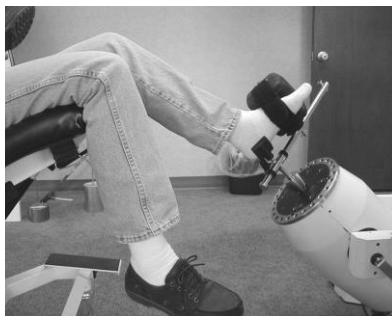
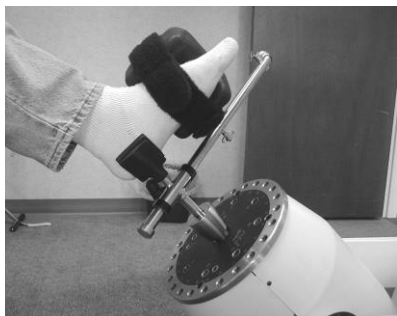
**Tool Setup:** Use the flat block in A position

**Patient Positioning Chair Setup:** Position as a bench

**Patient:** Place patient on bench so only the ankle and foot are extended over the edge of the bench.

### 8.8.2 Inversion/Eversion

The following pictures show ankle eversion. For inversion, place the block on the inside of the foot.



**Exercise Head:** Number three position.

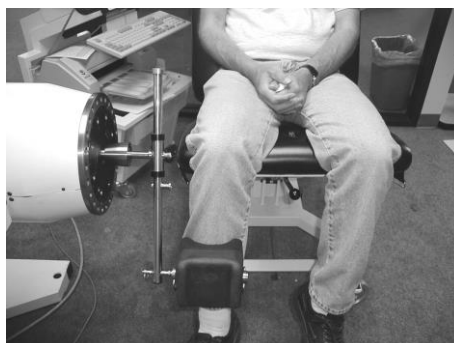
**Attachment:** 701

**Tool Setup:** Use padded block in the A position. Use V-block at rotation axis point.

**Patient Positioning Chair setup:** Position as a chair. Tilt back to align leg with shaft rotation.

**Patient:** Place patient on chair so the heel is positioned in the V-block. This exercise will work best if the patient removes his or her shoe.

### 8.8.3 Knee Extension



**Exercise Head:** Number five position.

**Attachment:** 701

**Tool Setup:** Use padded block in the B position

**Patient Positioning Chair Setup:** Position as a chair. Tilt seat back at least 30°.

**Patient:** Place patient on chair so the axis of the knee aligns with the center shaft. Position pad of the 701 tool at lower portion of shin. Push into extension against the pad, NOT the strap.

### 8.8.4 Knee Flexion

While you can perform knee flexion from a seated position, we recommend having the patient lay prone for better ROM and stabilization.



**Exercise Head:** Number five position.

**Attachment:** 701

**Tool Setup:** Use padded block in the B position.

**Patient Positioning Chair Setup:** Position as a bench.

**Patient:** Have patient lay prone and the knee aligned with the shaft rotation.

### 8.8.5 Hip Internal/External Rotation

The following pictures show hip external rotation. For internal rotation, place the pad on the inside of the leg.



**Exercise Head:** Number five position.

**Attachment:** 701

**Tool Setup:** Use padded block in the B position.

**Patient Positioning Chair Setup:** Position as a bench.

**Patient:** Have patient sit facing the PrimusRS. Align the knee/femur with the rotation of the shaft.

### 8.8.6 Hip Abduction/Adduction

The following pictures show hip abduction. For hip adduction, place the pad on the inside of the leg.



**Exercise Head:** Number five position.

**Attachment:** 701

**Tool Setup:** Use padded block. Place padded block in the B position.

**Patient Positioning Chair Setup:** Position as a bench.

**Patient:** Have patient side-lye on the bench. Align the hip joint with the rotation of the shaft.

**Note:**

This set-up may also be done with the patient standing. Use the same tool and follow all other guidelines. A chair may be necessary for the patient to hold on to for stabilization.

### 8.8.7 Hip Flexion/Extension

The following pictures show hip flexion. For hip extension, place the pad on the back of the leg.



**Exercise Head:** Number five position.

**Attachment:** 701

**Tool Setup:** Use padded block. Place padded block in the B position.

**Patient Positioning Chair Setup:** Position as a bench.

**Patient:** Have patient lie supine on the bench. Align the hip joint with the rotation of the shaft.

**Note:**

This set-up may also be done with the patient standing. Use the same tool and follow all other guidelines. A chair may be necessary for the patient to hold on to for stabilization.



# PRIMUSRS

## Section 9 - Definitions and Bibliography

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## Section 9 - Definitions and Bibliography

### 9.1 Definitions

*EC Publication 878-02-02: Type B Equipment*

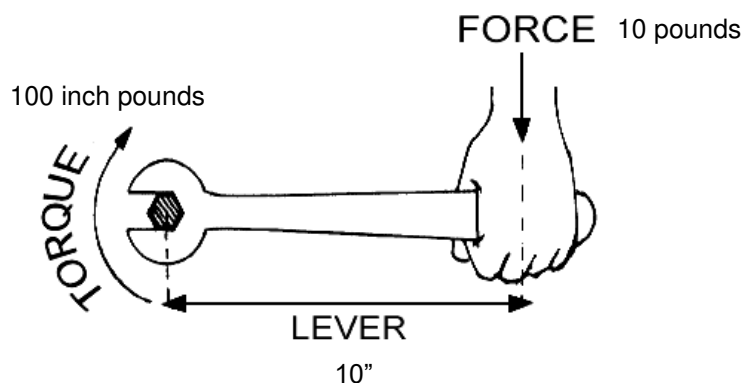
#### 9.1.1 Torque

The torque number on the BTE is a measure of a twisting force. Torque is applied to your watch stem when you wind your watch. You apply torque to a screwdriver when turning a screw, when opening or closing a jar lid, and when using a wrench to tighten or loosen a bolt. Torque can cause rotation of a shaft, or it can just set up a twisting force in a shaft that refuses to rotate. In other words, applying torque to a shaft does not necessarily mean that the shaft will move.

Torque is usually expressed in units of foot-pounds or in inch-pounds. The BTE PrimusRS uses inch-pounds because it is a very small unit of measure which can easily be applied to human performance. Inch-pounds can be converted to foot-pounds because there are 12 inch-pounds in every foot-pound.

To convert inch-pounds to pounds of force exerted at the handle, divide the torque reading by the length of the lever arm. If you know that 100 inch-pounds of torque is being applied to a shaft, and a 10 inch long lever is being used, there must be 10 pounds of weight on the end of the lever. In other words, 100 inch-pounds divided by 10 inches equals 10 pounds.

$$\frac{100 \text{ inch pounds}}{10 \text{ inches}} = 10 \text{ pounds}$$



To work the problem in reverse, the same principles of force and distance apply. If you apply 10 pounds of weight on a lever arm which is extending out 10 inches perpendicular to the center line of the shaft, the torque exerted on the shaft would be 10 inches x 10 pounds which equals 100 inch-pounds.

When using the BTE PrimusRS, an understanding of this basic principle will allow you to change the display and report information to actual pounds of force which is exerted by a patient on any attachment. All you need to do is measure the distance from the center line of the unit's exercise shaft, to the center of the patient's hand on the attachment. Remember, the distance is always measured perpendicular from the centerline of the shaft to the center point where the patient is holding the attachment.

#### 9.1.2 Coefficient of Variation (CV)

The coefficient of variation (CV) is a statistical analysis based on the mean and standard deviation. The CV is used to compare the trials within a test to determine the amount of fluctuation between the trials. This is important when you are looking at whether or not your patient is giving you a consistent effort. If a high CV is recorded, then there may have been something that interfered with your subject's performance. The formula for calculating the CV is as follows:

$$CV = \frac{\text{standard deviation}}{\text{mean}}$$

where standard deviation is:

$$\text{theta} = \sqrt{\left(\frac{\sum((x-\bar{x})^2)}{n}\right)}$$

**Example:**

Say your isometric test results were: 83, 75, and 91.

n is: 3

The mean is: 83

Subtract the mean

from the data:

then square the difference:

$$83 - 83 = 0$$

$$0^2 = 0$$

$$75 - 83 = -8$$

$$-8^2 = 64$$

$$91 - 83 = 8$$

$$8^2 = 64$$

Add the products,  $0 + 64 + 64 = 128$ ; and divide by 3 (n):  $128/3 = 42.7$

The square root of 42.7 (6.5), is the standard deviation.

The standard deviation (6.5), divided by the mean (83) times 100 equals the coefficient of variation.

$$6.5 / 83 \times 100 = 7.83 \text{ CV}$$

Studies that use the CV in determining consistency of effort have found this to be a reliable indicator. However, we would like to remind you that no single test will give you an absolute answer. You must form your opinions based on all the data you have available to you.

## 9.2 Conversions

$$1 \text{ engal} = .00197 \text{ watts}$$

$$1 \text{ engal} = .00000264 \text{ horsepower}$$

$$1 \text{ horsepower} = 378,000 \text{ engals}$$

1 foot-pound = 12 inch-pounds

### 9.2.1 Watts to METS Conversion

Since both watts and METS are measures of power (work performed per unit time) it follows that there is a mathematical relationship between them. There are however some possibilities for error and misapplication when using METS. One should examine the enclosed reprints carefully and possibly look into the subject further before applying METS to upper body ergometry. Wenger & Hellerstein state that for a given  $\text{VO}_2$  (oxygen uptake), which is the basis for the MET unit, the heart rate during upper body ergometry is disproportionately higher than during leg exercise. This could be important if, for example, an exercise prescription was given by a cardiologist for a certain MET level as obtained on a treadmill or by bicycle ergometry. If the therapist reproduced this level using upper extremity exercise, it is conceivable that the heart rate could go substantially higher than the physician desired. It is recommended then, that if upper body exercise is being used to fill an exercise prescription for a certain MET level, that the referring physician be notified that **upper body exercise** will be used.

#### Accepted Conversion Conventions

- $\text{VO}_2/\text{min}$  = oxygen uptake per minute
- $\text{VO}_2/\text{min}$  at rest =  $3.5\text{mlO}_2/\text{kg}/\text{min}$  = 1 MET (for the normal adult population)<sub>1</sub>
- $\text{kcal}/\text{min} = (4.825)(\text{VO}_2/\text{min})_2$
- 1  $\text{kcal}/\text{min}$  = 72 watts<sub>3</sub>

Resting  $\text{VO}_2/\text{min}$  levels can be calculated for the "average adult" using formula 2 from above:

$\text{VO}_2/\text{min}$  for 70kg male =  $245\text{ml}/\text{min}$  at rest ( $3.5 \times 70$ )  
 $\text{VO}_2/\text{min}$  for 55kg female =  $193\text{ml}/\text{min}$  at rest ( $3.5 \times 55$ )

These values represent the basal metabolic rate as expressed in oxygen uptake and define the unit of 1 MET.

Using formula 3 from above,  $\text{VO}_2/\text{min}$  can be converted to  $\text{kcal}/\text{min}$ :

- For males:  $\text{kcal}/\text{min} = (4.825 \times 245) = 1.182 \text{ kcal}/\text{min}$
- For females:  $\text{kcal}/\text{min} = (4.825 \times 193) = 0.931 \text{ kcal}/\text{min}$

Now using formula 4 from above we can convert  $\text{kcal}/\text{min}$  to watts:

- For males:  $72 \times 1.182 = 85.1 \text{ watts}$
- For females:  $72 \times 0.931 = 67.0 \text{ watts}$

Thus 1 MET for the "average" male = 85.1 watts, and for the "average" female = 67 watts. It follows then that the following formula may be used to convert watts from the Work Simulator to METS:

**Males: METS = watts/85.1**

**Females: METS = watts/67**

A few final points to note:

1. The accuracy of the conversion can be improved somewhat if the patient's actual weight is plugged into formula 2 and the  $\text{VO}_2$  is calculated for that specific weight.
2. The most accurate way to determine METS is to analyze respiratory gases during the exercise so as to get a complete picture of the **total** amount of work the patient is performing. The method of determining METS just from power input to a machine could be ignoring some other important factors. Don't forget that formula 2 was calculated on a normal population. Altered physiologic states such as emphysema or restrictive lung diseases, or altered biomechanical states which affect the efficiency of upper extremity movement could cause serious errors in interpretation of the data.

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## **Section 10 – Appendix**

- **Task Analysis Form**
- **PrimusRS Master Chart**
- **Information Related to Electromagnetic Disturbances**
- **Patient Positioning Chair**



[illegible]





Name \_\_\_\_\_ Occupation \_\_\_\_\_ Date \_\_\_\_\_

[illegible]





## Information Related to Electromagnetic Disturbances

The Primus is intended for use at:

- 1) Professional healthcare facility such as a hospital or large clinic and
- 2) Small clinic that could be located in a residential or office area.

The Primus does not have any essential performance characteristics.

**WARNING:** Use of this equipment adjacent to other equipment should be avoided because it could result in improper operation. If such use is necessary, this equipment and other equipment should be observed to verify that they are operating normally.

There are no cables, transducers or other accessories replaceable by the responsible organization that are likely to affect the Primus compliance with the IEC 60601-1-2:2014 (4<sup>th</sup> ed.) standard requirements, in particular with Clause 7 (emissions) and Clause 8 (immunity) requirements.

**WARNING:** Use of accessories, transducers and cables other than those provided or specified by BTE could result in increased electromagnetic emissions or decreased electromagnetic immunity of this equipment and result in improper operation.

**WARNING:** Portable RF communications equipment (including peripherals such as antenna cables and external antennas) should be used no closer than 30 cm (12 inches) to any part of the Primus, including cables provided or specified by BTE. Otherwise, degradation of the performance of this equipment could result.

The Primus is classified class A according to CISPR 11.

**NOTE:** The emissions characteristics of this equipment make it suitable for use in industrial areas and hospitals (CISPR 11 class A). If it is used in a residential environment (for which CISPR class B is normally required) this equipment might not offer adequate protection to radio-frequency communication services. The user might need to take mitigation measures, such as relocating or re-orienting the equipment.

No action needs to be taken to prevent adverse events to the patient and operator due to electromagnetic disturbances.

The Primus has been tested by an accredited laboratory and is in compliance with every applicable emission and immunity standard or test specified by IEC 60601-1-2:2014 (4<sup>th</sup> ed.) standard. In particular, the equipment has been tested for compliance with Group 1, Class A requirements specified in CISPR 11. The Primus does not have any essential performance characteristics.

No deviations from the IEC 60601-1-2:2014 standard or allowances have been applied during testing.

No special instructions are required for maintaining basic safety with regard to electromagnetic disturbances for the expected service life.

# Patient Positioning Chair

BTE offers a Patient Positioning Chair as an option to Primus users. Especially helpful for assessment and treatment of the lower extremities, the chair is designed for multiple positions. This versatility allows its use for children patients up to adults 6'5" weighing 300 pounds.

From a seated position the chair opens 180° to form a horizontal surface. This can be used for treating a patient in the prone position or as an actual treatment table itself.

**WARNING:** Sitting on the end of the chair back cushion when the chair is in the horizontal position is prohibited. Doing so could result in injury.

## Chair Adjustments

The Patient Positioning Chair features several devices for adjusting the seat and the back to accommodate any patient. Adjusting the angle of the chair helps isolate the muscle group to be tested by reducing a patient's ability for substitution.

- The seat angle adjustment lever is located directly beneath the front of the seat (Figure ).
- The large black knobs on either side (Figure ) allow you to change the depth of the chair.
- Figure o shows the pinch adjustment on the back of the chair. This is used to adjust the angle of the chair back.
- Push the chair to the appropriate distance from the exercise head.

Once you have adjusted the chair to fit your patient for his or her treatment, activate the brake with your foot to lock it in place (Figure p).



Figure a



Figure m

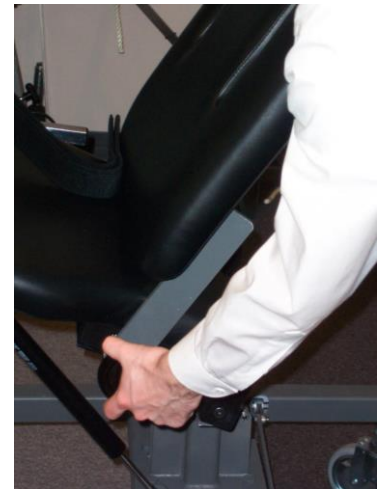


Figure n

**Note:** For lower extremity exercises conducted at high forces, do not lock the chair until you have set up the Chair Connection Bar (Section 8.3.2).



Figure b

## Chair Connection Bar

A special connection bar secures the chair to the exercise head. This should be used to prevent chair movement and exercise head vibration, in order to increase stability of the system (Figure q).

Insert the round arm of the connection bar into the tube beneath the seat of the chair (Figure r) and push it in as far as it will go (**Error! Reference source not found.**).

With the chair wheels unlocked, move the chair to a position within 90 degrees of the exercise head.



Figure c



Figure d



Figure e

Grasp the large black knob on the connection bar, and raise it so that the threaded bolt aligns with one of the lower holes on the mounting ring of the exercise head (Figure ). Turn the black knob until the connection bar is attached firmly to the exercise head. If necessary, lower or raise the exercise head to meet the threaded bar bolt.

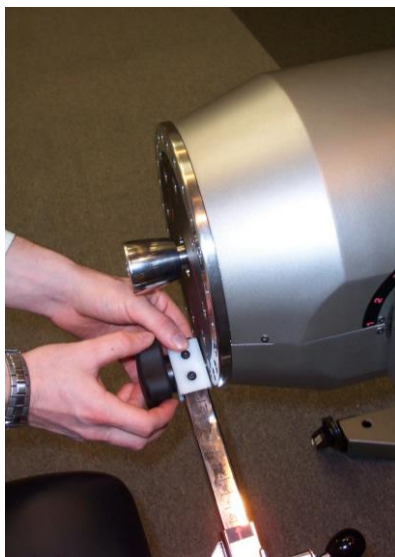


Figure t

If the bar does not reach, adjust its length with the spring-loaded pin (Figure ).

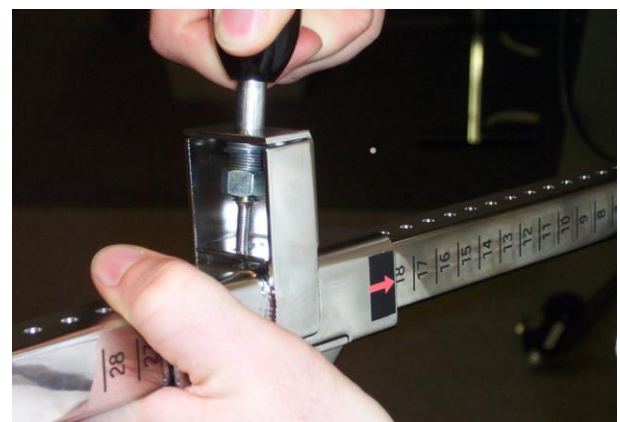


Figure u



Pull the pin and tilt it to the left (Figure ). Push or pull the chair to the appropriate position, and tilt the pin back (Figure ). It will snap into the closest hole and lock the bar to that length.

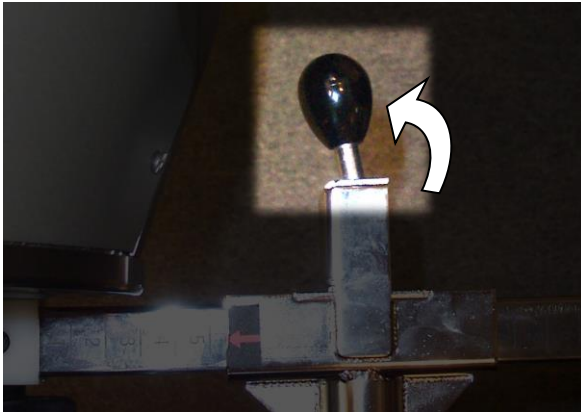


Figure w

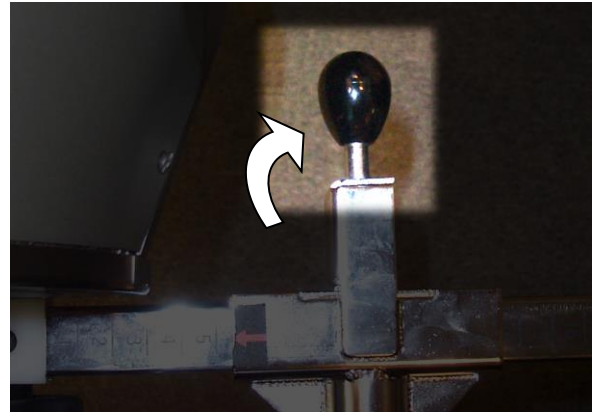


Figure v

Finally, lock the chair by stepping on the locking pedal (Figure p).

Once fully adjusted and attached, the chair will appear as shown in Figure .



Figure x

**NOTE:** For safety purposes, always check that the casters' locking mechanism is engaged prior to patient sitting on the chair and prior to starting a test or exercise.



# Clinical Applications Manual

A clinically-oriented reference manual for  
users of the BTE Primus<sup>RS</sup>.

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## CLINICAL APPLICATIONS FOR THE BTE PRIMUS<sup>RS</sup>

When discussing how the BTE Primus<sup>RS</sup> can be utilized in a rehabilitation program, two primary areas can be identified. One area focuses on **how** it can be used and the other **with whom** it can be used.

How the Primus<sup>RS</sup> can be used falls into three general categories:

- 1) Treatment
- 2) Evaluation
- 3) Ergonomic analysis

Who can use it can be further defined according to diagnosis:

- 1) Injury
- 2) Surgical procedure
- 3) Condition or disease

The following briefly presents various clinical applications for the BTE Primus<sup>RS</sup>.

### TREATMENT

Used acutely to increase:

- range of motion
- strength
- endurance
- isolated joint exercises
- task-oriented; training for functional independence
- improve general body conditioning

For work hardening - a continuation of the above with the addition of work-related tasks (work simulations)

### EVALUATION

- to identify and/or confirm a diagnosis or condition
- of physical capabilities/functional capacity (employability)
- of work capacity
- for pre-placement screening
- for isolated joint and muscle group assessment

### ERGONOMIC ANALYSIS

- of biomechanics:
  - of person (body mechanics)
  - required by work task
  - required by work station
- of tools; to assess if problematic and to suggest and then evaluate the effectiveness of alternatives, adaptations

### CONDITIONS/DIAGNOSES

The Primus<sup>RS</sup> is applicable for all ages, from pediatrics to geriatrics, with a congenital problem, traumatic injury, or onset of a condition or disease. Some of the common uses include:

## **MUSCULOSKELETAL PROBLEMS**

**Fractures** - involving the upper and lower extremities

**Arthroplasties** - of upper and lower extremities

**Tendon repairs, tendon transfers** - for muscle re-education, strengthening, and endurance

**Rotator cuff problems**

**Impingement syndromes**

**"Itises"** - bursitis, tendinitis, arthritis

**Back injuries** - sprains, strains, post-op rehab.

useful in treatment, evaluation, and instruction in proper body mechanics

## **CUMULATIVE TRAUMA DISORDERS/REPETITIVE STRAIN INJURIES**

musculoskeletal or nerve

**Carpal tunnel syndrome (CTS)**

**Tendinitis** - ie. DeQuervain's, epicondylitis, etc.

## **OTHER PERIPHERAL NERVE-RELATED DIAGNOSES**

**Nerve compressions**

**Nerve repairs**

## **NEUROLOGIC CONDITIONS AND/OR INJURY**

**Head injury**

**Spinal cord injuries**

**Multiple sclerosis**

**Cerebral vascular accident (CVA)**

## **NEUROMUSCULAR DISORDERS**

**Muscular dystrophy**

**Cerebral palsy**

In the neurological and neuromuscular areas, characteristic problems can include muscle weakness, decreased muscle endurance, impaired coordination, perceptual problems, and poor cardiovascular conditioning to name a few. A more functionally-oriented rehab is indicated in these cases as opposed to the typical weight- or resistance-oriented strengthening/endurance programs. In fact, strengthening (stressing) may be contraindicated, depending on the diagnosis.

## **CARDIAC AND PULMONARY CONDITIONS**

## **BURNS**

**AMPUTATIONS** - of upper and lower extremities; prosthetic training can be a goal of treatment.

## **BTE *Primus*<sup>RS</sup> USES WITH UPPER EXTREMITY INJURIES/CONDITIONS**

The following represents suggested areas of assessment and uses of the BTE *Primus*<sup>RS</sup> for patients with upper extremity involvement. This assessment encourages the therapist to evaluate the patient as a whole but can be condensed into an upper extremity only evaluation.

### **Areas to be assessed:**

1. manual dexterity and fine motor skills (manipulation)
2. handling, grasping
3. range of motion
4. strength - static and dynamic
5. endurance
6. neuromuscular coordination
7. effects of repetition, if indicated
8. work tolerances to include: reaching  
overhead posturing  
pushing, pulling  
lifting

### **Manual Dexterity and Fine Motor Skills (manipulation)**

Assessment of these areas addresses the coordination of the hand and wrist in performing purposeful motions.

Appropriate tools that can be used to assess manipulation skills include:

- #102 - one inch diameter knurled knob
- #103 - bolt head
- #303 - round knob
- #202 - key shape
- #162 - grip tool
- #151 - pinch tool

### **Handling, Grasping**

Handling and grasping are important to assess with hand injuries.

Appropriate tools that can be used to assess these skills include:

- #162 - grip tool
- #302 - three inch diameter knurled knob
- #502, #504 - medium and large screwdriver handles
- #303 - round knob
- #601 - cylindrical handle
- #701 - small lever
- #802 - large lever
- #901 - end/side handle attachment

## **Range of Motion**

Range of motion exercises for both improving ROM and pre exercise warm-up can be accomplished with the following attachments:

- #302, #601 - wrist ulnar and radial deviations
- #601 - supination and pronation
- #701 - wrist flexion and extension
  - elbow flexion and extension
  - shoulder internal and external rotations
- #802 - shoulder flexion and extension
  - shoulder abduction and adduction
- #162, #151 - finger extension

## **Strength**

Static and dynamic strength of isolated muscle groups can be measured by performing isolated joint motions and of combined muscle groups by performing specific tasks. The isometric strength and dynamic power testing protocols are applicable for this assessment.

Appropriate tools that can be used to assess static and dynamic strength of isolated muscle groups include:

- #162 - grip
- #151 - pulp to pulp pinch, 3-jaw chuck, lateral pinch
- #701 - wrist flexors and extensors
  - elbow flexion and extension
  - shoulder flexion and extension
  - shoulder abduction and adduction
  - shoulder internal and external rotations
- #302, #601 - radial and ulnar deviators of wrist
- #601 - supination and pronation
- #802 - shoulder flexion and extension
  - shoulder abduction and adduction

Appropriate tools that can be used to assess the static and dynamic strength of combined muscle groups required for a particular task include:

all tools - hundreds of tasks

## **Endurance (muscular)**

The endurance of isolated muscle groups can be measured by performing isolated joint motions and of combined muscle groups by performing particular tasks. The dynamic endurance testing protocol is applicable for this assessment.

Appropriate tools that can be used to assess dynamic endurance of isolated muscle groups include:

See the listing above for strength assessment of isolated muscle groups.

Appropriate tools that can be used to assess dynamic endurance of combined muscle groups required to perform a specific task include:

all tools - hundreds of tasks

## **Endurance (cardiovascular)**

Cardiovascular conditioning can be addressed by performance of upper extremity stressing (similar to that accomplished by a treadmill and lower extremity ergometer) and/or performance of repetitive

"whole body" tasks that prove to be aerobically stressful (e.g., repetitive lifting). Provide proper monitoring as you would with any other program geared toward assessing and improving general body conditioning.

Appropriate tools that can be used in the assessment of cardiovascular conditioning include:

- #136 - repetitive arm movement similar to turning a steering wheel.
- #181 - which is equivalent to climbing a ladder with the upper extremities.
- #191 - unlimited types of movement.

### **Neuromuscular Coordination**

Neuromuscular coordination can be addressed by performance of tasks that require interaction of some or all moving segments of the upper and lower extremities' and trunk musculature to produce purposeful, coordinated motions.

Appropriate tools that can be used to assess coordination include:

- #802, #701 - motions requiring static grip combined with simultaneous wrist, elbow and shoulder motions uni- or bilaterally
- #181 - simultaneous reaching and grasping involving fingers, wrists, elbow and shoulder bilaterally
- #901 - simultaneous static grasp with wrist, elbow and shoulder motions performed uni- or bilaterally
- #191 - unilateral and bilateral motions of entire upper extremity, either planar or diagonal patterns (i.e. PNF patterns)

### **Effects of Repetition**

Various cumulative trauma disorders are a result of repetitive motions. Therefore it is necessary to assess a patient's tolerance of repetition. This tolerance can be assessed by performing isolated joint motions, i.e. wrist flexion/extension or a specific repetitive task.

Appropriate tools that can be used to assess the effects of repetition include:

(see the listing above for range of motion assessment of isolated joint motions or set-up a simulation of the actual task.)

### **Work Tolerances**

Work tolerances should be addressed if information is necessary on the patient's "work ability". Therefore it is important to consider static work postures or repetitive dynamic motions/tasks required of the upper extremities by many work situations.

Examples of various work postures and motions and the appropriate tools that can be used for their assessment include:

- pushing, pulling - #802, #191, #701, #901,
- arm lift - #191, #802, #901
- reaching (static and dynamic at various heights) - #802, #191, #181, #136, #701, #901, #103
- (using wrenches), #504/502, #302, #601
- static grip - #302, #303, #502, #504, #601, #701, #802, #901, #136, #162,
- static pinch - #102, #202, #151,

## **BTE *Primus*<sup>RS</sup> USES WITH LOWER EXTREMITY INJURIES/CONDITIONS**

The following represents suggested areas of assessment and uses of the BTE *Primus*<sup>RS</sup> for patients with lower extremity involvement. This assessment encourages the therapist to evaluate the patient as a whole but can be condensed into a lower extremity only evaluation.

### **Areas to be assessed:**

1. range of motion
2. strength - static and dynamic
3. endurance
4. neuromuscular coordination
5. effects of repetition, if indicated
6. work tolerances to include: weight bearing  
weight shifting  
pushing, pulling  
lifting

### **Range of Motion**

Range of motion exercises for both improving ROM and pre exercise warm-up can be accomplished with the following attachments:

- #701 - knee flexion and extension
  - ankle planter and dorsi flexion
  - ankle inversion and eversion
  - hip internal and external rotation
- #701, #802 - hip flexion and extension
  - hip abduction and adduction

### **Strength**

Static and dynamic strength of isolated muscle groups can be measured by performing isolated joint motions and of combined muscle groups by performing specific tasks. The isometric strength and dynamic power testing protocols are applicable for this assessment.

Appropriate tools that can be used to assess static and dynamic strength of isolated muscle groups include:

- #701 - knee flexion and extension
  - ankle planter and dorsi flexion
  - ankle inversion and eversion
  - hip internal and external rotation
- #701, #802 - hip flexion and extension
  - hip abduction and adduction

Appropriate tools that can be used to assess the static and dynamic strength of combined muscle groups required for a particular task include:

all tools - hundreds of tasks

### **Endurance (muscular)**

The endurance of isolated muscle groups can be measured by performing isolated joint motions and of combined muscle groups by performing particular tasks. The dynamic endurance testing protocol is applicable for this assessment.

Appropriate tools that can be used to assess dynamic endurance of isolated muscle groups include:  
(See the listing above for strength assessment of isolated muscle groups.)

Appropriate tools that can be used to assess dynamic endurance of combined muscle groups required to perform a specific task include:  
all tools - hundreds of tasks

### **Neuromuscular Coordination**

Neuromuscular coordination can be addressed by performance of tasks that require interaction of some or all moving segments of the upper, lower extremities, and trunk musculature to produce purposeful, coordinated motions.

Appropriate tools that can be used to assess coordination include those which require whole body motion, weight bearing and weight shifting:

#802, #701 #901 - motions requiring upper extremity movement in combination with trunk and lower extremity

#181 - Squatting and lifting involving the whole body

#191 - unilateral and bilateral motions of entire upper body with lower extremity stabilization, with or without walking, either planar or diagonal patterns (ie. PNF patterns, pushing and pulling)

### **Effects of Repetition**

Various cumulative trauma disorders are a result of repetitive motions. Therefore it is necessary to assess a patient's tolerance of repetition. This tolerance can be assessed by performing isolated joint motions, i.e. knee flexion/extension or a specific repetitive task.

Appropriate tools that can be used to assess the effects of repetition include:  
(see the listing above for range of motion assessment of isolated joint motions or set-up a simulation of the actual task.)

### **Work Tolerances**

Work tolerances should be addressed if information is necessary on the patient's "work ability". Therefore it is important to consider static work postures or repetitive dynamic motions/tasks required of the lower extremities by many work situations

Examples of various work postures and motions and the appropriate tools that can be used for their assessment include:

pushing, pulling - #802, #191, #701, #901,

lifting - #802, #901, #191

## **BTE Primus<sup>RS</sup> USES WITH BACK INJURIES/CONDITIONS**

The following represents suggested areas of assessment and uses of the BTE Primus<sup>RS</sup> for patients with back injuries or conditions. This assessment encourages the therapist to evaluate the patient as a whole but can be condensed into a brief evaluation.

### **Areas to be assessed:**

1. task-related range of motion
2. neuromuscular coordination
3. strength
4. endurance
5. biomechanics
6. work tolerances to include: standing  
sitting  
kneeling  
squatting  
bending  
reclining  
reaching

### **Task-related Range of Motion**

Range of motion would be tested by having the individual perform total body tasks at various levels without resistance, to assess functional range of motion; ie. bending to floor to retrieve handle or crate, moving it various heights and returning it to the floor; reaching to overhead and pulling downward to various levels.

Appropriate tools to be used to assess ROM include:

- #191 - three dimensional motion attachment
- #802 - large lever
- #901 - end/side handle attachment
- #136 - steering wheel
- #181 - multiple handle crossbar

### **Neuromuscular Coordination**

Neuromuscular coordination addresses the interaction of various muscle groups (and body parts) in performing purposeful motions.

Appropriate tools to be used to assess neuromuscular coordination include:

- #191 - to perform designated lifts, planar and diagonal patterns (PNF)
- #901 - involves simultaneous upper and lower extremity and trunk actions
- #181 - involves simultaneous trunk and reciprocal upper extremity actions
- #802 - involves upper extremity movement with trunk and lower extremity stabilization

Contribution of trunk musculature depends on height of activity.



## **Strength**

Static and dynamic strength of isolated muscle groups can be measured by performing isolated joint motions and of combined muscle groups by performing specific tasks. Isolated strength testing of the back is not possible on the Primus<sup>RS</sup>, back strength is measured functionally.

The isometric and dynamic power testing protocols are applicable for this assessment

Appropriate tools to be used to assess strength both statically and dynamically include:

#802, #701 - shoulder flexors and extensors,  
shoulder abductors and adductors,  
shoulder internal and external rotators,  
static and dynamic pushing and pulling capabilities at various heights  
to obtain contribution from various trunk muscles

#191- dynamic lifting from floor-to-knuckle, knuckle-to-shoulder, shoulder-to-overhead, or job-specific lift (use psychophysical and kinesio-physical approaches to determine maximum weight capabilities),

- dynamic pushing and pulling at various heights to obtain contribution from various trunk muscles,
- static and dynamic arm lift

#901 - push, pull at various heights to assess upper and lower extremity and trunk muscle strength,

#181 - repetitive upper extremity attachment used at various heights to assess trunk and bilateral upper extremity strength

## **Endurance (muscular)**

The endurance of isolated muscle groups can be measured by performing isolated joint motions and of combined muscle groups by performing particular tasks. The dynamic endurance testing protocol is applicable for this assessment.

Appropriate tools to be used to assess dynamic endurance of isolated muscle groups include:

same as above listing for strength;

for combined muscle groups - task specific  
all tools - hundreds of tasks

## **Endurance (cardiovascular)**

Cardiovascular conditioning can be addressed by performance of upper extremity stressing (similar to that accomplished by a treadmill and lower extremity ergometer) and/or performance of repetitive "whole body" tasks that prove to be aerobically stressful (e.g., repetitive lifting). Provide proper monitoring as you would with any other program geared toward assessing and improving general body conditioning.

Appropriate tools used in conditioning include:

- #181 - which is equivalent to climbing a ladder but with the upper extremities
- #191 - for repetitive lifting tasks
- #802 - for repetitive push/pull

#136 - for repetitive bilateral upper extremity exercise

### **Biomechanics**

Evaluation of, instruction in, and practice in body mechanics can be accomplished using the Primus<sup>RS</sup>.

Appropriate tools to be used to assess body mechanics include:

#191 - for lifting, pushing and pulling

#802 - for lifting, pushing and pulling

### **Work Tolerances**

Work tolerances should be addressed if information is necessary on the patient's "work ability". Therefore it is important to consider static work postures and dynamic motions/tasks required by many work situations.

Examples of various work postures and motions and the appropriate tools used for their assessment include:

pushing, pulling - #802, #191, #701, #901,

lifting (at various heights) - #191, #802, #901

reaching (static and dynamic at various heights) - #802, #191, #181, #136, #701, #901

static grip - #302, #303, #502, #504, #162, #601, #701, #802, #901, #136

repetitive grip - #162

static pinch - #102, #202, #151,

dynamic pinch - #151

Various work postures can be addressed indirectly using the Primus<sup>RS</sup>. The patient can be distracted by performing an upper body task while maintaining a sitting, standing, kneeling, squat, or reclining posture. Time values can be obtained on how long the patient can maintain these postures before demonstrating intolerance to them. Also repetitive postures, such as bending and squatting, can be assessed in the same manner.

## **BTE *Primus*<sup>RS</sup> USES WITH PATIENTS S/P CVA**

The following represents a list of suggested uses of the BTE *Primus*<sup>RS</sup> with patients status-post CVA (stroke).

### **Cardiovascular Conditioning**

Cardiovascular conditioning can be addressed by performance of upper extremity stressing (similar to that accomplished by a treadmill and lower extremity ergometer) and/or performance of repetitive "whole body" tasks that prove to be aerobically stressful (e.g., repetitive lifting). Provide proper monitoring as you would with any other program geared toward assessing and improving general body conditioning.

Appropriate tools include:

- #136 for repetitive bilateral upper extremity exercise
- #181 which is equivalent to climbing a ladder with the upper extremities
- #191 for lifting tasks

### **Strength**

Strength of particular muscle groups of the upper extremity, cervical and trunk, and lower extremity can be assessed and improved by performing isolated joint motions.

Appropriate tools include:

- #162 for grip
- #151 for pulp to pulp, 3-jaw chuck and lateral pinches
- #701 for wrist flexors and extensors
  - elbow flexors and extensors
  - shoulder internal and external rotators
  - knee flexors and extensors
  - hip flexors and extensors
  - abductors and adductors
  - ankle dorsi and planter flexion
- #801, #701 for shoulder flexors and extensors
  - shoulder abductors and adductors
- #302, 601 for radial and ulnar deviators of the wrist
- #601 for forearm supination and pronation
- #191 for elbow flexors and extensors
  - shoulder flexors and extensors
  - shoulder abductors and adductors
  - hip flexors and extensors
  - hip abductors and adductors

Strengthening can also be addressed by functional and/or work-oriented task performance.

Appropriate tools are dependent upon the activity to be performed.

### **Endurance (muscular)**

Endurance of upper extremity, cervical and trunk, and lower extremity musculature can be

assessed and improved.

Appropriate tools are listed above in "strength".

### **Strength and Endurance for Transfers**

Muscle strength and endurance necessary to perform transfers can be assessed and improved.

#802 (with the square block rather than round handle) is most appropriate for this task

### **Strength and Endurance for Wheelchair**

Muscle strength and endurance necessary to propel a wheelchair can be assessed and improved.

#136 is most appropriate for this task

### **Passive Range of Motion**

Passive range of motion of the "involved" upper extremity can be provided with the CPM mode of the Primus<sup>RS</sup>.

Appropriate tools include all attachments.

### **Activities of Daily Living**

Evaluation and performance of many activities of daily living and other functional tasks can be addressed.

Appropriate tools are dependent upon the activity to be performed.

### **Eye-Hand Coordination**

Eye-hand coordination can be practiced.

Tools most appropriate for this task (as they require reaching and grasping of moving objects) are:

#181 - multiple handle crossbar

#136 - steering wheel

### **Neuromuscular Coordination**

Neuromuscular coordination can be addressed by performance of multi-joint tasks such as lifting, pushing, pulling, shoveling, etc. During these activities, the upper and lower extremities' and trunk musculature are required to work simultaneously to produce purposeful, coordinated motions.

Appropriate tools include:

#191 for lifting, pushing, pulling, PNF patterns, etc. which require upper extremity, trunk, and lower extremity motions

#802 for bilateral upper extremity motions/tasks

#181 for bilateral and reciprocal upper extremity motions

**Balance and Weight-Shifting Activities**

Balance and weight-shifting activities can be practiced by performing "whole body" tasks such as pushing and pulling.

Appropriate tools for performance of such activities include:

- #802 - large lever

- #136 - steering wheel

- #901 - end/side handle

- #191 - three dimensional motion attachment

## **BTE *Primus*<sup>RS</sup> USES WITH PATIENTS WITH ARTHRITIS**

The following represents suggested areas of uses of the BTE *Primus*<sup>RS</sup> for patients with arthritis. Patients' functional levels can be assessed in terms of range of motion, strength, endurance, activities of daily living and other postural and movement tolerances. Pre-operative assessments can be performed documenting limitations in these various areas and can then be compared to the results of a post-operative evaluation. The benefits obtained from reconstructive surgery can therefore be documented. Aside from these evaluation capabilities, the *Primus*<sup>RS</sup> serves as a rehabilitation device allowing patients to practice and improve their functional status.

Areas to be addressed:

1. manual dexterity and fine motor skills (manipulation)
2. handling, grasping
3. range of motion
4. strength - static and dynamic
5. endurance - muscular and cardiovascular
6. activities of daily living
7. other tolerances/postures

### **Manual Dexterity and Fine Motor Skills (manipulation)**

Assessment of this area addresses the coordination of the hand and wrist in performing purposeful motions.

Appropriate tools that can be used to assess manipulation skills include:

- #102 - small knob
- #202 - key attachment
- #303 - round knob
- #162 - grip tool
- #151 - pinch tool

### **Handling, Grasping**

Handling and grasping are important to assess in those patients with hand and wrist involvement.

Appropriate tools that can be used to assess these skills include:

- #162 - grip tool
- #302 - large knob
- #502, 504 - screwdriver handles
- #601 - D-handle
- #303 - round knob
- #701 - small lever
- #802 - large lever
- #901 - end/side handle

### **Range of Motion**

Joint ranges of motion or range of motion required of a particular task can be measured.

Appropriate tools that can be used to measure the range of motion of a specific joint include:

- #701 - wrist flexion and extension  
elbow flexion and extension,  
shoulder flexion and extension,  
shoulder abduction and adduction,  
shoulder internal and external rotations,  
knee flexion and extension  
ankle dorsi and planter flexion  
ankle inversion and eversion
- #302, 601 - wrist radial and ulnar deviations
- #601 - forearm supination and pronation
- #802 - shoulder flexion and extension,  
shoulder abduction and adduction,

Appropriate tools that can be used to measure the range of motion of a specific task include:

all tools - hundreds of tasks

### **Strength**

Static and dynamic strength of isolated muscle groups can be measured by performing isolated joint motions and of combined muscle groups by performing specific tasks. The isometric and dynamic power testing protocols are applicable for this assessment.

Appropriate tools that can be used to assess static and dynamic strength of isolated muscle groups include:

- #162 - grip
- #151 - pulp to pulp pinch, 3-jaw chuck, lateral pinch
- #701 - wrist flexors and extensors  
elbow flexors and extensors,  
shoulder flexors and extensors,  
shoulder abductors and adductors,  
shoulder internal and external rotators,  
knee flexors and extensors (limited use)  
ankle dorsi and planter flexion  
ankle inversion and eversion
- #302, 601 - wrist radial and ulnar deviators
- #601 - forearm supinators and pronators
- #802 - shoulder abductors and adductors,  
shoulder internal and external rotators,
- #191 - elbow flexors and extensors,  
shoulder flexors and extensors,  
shoulder abductors and adductors,

Appropriate tools that can be used to assess the static and dynamic strength of combined muscle groups required for a particular task include:

all tools - hundreds of tasks

**Endurance (muscular)**

Muscle endurance of isolated muscle groups can be measured by performing isolated joint motions and of combined muscle groups by performing particular tasks. The dynamic endurance testing protocol is applicable for this assessment.

Appropriate tools that can be used to assess dynamic endurance of isolated muscle groups include:  
see the listing above for strength assessment of isolated muscle groups.

Appropriate tools that can be used to assess dynamic endurance of combined muscle groups required to perform a particular task include:

all tools - hundreds of tasks

**Endurance (cardiovascular)**

Cardiovascular conditioning can be addressed by performance of upper extremity stressing (similar to that accomplished by a treadmill and lower extremity ergometer) and/or performance of repetitive "whole body" tasks that prove to be aerobically stressful (e.g., repetitive lifting). Provide proper monitoring as you would with any other program geared toward assessing and improving general body conditioning.

Appropriate tools used in conditioning include:

- #136 -for bilateral upper extremity exercises
- #181 - which is equivalent to climbing a ladder but with the upper extremities
- #191 - for repetitive lifting/pushing/pulling tasks
- #802 - for repetitive push/pull

**Activities of Daily Living**

It is important to assess patients' abilities to perform various ADL's and to have them practice them so as to improve their performance. The use of some assistive devices can also be evaluated and practiced using the Primus<sup>RS</sup>.

Appropriate tools that can be incorporated into an ADL evaluation using the Primus<sup>RS</sup> include:

- #102 - as a bottle top, small knob
- #202 - as a key
- #302 - as a jar lid
- #303 - door knobs
- #502, #504 - as screwdrivers
- #701 - as a car window crank
- #162 - as a car door handle, scissors, shears, pliers
- #191 - to lift groceries, boxes, etc;  
to push or pull a cart, stroller
- #901 - as an iron, vacuum cleaner, broom or brush, shovel;  
for one-handed lifting, as a shovel
- #136 - turning a steering wheel
- Many others as needs dictate.



### **Other Tolerances**

Other tolerances/postures should be addressed to measure the effects of arthritis on the spine and lower extremities. Weight-bearing and weight-shifting activities should be considered along with static work postures and dynamic, repetitive motions. Postures to be assessed can include prolonged static reach, standing, sitting, kneeling, squatting or reclining. The patient is distracted by an upper body activity while maintaining these particular postures. Time values can be obtained, documenting the length of time the patient can maintain the posture before demonstrating signs of intolerance to it. Repetitive postures such as bending, reaching, and squatting can be assessed in the same manner.

Examples of various postures and motions and the appropriate tools used for their assessment include:

- weight-shifting - #802, #901, #191
- pushing, pulling (at various heights) - #802, #191, #701, #901,
- lifting (at various heights) - #191, #802, #901
- reaching (at various heights) - #802, #191, #181, #136, #701, #901
- static grip - #302, #303, #502, #504, #162, #601, #701, #802, #901, #136
- repetitive grip - #162
- static pinch - #102, #202, #151
- dynamic, repetitive pinch - #151

# TREATMENT

## Why use the PRIMUS<sup>RS</sup> for exercise?

Since the common objectives of exercise programs include increasing range of motion, strength, and endurance and improving motor control and coordination, it is fitting that the BTE Primus<sup>RS</sup> be used in daily treatment. In addition, it has been found that "the more similar the exercise is to the activity being practiced for, the more likely the exercise is to be helpful in that activity. The best exercise to improve performance is likely the task itself."<sup>1</sup> This statement reinforces the benefits obtained when using the Primus<sup>RS</sup> as part of the treatment program. Early or acute treatment can be addressed as can the work hardening phase. The method of treatment is the same in either case, but it is the specific parameters of resistance, duration and choice of attachments that differ through the various phases of rehabilitation. Ultimately, improvement in function or performance is achieved.

The basis for the treatment approach advocated by BTE is that of progressive resistive exercise. Simply put, an initial resistance is determined and a certain number of repetitions are performed. Over several days, the number of repetitions or duration of exercise performed at that resistance is increased. After several increases are made in distance or time, an increase in resistance is recommended. With the increase in resistance, a decrease in distance or time may occur. Then again over several days, distance or time is gradually increased. The advantage to this treatment approach is that muscle strength, endurance, motor control, and coordination are all addressed, making this an efficient method of treatment. Modifications to the standard approach may be indicated by a patient's circumstances, but this standard method is very effective in the majority of cases.

## What protocol do I follow?

The first step in setting up a treatment program involves the usual history taking and assessment of the patient's physical and functional status. Evaluation of range of motion, muscle strength (by way of manual muscle testing, grip and pinch strength measurement using a grip dynamometer and pinch meter, etc.), sensation, manual dexterity, and other functional aspects as indicated provide information for the initial session on the Primus<sup>RS</sup>.

The second step involves performing a task analysis. With the aid of the **Task Analysis Form** (Section 10 – "Appendix"), the physical demands of work related tasks, activities of daily living, and leisure activities can be recorded. The focus has typically been on upper extremities and hand function (or the injured part) when using the Primus<sup>RS</sup>, but it is important to remember the demands placed on the total body. Include information regarding postures, the duration of the activity, whether or not it is static or dynamic, specific tools used, how they are handled, the forces needed to use them, ranges of motion required, loads handled, and so on. These observations assist the therapist in identifying the critical demands of the job or activity.

It is important when involved in work hardening or work conditioning that specific information be obtained when identifying critical demands of the job. Start out in general terms, such as the person's "occupational title", and refer to the Dictionary of Occupational Titles to obtain a description of the job to which the patient plans to return. Confer with the employer and/or

rehabilitation personnel to gather information regarding a specific job description or particular job demands. When obtaining information from the patient, rather than asking the patient to describe what he/she does on the job, ask him/her to recount the duties performed from the time the workday begins until it ends. This will help avoid leaving out a small but potentially difficult part of the patient's job. Certain tasks may only be done for short periods of time or only once or twice a day. These activities may be forgotten during the initial interview if a systematic approach is not taken when describing the work day.

In addition to verbal descriptions, a visit to the job-site would be very helpful. Analysis of the job entails a series of measurements of each work task. It is necessary to identify the specific physical demands of the job. A detailed description of what to measure and how to apply the data gathered is presented in Section 6 (of this manual) entitled "Task Analysis and Measurement".

When recording information on the Task Analysis Form, list job tasks, ADLs, and vocational activities one at a time. Fill in a description for each, keeping in mind that critical demands may vary from person to person. What may be difficult for a person with a back injury may not be for a person with a hand injury, and vice-versa. The critical demands are those aspects of the task that are most difficult for the patient to perform considering the injury or condition and the resultant physical limitations. Keep in mind that it is neither feasible nor realistic to simulate all aspects of a patient's job, ADL routine, or leisure activities. That is why it is important to identify the critical demands of the job or activity and exercise those requirements. Chances are that if the patient can perform the most difficult aspects of the task, then he/she can handle the whole of it.

Once the Task Analysis Form is complete, it is necessary to choose the appropriate attachments to simulate each task. It is helpful to go to the Primus<sup>RS</sup>, visualize the task, and then review the various attachments available. If possible, hang the poster of the various work, ADL, and leisure simulations on a wall near the Primus<sup>RS</sup>. This may provide pointers for set-up and stimulate ideas of clinicians as well as patients. As the appropriate attachment is identified for the task, its number should be entered in the right side column of the Task Analysis Form.

After the list of attachments has been identified, review the list and eliminate the tools that exercise the same joints or muscles or duplicate the same motion. This will avoid repetition of exercises and reduce the risk of aggravating symptoms or creating repetitive strain injuries. Create a condensed list of exercises in the **Primus<sup>RS</sup> Master Chart** (Section 10 – Appendix).

Once the list is condensed, click the Primus<sup>RS</sup> *Treatment Setup* tab and set up exercises using the appropriate attachments (Operator's Manual Section 5 – Treatment). Prioritize the tools so that the exercise program is efficient. Attend to the critical demands identified from the task analysis and choose attachments most appropriate for simulating the most difficult portions of the patient's job, activities of daily living, and leisure activities. Draw from your experience to identify "expected" rates of recovery and use this knowledge to determine which attachments should wait until later in the rehabilitation program and which should be initiated right away. Also choose the order in which the exercises are to be performed during each session. This decision will be dependent on how the various exercises stress the patient. Vary the muscles being stressed and joints moved. It is important not to fatigue the patient prematurely and create a program the patient cannot complete. Make the treatment program efficient; you will want to accomplish the most in the shortest period of time. On average, a patient in an acute phase of rehabilitation can handle 4 to 5 attachments on the Primus<sup>RS</sup> working for 15 to 20 minutes. In the work hardening phase, a patient will gradually be able to tolerate 8 to 12 attachments and work for a period of approximately 30 minutes. For

therapists in a work hardening program, you will want to move those clients with back injuries through the program in 4 to 6 weeks and those with hand/upper extremity injury in 6 to 8 weeks. These time frames are representative of the average durations of treatment for these specific injuries/conditions.

Having created exercises in *Treatment Setup* for each of the entries in your Primus Master List, you are ready to initiate treatment. Documentation of daily performance is important in all rehabilitation programs. To make this easy when using the Primus<sup>RS</sup>, all daily treatment information is recorded automatically and can be saved at the end of the exercise session. Once saved, set-up parameters, goals, and daily performance results for each attachment can be retrieved after each session.

Before the treatment begins, set-up parameters must be established and Notes should be entered (Section 5.3.4). These notes should include the position of the exercise head, height of the exercise shaft, direction of the ratchet, exercise level setting, and other notes associated with patient and/or machine positioning. Recording this information assures that training conditions can be duplicated from one treatment session to the next. It is reasonable to expect to only accomplish exercises using 3 to 5 attachments on the first day.

When introducing the patient to the Primus<sup>RS</sup> explain that it is a device designed to simulate different activities or tasks. Because it is computerized, it objectively measures forces applied during an exercise, the time taken to perform the activity, and the distance moved. Work and power will be calculated from these variables. Explain to the patient that he or she will be taught how to use the Primus<sup>RS</sup> so that he or she can work independently.

To begin the first session using the Primus<sup>RS</sup>, select the exercise you wish to start with from the Exercise Descriptions List in *Treatment Setup* (Section 5.4, Figure 5q - D). Now touch the *Treatment* Tab at the top of your screen. Use the *Static Trial* option to determine maximum strength capability. The computer will then calculate 30% of that maximum (or % determined by you) and set the resistance for the exercise. Another option may be used to determine exercise resistance. You may start with the resistance at zero and increase to “a comfortable but challenging level” as determined by the patient, using the resistance adjustment buttons in the Control Panel at the right of your screen (Section 2.4, Figure 2f – “F”) to adjust it to the desired level.

Insert the first tool, demonstrate the exercise, determine the set-up parameters, and instruct the patient to begin exercising. Repetitions should be performed at a comfortable pace to encourage full range of motion and prevent early fatigue. Because it is unrealistic to set goals on the first day of treatment, not knowing what the patient can do, gradually increase the resistance until the patient is exercising at a comfortable but challenging level. If the resistance is greater than what the patient can comfortably handle, the therapist may observe a decrease in speed, a decrease in the range of motion, the use of substitution patterns, or facial expressions indicating that the exercise is too hard. When these signs are noted, or the patient reports difficulty or discomfort, reduce the resistance. Once you find a comfortable but challenging resistance level have the patient continue exercising until he complains of being tired, or until the first signs of fatigue are observed. The signs of fatigue are the same as those associated with over-challenging the patient. Once the patient has begun to fatigue, stop the exercise. It is essential not to overextend the patient on the first attachment and to allow necessary rests between exercises.

By following the above procedure the therapist allows the patient to self-determine resistance,

repetitions performed, and the time needed to complete each exercise. Studies have shown that this is an effective way of establishing set-up parameters and goals and produces the most efficient rates of patient progress.<sup>2</sup>

Being conservative during the first few days of treatment is recommended to allow the patient to ease comfortably into the program. Doing so may help in avoiding excessive post-exercise soreness. Advising the patient that she may feel sore following the first session can prevent him/her from becoming anxious or overly concerned should this soreness occur. Moving slowly in the beginning also provides the therapist with an opportunity to observe the patient's physical skills, motivational level, ability to follow commands, personality, and other traits which may influence progress.

On the second day of treatment the Primus<sup>RS</sup> should still be set in the AUTOMATIC MODE. This allows the therapist to have control over how much of the exercise the patient is doing. When inserting the first couple of attachments begin to explain the set-up procedures to the patient. Demonstrate how to insert the tool, set the resistance, position the exercise head, and adjust the height of the exercise shaft. Instruct the patient that he/she need only be concerned with the BEGIN EXERCISE and the NEXT EXERCISE button on the screen in order to advance through the exercises in the Daily Treatment Chart. By the 3rd or 4th attachment have the patient insert the tool and set up the Primus<sup>RS</sup>.

Set up each exercise using the parameters established during the first session, making necessary modifications before exercising. The resistance used should be the one previously determined by the patient as a challenging but comfortable level. The results may be saved and captured on a print-out if this information is desired for documenting progress.

On the third day, review the set-up procedures with the patient and be available to provide verbal cues as needed. Enter the desired goals on the Daily Treatment Chart. Distance goals should be set by taking the number of degrees traveled during the preceding treatment session and rounding them off appropriately. When determining the amount of increase, note the number of degrees per repetition and multiply it by the number of repetitions desired. Add this number of degrees to the previous day's total to identify the goal for the day. Using time as a goal is also possible, although it is more difficult to objectively track day-to-day performance and identify appropriate increases since rate of performance is variable. If using time as a goal, it is important to note that patients work at different paces throughout a given day and/or from day to day. Therefore, if a patient performs significantly more repetitions on a given day, he may be at greater risk for aggravating his condition or creating a repetitive strain injury or cumulative trauma disorder. Work can also be used, which takes into account the force the patient was working against and the distance or "repetitions" completed. Work is an excellent goal because it used two variables that can change rather than just one.

### **How do I progress my patient?**

Changes in the treatment plan and setting of goals may be indicated by subsequent evaluation results. Designing appropriate treatment programs and setting goals are dependent upon what the patient needs to accomplish as a result of treatment. If strengthening is desired, focus may be on increasing resistance rather than distance or time when adjusting the exercise program. If increasing range of motion is necessary, it may be appropriate to have the patient exercise at low levels of resistance while moving through slow, deliberate repetitions and emphasizing the end-

points of the range. If an increase in endurance is needed, it may be appropriate to increase time or distance over a period of 6 to 7 days and then increase resistance using work as the goal. If the goal is to improve overall general body conditioning, the approach may be the same as that mentioned for increasing endurance. And if work tolerances need to be increased, the focus may need to be on the amount of time the patient spends performing the exercise rather than at what resistance he is working. Keep in mind here that "work tolerance" refers to postures and movements (static or dynamic) required by specific activities. Such postures may include sitting, standing, walking, kneeling, squatting, etc. In a work hardening or work conditioning program, the treatment program should be a close simulation of the job to which he/she is to return.

When deciding to increase exercise goals, regardless of which goals are being altered, it is important that adjustments be made appropriately. When making subsequent increases in resistance, use the method previously described in this section (the self-estimated "challenging but comfortable" level). Observe the patient, watching for signs of difficulty such as decreased range of motion, slowing of pace, use of substitution patterns, and/or facial expressions. This will assist in determining whether the adjusted resistance is appropriate.

### **How do I interpret the results?**

With these increases and decreases in the various parameters, it may be difficult to determine progress without viewing a graph that shows the overall trend in performance. The graphs displayed represent the power generated per attachment (shown on the vertical axis of the top graph) during each treatment session (shown on the horizontal axis) and the work performed (shown on the vertical axis of the bottom graph) during each treatment session (horizontal axis). When looking at the overall trend line, peaks and valleys may be noted; however a general trend towards higher power numbers should be observed. Increases and decreases in the power numbers may suggest the need for changes in the treatment program or be indicative of an adjustment that was just made.

The treatment method described above is endorsed by many clinicians. One study by Blackmore S, Beaulieu D, et. al.<sup>2</sup> has been published, lending support to this approach. Certainly the efficacy of progressive resistive exercise programs is well documented in the literature.

<sup>1</sup>Joynt RL: Therapeutic Exercise. In Delisa JA (ed.): Rehabilitation Medicine: Principles and Practice. Philadelphia: J.B. Lippincott, pp. 346-371, 1988

<sup>2</sup>Blackmore S, Beaulieu D, Petralia PB, Bruening L: Discussion of a comparison study of three methods to determine exercise resistance and duration for the BTE Primus. J Hand Ther 1(4):165-171, 1988







# CONSISTENCY OF EFFORT TESTING

## CAN I ASSESS CONSISTENT EFFORT?

Clinicians are often asked whether or not their clients or patients are providing an honest effort during evaluations and treatment. It is a challenge for the clinician to determine whether the individuals they see are giving their best effort. Characteristic to applying one's best effort is the ability to generate reproducible test scores. By asking an individual to participate in isometric strength testing, using a device that objectively measures effort, consistency of effort can be assessed. Consistency is measured by taking test results from three or more closely spaced serial trials; a coefficient of variation is calculated, and the consistency of the scores determined. With this in mind, a number of protocols can be performed with the Primus<sup>RS</sup> using the isometric *line graph* and *alternating trials* tests

Consistency of performance is best determined using isometric strength trials. Because there is no movement, reproducibility of performance is made easy. Issues of moving the same way and returning to the same starting position do not interfere with reproducing set-up parameters and/or test scores. Because this evaluation technique uses the psychophysical approach to strength testing, an individual is permitted to exert a self-determined amount of effort until he/she senses that maximum has been reached. Unidentified impairment, fatigue, pain, fear of re-injury, test anxiety, and symptom magnification syndrome represent some of the factors that can influence maximum voluntary effort.<sup>1-4</sup> If an individual stops applying effort at the same point each trial, his/her test scores should demonstrate minimal variance, resulting in coefficients of variation below experimentally derived cut-points.

Generating consistent test scores while applying less-than-maximum effort is difficult, but can be done. To increase the difficulty in reproducing sub-maximal effort, a change in the direction of effort between trials has been suggested.<sup>3</sup> Because most opposing muscle groups produce different strengths, it becomes even harder to remember how much sub-maximal effort was applied the last time a particular muscle group was tested. Having individuals perform peak isometric strength tests while alternating directions between trials has been shown to be an effective means of testing maximum voluntary effort.<sup>1,3,5</sup> This test method can be easily accomplished using the Primus<sup>RS</sup> using the *Alternating Trials* in the Isometric Menu

Because the clinician has the opportunity to test isolated muscle groups unaffected by the injury or condition, this type of testing works well with a variety of patients. By testing away from the injury, there should be no physiological reason for inconsistent performance. Regardless, this type of testing should be executed with caution due to safety issues related to isometric testing in general.<sup>3,5-8</sup> Injuries have been reported as a result of performing isometric lift tests to determine consistency of effort. To avoid possible injury, all individuals must be forewarned to stop immediately if they experience any objectionable pain or discomfort. They must also be encouraged to limit their performance to a self-perceived "acceptable" level.<sup>5,9</sup>

It has been stated that by directly involving impaired components in testing procedures, the risk of further injury increases and leads to questionable reliability of the test results<sup>5</sup>. Testing away from the involved area is imperative during acute phases of rehabilitation; however, somewhere in time, perhaps during a functional capacity assessment, testing of an impaired area may be necessary.

When injured components are tested, the reliability of test results may become questionable. Therefore, it is important to measure consistency of the test scores of the injured and non-injured sides. Since there should be no physiological reason for the non-injured side to be inconsistent, the clinician should be able to better assess whether a person is trying their best based on such a measurement. If the individual complains that pain is the limiting factor, consistent test scores should still be demonstrated. Preliminary data show that if a person experiences pain when exerting maximum effort, the point of pain should be relatively the same each trial. It has been found that if the individual being tested is carefully instructed to stop immediately when he/she experiences pain or discomfort, consistency should still be noted, if the pain is real.

Although often proving advantageous, consistency of effort testing is not appropriate for certain diagnostic groups due to risk of injury or exacerbation of symptoms. Individuals with impaired cardiovascular or metabolic systems, whether a result of a disease process or extreme deconditioning, are not appropriate candidates for maximum voluntary effort testing. Also at increased risk under these test conditions are those suspected of having cardiovascular disease, cerebrovascular disease, or cardiopulmonary impairment.<sup>3,5</sup> Such patients should not undergo testing without their physician's approval, real-time monitoring, and immediate availability of emergency health care.

### How is consistent performance measured?

Consistency of performance is best determined when a person is tested isometrically. Studies have shown that a person applying maximum voluntary effort during several trials of isometric testing should be able to reproduce test scores within a certain percentage.<sup>1,3,5,11-13</sup> This percentage is represented by the coefficient of variation (CV).

The CV is the standard deviation divided by the mean and is always expressed as a percentage. It requires data from three or more closely spaced trials in order to be calculated. CV's are automatically calculated by the Primus<sup>RS</sup>; however, they can also be calculated using a scientific calculator or manually. (Refer to page 313 for instructions). There are two different formulas used to determine standard deviation: one is representative of a complete population of scores (Formula #1) and the other is based on a sample of scores (Formula #2).<sup>14</sup> For the purpose of this test, the first formula is most appropriate.

<p>Formula #1</p> $\sigma = \sqrt{\frac{\sum (x - \mu)^2}{n}}$	<p>Formula #2</p> $s = \frac{\sum (x - \bar{x})^2}{n - 1}$
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If you are using a scientific calculator, be sure to check the instruction manual of your calculator to assure use of the correct one (formula #1).

### What test procedure should I follow?

Based on this information, there are four ways of testing consistency of effort using the Primus<sup>RS</sup>. Two methods involve measuring peak isometric strength only. One method measures isometric strength over a six second contraction. Using the *Alternating Trials* and *Line Graph* you can

document the maximum strength capabilities of a particular muscle group.

*Alternating Trials* was developed to allow testing of opposing muscle groups by alternating directions between trials. This testing method, designed to decrease chances of consistent sub-maximal performance, has been suggested by various authors.<sup>1,3,5,15</sup> This would be the option of choice when testing a patient suspected of giving sub-maximal effort. This test can also be used for looking at the "bell curve" traditionally associated with the Jamar hand dynamometer as well as the "rapid exchange test" also performed with the Jamar hand dynamometer

Another method of testing consistency of effort is based on work by Chaffin and others.<sup>10,11</sup> This procedure requires the performance of three static strength trials of sustained effort (6 seconds) while a real-time graph is produced representing the actual force applied. Given that there are three trials, a coefficient of variation is calculated for the average force applied from the beginning of the third second to the end of the 5th second of each trial. This three second period of time is where the sustained effort should be most consistent (the first two seconds of build-up time and the last second affected by fatigue are eliminated). In addition to looking at consistency through peak and average forces, the evaluator can also observe the visual representation of the individual's performance. The line graphs produced in the *Line Graph test* should be consistent in appearance. The lines should rise to a peak, level out, and then gently slope downward. And, the peak forces should occur at approximately the same time each trial.

### **How do I standardize my test methods?**

The key to obtaining valid test results lies in the reproducibility of the test. When making a custom selection of attachments for evaluating consistency of effort, a number of issues must be considered. An individual's test performance is greatly influenced by the selection of the attachment, the position assumed during testing, and the instructions provided by the evaluator. It is critical that the test be performed the same way each trial and from one test session to the next in order that consistency may be fairly determined. Creating standardized testing procedures is an important first step for determining consistency of effort.

Attachments must be carefully chosen to isolate the specific muscle group or joint movement being tested. By allowing input from adjacent muscle groups, an inaccurate assessment of an individual's effort will be made. If possible, attachments with shorter lever arms should be selected to help reduce variance in test scores sometimes due in part to input from substitute muscle groups. If necessary, reduce the length of adjustable tools to their shortest workable length. Longer lever arms may permit an individual to overcome the maximum resistance of the exercise head, resulting in invalid test scores.

Patient positioning must also be considered. Test positions should be easily duplicated from one test session to the next. It is recommended that landmarks be identified on each attachment to facilitate consistent hand placement. If using an attachment in which the individual is required to grasp the handle, instruct her to centrally grasp the handle or align either side of the hand with either end of the handle. If landmarks do not exist on the attachment, create them using tape, string, or the like. Mark the center of the handle where hands should be placed on the attachment. Instruct the individual to place his hand over the marking so that the marking lies between the metacarpal of the middle and ring fingers. For evaluation of bilateral activities, instruct the individual to place both hands on the tool with the marking between the hands. The location of the hand on the handle may be important, but what is more critical here is that the hand be placed in

the same position during every trial of every test session.

Another way of promoting duplication of set-up parameters includes marking foot placement. For example, a grid marked with tape on the floor to indicate where the individual stands when tested. If a grid is too cumbersome or not feasible, a piece of tape can be placed on the floor extending perpendicular from the base of the Primus<sup>RS</sup> beneath and parallel to the exercise shaft. The patient can then be instructed to place her foot on or next to the tape when assuming the test position.

In addition to appropriately selecting and standardizing attachments, accurate replication of the movement being tested is also critical. The patient's ability to perform the same way each time he/she is tested will influence the reproducibility of the test. By testing isolated muscle groups rather than full body movements, greater restriction of movement occurs and the chance of employing substitute movement patterns decreases. By limiting the variables associated with full body movements, the chance of producing lower variance between trials improves.

Although properly selected attachments allow for the evaluation of specific isolated muscle groups and joint motions, additional measures may be appropriate for the prevention of substitute movement patterns. For example, place a small object (such as a rolled up towel or the flat block handle for the 701 and 802 attachments) between the arm being tested and the individual's side during pronation and supination tests. The individual is instructed to hold the object under his arm just above the elbow to control shoulder movement. If the individual abducts or flexes his shoulder the object will fall out from under the arm, indicating input from substitute muscle groups. It is important that the object not be positioned up in the axilla area since movement of the shoulder could occur without the object falling. This technique is also appropriate when testing grip strength or other isolated muscle groups distal to and including the elbow where proximal stabilization is required.

Please refer to pages 308 and 309 for general testing procedures. Included are verbal instructions and important highlighted notes. For patient positioning information, refer to the specific test in Section 7.

### **What does the test data mean?**

The coefficient of variation provides the evaluator with an objective means of quantifying consistency of patient performance, assuming test methods are standardized and consistent. For example, if an individual produces CV's above experimentally derived cut-points, it does not necessarily mean that he is not trying, nor does it mean that a person who produces CV's within acceptable limits is invariably giving his best effort. If a patient is not producing scores that are consistent with established cut-points documented in the literature, it is recommended that that person undergo a battery of tests using a number of testing instruments before the conclusion is made that he is not giving maximum voluntary effort.

According to the Work Practices Guide for Manual Lifting, "It should be possible in physical capability tests to achieve a coefficient-of-variation of less than 15%."<sup>11</sup> However, in a study done at the Employment and Rehabilitation Institute of California (E.R.I.C.) which employed the BTE Work Simulator, the 15% cut-point was found to be liberal.<sup>3</sup> As a result of this study, individual cut-points for specific attachments were developed, many falling below 10%. Results of the BTE National Database study using #601 to test supination and pronation also presented cut-points falling below 10%.<sup>13</sup> The variations that exist between the cut-points cited in these various studies

are due to varied test positions and the muscle groups tested. The more isolated the test motion, the higher the test reproducibility.

Although CV's higher than 15% should be a red flag, they do not indicate that a person is not sincere in her effort. It is important to look at test scores of individual trials to observe trends in performance. If fatigue is an issue, a significant drop in test scores during successive trials may be noted. Pain or discomfort may also bias test results, requiring the evaluator to closely observe and document the patient's responses to testing. If the patient does not understand what is expected of her, test results could be inconsistent. Clinical observations cannot be ignored during testing. Patient positioning must be monitored carefully to identify any predisposing factors to high CV's. Keen observation skills are needed throughout testing to judge if changes in leverage occurred or if substitute movement patterns were used. Deviations may be slight and difficult to note, appearing only as minimal changes in hand positioning or foot placement. Being able to identify these occurrences is critical to valid testing, because even the most motivated patients can produce high CV's if they have altered their position between trials.

Because there is a chance of recording false positives, the probability of a fair representation of an individual's effort will increase as more tests are performed. The Maximum Voluntary Effort battery developed at E.R.I.C. requires that 20 isometric strength tests be performed on the Primus<sup>RS</sup>.<sup>3,15</sup> Additional tests using various instruments should also be included in the battery. Based on observations made from testing on the Work Simulator, it has been found that the evaluator should not be concerned unless more than 5 to 6 trials of the 20 performed on the Primus<sup>RS</sup> have CV's higher than the established cut-points. King and Berryhill<sup>1</sup> used two different instruments to assess maximum effort in upper extremity testing, the Work Simulator and Jamar dynamometer. They found that 4 successful tests out of 5 indicated that the patient was giving maximum voluntary effort. Results not consistent with those documented in the literature indicate that further testing is needed. They do not give the therapist permission to make conclusions regarding an individual's effort, without further investigation.

When testing individuals with upper extremity injuries, it is important to note the scores recorded from both sides. Although the injured extremity may produce CV's above the accepted cut-points, the uninjured side should demonstrate reproducible test scores. If an individual tries to overcompensate on the uninjured side, to make the injured side look worse, chances are the uninjured side will show high CV's. On the other hand, preliminary data support that injured upper extremities may still produce consistent scores, finding that the point at which the patient ceases to give maximum effort is relatively consistent with the level of pain. Whether true pain is a limiting factor on a consistent basis is controversial to date. One cannot disprove pain; however if the pain is genuine, it will most likely be exhibited consistently.

The choice of attachments can also provide the evaluator with important information, making tool selection critical during consistency of effort testing. So long as the patient is applying consistent effort, the evaluator should see higher torque readings when testing the same muscle groups with attachments having longer lever arms. For example, when testing with the assorted sized screwdrivers, one should see different torque readings for each due to the varying diameters. Because #504 has the largest diameter, it provides the greatest leverage and therefore should produce the greatest amount of torque when compared to #502.

### **Can the test methods be modified?**

Methods of testing consistency of effort are adaptable. Several studies cited above employed specific attachments in their test method. A variety of attachments can be used and/or a number of different joint movements can be tested. However, extreme caution must be used when selecting attachments, identifying set-up parameters, and determining patient positioning since test protocols should produce repeatable results. Body mechanics and hand placement must be carefully observed and must be consistent throughout testing. As stated previously, even the smallest of changes in positioning may increase or decrease a patient's mechanical advantage. Changes may be as minimal as moving a foot back 1" or moving the hand 1/2" on the tool, resulting in high CV's because either the center of gravity was shifted or leverage was altered. Whenever possible, use standard positions published in the literature to ensure the validity of testing techniques.

The Maximum Voluntary Effort Test Battery developed by E.R.I.C. is easily performed on the Primus<sup>RS</sup> for evaluating consistency of effort.<sup>3,5,12,15</sup> It involves isometric testing of both hands in clockwise and counterclockwise directions using five different attachments: #302, #502, #504, #601, and #701. These attachments were chosen for their low inherent variability and because they allowed for easy and appropriate isolation of the muscle groups being tested. All attachments test supination and pronation with the exception of #701 which is used to evaluate elbow flexion and extension. Set-up parameters are also identical for each test with, the exception of #701. This test protocol yields 20 coefficient of variations which can be compared against normative values. By standardizing tool selection, patient positioning, and testing procedures, the scores have been studied and identified as reliable.

Other studies have been conducted to investigate additional test instruments used for evaluating maximum voluntary effort. One study performed by King and Berryhill,<sup>1</sup> examined the Jamar hand-held dynamometer and attachments #302, #502, and #162. Although the CV cut-points identified by Matheson were used for these attachments, the set-up parameters and movements being tested differed (except for #162). Rather than testing supination and pronation, the exercise head was placed in the vertical position and wrist movements were studied. In addition to studying CV's, grip strength test scores were compared to those obtained from the Jamar dynamometer. The study concluded that testing with these instruments was a reliable means for assessing consistency of effort while also demonstrating a correlation of test scores using the two different instruments.

<sup>1</sup>King JW, Berryhill BH: Assessing maximum effort in upper extremity functional testing. WORK 1(3): 65-76, 1991

<sup>2</sup>Niemeyer LO, Jacobs K: Work Hardening - State of the Art. New Jersey: Slack, Inc., pp 100-103, 1989

<sup>3</sup>Niemeyer LO, Matheson LN, Carlton RS: Testing consistency of effort: BTE Primus. Industrial Rehab. Quarterly 2(1): 5-32, 1989

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<sup>8</sup>Zeh J, Hansson T, et al.: Isometric strength testing: recommendations based on a statistical analysis of the procedure. Spine 11(1): 43-46, 1986

<sup>9</sup>Khalil TM, Waly SM, et al.: Determination of lifting abilities: a comparative study of four techniques. Am Ind Hyg Assoc J 48(12): 951-956, 1987

<sup>10</sup>Chaffin DB, Andersson G: Occupational Biomechanics. New York: John Wiley & Sons, Inc., 1984

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- <sup>14</sup>Koosis DJ: Statistics (3rd ed.). New York: Wiley Press, p. 77, 1985
- <sup>15</sup>Barren N, Gant A, Ng F, Slover P, Wall J; The Validity of the ERIC Maximum Voluntary Effort Protocol in Distinguishing Maximal from Submaximal Effort on the BTE Work Simulator. *NARPPS Journal & News* (7)6; 223-228; Oct 1992

# Alternating Direction Test

The following represents a suggested test method to be used when assessing consistency of effort. The theory that supports this procedure has been detailed on the previous pages. Primus<sup>RS</sup> operation, instructions to patients, suggested methods for standardization of test procedure, etc. are included below.

## TEST PROCEDURES:

1. Choose "ALTERNATING DIRECTIONAL" at the ISOMETRIC sub-menu. Select the desired attachment code and proceed to the test screen.
2. Place the exercise head in the appropriate position. The shaft should be horizontal. Adjust the height of the exercise head. The height should be such that the subjects elbow is at 90°. The height should remain the same when testing both sides.
3. Demonstrate to the patient the proper test position and the motion being tested.
4. Properly position the patient with the attachment being used.

**NOTE: Hand and body positioning are critical in obtaining consistent results. Since minor deviations will influence outcomes, positioning must remain uniform throughout testing.**

**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous or has a bilateral injury, test the right side first.**

5. Have the patient assume the test position. If the position of the attachment needs adjustment, touch the UNLOCK TOOL button and move it to the proper position. Touch the LOCK TOOL button to lock it in place.

**NOTE: Do not allow the patient to use substitution patterns.**

6. Verbally describe the procedure:
  - this is a test of strength, exert maximum effort during the test;
  - the tool will not move, we are only measuring effort applied;
  - do not jerk the tool; effort should be applied in a smooth but rapid manner;
  - positioning is very important; be sure to stay in the same position throughout the test; do not move your feet between trials;
  - stop immediately if you feel any pain or discomfort.
7. Allow the patient one trial at sub-maximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics. Start with the supination direction or with the flexion motion.
8. Turn the computer screen so that the patient cannot see it.
9. Make sure that the tool is securely attached and the patient properly positioned. Touch



BEGIN TRIAL to begin trial 1.

**NOTE: Do not coach the patient in any manner during testing. This could influence the patient's performance, especially if there are inconsistencies in your delivery.**

10. Proceed through three trials in each direction beginning and ending each trial by touching the appropriate button on the screen. Begin each trial by instructing the patient to apply maximum effort against the tool in either the clockwise or counterclockwise direction. When maximum is reached, tell the patient to stop, change his/her hand position (if necessary), and apply maximum effort in the opposite direction. For example, if the patient applied effort in the clockwise direction during the first trial, then he/she should now be moving in the counterclockwise direction. Repeat the application of maximum effort two more times in each direction, alternating between each, to complete three trials each in the clockwise and counterclockwise directions.

**NOTE: Only the direction of the force should be alternated between trials of each test. Use the same hand until all three trials in both directions are completed.**

**NOTE: Hand positioning should be kept consistent between trials. In addition, be sure the patient's position does NOT vary during the testing process. A change in position from trial to trial may significantly alter data due to a change in leverage.**

11. Data has now been collected for two tests: one side or hand tested in two directions. The results will automatically be displayed on the screen for each test.
12. Print the screen if desired, then touch EXIT and SAVE the data.
13. Reselect the ALTERNATING TRIALS test and continue testing using the same attachment to test the opposite side or hand in the same way or continue with other attachments if appropriate. Always begin with the dominant or uninjured side and alternate directions between trials.

Calculations for data presentation and interpretation can be found on page 305.

#### **PROCEDURE/DESCRIPTION:**

The Employment and Rehabilitation Institute of California (E.R.I.C.) has developed a Maximum Voluntary Effort Test Battery which includes the use of the BTE Work Simulator as a tool for evaluating consistency of effort. Since this procedure involves isometric testing of both hands in clockwise and counterclockwise directions using five attachments (#302, #502, #504, #601, and #701) common to the Work Simulator and the Primus<sup>RS</sup>, this procedure can also be performed on the BTE Primus<sup>RS</sup>. This test yields 20 coefficient of variations, gathered in approximately 15 minutes. Having the patient perform peak strength trials in alternating directions has been adopted because it has been found that less-than-maximum scores are more difficult to reproduce when directions are changed between trials.

The following procedure is based on the guidelines set by E.R.I.C.:

1. Choose "ALTERNATING DIRECTIONAL" at the ISOMETRIC sub-menu. Select the desired

attachment code and proceed to the test screen.

2. Place the exercise head in the horizontal position with the shaft facing forward (position #5).
3. Demonstrate to the patient the motion being tested (supination/pronation or elbow flexion/extension) and the proper positioning described below.
4. Position the patient in front of and facing the exercise head for all supination/pronation tests (attachments #302, #502, #504, and #601) and to the side of and facing the exercise head for elbow flexion/extension tests (attachment #701).

**NOTE: Hand and body positioning are critical in obtaining consistent results. Since minor deviations will influence outcomes, positioning must remain uniform throughout testing. To help insure this, it is recommended that a piece of tape be placed on the floor under the exercise head extending perpendicular from the base of the Primus<sup>RS</sup>. The tape should be in alignment with and parallel to the exercise shaft. Instruct the patient to stand with the outside of the foot of the side being tested next to the tape during pronation and supination tests.**

**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous, test the right side first.**

5. Adjust the height of the exercise head so that the axis of the exercise shaft is in alignment with the elbow joint. The height should remain the same throughout the testing procedure when using the five attachments stated previously.
6. For all tests, the patient is positioned with the shoulder of the side being tested in adduction and neutral with regard to flexion, the elbow at 90 degrees of flexion, the forearm in alignment with the exercise shaft, the wrist in neutral, and the hand place as specified for each tool. When using #701, the patient stands to the side of and facing the exercise head which means that the forearm will not be in alignment with the exercise shaft but will be perpendicular to it.
7. With regard to hand placement, use the following techniques:

**#302, large knurled knob:** have the patient grasp the tool with the MP joints resting on its outside edge. Instruct the patient to place his/her hand on the top side of the tool (palm down) when testing supination and on the bottom (palm up) when testing pronation.

**#502 and #504, medium and large screwdriver handles:** insert the tools so that the top side is parallel to the floor, in other words, flat on the top. Instruct the patient to place his/her hand on the top side of the tool (palm down) when testing supination and on the bottom (palm up) when testing pronation.

**#601, D-handle:** insert the tool so that it is perpendicular to the floor. Instruct the subject to place his/her hand in the center of the handle with the thumb side up. The forearm should be in neutral and hand position is the same for both supination and pronation tests using this attachment.

**#701, small variable position crank:** insert the tool so that it is parallel to the floor and the

handle is positioned toward the side on which the patient is standing. Set the tool length at four inches. Instruct the patient to grasp the handle while aligning the forearm with the attachment. The forearm should be pronated when testing elbow extension and supinated when testing flexion.

The hand not being tested should rest at the subject's side, and the patient should stand with feet flat on the floor and shoulder width apart.

**NOTE: Do not allow the patient to use substitution patterns.**

**NOTE: To prevent substitution, place a small unbreakable object between the arm being tested and the patient's side. Instruct the patient to hold it under his/her arm just above the elbow during testing. This will help control shoulder movement which, if it occurs, will cause the object to fall out from under the arm. Be sure that the object is not positioned up in the axilla area since movement of the shoulder could still occur without the object falling.**

8. Verbally describe the procedure:
  - this is a test of strength; exert maximum effort during the test;
  - the tool will not move, we are only measuring effort applied;
  - do not jerk the tool; effort should be applied in a smooth but rapid manner; and maximum effort should be reached in 2 to 3 seconds;
  - positioning is very important; keep your back straight; do not lean; keep this small object under your arm throughout the test;
  - report immediately if you feel any unusual pain or discomfort; stop at any time you feel you cannot continue without risk of injury.
9. Start the first trial and allow the patient one trial at submaximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.

**NOTE: Allow the patient to see the computer screen during the practice trial so that he/she can see that his/her effort is being recorded.**

10. Turn the computer screen so that the patient can not see it and select REDO TRIAL to erase the practice trial.
11. Making sure that the tool is securely attached, the patient properly positioned. Touch BEGIN TRIAL to begin trial 1.

**NOTE: Do not coach the patient in any manner during testing. This could influence the patient's performance, especially if there are inconsistencies in the delivery.**

12. Proceed through three trials in both clockwise and counterclockwise directions. Begin by instructing the patient to apply maximum effort against the tool while supinating. When maximum is reached, END TRIAL and ask the patient to change his/her hand position (except with #601) and reverse directions. He/she should now be applying maximum effort while pronating. When using #701, have the patient begin with elbow extension, change hand position, and then flex the elbow. Repeat the application of maximum effort two more times in each direction, alternating between each, to complete three trials of clockwise and

counterclockwise movements.

**NOTE: Be sure the patient's position does NOT change (except for hand positions) for the duration of the testing process. A change in position from trial to trial may significantly alter data due to a change in leverage.**

13. You have now collected data from two out of the 20 tests performed when following this procedure.
14. EXIT and SAVE the results.
15. Reselect the ALTERNATING TRIAL test and continue with the other hand, the remaining four attachments in order as they are listed above, always beginning with the dominant or uninjured side and alternating directions between trials.

## CALCULATING THE COEFFICIENT OF VARIATION

$$\text{Coefficient of Variation (CV)} = \frac{\text{Standard Deviation}}{\text{Mean}}$$

where standard deviation is:

$$\sigma = \sqrt{\frac{\sum(x-\mu)^2}{n}}$$

### Example:

Recorded isometric test results were: 83, 75, and 91

$$\begin{aligned} n &= 3 \\ \text{mean} &= 83 \end{aligned}$$

Subtract the mean from the data:

$$\begin{aligned} 83 - 83 &= 0 \\ 75 - 83 &= -8 \\ 91 - 83 &= 8 \end{aligned}$$

then square the difference:

$$\begin{aligned} 0^2 &= 0 \\ -8^2 &= 64 \\ 8^2 &= 64 \end{aligned}$$

Add these numbers,  $0 + 64 + 64 = 128$ ;

and then divide by the  $n$  (3):  $128 \div 3 = 42.7$

The square root of 42.7 = 6.5, giving you the standard deviation.

The standard deviation (6.5) divided by the mean (83) times 100 equals the coefficient of variation (CV).

$$(6.5 \div 83)100 = 7.83\% \text{ CV}$$



# ASSESSMENT OF MUSCLE PERFORMANCE

## HOW DO I MEASURE FUNCTIONAL PERFORMANCE?

Strength, power, and endurance are all basic components of muscle performance. The purpose for evaluating these components is to determine an individual's functional abilities and/or limitations, and to establish a baseline against which progress can be measured. The following procedure is the one recommended for general testing. It allows the evaluator to test the three components of function: maximum strength, dynamic power, and dynamic endurance.

### Maximum Strength

The evaluation of strength has long played an important role in the assessment of human performance. Strength has been defined as the maximum force or tension that a muscle can exert in a single voluntary effort.<sup>2,3,4,5</sup> It is measured by recording the force applied during an isometric contraction in which there is no movement of the joint being tested. Recording this force allows the evaluator to document peak strength and consistency of effort.<sup>5-10</sup> It also allows for comparisons between injured and non-injured extremities, dominant and non-dominant extremities, agonistic and antagonistic muscle groups, an individual's performance compared to normative data, and/or an individual's performance compared to physical job demands.

Because of patients' varying abilities to achieve maximum effort, a mean score of more than one trial should be used to measure isometric strength. Factors that affect performance during strength testing have been identified, offering explanation to the differences in test scores from trial to trial.<sup>10</sup> These determinants can be divided into three categories: peripheral, neural, and environmental. The cross-sectional size of a muscle, the orientation of the muscle fibers, the dominant fiber type, the accumulation of fatigue substances, the depletion of energy sources, and the temperature of the muscle represent a number of peripheral factors. Neural influences include: an individual's ability to activate motor fibers and to achieve complete activation of those fibers and, the percentage of slow twitch fibers to high twitch fibers. This percentage varies from muscle to muscle and among people. Individuals who are accustomed to exercising often have a larger percentage of high twitch fibers and may demonstrate a lower variance in peak strength over several trials. An individual's physical surroundings represent the environmental factors. An increase in the volume of a command or the use of unusual sensory stimulation, such as a loud noise or clapping, can influence the force an individual can generate. Also of influence are temperature and visual stimuli.

Because it has been recommended that multiple trials should be used to identify isometric strength, methods for identifying the criterion score of these tests have been examined. Of the three methods studied, it was found that the mean of three trials had the highest test-retest reliability and the lowest day-to-day variability.<sup>10</sup>

The time allowed for each contraction during static strength testing has been recommended by Chaffin and presented in the *Ergonomics Guide for the Assessment of Human Static Strength* developed by the American Industrial Hygiene Association (AIHA).<sup>3,4</sup> Because the development of muscle fatigue can result in decreased strength during exertion periods that are too long, the length of time the contraction is held needs to be considered. A period of less than 4 seconds can be used if the exertion involves a limited set of muscles and the instructions require that the individual apply maximum effort quickly. Additional considerations include the complexity of the exertion and the individual's neuromuscular coordination. The more complex the task, such as when moving a

heavy load, the greater the number of muscle actions which need to be coordinated. If an individual is allowed to practice the task prior to testing, then the force build-up time will most likely become shorter. For the purpose of measuring maximum strength capabilities (peak effort), a 2 to 3 second period should be of sufficient duration as to allow the patient to reach maximum. Frequently, physiologic tremor can be observed when maximum is achieved. If additional information about effort is sought (i.e. consistency and rate of fatigue), a longer duration (sustained effort) is indicated. Using a sustained effort of 6 seconds to observe strength capabilities is discussed in the "Consistency of Effort" section (Section 3) of this manual.

Rest periods between trials have also been studied concluding that duration should be controlled, sufficient enough to allow for the restoration of energy sources, and identical for re-evaluations. An interval of at least one minute has been identified by Trossman and Li<sup>5</sup> as a conservative measure; however, Chaffin<sup>3</sup> recommends a rest period from 30 seconds to 2 minutes depending upon the length of the contraction. Contractions of less than 4 seconds, as recommended by this protocol, require the minimal amount of recovery time. In a study examining the relationship of endurance to static and dynamic performances using the Work Simulator,<sup>11</sup> a 15 second rest period was identified between trials, while the BTE National Database identified a rest period of approximately 5 seconds in its protocol.<sup>6</sup> Matheson utilized a 5 to 10 second rest in his "Consistency of Effort" test protocol, maintaining that this was sufficient enough so that fatigue is not an issue.<sup>12</sup> The standard protocol for testing peak isometric strength presented in this manual has been used in a number of studies.<sup>13-17</sup> It is based on the information presented above and provides a reliable and valid means of testing static strength.

Methods of testing static strength have evolved into standardized procedures.<sup>3,4</sup> The procedure presented in this manual is relatively simple. It specifies that the individual being tested assumes a standardized position and is asked to exert maximum effort against a stable measuring device. Because the individual's body position and joint angles are controlled by the evaluator, the only existing variable is the amount of force applied. Since the exertion is isometric and completely voluntary, there is a minimal risk of injury. If an injury occurs, it is often comparatively minor in nature, such as a muscle strain.<sup>3</sup> To avoid injury, the individual should be instructed to apply effort slowly and to stop immediately if he/she experiences any discomfort. The duration of the exertion should be relatively short and should be ceased once maximum effort is reached to avoid fatigue. The measuring device should allow for the recording of peak strength and should hold the peak force so that test scores can be appropriately documented. The testing device should also be applicable to the individual without creating discomfort due to localized pressure. Rest periods should be adequate and consistent between trials and dependent upon the duration of the muscle contraction.

Instructions given to the individual should be stated carefully and clearly, indicating that participation is voluntary and that potential risks are involved. Performance values should not be disclosed during testing and coaching should be avoided so that the outcome of the test is not influenced in any way. If possible, testing should be done where minimal environmental distractions exist. Noise, lighting, temperature, and spectators may interfere with an individual's test performance. Set-up parameters should be standardized to assure that the same body position and test postures are used each test session. If identical set-up parameters are used throughout testing and during re-evaluations, test/retest values should highly correlate with coefficients of variation less than 15%.<sup>4</sup> By testing consistently each time, this method of static strength testing has been shown to have a high degree of reliability.



## Dynamic Power

Power, in contrast to strength testing, is tested dynamically. It involves joint movement caused by reciprocal contraction and relaxation of the muscle. Because a significant number of jobs require dynamic motion, it is felt that the measurement of dynamic power may be a better indicator of function than isometric contraction.<sup>4,15,18,19</sup> Power represents the amount of work produced in a period of time or, how efficiently an individual performs a task. In order to be calculated, it requires the identification of force, distance, and time, all of which are objectively measured and documented with the Primus<sup>RS</sup>. Quantifying an individual's power output allows for comparison to the demands of a job, daily activity, or avocational task. It also provides valuable information regarding functional abilities and/or limitations, and can be used as an indicator of progress when compared over time.

The standard protocol presented in this manual for testing power requires that an individual be tested at 50% of the peak isometric strength. It is a controlled test, asking the individual to move through full range of motion as fast as he/she can for a ten second duration. This leaves only one variable: the speed of performance. A study at the University of Maryland (unpublished) has indicated that these conditions are optimal for studying power. Because the average person fatigues at approximately eight seconds into this type of evaluation, ten seconds has been identified as the preferred length of time for this test. A review of the literature reveals a number of studies which have used 50% of an individual's average peak isometric strength for testing dynamic power,<sup>6,13-17</sup> and it has also been recommended in the BTE Primus<sup>RS</sup> Operator's Manual.

## Dynamic Endurance

Endurance is the measurement of an individual's level of stamina or fatigue. It is tested to identify the length of time a person can perform a specific muscle activity, joint motion, or simulated task. This is an important component of function because the majority of muscles are required to work on a continuous basis during most activities. By measuring the amount of work generated, or the length of time an activity is sustained, the duration of muscle performance can be quantified.

When testing endurance, all variables are controlled except for the time allotted for the activity. Force, range of motion, and the pace of the activity must remain consistent from one test session to the next, or from one extremity to the other in order to make a fair comparison. When comparing extremities, the evaluator must use a percentage of the lesser of the two peak strength measurements to set the force (30% to 50% is common) and the lesser of the two joint ranges to set the range of each repetition. The pace of the activity, which also needs to be controlled, is dependent upon the size of the attachment and/or the range of motion required to complete one repetition; it may also be specific to a particular job task or simulated activity. By keeping all variables consistent except for time, endurance can be measured by looking at the amount of work produced or by the duration of the activity.

## TERMINOLOGY:

### **Force**

Force is the weight of an object being handled or the effort applied to move a load. On the Primus<sup>RS</sup> it is measured in terms of *torque*, which is a twisting force or the effort applied to rotate an object about its axis. It is generated when turning an object, such as a key or screwdriver, and represents the amount of effort applied to turn a door knob or dial a rotary phone. Because it takes

greater force to start an object moving than it does to keep it moving, its measurement is greater when force is initially applied. It can be applied statically, such as when trying to loosen a bolt that has become "frozen" by rust, or it can be applied dynamically, such as when turning a well-lubricated valve.

Torque is measured in inch-pounds on the Primus<sup>RS</sup>. It can be converted to pounds by dividing the inch-pound reading by the length of the lever arm in inches. You also have the option of entering the lever length at the test screen and have the results reported in pounds. The length of the lever arm is determined by measuring the distance from the center of the exercise shaft to the center point of the application of pressure. See the conversion formula below:

$$\frac{\text{inch-pounds}}{\text{inches}} = \text{pounds}$$

Maintaining the same lever arm length is critical when performing evaluations and making comparisons. Its length significantly influences the amount of torque generated. If a person is applying maximum effort, a higher torque will be produced with the use of a longer lever arm. Therefore lever arms must remain consistent between test trials, from one extremity to the other and from one test session to the next, in order to make fair comparisons. Where hands are placed on the tool should also be noted, since slight movement toward or away from the center of the exercise shaft will alter leverage. Note that inconsistencies, in the length of the lever arm or in hand placement, will result in invalid test data.

### ***Distance***

Distance measures the excursion of the load or the point from which force is applied to the point where it is released. Distance on the Primus<sup>RS</sup> is recorded as degrees of rotation, where 360° represents one complete revolution of the shaft.

### ***Time***

Time indicates how long an activity or movement is performed. It is recorded in seconds on the Primus<sup>RS</sup>.

### **Work and Power**

You should now have an understanding of the factors that influence power and how to measure them. To calculate power, the amount of work produced is divided by length of time it took to complete it. Work is calculated by multiplying the force generated by the distance traveled. See the formulas for work and power below:

<p style="text-align: center;"><b>WORK</b></p> <p style="text-align: center;">(force x distance) = work</p>
---

<p style="text-align: center;"><b>POWER</b></p> <p style="text-align: center;">work ----- = power time</p>
--

On the Primus<sup>RS</sup>, work (inch-pound-degrees) is measured in Joules and power (inch-pound-degrees per second) in Watts. One foot-pound of work equals 1.36 Joules or, conversely, 1 Joule equals 0.74 foot-pounds of work.

Any change in the work or time recordings will result in a power change. When assessing how efficiently an individual works, one would expect to see an increase in power as neuromuscular coordination improves and strength and endurance increase. However, as individuals move through their rehabilitation programs, increases and decreases in power may be noted. Let us look at the following examples:

If an individual performs 60,000 inch-pound-degrees of work in 30 seconds, his average power output would be 2,000 units of work per second. This number is derived using the following method:

$$\frac{60,000 \text{ units of work}}{30 \text{ units of time}} = 2,000 \text{ units of power}$$

If the same individual continues to perform 60,000 units of work the next day but does so in 20 seconds, then his average power would increase to 3,000 units. This is because the same amount of work has been done in a shorter period of time, resulting in the generation of greater power.

$$\frac{60,000 \text{ units of work}}{20 \text{ units of time}} = 3,000 \text{ units of power}$$

Now let us suppose that the same individual produces 75,000 units of work in the same 30 second period as recorded on the first day. The result would be 2,500 units of power, clearly demonstrating that greater power has been generated here as well. This is because more work has been produced in the same amount of time.

$$\frac{75,000 \text{ units of work}}{30 \text{ units of time}} = 2,500 \text{ units of power}$$

To provide one more example, let us see what happens if the individual takes 60 seconds to produce 60,000 units of work, the same amount done on the first day. The power generated would decrease to 1,000 units because it has taken more time to do the same amount of work.

$$\frac{60,000 \text{ units of work}}{60 \text{ units of time}} = 1,000 \text{ units of power}$$

To summarize the variables that alter power output between test sessions, one needs to look at the amount of work generated and the time it took to produce it. This also applies when making comparisons between extremities. If comparing results from dynamic power tests in which the duration of all tests is a constant 10 seconds, the evaluator must look for changes that have occurred in the amount of work generated. The variables that influence work output are the average force and/or distance traveled. An increase in resistance should result in an increase in work, unless distance is compromised by the greater resistance. If the distance decreases as force increases, the amount of work may or may not change significantly. This is due to a balance created by an increase in one variable and a decrease in the other. If the distance shows an increase while the average force remains the same, the amount of work would increase. This demonstrates that force and distance represent the variables to be considered when changes in work are noted.

If the work produced remains the same from one test to the next, but generated power differs, then time has changed. If the amount of time shows a decrease while the amount of work remains the same (same amount of work performed in a shorter period of time), this indicates that the individual is generating greater power or performing more efficiently. If the time increases under the same conditions (same amount of work in a longer period of time), the patient may be showing signs of fatigue or of being over-challenged. If the time and distance increases while the force remains the same (increase in work in a longer period of time), this is reflective of increased endurance. If the time increases but the distance remains unchanged (increase in work in a longer period of time), this may be a result of an adjustment (an increase) to the resistance. Due to the increased resistance, the same number of repetitions are performed but at a slower pace. Time and distance represent the variables to be considered when comparing dynamic endurance tests and simulated activities.

## HOW DO I USE THIS DATA?

Comparisons of test results can be within a test session as well as between test sessions. To compare results within a session, several methods can be used. These include 1) dominant vs. non-dominant, 2) injured vs. non-injured, 3) agonist vs. antagonist, 4) patient performance scores vs. task analysis measurements, and 5) patient performance scores vs. normative values. For the purpose of the standard protocol, the evaluator will most likely use one or both of the first two comparison methods listed above; however, all five will be presented in this section.

### INTER-SESSION COMPARISONS

#### **Dominant/Non-dominant - Injured/Non-injured**

Comparisons of dominant to non-dominant and injured to non-injured sides are made in the same manner. Scores obtained from measuring peak isometric strength, work, power, and/or endurance can be compared using this method. A percent difference is calculated, representing the non-dominant or injured side as a percent lesser or greater than the "normal or baseline" measurement. The formula for calculating this percentage is as follows:

$$\frac{\text{Non-dominant score}}{\text{dominant score}} \times 100 = \text{ } \% \quad \text{OR} \quad \frac{\text{injured score}}{\text{non-injured score}} \times 100 = \text{ } \%$$

The " - 1 " in this formula allows for the calculation of a negative number. This indicates that the non-dominant or the injured score is a certain percent "less than" the dominant or non-injured score rather than a percentage "of" the dominant score. A review of the literature reveals varied opinions when searching for a "normal" percent difference between extremities.

## Agonist/Antagonists

Comparisons of agonist to antagonists can only be made when testing opposing muscle groups of the same joint. This, for example, may be done when comparing elbow flexors to elbow extensors of the same extremity. Average strength ratios between opposing muscle groups are available from many kinesiology books and provide the evaluator with information needed to compare muscle strengths.

## Task Analysis Comparison

Comparing patient performance against task analysis measurements is applicable when it is necessary to obtain an accurate assessment of an individual's ability to perform a particular job. This may not be appropriate when testing specific muscle groups or joint motions but will be used when testing performance during specific task simulations.

## Norm Comparisons

A final comparison method involves comparing patient performance scores to normative values. Although this is a popular method of rating patient performance, it has its limitations. General population norms only provide the evaluator with information regarding the "average". Therefore, the variability between people must be considered when making this kind of comparison. Since there are limited norms available for strength and endurance using the Primus<sup>RS</sup>, the best method for determining impairment is still to compare the individual's injured extremity to his/her non-injured.<sup>11</sup> It is also important to realize that normative values have little value when making a decision regarding an individual's ability to return to work or to perform a specific job, since testing must be done in the way the individual has to perform on the job.<sup>4</sup>

## INTRA-SESSION COMPARISONS

Comparison of test results between test sessions is also possible. Test data from two test dates can be compared and used to indicate whether or not improvement in performance has occurred. In reporting isometric test results, calculate the percentage of change of the average peak torques recorded for the test dates being compared. Changes in dynamic power can be calculated using the watt numbers, and in endurance using the test time or work numbers.

Some clinicians use the calculated percentage difference between the involved and uninvolved to measure progress. This can be done, but caution must be exercised when utilizing this data. A

minimal change in the percent difference from one test date to another does not necessarily indicate that little progress has been made. In cases where a patient is moderately to severely deconditioned, improvement in strength, efficiency of performance, and endurance is likely to occur in both extremities. And, as a result, little change would be noted when looking at the percentage difference only. Be sure to review all test data before making a judgment.

<sup>1</sup>Matheson LN: Upper extremity strength testing as a component of functional capacity evaluation. *Industrial Rehab Quarterly* 4(4): 5-11, 1991

<sup>2</sup>Blackmore S, Beaulieu D, Petralia PB, Bruening L: Discussion of a comparison study of three methods to determine exercise resistance and duration for the BTE Primus. *J Hand Ther* (4):165, 1988.

<sup>3</sup>Chaffin DB, Andersson GBJ: Occupational Biomechanics. New York: John Wiley & Sons, 1984

<sup>4</sup>NIOSH: Work Practices Guide for Manual Lifting. Akron, OH: American Industrial Hygiene Association, 1983

<sup>5</sup>Trossman PB, Li PW: The effect of the duration of intertrial rest periods on isometric grip strength performance in young adults. *Occup Ther J Res* 9(6):363-78, 1989

<sup>6</sup>Jacobs JL, Vermette JE: BTE National Database - Supination/Pronation. Unpublished

<sup>7</sup>King JW, Berryhill BH: Assessing maximum effort in upper extremity functional testing. *WORK* 1(3):65-76, 1991

<sup>8</sup>Matheson LN: "How do you know that he tried his best?" The reliability crisis in industrial rehabilitation. *Industrial Rehab. Quarterly* 1(1): 1-12, 1988

<sup>9</sup>Niemeyer LO, Matheson LN, Carlton RS: Testing consistency of effort: BTE Primus. *Industrial Rehab. Quarterly* 2(1): 5-32, 1989

<sup>10</sup>Trossman PB, Suleski KB, Li PW: Test-retest reliability and day-to-day variability of an isometric grip strength test using the Primus. *Occup Ther J Res* 10(5):266-70, 1990

<sup>11</sup>Beck HP, Tolbert R, Lowery DJ, Sigmon GL: The relationship of endurance to static and dynamic performances as assessed by the BTE Primus. *Fourth National Forum on Issues in Vocational Assessment*, pp. 255-57, 1989

<sup>12</sup>Matheson LN: Use of the BTE Primus to screen for symptom magnification syndrome. *Industrial Rehab. Quarterly* 2(2): 5-28, 1989

<sup>13</sup>Anderson PA, et al: Normative study of grip and wrist flexion strength employing a BTE Primus. *J Hand Surg* 15A(3): 420-25, 1990

<sup>14</sup>Beck HP, Sigmon GL: The use of regression analysis to estimate preinjury static and dynamic performance on tool #162 of the BTE Primus. *Fourth National Forum on Issues in Vocational Assessment*, pp. 259-63, 1989

<sup>15</sup>Berlin S, Vermette J: An Exploratory Study of Primus Norms for Grip and Wrist Flexion. *Vocational Evaluation and Work Adjustment Bulletin*, p.61, Summer 1985

<sup>16</sup>Rudy TE, Lieber S, et al: BTE Primus functional capacity evaluation protocol for back pain patients. Unpublished

<sup>17</sup>Youngblood K, Ervin K, Sigmon G, Beck H: A comparison of static and dynamic strength as measured by the BTE and West 4. *Fourth National Forum on Issues in Vocational Assessment*, pp. 265-68, 1989

<sup>18</sup>Isernhagen SJ: Work Injury - Management and Prevention. Rockville, MD: Aspen Publishers, Inc., 1988

<sup>19</sup>Niemeyer LO, Jacobs K: Work Hardening - State of the Art. New Jersey: Slack, Inc., 1989



# LIFT/PUSH/PULL EVALUATION

## WHY IS LIFT TESTING NECESSARY?

It is not uncommon that some form of lifting, pushing, or pulling is required by many jobs today. According to the National Institute of Occupational Safety and Health (NIOSH),<sup>1</sup> approximately one third of the U.S. work force is required to perform significant physical effort on the job. Manual handling tasks have been identified as a major source of work injuries for which compensation has been received,<sup>2,3,4</sup> and a significant percentage of these injuries have been caused by lifting activities.<sup>5,6</sup> As a result, there is a strong need to identify appropriate tools and techniques for quantifying lift capacities, especially since testing in this area has become an important part of functional evaluations.<sup>4,6,7</sup>

## TEST METHODS

Various methods are currently used for evaluating load handling capacities; they include the psychophysical, biomechanical, physiological, and kinesiophysical approaches to strength testing.<sup>7,12,16-18</sup> These approaches define who is in control of the test. The psychophysical approach to testing places the patient in control of determining the maximum. The kinesiophysical approach allows that decision to be made by the therapist. These approaches will be discussed in more detail later in this section.

There are also different types of tests utilized to determine maximum strength capabilities; for example, isometric, isoinertial, isotonic, and isokinetic testing. Isometric strength testing is recognized as an acceptable and reliable means of measuring human strength.<sup>1,7,8</sup> It is determined by measuring the effort generated by a single maximum voluntary contraction against an immovable measuring device. Results of isometric lift tests have been used to identify individuals at increased risk of injury,<sup>1,7,8</sup> however, the validity and the safety of this technique have been questioned.<sup>5,9</sup> Back injuries have been reported as a result of performing isometric lift evaluations,<sup>8,10</sup> possibly due to overexertion caused by the poor ability to judge the amount of effort being applied.<sup>11</sup> It has also been found that since there is no movement during a static strength test, people tend to overestimate their ability to lift an object.<sup>3,7</sup>

Isokinetic test methods, by contrast, tend to "accommodate" the patient's effort.<sup>3,8,11</sup> Although not totally constrained as with isometric lifting evaluations, isokinetic test methods restrict velocity and acceleration variables (constant velocity), allowing only the resistance to vary independently. Such limitations interfere with the testing of agility and coordination, resulting in a lift that is not representative of a "real world" situation.

Isoinertial and isotonic testing represent the least restrictive of the aforementioned test methods. Both are dynamic in nature and can be used to determine the maximum load a person can lift.<sup>2,3,13</sup> No restrictions are posed on velocity or acceleration, making either method very realistic. However the trajectory of the motion can be confined when using certain test devices, due to the constraints of the device itself (those with "fixed" arms). To differentiate between the terms isoinertial and isotonic, it is necessary to identify the constant and variable factors. In the isotonic condition, the force or torque is constant. Whereas in the isoinertial condition, mass remains constant. Isoinertial force is the actual force exerted when lifting (or pushing and pulling). For example, when lifting an object which weighs 30 pounds not only is mass considered but acceleration and velocity is also factored in. It is necessary to exert a force greater than the mass of the object being moved.



The Primus<sup>RS</sup> allows for three-dimensional movement and has few restrictions. It measures isotonic forces.

### **THEORETICAL APPROACHES:**

There are four theoretical approaches used to estimate manual handling capacities. They are the psychophysical, the biomechanical, the physiological, and the kinesiophysical.<sup>7,8,12,18</sup> The psychophysical approach may be used to determine acceptable load levels regardless of the handling frequency. The physiological approach is limited to analyzing frequent tasks.<sup>7,8,12</sup> The biomechanical approach has been developed to look at how specific job tasks stress an individual, not how the individual performs the task, and is limited to infrequent tasks. Evaluation of body movement is the focus of the kinesiophysical approach to testing.<sup>18</sup>

In addition to the focus of each approach, two of these test methods dictate who is in control of the test, who determines when maximum has been reached. These are the psychophysical and kinesiophysical test methods. The psychophysical approach is based on subjective estimates of load handling tolerances.<sup>6,7,9</sup> Allowing the patient to control one task variable, the evaluator typically has the patient adjust the weight of the object being handled. The patient adjusts the load so that lifting or handling for long periods of time is psychologically acceptable.<sup>2</sup> This is considered a "comfortable" limit for the patient and is not representative of that person's capacity. Having the patient determine the maximum acceptable weight handled in this manner has proven reliable. Traditionally, the technique utilized a box to which weight was added.<sup>2</sup> Increases in the load were determined by the patient. Subsequent to Snook's description, other researchers have applied the theory to isometric and isoinertial testing.<sup>3,4,14-16</sup> Although this approach has been criticized for having a subjective end-point and questionable validity and reproducibility, studies have shown high reliability.<sup>3,6,9,12,16</sup> It has also been praised for being characteristic of "real world" lifting.<sup>2</sup> Due to complete freedom when lifting, coordination and agility variables are not compromised, leading to a higher true lifting capacity<sup>11</sup> and the best estimate of the maximum load a person is willing to handle.<sup>3</sup>

The test method described by Isernhagen<sup>18</sup>, the kinesiophysical approach, indicates that the therapist should be in control of the test. This is not to say that feedback is not obtained from the patient or is ignored. But since the therapist is knowledgeable in the areas of kinesiology, biomechanics, pathology, etc., sound judgment can be exercised by the clinician in determining how far to go with the evaluation. Therefore, the results are based on objective observations made by the therapist. And, any limitations in performance can be interpreted and managed accordingly.

Both the psychophysical and kinesiophysical test methods can be incorporated into the suggested test procedure for assessing maximum lifting, pushing, and pulling capabilities using the Primus<sup>RS</sup>. Dynamic lifting, pushing, and pulling can be accomplished by utilizing attachment #191. The protocol suggests that the three standard dynamic lift ranges identified by NIOSH<sup>1</sup> be assessed unless a specific job requirement exists. These ranges are floor to knuckle, knuckle to shoulder, and shoulder to overhead. General instructions for performing the evaluation can be found on pages 507 and 508; detailed procedures can be found in Section 7, pages 767 through 778. Included in these written procedures are details of PRIMUS<sup>RS</sup> operation, subject positioning information, verbal instructions, and important highlighted notes.

## **WHEN DO I STOP THE TEST?**

In addition to obtaining objective data from the Primus<sup>RS</sup>, good observational skills are needed for determining a person's maximum load handling capability. A patient's performance plays a critical role in deciding whether or not that person is capable of handling a load safely. It is possible when following the procedure presented in this manual that a patient's maximum load handling capability exceed the maximum safe acceptable load for that person. It is up to the therapist to appropriately judge each individual's ability. One guideline that can be kept in mind is that the maximum load should not exceed 55% to 65% of the individual's body weight.

Movement patterns and velocity provide important information regarding acceptable limits. The use of substitute movement patterns may indicate that the patient is having difficulty handling the load or that he/she does not understand how to correctly or efficiently handle the task. This poses a risk of injury, especially at higher resistances. Speed in handling also influences whether a load is an acceptable level.<sup>3</sup> Noticing movements, such as jerking or ballistic movements, stalling, decreasing speed, and/or hesitations will tell the therapist that the load is too challenging. If the patient is unable to complete the lift after the load has been adjusted, it is apparent that the load is too great. The power per repetition number reported at the end of each lift takes into account the three variables of a lift (weight, distance and velocity), and can be a very good identifier of a person's maximum safe lifting ability.

In addition to observing changes in body mechanics, posture, velocity, etc., you must also observe the patient for other signs that indicate stress or overchallenge. Signs of pain or discomfort such as grimacing, moaning, or sudden stops, can provide information for the therapist. Making notes as to whether these signs occur consistently or erratically during testing may evoke questions regarding consistency of effort.

Considering the patient's cardiopulmonary status will also provide details regarding load handling capacity. Changes in breathing patterns, heart rate, and perspiration assist in determining how much a person is being stressed by a load. Because lifting tasks incorporate aerobic activity, cardiopulmonary status may be the limiting factor of task performance.<sup>5</sup> A specific aerobic goal should be identified prior to testing and periodic pulse checks should be made to ensure that the patient is not exceeding this limit. Unless cardiac precautions are specified or rate-limiting medications are being used, this end-point should be 85% of age-determined "maximum heart rate".<sup>5</sup> Adequate rest periods are important during lift testing and may vary from patient to patient.

Again, it is the therapist's responsibility to document the safe acceptable load a person handles based on observations as well as objective data collected. The way in which the load stresses the individual will indicate the maximum safe acceptable limit. This safe acceptable limit must be recorded in the evaluation report, especially if it is different from the maximum load lifted.

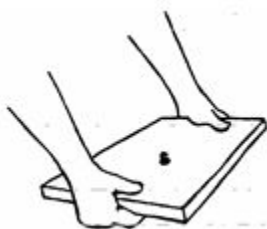
## **HOW CAN I MAKE THE TEST MORE JOB SPECIFIC?**

Tools other than #191 can be utilized when performing these maximum effort tests. Lifting, pushing, or pulling activities required on the job may be better simulated through the use of other attachments.

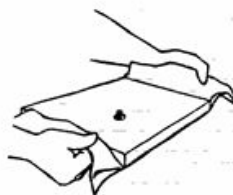
If planning to use more than one test instrument to validate an individual's load handling capability, it is critical that the physical set-up parameters of each test be identical or as close as possible. For example, if comparing an individual's lifting capacity using boxes or crates to that which he/she is capable of lifting on the Primus<sup>RS</sup>, the evaluator must adapt the Primus<sup>RS</sup> to simulate the boxes.

Comparing the results obtained using a handle on the Primus<sup>RS</sup> that is different than the box you are using is like comparing apples to oranges. Not only are the loads lifted using different grips and hand placements, but the two objects are also held at different distances away from the body resulting in an altered center of gravity. This is not a fair comparison and does not provide the therapist with any useful information regarding consistency.

The three standard dynamic lift ranges presented in this manual utilize the straight handle with the #191 cable system; however, testing is not restricted to the use of this handle. Certainly, specific job tasks may require that the handle be adapted or even replaced by an object that more closely simulates the size and the shape of the object being handled. Two additional handles are provided; a single hand handle and an "S" handle that simulates lifting a box or milk crate. The following suggestions are but a few examples to help facilitate the seemingly endless options available when using the cable system on the Primus<sup>RS</sup>. The single hand handle may be used to simulate lifting a bucket, pulling down a garage door, or pushing a sliding door.



*Figure 2a*



*Figure 2b*

If it is necessary to simulate lifting a box or box-shaped object such as a cinderblock, the "S" handle may be used. You may also wish to create a handle that more closely resembles and/or feels like the actual object you are simulating. For example, you can use a piece of 3/4" plywood cut to the desired size. Insert a 1/4" closed or solid eyebolt through the center of the board securing it with two nuts for safety purposes. This will serve as the attachment point for the #191 clip. It is recommended that plywood be used rather than a solid board due to the inherent strength of the plywood (see Figure 2a). Whenever an adapted handle is to be used on the Primus<sup>RS</sup>, it should be able to withstand three times the amount of force required by patient usage.

A variation of the above modification may be used to simulate the handling of cloth bags or the moving of patients in a bed. This is done by attaching a piece of durable fabric, such as denim or canvas, to the underside of the board. Cut a small slit in the fabric to allow the "eye" of the eyebolt to pass through. The fabric, when fastened to the plywood, should extend approximately four to six inches beyond the length of the board on both sides to allow for gripping (see Figure 2b).

Another way to simulate the handling of boxes or crates is by attaching an actual milk crate to the cable system. This is done by threading the rope through the center of the bottom of the crate, and attaching it to a 1" diameter rod or dowel inside the crate. The reason for attaching to a dowel is to distribute the pressure evenly over the bottom of the crate when force is applied. If a plastic crate is used and the cable is attached directly to the bottom, the force may be too great and cause the plastic to snap. If the desire is to simulate lifting a box from the floor, the crate may be turned upside down, the cable threaded up through the inside of the crate, and the dowel attached across the bottom on the outside of the crate.

It is important when adapting any attachment on the Primus<sup>RS</sup> that it be tested before patients are allowed to use it. It must be able to withstand three times the amount of force under which it will be used in order to ensure its safety. If attaching an eyebolt to an object for use with #191, be sure to use a 1/4" closed eyebolt. Eyebolts that are not welded shut or are not closed may pull open under increased force. Also, attach the eyebolts with two nuts rather than one as insurance in case one should become loose or fall off. If using wood to simulate an object, use plywood rather than solid boards. Plywood is much stronger and resists breaking or splintering when forces are applied. Whatever materials are used, it is the evaluator's responsibility that the apparatus be safe for patient use.

<sup>1</sup>NIOSH: Work Practices Guide for Manual Lifting. Akron, OH: American Industrial Hygiene Association, 1983

<sup>2</sup>Snook SH: The Ergonomics Society: The society's lecture 1978 -"The design of manual handling tasks". Ergonomics 21(12): 963-985, 1978

<sup>3</sup>Khalil TM, Waly SM, et al.: Determination of lifting abilities: a comparative study of four techniques. Am Ind Hyg Assoc J 48(12): 951-956, 1987

<sup>4</sup>Troup JDG, Foreman TK, et al.: The perception of back pain and the role of psychophysical tests of lifting capacity. Spine 12(7): 645-657, 1987

<sup>5</sup>Mayer TG, Barnes MA, et al.: Progressive isoinertial lifting evaluation: I. a standardized protocol and normative database. Spine 13(9): 993-997, 1988

<sup>6</sup>Sharp MA, Legg SJ: Effects of psychophysical lifting training on maximal repetitive lifting capacity. Am Ind Hyg Assoc J 49(12): 639-644, 1988

<sup>7</sup>Garg A, Mital A, Asfour SS: A comparison of isometric and dynamic lifting capability. Ergonomics 23(1): 13-27, 1980

<sup>8</sup>Battie MC, Bigos SJ, et al.: Isometric lifting strength as a predictor of industrial back pain reports. Spine 14(8): 851-56, 1989

<sup>9</sup>Niemeyer LO, Matheson LN, Carlton RS: Testing consistency of effort: BTE Primus. Industrial Rehab. Quarterly 2(1): 5-32, 1989

<sup>10</sup>Zeh J, Hansson T, et al: Isometric strength testing: recommendations based on a statistical analysis of the procedure. Spine 11(1): 43-46, 1986

<sup>11</sup>Mayer TG, Barnes MA, et al.: Progressive isoinertial lifting evaluation: II. a comparison with isokinetic lifting in a disabled chronic low-back pain industrial population. Spine 13(9): 998-1002, 1988

<sup>12</sup>Mital A: The psychophysical approach in manual lifting - A verification study. Human Factors 25(5): 485-491, 1983 <sup>13</sup>Kroemer KHE: An isoinertial technique to assess individual lifting capability. Human Factors 25: 493-506, 1983

<sup>14</sup>Griffin AB, Troup JDG, Lloyd DCEF: Tests of lifting and handling capacity: Their repeatability and relationship to back symptoms. Ergonomics 27: 305-320, 1984

<sup>15</sup>Foreman TK, Baxter CE, Troup JDG: Ratings of acceptable load and maximal isometric lifting strengths: The effects of repetition. Ergonomics 27: 1283-1288, 1984

<sup>16</sup>Khalil TM, Goldberg ML, et al: Acceptable maximum effort (AME): A psychophysical measure of strength in back pain patients. Spine 12(4): 372-376, 1987

<sup>17</sup>Isernhagen SJ: Return to work testing. Ortho Phys Ther Clinics 1(1): 83-98, 1992

<sup>18</sup>Isernhagen SJ: Work Injury - Management and Prevention. Rockville, MD: Aspen Publishers, 1988

## PROCEDURE/DESCRIPTION FOR LIFTING AND OTHER EVALUATIONS USING THE #191 CABLE SYSTEM

1. Choose "LIFT/PUSH/PULL" at the EVALUATION sub-menu.
2. Set up #191 to the desired position for the movement pattern you are doing. Be sure to adjust the height of the exercise head and choose the appropriate range-of-motion locator hole in order to achieve the desired starting height and angle for the activity being tested.
3. Verbally describe the procedure:
  - "this is a test to determine the maximum amount of weight you can lift (push, or pull);
  - you will be instructed how to do the lift/push/pull and then we will begin the test;- you will be asked to perform the task once, after which I will ask you if you can handle more weight;
  - after each repetition, I will increase the amount of weight, but only with your approval;
  - there will be a minimum of 15 seconds rest between each repetition; wait until I give you permission to perform the next rep;
  - during the test, you are to maintain the same position and not alter the position of your feet."
4. Demonstrate the movement being tested and the proper positioning for that activity. This may be specific to a simulated job task, PNF pattern, or it may be one of the standard dynamic lift ranges described in the Work Practices Guide for Manual Lifting. (Three of these standard lifts are described in this manual.)
5. With the resistance at five lbs., give the patient a practice trial, allowing him/her to practice the activity. This gives the therapist an opportunity to observe body mechanics and to assure that the patient understands what is required during the testing procedure. It is the therapist's responsibility at this point to teach the patient the proper way to execute the movement pattern and to ensure that the he/she is capable of performing the activity in a safe manner.
6. After the patient has properly demonstrated the movement being tested, begin the test following the guidelines discussed earlier in this chapter and the instructions in the BTE Primus<sup>RS</sup> Operator's Manual.
7. Allow a minimum of 15 seconds between each lift/push/pull. If the patient is moderately deconditioned, a longer rest period will be necessary. Increasing the duration of the rest break from 15 seconds is permissible as long as it remains consistent.
8. After each lift, ask the patient if he/she can handle more weight. Adjust the weight with the patient's approval.

**NOTE: Gradually increase the load lifted/pushed/pulled by 5 to 10 pounds. Touch the weight adjustment areas on the screen until the desired change is noted.**

9. Discontinue the test when one or more of the following occur:

- a. patient refuses to continue, feeling that maximum has been reached and/or fearing injury if the load is increased;
- b. patient can no longer handle the load, demonstrating hesitancy or stalling, a change in velocity, difficulty or inability to complete the range, recruitment of additional muscle groups, or signs of fatigue;
- c. patient demonstrates improper body mechanics or techniques, increasing risk of injury; or
- d. therapist feels that additional weight would put the patient at risk of injury despite the use of proper body mechanics and load handling techniques.

# TASK ANALYSIS AND MEASUREMENT

As the demand for functional evaluations related to work and home activities, as well as pre-placement/post-offer screenings increases, therapists are responding by developing programs and providing such services. As providers, you must be concerned that you are offering accurate, time efficient, cost effective treatment and evaluation data to the client, physician, rehabilitation worker, insurance carrier, employer, and attorney.

The value of proficient task analysis skills are realized here. Information obtained from a job site or home visit allows the therapist to recognize the physical demands of a task and construct a comprehensive rehabilitation program for an injured person. Using the data obtained from the site permits the clinician to accurately assess the current level of a patient's physical abilities to perform that task and design a treatment program that is geared toward meeting the physical demands of that task. Upon completion of the rehabilitation course, an intelligent decision can be made about the patient's ability to perform and return to that activity. Questions such as "can he/she do the job", "is light-duty indicated", "can he/she return to an independent lifestyle at home", "are modifications necessary", can be accurately answered.

We recognize that proficiency comes with experience but basic knowledge is a necessary element. It is our purpose, therefore, to provide information to assist you in the process of task analysis. This section is certainly not a detailed "how to", but provides a brief overview to those considering or just beginning to do task analysis in the home and at worksites.

## WHY DO A SITE VISIT?

When looking at an individual's ability to perform a particular task, it is unrealistic to predict that person's ability based on scores generated from standardized tests. Standardized tests have been developed to evaluate specific physical skills and do not indicate whether or not a person can meet the physical demands of a job or other activity. Given that the strengths of different muscles are weakly correlated, even within a subject, it is not possible to test isolated joints and make a conclusion regarding a person's functional ability based on those tests. For example, if asked to determine a person's ability to ride a bike, it would not be accurate to test range of motion, muscle strength, etc. and judge whether that person can ride a bike. Likewise, it would be unfair to say that a person with limited range of motion of one knee could not ride a bike. Thus, there are no such things as job norms, only job requirements. As a result, testing needs to be job specific.

When dealing with a worker's ability to perform a specific job, the ADA states that job decisions cannot be made based on norms since they do not accurately indicate whether or not a person can do a job. According to the Work Practices Guide for Manual Lifting,<sup>1</sup> page 36, "...when it is necessary to determine a person's ability to perform a particular job element, it is often more accurate to simulate the job's activity in a strength test, rather than trying to predict job strength from standardized tests." Therefore, a thorough process of analyzing specific job demands and testing under simulated circumstances is a critical step in determining a person's ability to handle job demands safely.

A job site analysis is critical for understanding what is required on the job. Knowing the physical demands of the job leads to an accurate evaluation of a person's ability to meet specific job requirements. If unable to perform a job site analysis, contact the case worker, rehabilitation nurse, or rehabilitation specialist so he/she can do the job site analysis for you.

The purpose of a job site visit is multifold. It can provide very specific information about a client's job tasks, enabling the therapist to design a more effective treatment program with realistic goals. In work hardening, more realistic work simulations are possible. In evaluation, the information is used to plan aspects of a work capacity evaluation. It allows the appropriate tests to be chosen; standardized tests as well as physical demands aspects.

If the client is unable to return to his previous job, his current physical capabilities and limitations are documented and can be used by the rehabilitation worker, employer, and others in identifying realistic job possibilities.

Analysis of job tasks requires the therapist to recognize components to be assessed. View the task as a whole, then in components, and lastly as a whole again. The physical demands of each task must be noted. These may include:

lifting	bending
carrying	reaching
pushing	twisting/rotation
pulling	jumping
sitting	climbing (stairs, ladders, etc.)
kneeling	balancing
squatting/crouching	handling
crawling	grasp and release
reclining	fingering (fine motor skills)
standing	positioning
walking	eye/hand coordination

Analysis of tasks can be easily done by body parts; head and neck, trunk, arms, fingers/hands, and legs and feet. Measurement of these demands should include frequency, duration, rate, force/torque/resistance/load, appropriate distances, extremes of ranges of motion of all body parts necessary to perform the task, and static and dynamic postures. The body's center of gravity and how it is altered/shifted during the activity and/or by the load must be considered.

This type of evaluation is also very valuable when evaluating a patient's ability to remain independent at home and to determine what adaptive equipment if any is necessary for independence.

## **BENEFITS**

Numerous benefits are obtained from a site visit. Knowing the details of each task allows the clinician to assess the client's performance specific to the task and then pass pertinent information along to others involved in the rehabilitation process. Others players in the process include the physician, rehabilitation worker, employer, insurance carrier, and attorney(s). The end-product is an intelligent, objective decision regarding the client's level of performance in relation to the requirements of work and home life.

For the therapist, the visit serves to educate him or her and allow for development of a realistic rehabilitation program which is very goal specific. In performing a work capacity evaluation, the therapist has first hand knowledge about details of the job and is able to perform a thorough evaluation, resulting in an intelligent recommendation of the client's ability to return to work. The



feasibility of alternatives/adaptations to environment, equipment, work schedule, and work assignment is also realized.

As an aside, a job site visit provides a marketing opportunity for you as the therapist. Direct contact with employers allows you to detail your services and to describe what benefit they can be to the company.

The client benefits from the knowledge that the therapist gains since the treatment program is very specific to the job or task. Realistic simulations allow him or her to "practice" the tasks, thereby improving his skills and increasing his confidence level. This also allows the patient to learn and practice alternative methods of accomplishing tasks with increasing proficiency and with less stress. As a result, fear and anxiety are decreased since the client knows what to expect upon return to work.

For the physician, objective data are at his/her disposal, allowing for a conclusive decision regarding the patient's ability to return to work. Work restrictions, if indicated, can be specific rather than guesswork.

### **THE VISIT**

A certain amount of planning is involved with a job site visit. First, approval from the insurance carrier is necessary. Once approved, the employer must be contacted directly by the therapist or through the rehabilitation worker. The contact person varies from one company to another, but the primary contacts are in medical services, personnel, and safety departments. An explanation of the purpose(s) of the visit should be provided, briefly describing the information gathering process. Detail what will be done and why. Determine a mutually agreeable date and time, and ask for permission for videotaping and/or picture-taking. Inquire about necessary attire, directions to the company, where to go on arrival, and appropriate names.

Upon arrival at the company, you most likely will be met by the supervisor or foreman. While walking to the job station, ask the supervisor to provide you with a verbal description of the job. Mentally compare this information to that provided by the employee. Check for any discrepancies. Next, you want to observe a worker performing the job task. Watch him for fifteen to twenty minutes (time is dependent on the complexity of the task being observed). If possible, videotape or take still shots to visually record performance required by the task.

There are many aspects of the work environment which should be assessed. Work surface, thermal and visual environments, physical demands, tools, and other factors that can affect work performance capabilities. For example, in documenting environmental conditions note temperature and humidity, noise, odors, fumes, smoke, dust, lighting, etc. Be sure to also note the presence of hazards; wet floors, moving parts, sharp objects, and the like.

Floor surface material, texture, and condition are important to consider, particularly if dealing with back and lower extremity injuries and conditions. Is the work surface concrete, wood, or carpeted? Is it wet or dry? Many of these factors can increase stresses on the back and lower extremities and lead to high risk of slipping, tripping, etc.

Thermal environment must be noted as many medical conditions are affected by cold, extreme heat, humidity, etc.

Visual environment and requirements should be documented. What is the amount of light available? Is vision-eliminated work required?

Physical demands of the job are, of course, the primary focus of the visit. It is important to assess work postures; are they mechanically advantageous or disadvantageous? What hazards or risks are posed by this posture to the worker? What alternatives are there which do not interfere with the performance of the task? Measure and document the actual loads that are handled and the frequency of that handling.

The following is a listing of physical demands which are of importance to the evaluator:

lifting	squatting/crouching
carrying	kneeling
pushing	crawling
pulling	reclining
standing	climbing (stairs, curbs, ramps, ladders)
walking	reaching
running	handling/grasping
jumping	release
sitting	positioning
bending	fingering
twisting (rotation)	eye/hand coordination
pivoting	

Measurements of these tasks should include:

frequency	duration
rate	distance involved
static or dynamic	extremes of ROM of all body parts

If a load or force is involved, what is the weight, shape, dimensions, position relative to the body (horizontal distance between center of gravity (COG) of the load and COG of the body), and the displacement of the load (starting and ending points). Is moving of materials/loads done by the worker or by mechanical means (conveyor, crane, hoist, or other industrial vehicle), or a combination of both?

Tools, machines, and other accessories required by the job must also be evaluated. Frequency, duration, and distance of use; the weight, forces, or torques involved; vibration; and other forces (ie. impact, distraction) resultant to their use must be assessed. Make note of handles - size, shape, surface texture, etc. Consider any mechanical, thermal, vibratory, circulatory, compressive, or distractive stresses that result due to usage of the tool. When assessing machinery, determine what risk factors are involved; for example, moving and sharp parts of machines.

Any attire that is worn by the worker should be noted. Safety helmets, glasses, shoes, gloves, and tool belts must be included in the task evaluation. Safety shoes and tool belts add to body weight, gloves affect handling capabilities and dexterity. These are important aspects that cannot be neglected.

Once you have completed data collection, review the information with the supervisor. Summarize

the job demands and ask for any necessary clarifications. Discuss the possibility of modifications to the work schedule, task frequency and duration, weights/loads, tools, work station, and work environment. Have the supervisor define the company's return to work policy, availability and examples of light-duty jobs, and the feasibility of job transfers.

### **WHEN SHOULD I DO THE VISIT?**

Ideally a job site visit is performed in the early phase of treatment. The valuable information gained allows the therapist to design more realistic treatment programs and simulations which are beneficial to both the therapist and the worker. Otherwise a visit should be included in the plans for preparation for discharge.

As it is not realistic to do a visit for every client, it is important to identify types of jobs, diagnoses, clients, etc. that "require" a site visit. Priorities would probably be placed on those jobs involving repetitive motion tasks (i.e. assembly, packaging, and food processing), high risk jobs, and "out of the ordinary" jobs. Cases involving cumulative trauma disorders and serious injury with considerable residual deficits should also have priority. In any case, if you have difficulty visualizing the job, if the client's accuracy of reporting is insufficient or questionable, and/or if there are discrepancies between the reports given by the employee and employer, a visit is recommended.

### **WHAT EQUIPMENT NEEDED IS NEEDED?**

To determine what the job demands and to gather necessary data related to the work environment, various pieces of equipment are needed. To adequately analyze the multitude of job tasks that exist, the following equipment is needed:

**FORCE GAUGE:** A force gauge is used to determine forces applied during the activity being analyzed. It is recommended that the gauge be designed to measure both tension and compression, that it include a selection of accessories which allow for measurement of pushing, pulling, and lifting, that it have two handles for easy handling, and that it have a maximum reading indicator. It is important that appropriate forces be measured when analyzing activity; for example, the amount of force it takes to move a cart is not necessarily indicative of the amount of weight placed on that cart. Unless a person has to load and/or unload the cart, knowing the weight on the cart is not important. It is also important to remember that it takes a greater force to initiate the movement of an object than it does to keep that object moving.

**TAPE MEASURE:** Tape measures are used to measure linear distances in which objects are moved, work heights, reaching distances, dimensions of objects/loads, and lengths of lever arms.

**STOPWATCH:** A stopwatch is necessary to measure the amount of time it takes to complete a full task (task duration) or elements of a task. To determine frequency of activity, divide the duration of the task by the number of repetitions.

**SCALE:** In order to determine the weights of objects moved, a scale must be available. It is recommended that a scale with a remote read-out be used in case the object being weighed covers the dial of the scale.

**THERMOMETER:** A thermometer is required to record the temperature of the work environment or materials with which they work.

**GONIOMETER:** Goniometers can be used to measure postures and ranges of motion required of the worker by the task and distances necessary to turn objects; for example, wheels, valves, knobs.

**PEDOMETER:** To record distances walked, use a pedometer.

**CAMERA/VIDEO:** Cameras and video-recorders allow you to record actual work environments, work positions, and job activities. It is strongly recommended that permission be obtained prior to using photography at the work place.

**SAFETY GLASSES OR GOGGLES:** Many work sites require the use of safety glasses or goggles. Take your own pair with you on the visit.

**GRAPH PAPER:** Graph paper is useful if it becomes necessary to sketch a work station, machine, or tool to scale.

**DICTAPHONE:** A dictaphone is useful to record general observations while walking through the work area. The work atmosphere, lighting, and other pertinent environmental data can be verbalized rather than written for time efficiency.

**PATIENT:** Whenever possible, bring the patient with you when performing the job site analysis. This will help you identify specifically what needs to be done, especially if there is a conflict of information received from the patient and his/her supervisor regarding job requirements. The patient may have the opportunity to overcome psychological barriers interfering with the ability to go back to work by having him/her demonstrate the job task. He may find that he has the strength to perform the job.

The following test protocols can serve as a portion of a functional capacity assessment. If your goal is to document functional performance of the upper extremities only, these protocols can complete the assessment when coupled with the standard evaluations (range of motion measurement, MMT, strength testing using a Jamar dynamometer and pinch meter, sensory evaluation, and dexterity tests). If the goal of the evaluation is to measure employability, the protocols represent a lesser portion of the total assessment.

The statistics for the following protocols were gathered on the BTE Work Simulator. Unless otherwise specified, the attachments remain the same and the procedure is the same, therefore they can also be applied to the BTE Primus when the Standard Protocol is used.

These protocols are applicable to a FCA as they provide a means to measure various aspects of functional performance; i.e., maximum strength, dynamic power and endurance. If you incorporate all the sections of this manual, you should feel comfortable in using the test data in defining functional capabilities.

## GRIP STRENGTH

The grip tool for the Primus has been designed to closely match the Jamar grip dynamometer, both in handle shape and position. This allows you to use the grip attachment in much the same way you would use the Jamar dynamometer. The protocols you are familiar with, the five position "bell curve" test, position two and three peak strength test, and rapid exchange test can be administered on the Primus.

In a preliminary comparison study between the Primus grip tool and the Jamar dynamometer. A very high correlation was found to exist. All five positions on both devices were tested and compared. In addition, intra-instrument correlations were made to establish each tools reliability. The Jamar dynamometer received an overall correlation of 0.9774 (1.0 is a perfect score). The Primus received an overall correlation of 0.9753. The overall correlation between the Jamar and the Primus was 0.9285.

The correlation coefficient for each of the five handle positions were as follows:

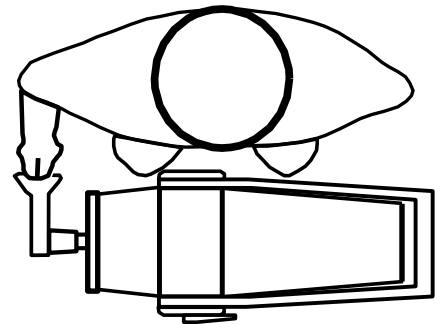
<u>Handle Position</u>	<u>Jamar</u>	<u>Primus</u>	<u>Jamar/Primus</u>
I	0.9089	0.9395	0.7330
II	0.9751	0.9722	0.9274
III	0.9825	0.9841	0.9432
IV	0.9777	0.9734	0.9541
V	0.9859	0.9627	0.9181
All Positions	0.9774	0.9753	0.9285

With the exception of position I, all positions exhibited a high to very high correlation between the two devices. Because of the high correlation between the two "power positions" (positions II and III), established normative data for the Jamar should be applicable to the Primus. Further research is needed and encouraged to confirm these preliminary findings.

# GUIDELINES FOR TESTING 3-JAW CHUCK

## Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #5).
2. Place the pin in position #1. No other changes need to be made to this tool and doing so will make normative comparisons invalid.
3. Insert tool #151 with the support arm placed in hole H, the top left hole on the face of the exercise head.
4. Demonstrate to the subject the function being tested (3-jaw chuck), and the proper positioning as described below.
5. Position the subject to the left side of and facing the exercise head. **When testing the right hand**, have the subject stand with the exercise head directly in front of him/her. **When testing the left hand**, have the subject take a step to the right so that the exercise head is NOT directly in front of him/her (see figure 1).



**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous, test the right side first.**

6. The hand position is as follows: the pads of the index and middle fingers should be placed on the flat surface of the top handle of the tool, and the pad of the thumb should be centrally placed under the flat surface of the bottom handle.
7. Adjust the height of the exercise head so that the subject is able to comfortably pinch the handles. The shoulder should be in zero (0) degrees of flexion, adducted, and neutral with regard to rotation. The elbow should be positioned in approximately 90 degrees of flexion, the forearm in pronation, and the wrist in neutral (0 to 15 degrees of extension) with zero (0) degrees of ulnar deviation. Enter the height in the set-up parameters. The height should be the same for both static and dynamic tests.
8. The test position is as follows: the subject should be standing with feet even in stance, flat on the floor, and shoulder width apart; shoulders should be level, adducted, and neutral with regard to rotation; both arms should be at the subject's side; and on the side being tested, the forearm should be pronated and the wrist should be in neutral with 0 to 15 degrees of extension and zero (0) degrees of deviation (see figure 2).

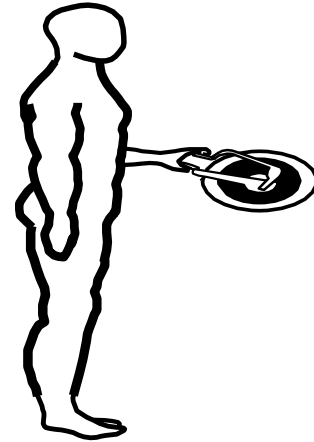
**NOTE: Do NOT allow the subject to use substitution patterns.**

9. If you wish to have the results reported in pounds instead of inch-pounds, measure the distance from the center of the shaft to the center of the point of pressure applied to the tool or look on page 212 of the Primus Operator's Manual for the appropriate lever length. Enter this number at the test screen by touching the LEVER LENGTH box.

10. Verbally describe the procedure:
- exert maximum effort during the test,
  - the tool will not move, we are only measuring effort applied,
  - do not jerk the tool,
  - effort should be applied in a smooth but rapid manner, and
  - maximum effort should be reached in 2 to 3 seconds.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

11. Allow the subject one trial at sub-maximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.



12. Turn the computer monitor so that the subject cannot see the displays.

13. Make sure that the tool is securely attached, the subject properly positioned. Touch BEGIN TRIAL to begin trial 1.

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

14. Proceed through the three trials touching BEGIN and END TRIAL as appropriate. Maximum effort should be reached within 2 to 3 seconds which may be indicated by a noticeable physiological tremor. Once maximum has been reached, tell the subject to relax momentarily but to NOT change hand or body position. Allow five (5) second rest periods in between trials.

**NOTE: Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may significantly alter data due to a change in leverage.**

15. Reposition the subject for pinch strength testing of the non-dominant or involved side (the tool should NOT be repositioned) and repeat Steps 11 through 14.

### Dynamic Testing

1. Select DYNAMIC TEST at the bottom of the screen to continue with a power test.

**NOTE: Tool set up and subject positioning for dynamic testing should NOT change from that used during isometric testing.**



2. The torque will set itself at one-half (1/2) the average isometric strength of the movement being tested. Each side will be tested using a different torque unless the average isometric strength on both sides is equal.
3. Verbally describe the procedures:
  - you will be timed for ten seconds,
  - move through full range of motion,
  - move as quickly as possible,
  - do as many repetitions as possible,
  - continue until I tell you to "stop", and
  - do not begin until I say "go".

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

4. Reposition the subject as stated in Steps 5 through 8 under Isometric Testing procedures.
5. Demonstrate to the subject the motion being tested (3-jaw chuck), and the proper positioning as described above. Touch BEGIN TRIAL and give the subject two practice trials to become familiar with the "feel" of the resistance set on the tool. Observe the subject for correct movement patterns. Let the remaining time run out and then select REDO TRIAL to erase the practice trials.

**NOTE: Do NOT allow the subject to use substitution patterns.**

6. Proceed through the trial by touching the BEGIN TRIAL box and instructing the patient to "GO".
7. Reposition the subject for the same test using the non-dominant or involved side (the tool should NOT be repositioned) and repeat Steps 4 through 6.

## 3-JAW CHUCK PINCH DESCRIPTIVE STATISTICS

### MALES -

N = 31

Age - minimum = 24  
           maximum = 75  
           mean = 41.7  
           S.D. = 12.6

Dominance - right-handed = 29  
                   left-handed = 2

### TEST STATISTICS

	<b>Dominant</b>		<b>Nondominant</b>	
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Isometric</u>	<u>(C.V.)</u>
minimum -	89.0	0.6	109.0	0.5
maximum -	292.0	10.4	284.0	12.7
mean -	181.1	4.4	181.1	5.1
S.D. -	46.2	2.8	45.1	3.0

### FEMALES -

N = 21

Age - minimum = 25  
           maximum = 46  
           mean = 35.5  
           S.D. = 7.3

Dominance - right-handed = 20  
                   left-handed = 1

### TEST STATISTICS

	<b>Dominant</b>		<b>Nondominant</b>	
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Isometric</u>	<u>(C.V.)</u>
minimum -	60.0	0.9	68.0	1.6
maximum -	160.0	11.7	154.0	14.8
mean -	116.5	4.1	111.4	5.9
S.D. -	28.0	2.6	24.4	3.4

## TOTAL SAMPLE POPULATION -

N = 52

Age - minimum = 24

maximum = 75

mean = 39.2

S.D. = 11.1

Dominance - right-handed = 49

left-handed = 3

## TEST STATISTICS

	<b>Dominant</b>		<b>Nondominant</b>	
	<u>Isometric (C.V.)</u>		<u>Isometric (C.V.)</u>	
minimum -	60.0	0.6	68.0	0.5
maximum -	292.0	11.7	284.0	14.8
mean -	155.5	4.3	155.0	5.4
S.D. -	50.9	2.7	51.3	3.2

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

<b>Dominant</b>	<b>Nondominant</b>
<u>Isometric</u>	<u>Isometric</u>
0.681	0.966

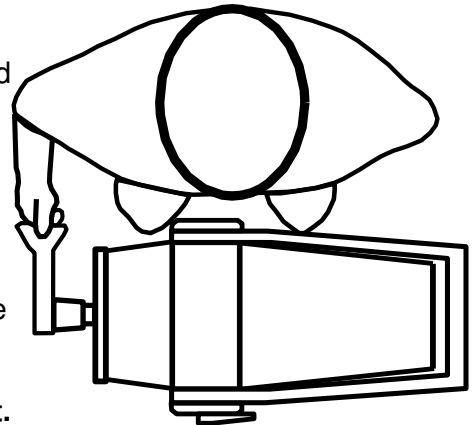
## PERCENTILE CHARTS:

<b>ALL MALES (AGE 24-75)</b>							<b>N=31</b>
<b>3-JAW CHUCK PINCH - Attachment #151</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	73	122	150	181	212	240	289
Nondominant	76	123	151	181	212	239	286
<b>ALL FEMALES (AGE 25-45)</b>							<b>N=21</b>
<b>3-JAW CHUCK PINCH - Attachment #151</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	51	81	98	117	135	152	182
Nondominant	55	80	95	111	128	143	168

# GUIDELINES FOR TESTING LATERAL PINCH

## Isometric Testing

1. Place the exercise head in the horizontal position, shaft facing forward (position #5).
2. Place the pin in position #1. No other changes need to be made to this tool and doing so will make test results invalid.
3. Insert tool #151 with the support arm placed in hole F, the bottom left hole on the face of the exercise head.
4. Demonstrate to the subject the motion being tested (lateral pinch), and the proper positioning as described below.
5. Position the subject to the left side of and facing the exercise head. **When testing the right hand**, have the subject stand with the exercise head directly in front of him/her. **When testing the left hand**, have the subject take a step to the right so that the exercise head is NOT directly in front of him/her (see figure 1).



**NOTE: Test the dominant or uninvolved side first.  
If the subject is ambidextrous, test the right side first.**

6. The hand position is as follows: the pad of the thumb of the hand being tested should be centrally placed on the flat surface of the top handle of the tool, and the lateral (radial) side of the index finger fingers should be centrally placed under the flat surface of the bottom handle.
7. Adjust the height of the exercise head so that the subject is able to comfortably pinch the handles. The shoulder should be in zero (0) degrees of flexion, adducted, and neutral with regard to rotation. The elbow should be positioned in approximately 90 degrees of flexion, the forearm should be in neutral, and the wrist should be in neutral (0 to 15 degrees of extension) with zero (0) degrees of ulnar deviation. Enter the height in the set-up parameters. The height should be the same for both static and dynamic tests.
8. The test position is as follows: the subject should be standing with feet even in stance, flat on the floor, and shoulder width apart; shoulders should be level, adducted, and neutral with regard to rotation; both arms should be at the subject's side; and on the side being tested, the forearm should be neutral, and the wrist should be in neutral with 0 to 15 degrees of extension and zero (0) degrees of deviation (see Figure 2).

**NOTE: Do NOT allow the subject to use substitution patterns.**

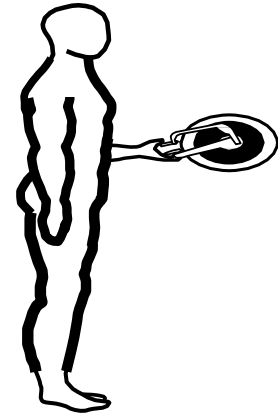
9. If you wish to have the results reported in pounds instead of inch-pounds, measure the distance from the center of the shaft to the center of the point of pressure applied to the tool or look on page 212 of the Primus Operator's Manual for the appropriate lever length. Enter

this number at the test screen by touching the LEVER LENGTH box.

10. Verbally describe the procedure:
  - exert maximum effort during the test,
  - the tool will not move, we are only measuring effort applied,
  - do not jerk the tool,
  - effort should be applied in a smooth but rapid manner, and
  - maximum effort should be reached in 2 to 3 seconds.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

11. Allow the subject one trial at submaximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.



12. Turn the computer monitor so that the subject cannot see the display.
13. Making sure that the tool is securely attached and the subject properly positioned. Touch BEGIN TRIAL to begin trial 1.

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

14. Proceed through the three trials touching BEGIN and END TRIAL as appropriate. Maximum effort should be reached within 2 to 3 seconds which may be indicated by a noticeable physiological tremor. Once maximum has been reached, tell the subject to relax momentarily but to NOT change hand or body position. Allow five (5) second rest periods in between trials.

**NOTE: Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may significantly alter data due to a change in leverage.**

15. Reposition the subject for pinch strength testing of the non-dominant or involved side (the tool should NOT be repositioned) and repeat Steps 11 through 14.

### **Dynamic Testing**

1. Select DYNAMIC TEST at the bottom of the screen to continue with the power test.

**NOTE: Tool set up and subject positioning for dynamic testing should NOT change from that used during isometric testing.**

2. The torque will set itself at one-half ( $1/2$ ) the average isometric strength of the movement being tested. Each side should be tested using a different torque unless the average isometric strength on both sides is equal.

**NOTE: When doing evaluations, set and record only the TORQUE number.**

3. Verbally describe the procedures:
- you will be timed for ten seconds,
  - move through full range of motion,
  - move as quickly as possible,
  - do as many repetitions as possible,
  - continue until I tell you to "stop", and
  - do not begin until I say "go".

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

4. Position the subject as stated in Steps 5 through 8 under Isometric Testing procedures.
5. Demonstrate to the subject the motion being tested (lateral pinch), and the proper positioning as described above. Touch BEGIN TRIAL and give the subject two practice trials to become familiar with the "feel" of the resistance set on the tool. Observe the subject for correct movement patterns. Let the remaining time run out and then select REDO TRIAL to erase the practice trials.

**NOTE: Do NOT allow the subject to use substitution patterns.**

6. Proceed through the trial by touching the BEGIN TRIAL box and instructing the patient to "GO".
7. Reposition the subject for the same test using the non-dominant or involved side (the tool should NOT be repositioned) and repeat Steps 4 through 6.

## LATERAL/KEY PINCH DESCRIPTIVE STATISTICS

### MALES -

N = 32

Age - minimum = 24

maximum = 75

mean = 41.7

S.D. = 12.4

Dominance - right-handed = 29

left-handed = 3

### TEST STATISTICS

	<b>Dominant</b>		<b>Nondominant</b>	
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Isometric</u>	<u>(C.V.)</u>
minimum -	11.0	0.2	108.0	1.3
maximum -	199.0	7.6	202.0	11.2
mean -	152.5	3.1	152.5	4.3
S.D. -	34.6	5.7	34.6	2.2

### FEMALES -

N = 21

Age - minimum = 25

maximum = 46

mean = 35.5

S.D. = 7.3

Dominance - right-handed = 20

left-handed = 1

### TEST STATISTICS

	<b>Dominant</b>		<b>Nondominant</b>	
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Isometric</u>	<u>(C.V.)</u>
minimum -	77.0	0.0	73.0	1.3
maximum -	147.0	10.5	143.0	8.6
mean -	102.9	3.3	100.5	4.2
S.D. -	18.5	2.7	19.8	2.1

## TOTAL SAMPLE POPULATION -

N = 53

Age - minimum = 24  
maximum = 75  
mean = 39.2  
S.D. = 10.9

Dominance - right-handed = 49  
left-handed = 4

## TEST STATISTICS

	<b>Dominant</b>		<b>Nondominant</b>	
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Isometric</u>	<u>(C.V.)</u>
minimum -	11.0	0.0	73.0	1.3
maximum -	199.0	10.5	202.0	11.2
mean -	132.4	3.2	133.1	4.3
S.D. -	37.9	2.2	35.7	2.1

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

<b>Dominant</b>	<b>Nondominant</b>
<u>Isometric</u>	<u>Isometric</u>
0.829	0.974

## PERCENTILE CHARTS:

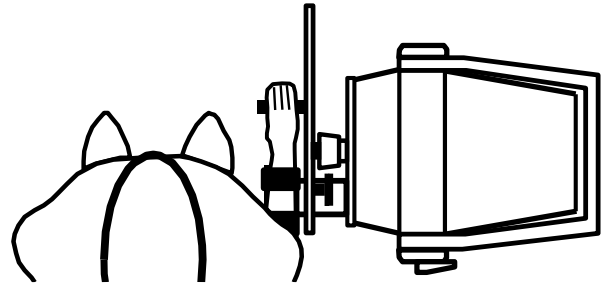
<b>ALL MALES (AGE 24-75)</b>							<b>N=31</b>
<b>LATERAL/KEY PINCH - Attachment #151</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	73	122	150	181	212	240	289
Nondominant	108	122	135	153	175	188	202
<b>ALL FEMALES (AGE 25-46)</b>							<b>N=21</b>
<b>LATERAL/KEY PINCH - Attachment #151</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	60	79	90	103	115	128	146
Nondominant	54	75	87	101	114	126	147



# GUIDELINES FOR TESTING WRIST FLEXION AND EXTENSION

## Isometric Testing

1. Place the exercise head in the horizontal position, shaft facing forward (position #5).
2. Insert attachment #701, setting the length at 3.5 inches.
3. Secure the armrest to the right side of the exercise head (see Fig. 1).
4. Demonstrate to the subject the motion being tested (either wrist flexion or extension), and the proper positioning as described below.
5. Position the subject to the right side of and facing the exercise head. The upper arm should be in the neutral position (not internally or externally rotated) and the forearm should be resting on the armrest when the height of the exercise head is properly adjusted (see Step 6).



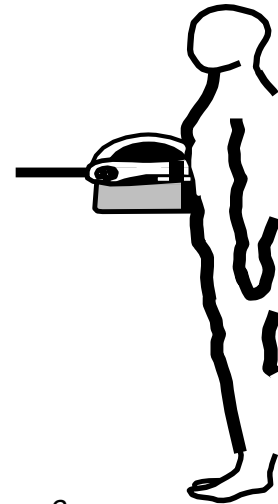
**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous, test the right side first**

6. Adjust the height of the exercise head so that the subject is able to grasp the handle of the tool while the forearm is resting in a pronated position on the arm rest and the axis of the wrist is in alignment with the exercise shaft. The elbow should be at 90 degrees of flexion, the wrist should be in neutral (0 to 15 degrees of extension) with zero (0) deviation, and the hand should be centrally placed on the handle. Enter the height in the set-up parameters. The height should be the same for both wrist flexion and extension tests.
7. Position the #701 in the horizontal plane (parallel to the floor).
8. The test position is as follows: the subject should be standing with feet even in stance, flat on the floor, and shoulder width apart; shoulders should be level, adducted, and neutral with regard to rotation; the elbow being tested should be flexed at 90 degrees; the forearm should be pronated; the wrist should be in neutral (0 to 15 degrees of extension) with zero (0) deviation; and the hand should be placed centrally on the handle. This position should be maintained throughout testing (see Fig. 2).
9. Verbally describe the procedure:
  - exert maximum effort during the test,
  - the tool will not move, we are only measuring effort applied,

- do not jerk the tool,
- effort should be applied in a smooth but rapid manner, and
- maximum effort should be reached in 2 to 3 seconds.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

10. Allow the subject one trial at submaximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.
11. Turn the computer monitor so that the subject cannot see the display.
12. Make sure the tool is securely attached and the subject is properly positioned. Touch BEGIN TRIAL to begin trial 1.



*Figure 2*

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

13. Proceed through the three trials touching BEGIN and END TRIAL as appropriate. Maximum effort should be reached within 2 to 3 seconds which may be indicated by a noticeable physiological tremor. Once maximum has been reached, tell the subject to relax momentarily but to NOT change hand or body position. Allow five (5) second rest periods in between trials.

**NOTE: Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may significantly alter data due to a change in leverage.**

14. Reposition the subject for the same test using the nondominant or involved side (the tool should NOT be repositioned) and repeat Steps 10 through 13.

### **Dynamic Testing**

1. Select DYNAMIC TEST at the bottom of the screen to continue with a power test. Select b CON/OFF mode.  
**NOTE: Except for the starting position of the wrist being tested, tool set up and subject positioning should NOT change for dynamic testing.**
2. The torque will set itself at one-half (1/2) the average isometric strength of the movement being tested. Each side will be tested using a different torque unless the average isometric strength on both sides is equal.
3. Verbally describe the procedures:

- you will be timed for ten seconds,
- move through full range of motion,
- move as quickly as possible,
- do as many repetitions as possible,
- continue until I tell you to "stop", and
- do not begin until I say "go".

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

4. Reposition the subject as stated in Steps 5 through 8 under Isometric Testing procedures. **When testing wrist flexion**, the start positioned is with the wrist in extension. **When testing wrist extension**, the start position is with the wrist in flexion.
5. Demonstrate to the subject the motion being tested (either wrist flexion or extension), and the proper positioning as described below.

**NOTE: Starting positions should be at the maximum range of motion possible from which the subject is able to initiate movement of the tool without the use of substitution patterns.**

**NOTE: Secure the forearm of the side being tested to the black platform of the armrest using the black straps as previously illustrated.**

6. Touch BEGIN TRIAL and give the subject two practice trials to become familiar with the "feel" of the resistance set on the tool. Observe the subject for correct movement patterns. Let the remaining time run out and then select REDO TEST to erase the practice trials

**NOTE: Do NOT allow the subject to use substitution patterns.**

7. Proceed through the trial using touching the BEGIN TEST box and instructing the patient to "GO".
9. Reposition the subject for the same test using the non-dominant or involved side and repeat Steps 4 through 7.

## WRIST FLEXION AND EXTENSION DESCRIPTIVE STATISTICS

### MALES -

N = 31

Age - minimum = 24

maximum = 75

mean = 41.8

S.D. = 12.6

Dominance - right-handed = 29

left-handed = 2

### TEST STATISTICS:

<b><u>WRIST FLEXION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	55.0	0.2	6241.0	61.0	0.0	7664.0
maximum -	320.0	9.7	20508.0	332.0	15.8	18579.0
mean -	204.6	4.0	12035.3	207.3	5.4	12003.0
S.D. -	63.8	2.2	3878.8	61.7	3.7	3133.8

<b><u>WRIST EXTENSION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	71.0	1.0	3081.0	11.0	0.0	3053.0
maximum -	170.0	12.6	6806.0	147.0	8.0	6572.0
mean -	107.7	4.1	4636.5	103.3	4.0	4034.6
S.D. -	25.5	3.0	952.9	28.6	1.9	927.3

## FEMALES -

N = 21

Age - minimum = 25  
maximum = 46  
mean = 35.5  
S.D. = 7.3

Dominance - right-handed = 20  
left-handed = 1

### TEST STATISTICS:

#### WRIST FLEXION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	29.0	1.6	2288.0	11.0	0.0	2510.0
maximum -	130.0	15.1	9103.0	136.0	13.0	7861.0
mean -	83.0	5.4	5716.6	82.8	5.4	5699.6
S.D. -	31.4	3.4	1628.3	35.4	2.7	1442.0

#### WRIST EXTENSION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	33.0	1.9	1313.0	26.0	1.0	1080.0
maximum -	81.0	13.5	2747.0	85.0	14.0	2993.0
mean -	60.7	5.0	2010.4	57.5	4.3	1930.1
S.D. -	14.5	3.3	495.4	15.6	3.5	570.1

## TOTAL SAMPLE POPULATION -

N = 52

Age - minimum = 24  
maximum = 75  
mean = 39.2

S.D. = 11.1

Dominance - right-handed = 49  
left-handed = 3

## TEST STATISTICS:

<b><u>WRIST FLEXION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	29.0	0.2	2288.0	11.0	0.0	2510.0
maximum -	320.0	15.1	20508.0	332.0	15.8	18579.0
mean -	157.0	4.6	8767.0	160.3	5.4	8960.0
S.D. -	80.1	2.8	4317.0	80.7	3.4	4018.9

<b><u>WRIST EXTENSION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	33.0	1.0	1313.0	11.0	0.0	1080.0
maximum -	170.0	13.5	6806.0	147.0	14.0	6572.0
mean -	89.3	4.5	3530.8	85.6	4.1	2832.0
S.D. -	31.7	3.1	1530.2	33.1	2.6	1286.7

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

<b><u>WRIST FLEXION</u></b>			
<b>Dominant</b>		<b>Nondominant</b>	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.930	0.984	0.938	0.974

<b><u>WRIST EXTENSION</u></b>			
<b>Dominant</b>		<b>Nondominant</b>	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.811	0.646	0.966	0.650

**PERCENTILE CHARTS:**

<b>ALL MALES (AGE 24-75)</b>							<b>N=31</b>
<b>WRIST FLEXION - Attachment #701</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	56	123	162	205	248	287	353
Nondominant	64	128	166	207	249	287	351
Dynamic Power - engals							
Dominant	2998	7051	9417	12035	14653	17020	21073
Nondominant	4701	7976	9888	12003	14118	16030	19305
<b>WRIST EXTENSION - Attachment #701</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	48	75	90	108	125	140	167
Nondominant	37	67	81	103	123	140	170
Dynamic Power - engals							
Dominant	2416	3412	3993	4637	5280	5861	6857
Nondominant	1874	2843	3409	4035	4661	5226	6195

<b>ALL FEMALES (AGE 25-46)</b>							<b>N=21</b>
<b>WRIST FLEXION - Attachment #701</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	10	43	62	83	104	123	156
Nondominant	0	37	59	83	107	128	165
Dynamic Power - engals							
Dominant	1923	3524	4617	5717	6816	7809	9511
Nondominant	2340	3847	4726	5800	6673	7553	9059
<b>WRIST EXTENSION - Attachment #701</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	27	42	51	61	70	79	94
Nondominant	21	37	47	58	68	78	94
Dynamic Power - engals							
Dominant	856	1374	1676	2010	2345	3647	3165
Nondominant	602	1198	1545	1930	2315	2663	3258





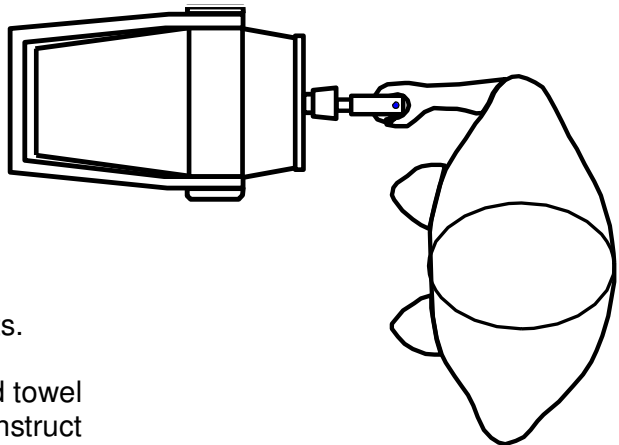
# GUIDELINES FOR TESTING SUPINATION AND PRONATION

## Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #5).
2. Insert the tool and lock it in place.
3. Demonstrate to the subject the motion being tested (either supination or pronation), and the proper positioning as described below.
4. Position the subject directly in front of and facing the exercise head. It will be necessary to ask the subject to step off to the side to allow the forearm of the extremity being tested to be in direct line with the exercise head shaft (see Figure 1).

**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous, test the right side first.**

5. Adjust the height of the exercise head so that the subject's elbow is in 90 degrees of flexion. The hand should be centrally placed on the handle so that the third metacarpal is centered with the exercise head shaft. Enter the height and other positioning information using the NOTES option. The height should be the same for both the supination and pronation tests.
6. Place the square block handle or a rolled towel between the subject's elbow and side. Instruct him/her not to let the object drop to the floor during the testing.



*Figure 1*

7. Position the #601 in the vertical plane (perpendicular to the floor).
8. The test position is as follows: the subject should be standing with feet even in stance, flat on the floor, and shoulder width apart; shoulders should be level, adducted, and neutral with regard to rotation; the elbow being tested should be flexed at 90 degrees; the forearm should be in the neutral position; the wrist should be in neutral to mild extension (0 to 15 degrees of extension) with zero (0) degrees of deviation; and the hand should be placed centrally on the handle. This position should be maintained throughout testing.

**NOTE: Do NOT allow the subject to use substitution patterns.**

10. Verbally describe the procedure:
  - exert maximum effort during the test,
  - the tool will not move, we are only measuring effort applied,
  - do not jerk the tool,

- effort should be applied in a smooth but rapid manner, and
- maximum effort should be reached in 2 to 3 seconds.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

11. Allow the subject one trial at submaximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.
12. Turn the computer monitor so that the subject cannot see the display.
13. Making sure that the tool is securely attached and the subject properly positioned. Touch BEGIN TRIAL begin trial 1.

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

14. Proceed through the three trials touching BEGIN and END TRIAL as appropriate. Maximum effort should be reached within 2 to 3 seconds which may be indicated by a noticeable physiological tremor. Once maximum has been reached, tell the subject to relax momentarily but to NOT change hand or body position. Allow five (5) second rest periods in between trials.

**NOTE: Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may significantly alter data due to a change in leverage.**

15. Reposition the subject for the same test using the nondominant or involved side (the tool should NOT be repositioned) and repeat Steps 11 through 14.

## **Dynamic Testing**

1. Select DYNAMIC TEST at the bottom of the screen to continue with a power test. Select the CON/OFF mode.

**NOTE: Except for the starting position of the extremity being tested, tool set up and subject positioning should NOT change for dynamic testing.**

2. The torque will set itself at one-half (1/2) the average isometric strength of the movement being tested. Each side will be tested using a different torque/force unless the average isometric strength on both sides is equal.
3. Verbally describe the procedures:
  - you will be timed for ten seconds,
  - move through full range of motion,

- move as quickly as possible,
- do as many repetitions as possible,
- continue until I tell you to "stop", and
- do not begin until I say "go".

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

4. Demonstrate to the subject the motion being tested (either supination or pronation), and the proper positioning as described above.
5. Reposition the subject as stated in Steps 4 through 8 under Isometric Testing procedures. **When testing supination**, the forearm should be positioned in pronation. **When testing pronation**, the forearm should be positioned in supination.

**NOTE: Starting positions should be at the maximum range of motion possible from which the subject is able to initiate movement of the tool without the use of substitution patterns.**

6. Touch BEGIN TRIAL and give the subject two practice trials to become familiar with the "feel" of the resistance set on the tool. Observe the subject for correct movement patterns. Let the remaining time run out, then select REDO TRIAL to erase the practice trials.

**NOTE: Do NOT allow the subject to use substitution patterns.**

8. Proceed through the trial using by touching the BEGIN TRIAL box and instructing the subject to "GO".
9. Reposition the subject for the same test using the nondominant or involved side and repeat Steps 5 through 8.

## SUPINATION AND PRONATION DESCRIPTIVE STATISTICS

### MALES -

N = 275

Age - minimum = 17  
 maximum = 78  
 mean = 34.3  
 S.D. = 10.5

Dominance - right-handed = 240  
 left-handed = 33  
 ambidextrous = 2

### TEST STATISTICS

<b><u>SUPINATION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	32.0	0.0	1102.0	31.0	0.0	1461.0
maximum -	230.0	21.2	27348.0	187.0	21.6	21280.0
mean -	96.1	5.3	8694.0	92.1	4.8	8154.0
S.D. -	24.9	3.6	3454.5	25.0	3.4	2974.0

<b><u>PRONATION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	35.0	0.0	1764.0	29.0	0.0	2709.0
maximum -	274.0	24.3	21032.0	226.0	20.5	19351.0
mean -	107.0	6.0	8803.0	102.0	6.1	8265.0
S.D. -	36.5	4.0	3459.0	33.7	3.8	3184.7

## FEMALES -

N = 325

Age - minimum = 17  
maximum = 64

mean = 31.4

S.D. = 8.6

Dominance - right-handed = 295

left-handed = 29

ambidextrous = 1

### TEST STATISTICS

<b><u>SUPINATION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	19.0	0.0	735.0	19.0	0.0	794.0
maximum -	100.0	24.5	12404.0	110.0	26.1	12800.0
mean -	49.7	6.1	3981.0	47.7	5.9	3846.0
S.D. -	13.1	4.4	1690.3	13.8	4.3	1609.6

<b><u>PRONATION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	18.0	0.0	687.0	14.0	0.0	621.0
maximum -	171.0	26.7	17565.0	165.0	24.5	18147.0
mean -	54.3	6.5	4078.3	50.1	6.5	3707.2
S.D. -	19.0	4.3	2019.0	18.5	4.2	1893.0

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

<b><u>SUPINATION</u></b>			
<b>Dominant</b>		<b>Nondominant</b>	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.916	0.883	0.909	0.816

<b><u>PRONATION</u></b>			
<b>Dominant</b>		<b>Nondominant</b>	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.897	0.829	0.891	0.794

# PERCENTILE CHARTS:

ALL MALES (AGE 17-78)						N=275		
SUPINATION - Attachment #601								
Percentiles		1	10	25	50	75	90	95
Isometric Strength - inch/pounds								
Dominant		49	64	76	95	110	128	175
Nondominant		37	62	75	91	107	123	162
Dynamic Power - engals								
Dominant		2200	4710	6185	8330	10389	13140	23500
Nondominant		2220	4240	6357	8010	9795	12170	16820
PRONATION - Attachment #601								
Percentiles		1	10	25	50	75	90	95
Isometric Strength - inch/pounds								
Dominant		35	52	79	104	129	150	224
Nondominant		34	62	80	100	122	147	225
Dynamic Power - engals								
Dominant		2100	4360	6415	8610	10695	12540	18640
Nondominant		2840	4220	6178	7950	9915	12510	17010

ALL FEMALES (AGE 17-64)							N=325
SUPINATION - Attachment #601							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	42	33	41	49	59	66	87
Nondominant	18	31	38	46	56	66	86
Dynamic Power - engals							
Dominant	930	2210	2798	3700	5045	6080	9660
Nondominant	980	2100	2812	3640	4685	5810	8700
PRONATION - Attachment #601							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	21	34	39	52	66	80	115
Nondominant	18	31	37	48	62	73	130
Dynamic Power - engals							
Dominant	770	1970	2675	3680	5410	6520	9500
Nondominant	900	1690	2388	3550	4735	5550	8720

MALES (AGE 17-29)											N=101
SUPINATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	52	67	80	91	96	100	104	110	114	127	146
Nondominant	36	62	74	80	88	96	99	105	113	123	143
Dynamic Power - engals											
Dominant	4440	5200	6210	7810	8650	9460	9860	10820	12130	14060	20610
Nondominant	3220	5100	6180	6650	7380	8280	9170	9580	10870	12800	16880
PRONATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	46	67	79	88	94	104	110	118	136	146	181
Nondominant	43	59	72	80	90	97	104	115	125	132	170
Dynamic Power - engals											
Dominant	2500	5190	6200	7750	8800	9350	10310	11100	12150	12980	18030
Nondominant	2800	4360	5890	6790	7500	8120	8910	9810	11150	13240	17160

MALES (AGE 30-39)											N=106
SUPINATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	32	66	75	82	87	94	100	107	115	129	150
Nondominant	31	64	72	78	87	92	98	104	112	124	162
Dynamic Power - engals											
Dominant	2090	5080	5880	6710	7510	8040	8930	9470	11170	12440	14240
Nondominant	3200	4890	6220	6920	7410	8190	8680	9190	10380	11540	14590
PRONATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	35	64	78	88	98	106	113	125	139	153	212

Nondominant	29	65	75	85	96	102	108	118	128	147	174
Dynamic Power - engals											
Dominant	1750	4960	5960	6840	7530	8620	9210	10080	11540	12900	17190
Nondominant	2830	4710	5970	6520	7090	8000	9010	9950	12550	12540	15690

MALES (AGE 40-49)											N=44
SUPINATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	51	60	72	80	84	89	104	107	112	126	152
Nondominant	50	60	65	76	80	87	99	105	109	118	154
Dynamic Power - engals											
Dominant	2230	3810	5540	6380	7080	7630	8210	8840	9560	11420	12200
Nondominant	2200	2960	4110	6510	7190	7650	7860	8650	8990	10180	11840
PRONATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	44	55	64	78	92	104	110	119	135	163	220
Nondominant	52	60	69	85	90	98	107	116	136	165	213
Dynamic Power - engals											
Dominant	2040	3590	5380	6940	7310	7590	8160	9310	9950	11610	18570
Nondominant	2700	4160	5170	6320	6820	7400	8390	8790	9810	12440	16750

MALES (AGE 50-59)											N=17
SUPINATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	49	58	65	71	74	82	91	105	120	138	167
Nondominant	43	54	63	68	73	84	86	89	100	114	140
Dynamic Power - engals											
Dominant	NA	2790	4730	5590	6570	6840	7590	8030	8890	1232	1516



										0	0
Nondominant	NA	4290	4750	5250	6540	7000	7820	8710	10440	11550	12230
<b>PRONATION - Attachment #601</b>											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	45	62	74	83	95	106	112	120	127	135	223
Nondominant	35	67	78	81	86	91	102	105	114	125	207
Dynamic Power - engals											
Dominant	NA	3720	4250	4980	6030	7170	9010	9830	10130	11470	12040
Nondominant	NA	3550	4390	6060	7510	8510	8650	9210	9320	9760	11850

<b>MALES (AGE 60-78)</b>											<b>N=7</b>
<b>SUPINATION - Attachment #601</b>											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	NA	51	54	56	59	64	67	71	81	96	109
Nondominant	NA	45	49	55	56	57	66	75	78	84	87
Dynamic Power - engals											
Dominant	NA	1020	1170	2470	2980	3790	4230	4550	4830	5490	6800
Nondominant	NA	1080	1460	2380	3300	3330	3360	4050	4750	6180	7230
<b>PRONATION - Attachment #601</b>											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	NA	81	84	87	91	96	99	102	109	124	131
Nondominant	NA	64	68	70	72	81	85	90	97	105	111
Dynamic Power - engals											
Dominant	NA	3660	3970	4080	4360	4710	4830	4860	5070	7790	8700
Nondominant	NA	3550	3730	3820	3890	3960	4070	7220	6950	7430	7610

FEMALES (AGE 17-29)											N=163
SUPINATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	26	34	39	43	47	51	54	58	61	67	97
Nondominant	20	33	37	40	44	46	50	53	61	68	91
Dynamic Power - engals											
Dominant	930	2350	2740	3030	3450	3770	4280	4900	5410	6090	9680
Nondominant	1060	2130	2680	3150	3499 0	3870	4280	4560	5140	5880	9800
PRONATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	18	33	37	43	47	50	57	63	73	81	108
Nondominant	14	30	34	39	43	49	54	59	64	73	112
Dynamic Power - engals											
Dominant	1190	2250	2590	3040	3500	3990	4670	5420	6160	6880	8970
Nondominant	1090	1800	2470	3020	3520	3850	4090	4720	5350	6230	8890

FEMALES (AGE 30-39)											N=113
SUPINATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	23	32	37	42	47	50	53	55	58	63	81
Nondominant	20	33	34	40	43	47	50	53	58	63	82
Dynamic Power - engals											
Dominant	730	2190	2520	3010	3370	3700	4080	4780	5210	5970	7700
Nondominant	790	2010	2360	2860	3210	3470	3880	4310	1460	5680	8460
PRONATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	18	33	36	41	46	50	55	58	69	80	104
Nondominant	18	30	34	37	40	46	50	56	64	74	103
Dynamic Power - engals											
Dominant	680	1820	2470	2480	3180	3490	3750	4410	5170	5770	8600
Nondominant	620	1640	2090	2630	2970	3290	3860	4290	4870	5530	9120

FEMALES (AGE 40-49)											N=34
SUPINATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	19	30	34	38	40	43	48	51	56	66	85
Nondominant	22	29	33	35	40	44	48	51	53	55	89
Dynamic Power - engals											
Dominant	1540	2170	2280	2750	3190	3620	3970	4150	4510	5890	6650
Nondominant	1560	2400	2760	3110	3480	3640	3670	3990	4400	5110	6770
PRONATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	19	35	39	41	47	52	55	58	63	76	96
Nondominant	18	29	34	41	49	51	53	56	59	38	76
Dynamic Power - engals											
Dominant	1210	1700	2250	2490	2730	3320	3840	4010	4750	5340	6810
Nondominant	1160	1470	1580	2290	2610	3140	3490	4230	4620	4750	4950

FEMALES (AGE 50-64)											N=15
SUPINATION - Attachment #160											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	24	32	37	39	43	46	48	49	53	55	64
Nondominant	21	27	36	40	42	43	44	48	49	52	57
Dynamic Power - engals											
Dominant	1650	1710	2020	2270	2530	2700	2770	2960	3010	4680	4870
Nondominant	2030	2090	2160	2180	2220	2370	2570	2930	3240	3860	5950
PRONATION - Attachment #601											
Percentiles	1	10	20	30	40	50	60	70	80	90	99
Isometric Strength - inch/pounds											
Dominant	35	38	40	41	43	50	60	65	68	73	75
Nondominant	31	33	38	40	41	44	45	52	54	63	70
Dynamic Power - engals											
Dominant	1380	1490	1790	2110	2240	2400	3180	3260	4070	4270	7437 0
Nondominant	NA	1180	1650	1860	1880	2280	2450	3180	3190	3850	3900



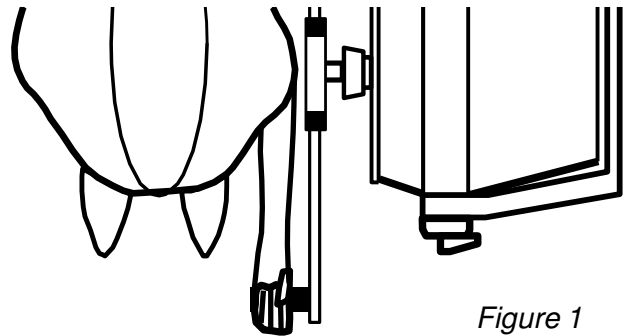
# GUIDELINES FOR TESTING ELBOW FLEXION AND EXTENSION

## Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #5).
2. Attach the cylindrical handle to position A of tool #701. Insert and secure the tool into the exercise shaft.
3. Demonstrate to the subject the motion being tested (either elbow flexion or extension), and the proper positioning as described below.
4. Position the subject in front of the exercise head with the side to be tested facing the exercise head.

**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous, test the right side first.**

5. With the upper extremity to be tested resting by the subject's side, adjust the height of the exercise head so that the axis of the exercise shaft is in alignment with the axis of the elbow joint. Enter the height in NOTES. The height should be the same for both elbow flexion and extension tests.
6. Adjust the length of the tool so that the subject is able to grasp the cylindrical handle in the palm of his/her hand while maintaining the alignment of the exercise shaft with the axis of the elbow. When the proper length has been set, securely, tighten the adjustment knob. The length will remain the same for both isometric and dynamic elbow flexion and extension tests.



*Figure 1*

7. Position the attachment so that the elbow being tested is in 90 degrees of flexion.
8. The test position is as follows: the subject should be standing with feet even in stance, flat on the floor, and shoulder width apart; shoulders should be level, adducted, and neutral with regard to rotation; the elbow being tested should be flexed at 90 degrees; the forearm should be supinated; the wrist should be in neutral (0 to 15 degrees of extension) with some radial deviation; and the hand should be placed centrally on the handle. This position should be maintained throughout testing (see Figures 1 & 2).

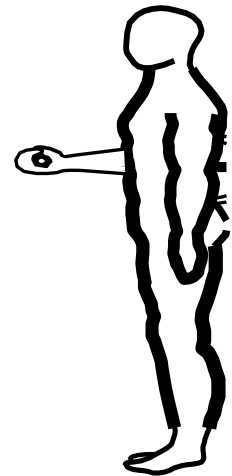
**NOTE: Do NOT allow the subject to use substitution patterns.**

10. Verbally describe the procedure:

- exert maximum effort during the test,
- the tool will not move, we are only measuring effort applied,
- do not jerk the tool,
- effort should be applied in a smooth but rapid manner, and
- maximum effort should be reached in 2 to 3 seconds.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

11. Allow the subject one trial at sub-maximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.
12. Turn the computer monitor so that the subject cannot see the display.
13. Making sure that the tool is securely attached and the subject properly positioned. Touch BEGIN TRIAL to begin trial 1.



*Figure 2*

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

14. Proceed through the three trials touching BEGIN and END TRIAL as appropriate. Maximum effort should be reached within 2 to 3 seconds which may be indicated by a noticeable physiological tremor. Once the maximum has been reached, tell the subject to relax momentarily but to NOT change hand or body position. Allow five (5) second rest periods in between trials.

**NOTE: Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may significantly alter data due to a change in leverage.**

15. In order to test the nondominant or injured extremity, the tool must be rotated 180 degrees. Use the UNLOCK TOOL button to release the attachment, reposition it, then touch LOCK TOOL to lock it in place. Reposition the subject for the same test, repeating Steps 11 through 14.

## **Dynamic Testing**

1. Select DYNAMIC TEST at the bottom of the screen to continue with a power test. Select the CON/OFF mode.

**NOTE: Except for the starting position of the elbow being tested, tool set up and subject positioning should NOT change for dynamic testing.**

2. The torque will set itself at one-half (1/2) the average isometric strength of the movement being tested. Each side should be tested using a different torque/force unless the average

isometric strength on both sides is equal.

3. Verbally describe the procedures:
  - you will be timed for ten seconds,
  - move through full range of motion,
  - move as quickly as possible,
  - do as many repetitions as possible,
  - continue until I tell you to "stop", and
  - do not begin until I say "go".

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

4. Except for the starting position of the side being tested, reposition the subject as stated in Steps 4 through 8 under Isometric Testing procedures. **When testing elbow flexion**, the elbow should be positioned in extension. **When testing elbow extension**, the elbow should be positioned in flexion.

**NOTE: Starting positions should be at the maximum range of motion possible from which the subject is able to initiate movement of the tool without the use of substitution patterns.**

5. Demonstrate to the subject the motion being tested (either elbow flexion or extension), and the proper positioning as described below. Touch BEGIN TRIAL and give the subject two practice trials to become familiar with the "feel" of the resistance set on the tool. Observe the subject for correct movement patterns. Let the remaining time run out and then select REDO TRIAL to erase the practice trials.

**NOTE: Do NOT allow the subject to use substitution patterns.**

6. Proceed through the trial by touching the BEGIN TRIAL box and instructing the patient to "GO".
7. Reposition the subject for the same test using the non-dominant or involved side and repeat Steps 4 through 6.

# ELBOW FLEXION AND EXTENSION DESCRIPTIVE STATISTICS

## MALES -

N = 31

Age - minimum = 24

maximum = 75

mean = 41.6

S.D. = 12.6

Dominance - right-handed = 30

left-handed = 1

## TEST STATISTICS

### ELBOW FLEXION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	232.0	0.4	15669.0	241.0	0.6	16057.0
maximum -	728.0	11.2	43270.0	723.0	8.1	40860.0
mean -	548.8	3.6	26922.3	533.4	2.9	27774.0
S.D. -	126.5	2.4	7407.5	113.0	1.9	7097.7

### ELBOW EXTENSION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	225.0	0.1	12777.0	254.0	0.9	14958.0
maximum -	706.0	9.5	44906.0	688.0	8.1	48622.0
mean -	455.2	3.8	27488.5	464.2	3.5	26523.9
S.D. -	131.6	2.5	8304.2	126.5	1.8	8071.8



## FEMALES -

N = 21

Age - minimum = 25

maximum = 46

mean = 35.5

S.D. = 7.3

Dominance - right-handed = 20

left-handed = 1

### TEST STATISTICS

#### ELBOW FLEXION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	111.0	0.6	4143.0	118.0	0.2	4737.0
maximum -	359.0	10.8	19465.0	346.0	8.7	19175.0
mean -	252.8	4.8	11189.3	255.2	3.4	11590.5
S.D. -	67.5	2.9	3658.1	65.1	2.0	3607.2

#### ELBOW EXTENSION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	83.0	0.4	6670.0	88.0	0.4	5350.0
maximum -	353.0	13.3	19635.0	337.0	11.3	21703.0
mean -	215.6	3.6	13247.2	225.3	3.3	14528.6
S.D. -	63.6	3.2	3568.0	69.7	2.5	4486.1

## TOTAL SAMPLE POPULATION -

N = 52

Age - minimum = 24

maximum = 75

mean = 39.2

S.D. = 11.1

Dominance - right-handed = 50

left-handed = 2

## TEST STATISTICS

### ELBOW FLEXION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	111.0	0.4	4143.0	118.0	0.2	4737.0
maximum -	728.0	11.2	43270.0	723.0	8.7	40860.0
mean -	424.9	4.1	18593.1	423.4	3.1	20719.6
S.D. -	181.1	2.7	9765.8	167.8	1.9	9970.7

### ELBOW EXTENSION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	83.0	0.1	6670.0	88.0	0.4	5350.0
maximum -	706.0	13.3	44906.0	688.0	11.3	48622.0
mean -	361.4	3.7	19922.8	370.7	3.4	19776.6
S.D. -	161.0	2.7	9478.8	159.2	2.1	8655.1

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

### ELBOW FLEXION

Dominant		Nondominant	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.958	0.883	0.978	0.942

### ELBOW EXTENSION

Dominant		Nondominant	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.725	0.876	0.869	0.929

**PERCENTILE CHARTS:**

<b>ALL MALES (AGE 24-75)</b>							<b>N=31</b>
<b>ELBOW FLEXION - Attachment #701</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	254	386	463	549	634	711	844
Nondominant	270	388	457	533	610	679	797
Dynamic Power - engals							
Dominant	9663	17404	21922	26922	31922	36441	44182
Nondominant	11236	18653	22983	27774	32565	36895	44312
<b>ELBOW EXTENSION - Attachment #701</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	149	286	366	455	544	624	762
Nondominant	169	302	379	464	550	627	759
Dynamic Power - engals							
Dominant	8400	17078	22143	27749	33354	38419	47097
Nondominant	7717	16152	21075	26524	31972	36896	45331

<b>ALL FEMALES (AGE 25-46)</b>							<b>N=21</b>
<b>ELBOW FLEXION - Attachment #701</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	96	166	207	253	298	340	410
Nondominant	104	172	211	255	299	339	407
Dynamic Power - engals							
Dominant	2666	6489	8720	11189	13659	15890	19713
Nondominant	3186	6955	9156	11591	14025	16226	19995
<b>ELBOW EXTENSION - Attachment #701</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	67	134	173	216	569	297	364
Nondominant	63	136	178	225	272	315	388
Dynamic Power - engals							
Dominant	4934	8662	10839	13247	15656	17832	21561
Nondominant	4076	8764	11500	14529	17557	20293	24981

# GUIDELINES FOR TESTING SHOULDER FLEXION AND EXTENSION

## Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #5).
2. Attach the padded block with the short black Velcro strap to tool #802. Insert the tool into the exercise shaft and secure it with the locking collar.
3. Demonstrate to the subject the motion being tested (either shoulder flexion or extension), and the proper positioning as described below.
4. Position the subject in front of the exercise head with the side to be tested facing the exercise head.

**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous, test the right side first.**

5. With the upper extremity to be tested resting by the subject's side, adjust the height of the exercise head so that the axis of the exercise shaft is in alignment with the axis of the shoulder joint. Enter the height in the NOTES field. The height should be the same for both shoulder flexion and extension tests.
6. Adjust the length of the tool. Loosen the black, T-knob and slide the tool so that the pad is resting on the dorsum of the forearm at mid-forearm level (see Figure 1). When proper length has been set, securely tighten the T-knob and **record** the length of the tool in the NOTES field for consistency in future set-ups. Secure the pad to the forearm with the Velcro strap.

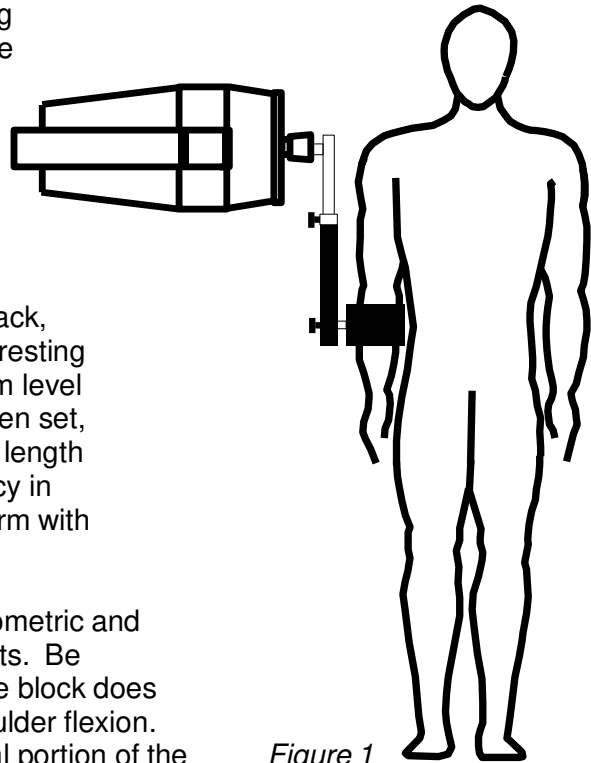


Figure 1

The length will remain the same for both isometric and dynamic shoulder flexion and extension tests. Be sure that the tool is not too long and that the block does not slide over the wrist during dynamic shoulder flexion. It is best that the block glide over the central portion of the forearm throughout full active range of motion since pressure over bony areas may be uncomfortable and influence test results.

7. Position the #802 so that the shoulder being tested is at 0 degrees of flexion. **When testing shoulder flexion**, the block should be located on top of or over the radial aspect

of the forearm. **When testing shoulder extension**, the block should be underneath or to the ulnar aspect of the forearm.

8. The test position is as follows: the subject should be standing with feet even in stance, flat on the floor, and shoulder width apart; shoulders should be level, adducted, and neutral with regard to rotation; the shoulder being tested should be at 0 degrees of flexion; the elbow fully extended, and the forearm in the neutral position.

**NOTE: Do NOT allow the subject to use substitution patterns.**

9. Verbally describe the procedure:
  - exert maximum effort during the test;
  - the tool will not move, we are only measuring effort applied;
  - do not jerk the tool;
  - effort should be applied in a smooth but rapid manner;
  - maximum effort should be reached in 2 to 3 seconds.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

10. Allow the subject one trial at sub-maximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.
11. Turn the computer monitor so that the subject cannot see the display.
12. Make sure that the tool is securely attached and the subject is properly positioned. Touch BEGIN TRIAL to begin trial 1.

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

13. Proceed through the three trials touching BEGIN and END TRIAL as appropriate. Maximum effort should be reached within 2 to 3 seconds which may be indicated by a noticeable physiological tremor. Once the maximum has been reached, tell the subject to relax momentarily but to NOT change hand or body position. Allow five (5) second rest periods in between trials.

**NOTE: Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may significantly alter data due to a change in leverage.**

14. To test the non-dominant or injured extremity, reposition the subject and attachment repeating steps 5 through 8 for the opposite side.
15. Repeat steps 9 through 13 to test the opposite side.

## Dynamic Testing

1. Select DYNAMIC TEST at the bottom of the screen to continue with the power test. Select the CON/OFF mode.

**NOTE: Except for the starting position of the shoulder being tested, tool set up and subject positioning should NOT change for dynamic testing.**

2. The torque will set itself at one-half (1/2) the average isometric strength of the movement being tested. Each side should be tested using a different torque unless the average isometric strength on both sides is equal.
3. Verbally describe the procedures:
  - you will be timed for ten seconds,
  - move through full range of motion,
  - move as quickly as possible,
  - do as many repetitions as possible,
  - continue until I tell you to "stop", and
  - do not begin until I say "go".

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

4. Except for the starting position of the side being tested, reposition the subject as stated in Steps 5 through 8 under Isometric Testing procedures. **When testing shoulder flexion**, the shoulder should be positioned in extension. **When testing shoulder extension**, the shoulder should be positioned in flexion.

**NOTE: Starting positions should be at the maximum range of motion possible from which the subject is able to initiate movement of the tool without the use of substitution patterns.**

**NOTE: Make sure the forearm of the side being tested is strapped to the pad with the short black Velcro strap.**

5. Demonstrate to the subject the motion being tested (either shoulder flexion or extension), and the proper positioning as described above. Touch BEGIN TRIAL and give the subject two practice trials to become familiar with the "feel" of the resistance set on the tool. Observe the subject for correct movement patterns. Let the remaining time run out and then touch REDO TRIAL to erase the practice trials.
6. Proceed through the trial touching the Begin Trial box and instructing the patient to "Go."
7. Reposition the subject and attachment for the same using the nondominant or involved side and repeat Steps 4 through 6.

## SHOULDER FLEXION AND EXTENSION

### DESCRIPTIVE STATISTICS

#### MALES: -

N = 31  
Age - minimum = 24  
          maximum = 75  
          mean = 41.7  
          S.D. = 12.6  
Dominance - right-handed = 29  
              left-handed = 2  
              ambidexterous = 0

#### TEST STATISTICS:

<b><u>SHOULDER FLEXION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	277.0	0.5	16616.0	235.0	0.7	15420.0
maximum -	758.0	11.9	54740.0	736.0	10.4	50104.0
mean -	532.3	3.9	30536.7	530.4	3.7	29573.9
S.D. -	112.9	2.9	9708.1	120.8	2.4	9760.0

<b><u>SHOULDER EXTENSION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	403.0	1.6	24252.0	423.0	0.3	20339.0
maximum -	743.0	17.2	51120.0	750.0	9.7	51120.0
mean -	617.5	5.9	37540.3	631.1	3.9	37540.3
S.D. -	115.9	3.6	8635.5	92.6	2.5	8635.5

#### DESCRIPTIVE STATISTICS:

#### FEMALES -

N = 21

Age - minimum = 25  
maximum = 46  
mean = 35.5  
S.D. = 7.3  
Dominance - right-handed = 20  
left-handed = 1  
ambidexterous = 0

## TEST STATISTICS:

<b><u>SHOULDER FLEXION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	134.0	1.0	6141.0	98.0	0.2	5830.0
maximum -	335.0	8.3	20719.0	385.0	12.6	21372.0
mean -	244.7	5.3	13348.7	239.6	4.0	12363.7
S.D. -	59.1	2.1	4653.7	73.8	3.3	4517.8

<b><u>SHOULDER EXTENSION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	155.0	0.5	8141.0	148.0	0.7	8952.0
maximum -	600.0	12.9	36200.0	547.0	10.8	37805.0
mean -	386.3	6.1	19518.2	368.0	4.2	19266.1
S.D. -	115.7	4.0	7873.1	107.2	2.5	7741.8

## DESCRIPTIVE STATISTICS:

### TOTAL SAMPLE POPULATION -

N = 52  
Age - minimum = 24  
maximum = 75  
mean = 39.2  
S.D. = 11.1  
Dominance - right-handed = 49  
left-handed = 3  
ambidexterous = 0



## TEST STATISTICS:

<b><u>SHOULDER FLEXION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	134.0	0.5	6141.0	98.0	0.2	5830.0
maximum -	758.0	11.9	54740.0	736.0	12.6	50104.0
mean -	416.0	4.4	23114.6	410.3	3.8	22198.1
S.D. -	170.9	2.7	11655.0	177.7	2.7	11670.7

<b><u>SHOULDER EXTENSION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	155.0	0.5	8141.0	148.0	0.3	8952.0
maximum -	743.0	17.2	51120.0	750.0	10.8	49046.0
mean -	495.5	6.0	27756.9	492.2	4.1	28203.2
S.D. -	163.5	3.8	12193.8	166.0	2.4	12631.2

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

<b><u>SHOULDER FLEXION</u></b>			
<b>Dominant</b>		<b>Nondominant</b>	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.963	0.925	0.965	0.939

<b><u>SHOULDER EXTENSION</u></b>			
<b>Dominant</b>		<b>Nondominant</b>	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.952	0.960	0.933	0.919

## SHOULDER FLEXION AND EXTENSION

### PERCENTILE CHARTS:

		ALL MALES (24 - 75)						N = 31
PERCENTILES	1	10	25	50	75	90	99	
<b>SHOULDER FLEXION - #802</b>								
<i>Static/Isometric Torque (in-lbs.)</i>								
Dominant	269	387	456	532	609	677	795	
Nondominant	249	375	449	530	612	686	812	
<i>Dynamic Power (engals)</i>								
Dominant	17917	18062	23984	30537	37090	43012	53157	
Nondominant	16833	17032	22986	29574	36162	42116	52315	
<b>SHOULDER EXTENSION - #802</b>								
<i>Static/Isometric Torque (in-lbs.)</i>								
Dominant	347	469	539	618	696	766	888	
Nondominant	415	512	569	631	694	750	847	
<i>Dynamic Power (engals)</i>								
Dominant	8184	8564	11817	13529	16051	21061	25902	
Nondominant	8356	84144	10482	13112	15617	19907	25041	

		ALL FEMALES (25 - 46)						N = 21
PERCENTILES	1	10	25	50	75	90	99	
<b>SHOULDER FLEXION - #802</b>								
<i>Static/Isometric Torque (in-lbs.)</i>								
Dominant	107	169	205	245	285	321	382	
Nondominant	68	145	190	240	289	334	412	
<i>Dynamic Power (engals)</i>								
Dominant	2506	7369	10207	13349	16490	19329	24192	
Nondominant	1837	6558	9314	12364	15413	18169	22890	
<b>SHOULDER EXTENSION - #802</b>								
<i>Static/Isometric Torque (in-lbs.)</i>								
Dominant	117	238	308	386	464	535	656	
Nondominant	118	230	296	368	440	506	618	
<i>Dynamic Power (engals)</i>								
Dominant	1174	9401	14204	19518	24833	29635	37863	
Nondominant	1228	9318	14040	19266	24492	29214	37304	



# GUIDELINES FOR TESTING SHOULDER ABDUCTION AND ADDUCTION

## Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #5).
2. Attach the padded block with the short Velcro strap to tool #802 or #701. Insert the tool into the exercise shaft and secure it with the locking collar.
3. Demonstrate to the subject the motion being tested (either shoulder abduction or adduction), and the proper positioning as described below.
4. The subject should stand with the posterior aspect of the shoulder being tested positioned in front of the exercise head as illustrated.

**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous, test the right side first.**

5. With the upper extremity to be tested resting by the subject's side, adjust the height of the exercise head so that the axis of the exercise shaft is in alignment with the axis of the shoulder joint. Enter the height in the NOTES field. The height should be the same for both shoulder abduction and adduction tests.
6. Adjust the length of the tool. Loosen the black T-knob and slide the tool so that the pad is resting on the dorsum of the forearm at mid-forearm level. When proper length has been set, securely tighten the T-knob and **record** the length of the tool in the NOTES field for consistency in future set-ups. Secure the pad to the forearm with the Velcro strap.

The length will remain the same for both isometric and dynamic shoulder abduction and adduction tests. Be sure that the tool is not too long and that the padded block does not slide over the wrist during dynamic shoulder abduction. It is best that the block glide over the central portion of the forearm throughout full active range of motion since pressure over bony areas may be uncomfortable and influence test results.

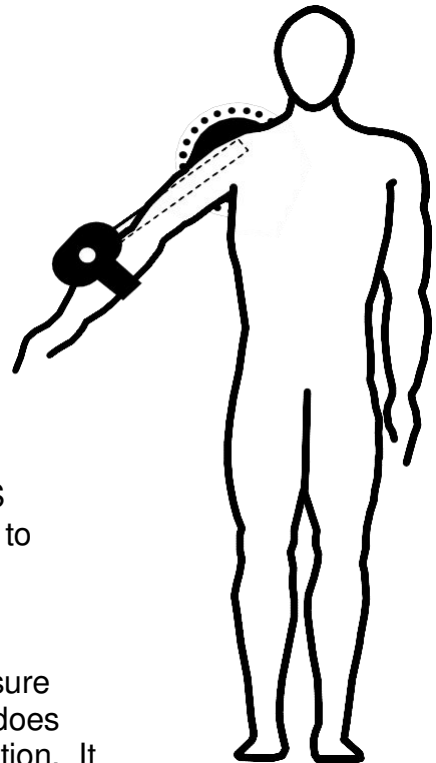


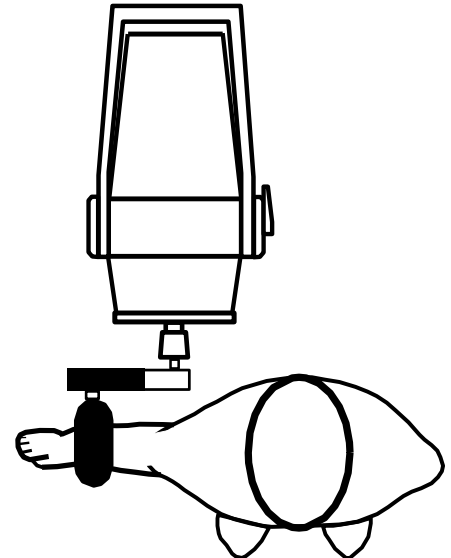
Figure 1

7. Position the tool so that the shoulder being tested is in 45 degrees of abduction. **When testing shoulder abduction**, the block should be located on top of or over the radial aspect of the forearm. **When testing shoulder adduction**, the block should be underneath or to the ulnar aspect of the forearm.

8. The test position is as follows: the subject should be standing with feet even in stance, flat on the floor, and shoulder width apart; shoulders should be level, adducted, and neutral with regard to rotation; the shoulder being tested should be at 45 degrees of abduction; the elbow fully extended, and the forearm in neutral (Figures 1 & 2).

**NOTE: Do NOT allow the subject to use substitution patterns.**

9. Verbally describe the procedure:
- exert maximum effort during the test,
  - the tool will not move, we are only measuring effort applied,
  - do not jerk the tool,
  - effort should be applied in a smooth but rapid manner, and
  - maximum effort should be reached in 2 to 3 seconds.



*Figure 2*

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

10. Allow the subject one trial at sub-maximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.
11. Turn the computer monitor so that the subject cannot see the display.
12. Making sure that the tool is securely attached, the subject properly positioned, touch BEGIN TRIAL to begin trial 1.

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

13. Proceed through the three trials touching BEGIN and END TRIAL as appropriate. Maximum effort should be reached within 2 to 3 seconds which may be indicated by a noticeable physiological tremor. Once maximum has been reached, tell the subject to

relax momentarily but to NOT change hand or body position. Allow five (5) second rest periods in between trials.

**NOTE: Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may significantly alter data due to a change in leverage.**

14. To test the non-dominant or injured extremity, reposition the subject and attachment, repeating Steps 5 through 8 for the opposite side.
15. Repeat steps 10 through 13 to test the opposite side.

## Dynamic Testing

1. Select DYNAMIC TEST at the bottom of the screen to continue with the power test. Select the CON/OFF mode.

**NOTE: Except for the starting position of the shoulder being tested, tool set up and subject positioning should NOT change for dynamic testing.**

2. The torque will set itself at one-half (1/2) the average isometric strength of the movement being tested. Each side should be tested using a different torque unless the average isometric strength on both sides is equal.
3. Verbally describe the procedures:
  - you will be timed for ten seconds,
  - move through full range of motion,
  - move as quickly as possible,
  - do as many repetitions as possible,
  - continue until I tell you to "stop", and
  - do not begin until I say "go".

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

4. Except for the starting position of the side being tested, reposition the subject as stated in Steps 5 through 8 under Isometric Testing procedures. **When testing shoulder abduction**, the shoulder should be positioned in adduction. **When testing shoulder adduction**, the shoulder should be positioned in abduction.

**NOTE: Starting positions should be at the maximum range of motion possible from which the subject is able to initiate movement of the tool without the use of substitution patterns.**

**NOTE: Make sure the forearm of the side being tested is strapped to the pad with the short black Velcro strap.**

5. Demonstrate to the subject the motion being tested (either shoulder abduction or adduction) and the proper positioning as described above. Touch BEGIN TRIAL and give the subject two practice trials to become familiar with the "feel" of the resistance set on the tool. Observe the subject for correct movement patterns. Let the remaining time run out, then touch REDO TRIAL to erase the practice trials.

**NOTE: Do NOT allow the subject to use substitution patterns.**

6. Proceed through the trial touching the BEGIN TRIAL box and instructing the patient to "GO".
7. Reposition the subject and attachment for the same test using the nondominant or involved side and repeat Steps 4 through 6.

# SHOULDER ABDUCTION AND ADDUCTION DESCRIPTIVE STATISTICS

## MALES -

N = 31

Age - minimum = 24  
maximum = 75

mean = 41.7

S.D. = 12.6

Dominance - right-handed = 29  
left-handed = 2

## TEST STATISTICS

### SHOULDER ABDUCTION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	177.0	0.2	7316.0	211.0	0.8	8136.0
maximum -	699.0	10.1	41176.0	691.0	13.6	37119.0
mean -	480.4	4.2	25111.4	473.5	4.4	23812.3
S.D. -	131.2	2.4	9753.4	136.0	3.0	8736.5

### SHOULDER ADDUCTION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	439.0	0.2	17219.0	455.0	0.9	17567.0
maximum -	729.0	11.3	41428.0	725.0	7.3	40167.0
mean -	617.9	3.3	31931.6	610.7	3.8	31881.2
S.D. -	93.5	2.6	7171.6	106.8	2.4	6544.1



## FEMALES -

N = 21

Age - minimum = 25

maximum = 46

mean = 35.5

S.D. = 7.3

Dominance - right-handed = 20

left-handed = 1

### TEST STATISTICS

#### **SHOULDER ABDUCTION**

	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	127.0	1.2	5112.0	135.0	1.1	5034.0
maximum -	285.0	14.1	17158.0	284.0	14.6	14531.0
mean -	221.4	5.3	10316.0	218.5	6.1	9640.3
S.D. -	46.3	2.9	3176.6	49.1	4.2	2766.3

#### **SHOULDER ADDUCTION**

	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	200.0	0.6	7216.0	202.0	0.1	7995.0
maximum -	525.0	7.7	29757.0	584.0	8.6	29160.0
mean -	366.7	3.3	17356.1	380.0	3.9	17308.4
S.D. -	97.8	2.2	6166.7	101.1	2.3	5666.3

## TOTAL SAMPLE POPULATION -

N = 52

Age - minimum = 24  
maximum = 75

mean = 39.2

S.D. = 11.1

Dominance - right-handed = 49  
left-handed = 3

## TEST STATISTICS

<b><u>SHOULDER ABDUCTION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	127.0	0.2	5112.0	135.0	0.8	5034.0
maximum -	699.0	14.1	41176.0	691.0	14.6	37119.0
mean -	375.7	4.6	18722.5	370.4	5.1	17879.8
S.D. -	165.7	2.6	10596.0	166.8	3.6	9836.5

<b><u>SHOULDER ADDUCTION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	200.0	0.2	7216.0	202.0	0.1	7995.0
maximum -	729.0	11.3	41428.0	725.0	8.6	40167.0
mean -	481.5	3.3	23277.4	469.3	3.8	22166.0
S.D. -	158.3	2.4	9741.0	152.8	2.3	9120.2

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

<b><u>SHOULDER ABDUCTION</u></b>			
<b>Dominant</b>		<b>Nondominant</b>	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.983	0.788	0.984	0.973

<b><u>SHOULDER ADDUCTION</u></b>			
<b>Dominant</b>		<b>Nondominant</b>	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.981	0.965	0.919	0.859



**PERCENTILE CHARTS:**

<b>ALL MALES (AGE 24-75)</b>							<b>N=31</b>
<b>SHOULDER ABDUCTION - Attachment #802</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	175	312	392	480	569	649	786
Nondominant	157	299	382	474	565	648	790
Dynamic Power - engals							
Dominant	2386	12578	18528	25111	31695	37645	47837
Nondominant	3456	12586	17915	23812	29709	35039	44168
<b>SHOULDER ADDUCTION - Attachment #802</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	400	498	555	618	681	738	836
Nondominant	362	473	539	611	683	748	860
Dynamic Power - engals							
Dominant	15222	22716	27091	31932	36722	41147	48641
Nondominant	16633	23472	27464	31881	36198	40290	47129

<b>ALL FEMALES (AGE 25-46)</b>							<b>N=21</b>
<b>SHOULDER ABDUCTION - Attachment #802</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	114	162	190	221	253	281	329
Nondominant	104	155	185	219	252	282	333
Dynamic Power - engals							
Dominant	2915	6234	8172	10316	12460	14398	17717
Nondominant	3195	6086	7773	9640	11508	13195	16086
<b>SHOULDER ADDUCTION - Attachment #802</b>							
Percentiles	1	10	25	50	75	90	95
Isometric Strength - inch/pounds							
Dominant	139	214	301	367	433	492	595
Nondominant	144	250	312	380	448	510	616
Dynamic Power - engals							
Dominant	2988	9432	12194	17356	21519	25280	31725
Nondominant	4106	10027	13484	17308	31133	24590	30511

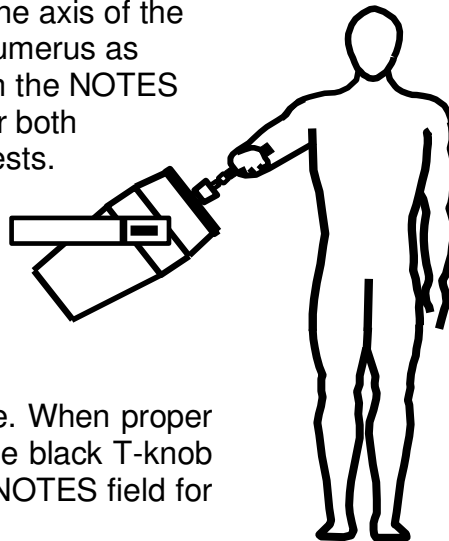
# GUIDELINES FOR TESTING SHOULDER INTERNAL AND EXTERNAL ROTATION

## Isometric Testing

1. Position the exercise head with the shaft pointing up at a 45 degree angle (position #3).
2. Attach the cylindrical attachment to position B of tool #701. Insert the tool into the exercise shaft and secure it with the locking collar. Attach the padded V-block to the tool where the elbow will contact the attachment.
3. Demonstrate to the subject the motion being tested (either shoulder internal or external rotation), and the proper positioning as described below.
4. Position the subject in front of the exercise head with the side to be tested facing the exercise head.

**NOTE: Test the dominant or uninvolved side first. If the subject is ambidextrous, test the right side first.**

5. With the shoulder to be tested positioned in 45 degrees of abduction and the elbow in 90 degrees of flexion, adjust the height of the exercise head so that the axis of the exercise shaft is in alignment with the humerus as illustrated in figure 1. Enter the height in the NOTES field. The height should be the same for both shoulder internal and external rotation tests.
6. Adjust the length of the tool. Loosen the black T- knob and slide the tool so that the perpendicular handle, on which the cylinder is attached, is in alignment with the MP's. The subject should then be able to grasp the handle. When proper length has been set, securely tighten the black T-knob and record the length of the tool in the NOTES field for consistency in future set-ups.



*Figure 1*

The length will remain the same for both isometric and dynamic shoulder internal and external rotation tests.

7. Position the attachment in the horizontal plane (parallel to the floor).
8. The test position is as follows: the subject should be standing with feet even in stance, flat on the floor, and shoulder width apart; shoulders should be level, adducted, and neutral with regard to rotation; the shoulder being tested should be at 45 degrees of abduction; the elbow should be flexed at 90 degrees; the forearm should be neutral; the wrist should be in neutral (0 to 15 degrees of extension) with some radial deviation; and the hand should be placed centrally on the handle. This position should be maintained throughout testing (Figure 1).

**NOTE: Do NOT allow the subject to use substitution patterns.**

9. Verbally describe the procedure:
  - exert maximum effort during the test,
  - the tool will not move, we are only measuring effort applied,
  - do not jerk the tool,
  - effort should be applied in a smooth but rapid manner, and
  - maximum effort should be reached in 2 to 3 seconds.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

10. Allow the subject one trial at sub-maximal effort so that he/she knows what to expect once the actual testing begins. This enables you to check that he/she is performing the correct motion and is using correct body mechanics.
11. Turn the computer monitor so that the subject cannot see the display.
12. Making sure that the tool is securely attached, the subject properly positioned, touch BEGIN TRIAL to begin trial 1.

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

13. Proceed through the three trials touching BEGIN and END TRIAL as appropriate. Maximum effort should be reached within 2 to 3 seconds which may be indicated by a noticeable physiological tremor. Once maximum has been reached, tell the subject to relax momentarily but to NOT change hand or body position. Allow five (5) second rest periods in between trials.

**NOTE: Be sure that the subject's position has NOT changed and does NOT change for the duration of the testing process. This includes stance, upper body, and upper extremities. A change in position from trial to trial may**

**significantly alter data due to a change in leverage.**

14. In order to test the non-dominant or injured extremity, the tool must be rotated 180 degrees. Then reposition the subject for the same test, repeating Steps 5 through 8.
15. Repeat steps 10 through 13 to test the opposite side.

## **Dynamic Testing**

1. Select DYNAMIC TEST at the bottom of the screen to continue with the power test. Select the CON/OFF mode.

**NOTE: Except for the starting position of the shoulder being tested, tool set up and subject positioning should NOT change for dynamic testing.**

2. The torque will set itself at one-half (1/2) the average isometric strength of the movement being tested. Each side should be tested using a different torque unless the average isometric strength on both sides is equal.
3. Verbally describe the procedures:
  - you will be timed for ten seconds,
  - move through full range of motion,
  - move as quickly as possible,
  - do as many repetitions as possible,
  - continue until I tell you to "stop", and
  - do not begin until I say "go".

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

4. Except for the starting position of the side being tested, reposition the subject as stated in Steps 5 through 8 under Isometric Testing procedures. **When testing shoulder internal rotation**, the shoulder should be positioned in external rotation. **When testing shoulder external rotation**, the shoulder should be positioned in internal rotation.

**NOTE: Starting positions should be at the maximum range of motion possible from which the subject is able to initiate movement of the tool without the use of substitution patterns.**

5. Demonstrate to the subject the motion being tested (either internal or external rotation) Touch BEGIN TRIAL and give the subject two practice trials to become familiar with the "feel" of the resistance set on the tool. Observe the subject for

correct movement patterns. Let the remaining time run out and then touch REDO TRIAL to erase the practice trials.

**NOTE: Do NOT allow the subject to use substitution patterns.**

6. Proceed through the trial touching the BEGIN TRAIL box and instructing the patient to "GO".
7. Reposition the subject for the same test using the non-dominant or involved side and repeat Steps 4 through 6.



# SHOULDER INTERNAL AND EXTERNAL ROTATION DESCRIPTIVE STATISTICS

## MALES -

N = 33

Age - minimum = 24  
maximum = 75  
mean = 41.3  
S.D. = 12.4

Dominance - right-handed = 30  
left-handed = 3

## TEST STATISTICS

<b><u>SHOULDER INTERNAL ROTATION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	234.0	0.4	12613.0	219.0	0.6	14917.0
maximum -	628.0	12.2	55380.0	628.0	8.4	54104.0
mean -	433.1	3.8	30039.4	437.3	3.2	29592.3
S.D. -	104.1	2.7	10875.6	103.8	1.9	10375.1

<b><u>SHOULDER EXTERNAL ROTATION</u></b>						
	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	137.0	0.5	8184.0	133.0	0.6	8356.0
maximum -	408.0	9.4	25902.0	432.0	5.7	25041.0
mean -	277.2	3.8	14493.0	274.2	3.0	13935.3
S.D. -	73.7	4.1	4923.4	74.9	1.6	4852.1

## FEMALES -

N = 21

Age - minimum = 25

maximum = 46

mean = 35.5

S.D. = 7.3

Dominance - right-handed = 20

left-handed = 1

### TEST STATISTICS

#### **SHOULDER INTERNAL ROTATION**

	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	123.0	0.6	6732.0	117.0	0.2	7089.0
maximum -	287.0	5.6	22161.0	324.0	8.6	22609.0
mean -	200.9	2.8	12718.7	203.3	4.4	12896.9
S.D. -	46.6	1.4	3895.3	54.6	2.5	4008.8

#### **SHOULDER EXTERNAL ROTATION**

	<b>Dominant</b>			<b>Nondominant</b>		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	74.0	1.7	3552.0	64.0	0.7	2716.0
maximum -	343.0	9.0	16102.0	326.0	11.6	17685.0
mean -	150.4	3.8	7570.9	146.0	3.6	7249.8
S.D. -	57.9	2.0	2789.9	57.6	2.5	3418.4

## TOTAL SAMPLE POPULATION -

N = 54

Age - minimum = 24

maximum = 75

mean = 39.0

S.D. = 10.9

Dominance - right-handed = 50

left-handed = 4

## TEST STATISTICS

### SHOULDER INTERNAL ROTATION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	123.0	0.4	6732.0	117.0	0.2	7089.0
maximum -	628.0	17.8	55380.0	628.0	8.6	54104.0
mean -	341.4	6.7	23161.8	344.5	3.7	22940.5
S.D. -	142.6	5.2	12235.4	144.7	2.2	11789.7

### SHOULDER EXTERNAL ROTATION

	Dominant			Nondominant		
	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>(C.V.)</u>	<u>Dynamic</u>
minimum -	74.0	0.5	3552.0	64.0	0.6	2716.0
maximum -	408.0	9.4	25902.0	432.0	11.6	25041.0
mean -	220.1	3.8	11298.2	218.3	3.2	10944.4
S.D. -	92.0	2.3	5334.9	93.0	2.1	5397.0

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

### SHOULDER INTERNAL ROTATION

Dominant		Nondominant	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.966	0.951	0.985	0.962

### SHOULDER EXTERNAL ROTATION

Dominant		Nondominant	
<u>Isometric</u>	<u>Dynamic</u>	<u>Isometric</u>	<u>Dynamic</u>
0.983	0.973	0.981	0.934

# PERCENTILE CHARTS:

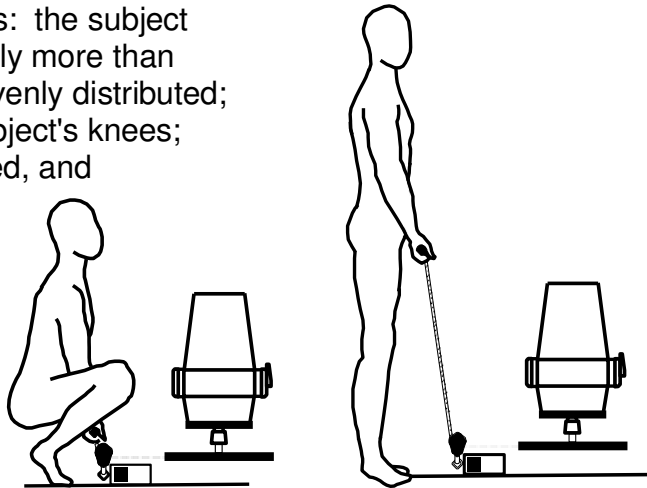
ALL MALES (AGE 24-75)								N=31
SHOULDER INTERNAL ROTATION - Attachment #701								
Percentiles	1	10	25	50	75	90	95	
Isometric Strength - inch/pounds								
Dominant	191	299	363	433	503	567	676	
Nondominant	195	304	367	437	507	571	379	
Dynamic Power - engals								
Dominant	4699	16064	22698	30039	37380	44015	55380	
Nondominant	5418	16260	22589	29592	36595	42924	53766	
SHOULDER EXTERNAL ROTATION - Attachment #701								
Percentiles	1	10	25	50	75	90	95	
Isometric Strength - inch/pounds								
Dominant	105	182	227	277	327	372	499	
Nondominant	100	178	224	274	325	371	499	
Dynamic Power - engals								
Dominant	3021	8166	11170	14493	17816	20820	25965	
Nondominant	2630	7700	10660	13935	17210	20170	25241	

ALL FEMALES (AGE 25-46)								N=21
SHOULDER INTERNAL ROTATION - Attachment #701								
Percentiles	1	10	25	50	75	90	95	
Isometric Strength - inch/pounds								
Dominant	92	141	169	201	232	261	309	
Nondominant	76	133	166	203	240	273	331	
Dynamic Power - engals								
Dominant	3643	7713	10089	12719	15348	17724	21795	
Nondominant	3556	7746	10191	12897	15603	18048	22237	
SHOULDER EXTERNAL ROTATION - Attachment #701								
Percentiles	1	10	25	50	75	90	95	
Isometric Strength - inch/pounds								
Dominant	15	74	11	150	189	225	285	
Nondominant	12	72	107	146	185	220	280	
Dynamic Power - engals								
Dominant	1070	3986	5688	7571	9454	1156	14071	
Nondominant	NA	2857	4942	7250	9557	11642	15215	

# GUIDELINES FOR TESTING MAXIMUM DYNAMIC LIFTING CAPACITIES

## FLOOR TO KNUCKLE HEIGHT

1. Set up attachment #191 placing the fastening lever in position #14 of the outer ring on the exercise head face plate. Tighten securely keeping inward pressure on the center of the 191 attachment. You do not need to secure the locking collar. Unlock the locking lever on the right side of the exercise head and rotate the head to the #9 position. Push the locking lever back in place. Lower the exercise head to the lowest position.
2. Place the cable through the pulley and attach the straight handle. Hold the cable at the start position and rotate the 191 disk to take up the excess cable.
3. Select the MAXIMUM LIFT/PUSH/PULL test and enter the desired parameters.
4. Demonstrate to the subject the motion being tested (floor to knuckle height lift), and the proper positioning as described below (Figure 1).
5. Position the subject on the same side as the handle facing the exercise head.
6. The **starting position** is as follows: the subject should be squatting with feet slightly more than shoulder width apart and weight evenly distributed; arms should be in between the subject's knees; shoulders should be level, abducted, and slightly externally rotated; elbows should be extended; forearms should be supinated; wrists should be neutral (0 to 15 degrees of extension) and somewhat radially deviated; and hands should be evenly spaced approximately 12 inches apart using a cylinder grip.



*Figure 1*

The **ending position** is as follows: the subject will move to standing while lifting the handle until he/she is standing with feet flat on the floor and weight evenly distributed. The arms should remain in the same positions as described above and elbows should NOT flex.

**NOTE: Be sure to position the subject close to the Primus so that the lift of the handle and the trail of the cable is as vertical as possible. The subject should NOT be pulling the handle.**

7. Verbally describe the procedure:
  - lift the handle from floor to knuckle height,
  - do not jerk the handle when lifting,
  - slowly lower the handle back to the start position after each lift,
  - do not let go of the handle, and
  - do not begin until I say "go".
8. Turn the computer monitor so that the subject cannot see the display.
9. Set the lifting range. Touch BEGIN TEST, then follow the instructions on the screen to teach the computer the proper range.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

12. Make sure that the tool is securely attached and the subject is properly positioned. Instruct the subject to "GO".

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

13. After each trial, increase the weight by touching the INCREASE 1 LB and/or INCREASE 5 LBS. box until the desired increase is reached. Five to 10 lb. increases after each trial is common.
14. The number of seconds allowed for each trial is counted in the highlighted box in the upper center portion of the screen. After the selected CYCLE TIME has passed, the subject will be signaled to perform the next lift.
15. Continue the sequence of having the subject complete the lift followed by the evaluator increasing the weight on the Primus. This should continue until the subject voluntarily discontinues testing or until he/she can no longer complete the lift or lift the load in a safe manner.

**NOTE: A "RECOMMENDED" safe lift may not be the same as a subject's "MAXIMUM" lift capability. If the subject does not voluntarily discontinue testing, it is up to the evaluator to determine the limit at which the subject is capable of safely lifting. This limit may be based on observations made by the evaluator, such as fatigue or use of improper lifting techniques. The safe**

maximum lift capability may not necessarily be based on what the subject says he/she is capable of doing.

## MAXIMUM FLOOR TO KNUCKLE LIFT DESCRIPTIVE STATISTICS

### MALES -

N = 33

Age - minimum = 24  
maximum = 75  
mean = 41.3  
S.D. = 12.4

Dominance - right-handed = 32  
left-handed = 1

### TEST STATISTICS

<b><u>FLOOR TO KNUCKLE LIFT</u></b>		
	<u>Maximum Lift</u>	<u>Safe Recommended Lift</u>
minimum -	41.0 lbs.	41.0 lbs.
maximum -	225.0 lbs.	225.0 lbs.
mean -	130.8 lbs.	124.4 lbs.
S.D. -	45.6	43.2

### FEMALES -

N = 21

Age - minimum = 25  
maximum = 46  
mean = 35.5  
S.D. = 7.3

Dominance - right-handed = 20  
left-handed = 1

### TEST STATISTICS

<b><u>FLOOR TO KNUCKLE LIFT</u></b>		
	<u>Maximum Lift</u>	<u>Safe Recommended Lift</u>
minimum -	33.0 lbs.	27.0 lbs.
maximum -	127.0 lbs.	125.0 lbs.
mean -	76.2 lbs.	71.2 lbs.
S.D. -	21.9	23.0

## TOTAL SAMPLE POPULATION -

N = 54

Age - minimum = 24

maximum = 75

mean = 39.0

S.D. = 11.0

Dominance - right-handed = 52

left-handed = 2

## TEST STATISTICS

<b><u>FLOOR TO KNUCKLE LIFT</u></b>		
	<b><u>Maximum Lift</u></b>	<b><u>Safe Recommended Lift</u></b>
minimum -	33.0 lbs.	27.0 lbs.
maximum -	225.0 lbs.	225.0 lbs.
mean -	110.5 lbs.	104.6 lbs.
S.D. -	46.6	44.9

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

<b><u>FLOOR TO KNUCKLE LIFT</u></b>	
<b>Maximum Load</b>	<b>Recommended Safe Load</b>
0.895	0.898

## PERCENTILE CHARTS:

<b>ALL MALES (AGE 24-75)</b>								<b>N=31</b>
FLOOR TO KNUCKLE LIFT - Attachment #191								
Percentiles	1	10	25	50	75	90	95	
Maximum Lift - pounds								
Bilateral	25	72	100	131	162	189	237	
Recommended Safe Lift - pounds								
Bilateral	24	69	95	124	154	180	225	
<b>ALL FEMALES (AGE 25-46)</b>								<b>N=21</b>
Maximum Lift - pounds								
Bilateral	25	48	61	76	91	104	127	
Recommended Safe Lift - pounds								
Bilateral	18	42	56	71	87	101	125	



## KNUCKLE TO SHOULDER HEIGHT

1. Set up attachment #191 placing the fastening lever in position #18 of the outer ring on the exercise head face plate. Tighten securely keeping inward pressure on the center of the 191 attachment. You do not need to secure the locking collar. Place the exercise head at the #5 position.
2. Select the MAXIMUM LIFT/PUSH/PULL test and enter the desired parameters.
3. Adjust the exercise head height so the subject can comfortably hold the handle in the knuckle position. Enter the height in the NOTES field if desired. Demonstrate to the subject the motion being tested (knuckle to shoulder height lift), and the proper positioning as described below (Figure 2).
4. Position the subject on the same side as the handle facing the exercise head.

5. The **starting position** is as follows: the subject should be standing with feet shoulder width apart, flat on the floor, and weight evenly distributed; shoulders should be level, adducted, and slightly externally rotated; elbows should be extended; forearms should be supinated; wrists should be neutral (0 to 15 degrees of extension) and somewhat radially deviated; and hands should be placed approximately 12 inches apart using a cylinder grip.

The **ending position** is as follows: the subject will remain standing while lifting the handle from knuckle to shoulder height. Hand and shoulder positions should remain the same as described above, however elbows should flex.

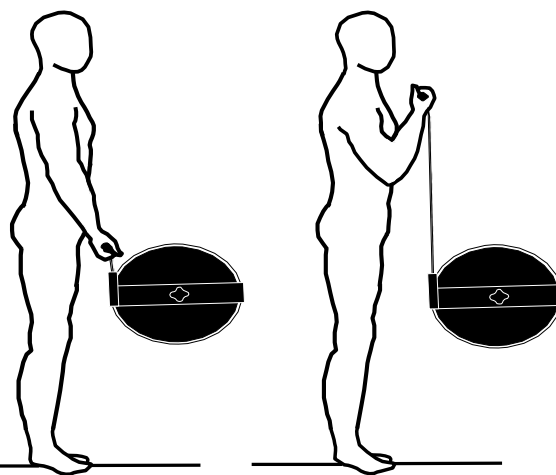


Figure 2

**NOTE: Be sure to position the subject close to the Primus so that the lift of the handle and the trail of the rope is as vertical as possible. The subject should NOT be pulling the handle.**

6. Verbally describe the procedure:
  - lift the handle from floor to knuckle height,
  - do not jerk the handle when lifting,
  - slowly lower the handle back to the start position after each lift,
  - do not let go of the handle, and
  - do not begin until I say "go".

7. Turn the computer monitor so that the subject cannot see the display.
8. Set the lifting range. Touch BEGIN TEST, then follow the instructions on the screen to teach the computer the proper range.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

9. Make sure that the tool is securely attached and the subject is properly positioned. Instruct the subject to "GO".

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

10. After each trial, increase the weight by touching the INCREASE 1 LB and/or INCREASE 5 LBS. box until the desired increase is reached. Five to 10 lb. increases after each trial is common.
11. The number of seconds allowed for each trial is counted in the highlighted box in the upper center portion of the screen. After the selected CYCLE TIME has passed, the subject will be signaled to perform the next lift.
12. Continue the sequence of having the subject complete the lift followed by the evaluator increasing the weight on the Primus. This should continue until the subject voluntarily discontinues testing or until he/she can no longer complete the lift or lift the load in a safe manner.

**NOTE: A "RECOMMENDED" safe lift may not be the same as a subject's "MAXIMUM" lift capability. If the subject does not voluntarily discontinue testing, it is up to the evaluator to determine the limit at which the subject is capable of safely lifting. This limit may be based on observations made by the evaluator, such as fatigue or use of improper lifting techniques. The safe maximum lift capability may not necessarily be based on what the subject says he/she is capable of doing.**

# **MAXIMUM KNUCKLE TO SHOULDER LIFT DESCRIPTIVE STATISTICS**

## **MALES -**

N = 34  
 Age - minimum = 24  
       maximum = 75  
       mean = 40.8  
       S.D. = 12.5  
 Dominance - right-handed = 33  
               left-handed = 1

### **TEST STATISTICS**

<u><b>KNUCKLE TO SHOULDER LIFT</b></u>		
	<u>Maximum Lift</u>	<u>Safe Recommended Lift</u>
minimum -	49.0 lbs.	49.0 lbs.
maximum -	100.0 lbs.	95.0 lbs.
mean -	76.0 lbs.	75.1 lbs.
S.D. -	13.3	13.1

## **FEMALES -**

N = 21  
 Age - minimum = 25  
       maximum = 46  
       mean = 35.5  
       S.D. = 7.3  
 Dominance - right-handed = 20  
               left-handed = 1

### **TEST STATISTICS:**

<u><b>KNUCKLE TO SHOULDER LIFT</b></u>		
	<u>Maximum Lift</u>	<u>Safe Recommended Lift</u>
minimum -	26.0 lbs.	26.0 lbs.
maximum -	59.0 lbs.	59.0 lbs.
mean -	36.6 lbs.	36.2 lbs.
S.D. -	8.3	8.5

## TOTAL SAMPLE POPULATION -

N = 54

Age - minimum = 24

maximum = 75

mean = 38.8

S.D. = 11.0

Dominance - right-handed = 53

left-handed = 2

## TEST STATISTICS

<b><u>KNUCKLE TO SHOULDER LIFT</u></b>		
	<b><u>Maximum Lift</u></b>	<b><u>Safe Recommended Lift</u></b>
minimum -	26.0 lbs.	26.0 lbs.
maximum -	100.0 lbs.	95.0 lbs.
mean -	62.2 lbs.	61.5 lbs.
S.D. -	22.3	22.0

## RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients -

<b><u>KNUCKLE TO SHOULDER LIFT</u></b>	
<b>Maximum Load</b>	<b>Recommended Safe Load</b>
0.982	0.996

## PERCENTILE CHARTS:

<b>ALL MALES (AGE 24-75)</b>							<b>N=31</b>
KNUCKLE TO SHOULDER LIFT - Attachment #191							
Percentiles	1	10	25	50	75	90	95
Maximum Lift - pounds							
Bilateral	45	59	67	76	85	93	107
Recommended Safe Lift - pounds							
Bilateral	45	58	66	75	84	92	105
<b>ALL FEMALES (AGE 25-46)</b>							<b>N=21</b>
Maximum Lift - pounds							
Bilateral	17	26	31	37	42	47	56
Recommended Safe Lift - pounds							
Bilateral	16	25	30	36	42	47	56

## SHOULDER TO OVERHEAD

1. Set up attachment #191 placing the fastening lever in position #18 of the outer ring on the exercise head face plate. Tighten securely keeping inward pressure on the center of the 191 attachment. You do not need to secure the locking collar. Place the exercise head at the #5 position.
2. Select the MAXIMUM LIFT/PUSH/PULL test and enter the desired parameters.
3. Adjust the exercise head height so the subject can comfortably hold the handle in the knuckle position. Enter the height in the NOTES field if desired. Demonstrate to the subject the motion being tested (shoulder to overhead lift), and the proper positioning as described below (Figure 3).
4. Position the subject on the same side as the handle facing the exercise head.
5. The **starting position** is as follows: the subject should be standing with feet shoulder width apart, flat on the floor, and weight evenly distributed; shoulders should be level, adducted, and *neutral* with regard to rotation; elbows should be flexed; forearms should be pronated; wrists should be neutral (0 to 15 degrees of extension) and somewhat ulnarly deviated; and hands should be placed approximately 12 inches apart using a cylinder grip.

The **ending position** is as follows: the subject will remain standing while lifting the handle from shoulder height to overhead. Hand positions should remain the same as described above, however shoulders should flex and elbows should fully extend.

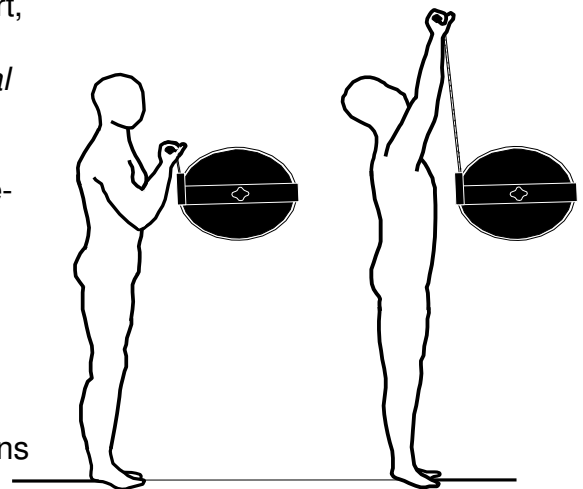


Figure 3

**NOTE: Be sure to position the subject close to the Primus so that the lift of the handle and the trail of the rope is as vertical as possible. The subject should NOT be pulling the handle.**

6. Verbally describe the procedure:
  - lift the handle from floor to knuckle height,
  - do not jerk the handle when lifting,
  - slowly lower the handle back to the start position after each lift,
  - do not let go of the handle, and
  - do not begin until I say "go".

7. Turn the computer monitor so that the subject cannot see the display.
8. Set the lifting range. Touch BEGIN TEST, then follow the instructions on the screen to teach the computer the proper range.

**NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.**

9. Make sure that the tool is securely attached and the subject is properly positioned. Instruct the subject to "GO".

**NOTE: Do NOT coach the subject in any manner during testing. This could influence the subject's performance, especially if there are inconsistencies in the delivery.**

10. After each trial, increase the weight by touching the INCREASE 1 LB and/or INCREASE 5 LBS. box until the desired increase is reached. Five to 10 lb. increases after each trial is common.
11. The number of seconds allowed for each trial is counted in the highlighted box in the upper center portion of the screen. After the selected CYCLE TIME has passed, the subject will be signaled to perform the next lift.
12. Continue the sequence of having the subject complete the lift followed by the evaluator increasing the weight on the Primus. This should continue until the subject voluntarily discontinues testing or until he/she can no longer complete the lift or lift the load in a safe manner.

**NOTE: A "RECOMMENDED" safe lift may not be the same as a subject's "MAXIMUM" lift capability. If the subject does not voluntarily discontinue testing, it is up to the evaluator to determine the limit at which the subject is capable of safely lifting. This limit may be based on observations made by the evaluator, such as fatigue or use of improper lifting techniques. The safe maximum lift capability may not necessarily be based on what the subject says he/she is capable of doing.**

**NOTE: Do NOT allow the subject to use substitution patterns.**

## MAXIMUM SHOULDER TO OVERHEAD LIFT DESCRIPTIVE STATISTICS

### MALES -

N = 34  
 Age - minimum = 24  
       maximum = 75  
       mean = 40.8  
       S.D. = 12.5  
 Dominance - right-handed = 33  
               left-handed = 1

### TEST STATISTICS

<b><u>SHOULDER TO OVERHEAD LIFT</u></b>		
	<u>Maximum Lift</u>	<u>Safe Recommended Lift</u>
minimum -	39.0 lbs.	39.0 lbs.
maximum -	94.0 lbs.	85.0 lbs.
mean -	62.9 lbs.	60.6 lbs.
S.D. -	11.2	10.3

### FEMALES -

N = 21  
 Age - minimum = 25  
       maximum = 46  
       mean = 35.5  
       S.D. = 7.3  
 Dominance - right-handed = 20  
               left-handed = 1

### TEST STATISTICS

<b><u>SHOULDER TO OVERHEAD LIFT</u></b>		
	<u>Maximum Lift</u>	<u>Safe Recommended Lift</u>
minimum -	21.0 lbs.	21.0 lbs.
maximum -	47.0 lbs.	45.0 lbs.
mean -	34.3 lbs.	33.9 lbs.
S.D. -	6.7	6.7

**TOTAL SAMPLE POPULATION -**

N = 55

Age - minimum = 24

maximum = 75

mean = 38.8

S.D. = 11.0

Dominance - right-handed = 53

left-handed = 2

**TEST STATISTICS**

<b><u>SHOULDER TO OVERHEAD LIFT</u></b>		
	<u>Maximum Lift</u>	<u>Safe Recommended Lift</u>
minimum -	21.0 lbs.	21.0 lbs.
maximum -	94.0 lbs.	85.0 lbs.
mean -	52.5 lbs.	50.9 lbs.
S.D. -	17.0	15.8

**RELIABILITY STATISTICS:**

Pearson Product-Moment Correlation Coefficients -

<b><u>SHOULDER TO OVERHEAD LIFT</u></b>	
<b>Maximum Load</b>	<b>Recommended Safe Load</b>
0.974	0.980

**PERCENTILE CHARTS:**

<b>ALL MALES (AGE 24-75)</b>							<b>N=31</b>
<b>SHOULDER TO OVERHEAD LIFT - Attachment #191</b>							
Percentiles	1	10	25	50	75	90	95
Maximum Lift - pounds							
Bilateral	37	49	55	63	70	77	89
Recommended Safe Lift - pounds							
Bilateral	37	47	54	61	68	74	85
<b>ALL FEMALES (AGE 25-46)</b>							<b>N=21</b>
Maximum Lift - pounds							
Bilateral	19	26	30	34	39	43	50
Recommended Safe Lift - pounds							
Bilateral	18	25	29	34	38	43	50





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