BTE™

SIMULATOR II™

OPERATOR'S MANUAL

Original Instructions

Printed in the U.S.A

40015903 Rev. D, CO 5062

This manual supports the BTE Technologies, Inc. Simulator II™

Manufacturer's Information:

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Safety and Regulatory Information

Simulator II Description and Intended Use

Product: Simulator II

Model: Sim II 5 and Sim II 03

General Description

The system provides active concentric torque resistance to patient motion. The system includes a dynamometer, mechanical adapters for various applications, a control system, and a computer for user interface and storing patient data.

Intended Use

<u>Summary</u>
The Simulator is intended to be used for musculoskeletal testing and treatment. The application is physical therapy. The system is intended to evaluate deficits, increase strength and range of motion, and track patient progress through the process.

<u>Detailed</u>
The Simulator is an exercise and evaluation device that is intended for use in occupational and physical rehabilitation. The system provides isometric and dynamic resistance for the physical rehabilitation. The system is used to improve muscle strength, endurance, and improve the range of motions at effected joints.

The Simulator can also be used in functional rehabilitation therapy where the patient is allowed to perform compound motions intended to simulate the motions of real life tasks, such as pushing a load, reaching overhead or pulling a handle. The intent is to improve the patient's general strength, endurance, and coordination for performing such movements.

The system measures force output (in terms of maximum isometric contraction), dynamic work (force x distance), and dynamic power (work/time) of patients using the device. 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.

Examples of injuries or disorders that are intended to be aided by the simulator are as follows.

- Mended fractures,
- Muscle strains,
- Ligamentous strains,
- Tendon injuries,
- Sprains,
- Cumulative trauma disorders
- Neuromuscular disorders

Application Specification

Intended Medical Indication
The Simulator II is an exercise and evaluation device that is intended for use in physical rehabilitation. The system is used to improve the muscle strength and endurance of selected body segments, and improve the range of motion at affected joints.

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.

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 rehabilitation.

Intended Anatomical Applicability
Evaluation and rehabilitation 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.

Applied Parts
Applied parts include tools and attachments. All applied parts are Type B.

Essential Functions
• Accuracy of Treatment including correct torque, speed, distance, direction, and response to user control
• Availability of Isotonic and Isometric resistance modes
• Exercise Head can travel up and down on the column and can be tilted to allow patient positioning required for the evaluation or treatment.

• The application provides feedback on torque applied by the user, speed applied by the user, and distance traveled.
• Accuracy of Output such as reports that must provide accurate 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 is unresponsive and the system must not apply excessive forces when in failure mode.
Essential Performance

<u>Simulator Essential Performance</u>
• Simulator II does not have any essential performance characteristics.

Definitions of Symbols and Certification Marking

Manufacturer		CE Marking	CE
Catalogue Number (Product and Model Number)	REF	Authorized Representative in the European Community	EC REP
Serial Number	SN	Alternating Current	~
Electromagnetic Field		"ON" (Power)	|
General Warning Sign		"OFF" (Power)	○
Type B Applied Part		Temperature Limit	
Certification Mark	MET c us	Humidity Limit	%
Follow instructions for use		Atmospheric Pressure Limitation	
		Protective Earth	

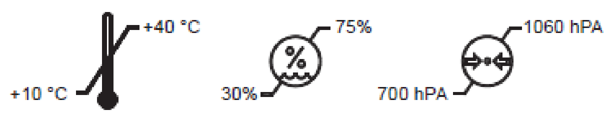
Safety and Regulatory Marking on the Equipment

CE (Where applicable)

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

CAUTION:
RISK OF ELECTRIC SHOCK.
DO NOT OPEN UNIT.
REFER SERVICING TO
QUALIFIED SERVICE PERSONNEL.

Permissible Environmental Conditions for Transport and Storage



WARNING
Only Simulator computer, printer, and monitor may be safely attached to the multiple-socket outlet.

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.

Warnings

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

WARNING
Only Simulator computer, printer, and monitor may be safely attached to the multiple-socket outlet.

WARNING
Connect to the multiple-socket outlet only the specified Simulator 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 Simulator system.

WARNING
Do not modify this equipment without authorization of the manufacturer

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

WARNING
The system is not intended to be serviced or maintained while in use by the patient

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

CAUTION
Risk of electric shock, do not open unit. Refer servicing to qualified service personnel.

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

Limit full column excursions to one per ten minute period.

Permissible Environmental Operating Conditions

Ambient temperature: +10°C to +40°C

Relative humidity: 30% to 75%

Atmospheric pressure: 700 hPa to 1060 hPa

Permissible Environmental Conditions for Transport and Storage

Ambient temperature: +10°C to +40°C

Relative humidity: 30% to 75%

Atmospheric pressure: 700 hPa to 1060 hPa

Electromagnetic Interference

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

Computer Ports

Only factory installed devices are to be used with the computer supplied with the Simulator II with the exception of the USB ports on the front of the computer. The USB ports on the front of the computer 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 computer as part of the standard installation are as follows.

Port	Devices
USB	Keyboard
	Touch Screen USB Interface
	Printer
Audio Out	
DVI	Touchscreen Monitor
Serial Port	Simulator Unit

Interchangeable or Detachable Parts by Service Personnel.
There are no components that are designated as repairable by service personnel. Components will be replaced if needed in accordance with BTE service policy

Servicing

- No parts shall be serviced or maintained while in use with a client.
- Upon request BTE will provide circuit diagrams, component parts lists, descriptions, calibration instructions, or other information to assist customer service personnel to repair parts.

IMPORTANT NOTES

The computer that was shipped with your Simulator is the brain of the system. Adding other software to this computer 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.

System Access

Your Simulator II 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: **WS**

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

IMPORTANT INFORMATION

This page highlights important considerations regarding the Simulator II. Please follow these important notes.

- A dedicated circuit is necessary to operate the Simulator II. The circuit should have:
    - Voltage Supply 110-120 VAC, 220-240 VAC (Refer to Product Label)
    - Supply Frequency 50–60 Hz
    - Power Input 2300 VA (volt-ampere)

- The Simulator II should not be plugged into an ungrounded circuit. Voltages ± 10 percent of the rated voltages for your country can result in error messages. Even if you have a dedicated outlet for your Simulator II, have a technician check the outlet with a voltmeter to ensure that the wall voltage does not exceed the specified voltage ± 10 percent. If your wall voltage exceeds these voltage specifications, call BTE immediately.

- Position the Simulator II in the desired location, near a dedicated outlet for the appropriate voltage for the Simulator II. Do not plug device into an outlet until installation is complete.

- The Simulator II sound pressure level does not exceed 70dbA at the head.

- There are no tests that have to be performed in the field to ensure basic safety other than preventative inspection described in the maintenance section.

- Calibration shall be performed as described in the manual.

Information Regarding EC Declaration of Conformity

BTE has issued the EC Declaration of Conformity declaring that the Simulator II meets the provisions of the European Union Medical Device Regulations and applicable Directives. The declaration may not apply to each unit.

The following information applies to the product:

Name and contact information of the manufacturer	BTE Technologies, Inc. 7455-L New Ridge Road Hanover, MD 21076, USA Telephone: (410) 850-0333 Fax: (410) 850-5244
Product identification	**Product Name**: Simulator II **Model**: SIM II 5
Medical device class	Class I
Route to compliance	Annex VII of the Medical Devices Directive
Intended use	The Simulator is intended to be used for musculoskeletal testing and treatment. The application is physical therapy. The system is intended to evaluate deficits, increase strength and range of motion, and track patient progress through the process.
Contact information of the manufacturer's Authorized Representative operating in the European Community	EC REP Emergo Europe Authorized Representative in Europe Prinsessegracht 20 The Hague 2514AP The Netherlands Email: Europe@emergogroup.com
CE Marking	CE The CE Conformity Marking is placed on the device where applicable.

A copy of the EC Declaration of Conformity can be obtained by sending a written request to BTE at the listed above address.

Notice to Customers Located in the European Union

Emergo Europe is BTE's Authorized Representative in the European Union as noted in section "Information Regarding EC Declaration of Conformity". The Authorized Representative's function is described in the Council Directive concerning medical devices. BTE Customer Service is your point of contact for technical support.

INTRODUCTION

The Simulator II™ can be used for isometric and isotonic evaluation and treatment. After you have followed all the assembly instructions in this manual and have your Simulator II ready to use, it is essential that you then read sections 2 and 3. These sections will help you to fully understand how to effectively use the basic set-up controls of the system.

Only with time and experience will you learn all the capabilities of the Simulator II. This manual is intended to get you started and answer your basic questions, but **it's up to you to realize the full potential of the Simulator II** in your particular program. We suggest that you take the time to go through the entire manual, as this will surely aid in the development of your program. While the first section explains the basics of operation and set-up, the *Clinical Applications Manual* provides insight as to how to use the Simulator II with your patients. Please take the time to read this section of the Operator's Manual as well, as it will greatly enhance how effectively you use the Simulator II with your patients.

If you have any problems with or questions about your Simulator II, we will be glad to assist you in any way possible. Call BTE toll-free at **800-331-8845** (1-410-850-0333 outside the US and Canada).

Section 1
SETUP AND INSTALLATION

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

Assembly Instructions

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

1) Place the base in the location where you want the SIMULATOR II to be used. Remove the wheels. **(NOTE: The base must be bolted to the floor. Please refer to the Installation Instructions following these Assembly Instructions)**

2) Remove the exercise head, computer CPU, monitor, printer and computer stand from their boxes.

3) Place the exercise head on the support platform on the base and use the 4 screws (1/4-20) provided to attach the head to the telescope. The screws go up through the telescope plate and into the underside of the exercise head. Start all four screws, then go back and tighten.

4) Take the cable from the exercise head and connect it to its mating plug on the box on the base of the unit. It will only fit one way. All plugs are keyed and must be aligned. Be sure plug is firmly seated.

5) Computer Cart Setup

a) Remove cart from its shipping carton.

b) Attach the chrome handle to the front of the top shelf using the included small hex screws.

c) Place the computer (CPU) on the bottom shelf of the cart. Place the printer on the middle shelf above the computer. Place the monitor and keyboard on the top shelf. You may also place the adjustable tray under the top shelf and place the keyboard on the tray instead. Place the speakers on the CPU or behind the printer

d) Remove the long vertical cover on the back of the computer cart (six hex screws)

e) Feed all cables through the nearest slot on the front of this column.

f) Connect the power cables for the CPU, printer and monitor to the outlet strip on the inside of the column. Make sure the power strip switch remains in the ON position.

g) Feed the monitor, keyboard, mouse, touch screen adapter, speaker and printer cables along the inside of the column, then out the slot nearest to the component it plugs into.

h) Connect each cable end to its proper receptacle. Connect the touch sensor cable to serial port 2. Replace the cover on the back of the computer cart.

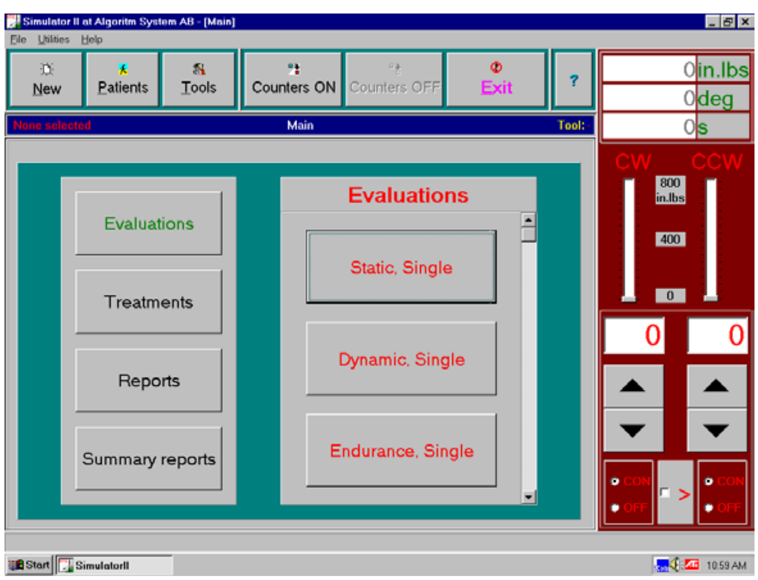
6) Connect the long cable from the computer cart to its mating connector on the box on the base of the unit. Be sure the connector is firmly secured.

7) Take the plug from telescope motor and plug it into the receptacle on the front of the box on the base.

8) Place toggle switch on power supply in the off (down) position.

9) Connect the power cord from power supply to standard <u>GROUNDED</u> 110 Volt AC outlet. <u>DO NOT</u> plug power supply into an ungrounded outlet. 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 SIMULATOR II power supply cord to the wall outlet. Move toggle switch on the power supply box to the "ON" (up) position. A pilot light on the power supply box will indicate that power is on. At this point power is flowing to the computer cart and the computer components may be switched on.

When the Windows desktop loads, click on the SimII icon to start the SIMULATOR II. The main menu and control panel will appear as follows:



The main power cord (supplied by BTE) is a 120 volt three prong hospital grade; UL and/or CSA approved for North America. For placement in other countries, the appropriate cord will be supplied by BTE.

IMPORTANT

The BTE SIMULATOR II must be bolted to the floor.

It is possible for the base to slide or the back of the base to lift slightly if this is not done. The base is drilled to accept 3/8" anchor bolts for this purpose (included in shipment). The upper hole will allow a standard socket wrench to pass through so the bolt can be tightened down against the lower pad. Please refer to the Installation Instructions below before using the BTE SIMULATOR II.

Installation Instructions

The BTE SIMULATOR II must be anchored to the floor before it is used for patient treatment! Do not proceed until you have completed the following steps.

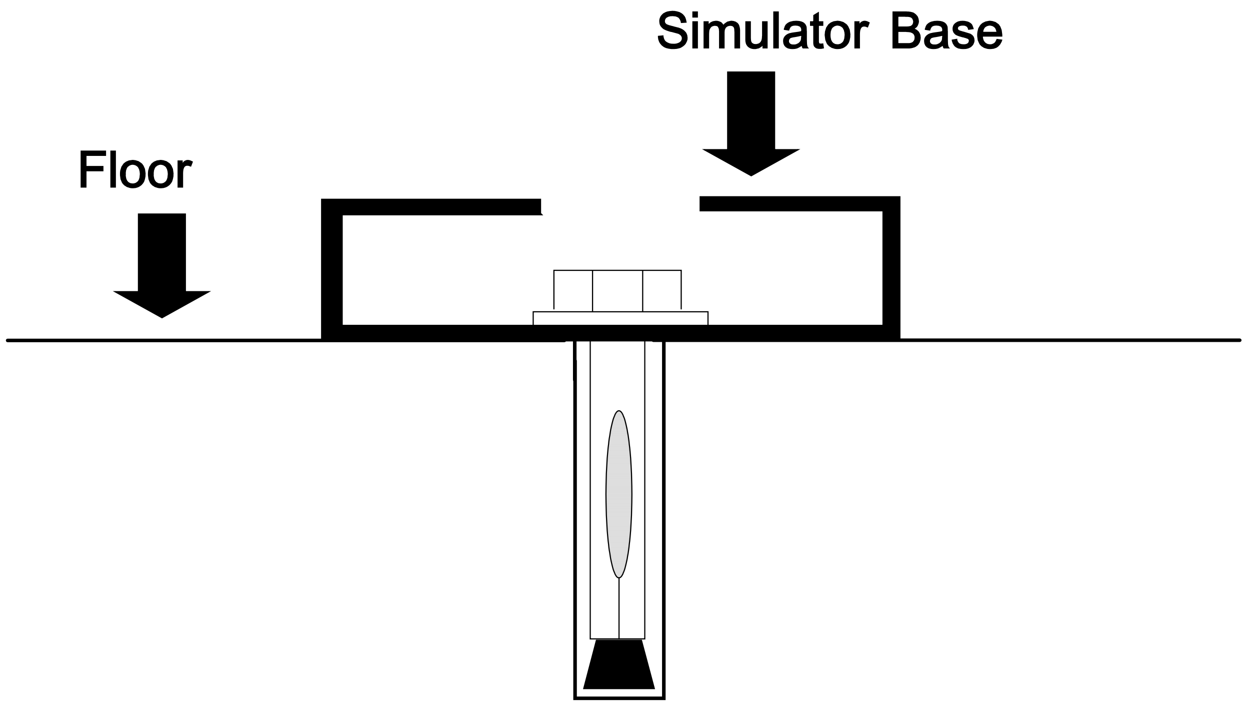
1) Position the unit in the exact location you want it in your clinic.

2) Mark the floor through the four holes in the base of the unit.

3) Move the SIMULATOR II base so the marks you made on the floor are visible.

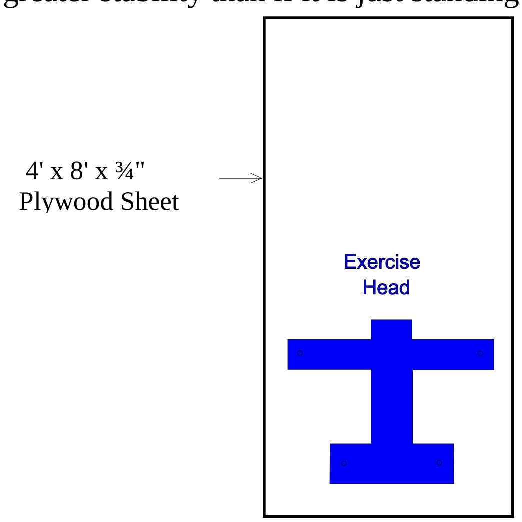
4) Drill the four holes with the 3/8" bit included with the SIMULATOR II. Make sure the holes are at least 3" deep.

5) Reposition the SIMULATOR II over the holes and insert the bolts (see figure below). Tighten them down firmly.



Alternate Installation

If conditions do not allow the SIMULATOR II to be bolted to the floor, we strongly recommend that your bolt it to a 4’x8’x¾” sheet of plywood. This will give the SIMULATOR II greater stability than if it is just standing on the floor.



Placement Guide – Alternate Installation

Notice

This equipment complies with the requirements in Part 15 of FCC Rules for a Class A device. Operation of this equipment in a residential area may cause unacceptable interference to radio and TV reception requiring the operator to take whatever steps are necessary to correct the interference.

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

Information regarding the magnetic field and action to be taken is included in the Safety and Regulatory Information section.

Section 2
General Operation

Getting Started

To turn the SIMULATOR II "ON", move the power switch in the power box to the ON (**I**) position. Then, turn the CPU, monitor and printer on.

Note: When you shut the system down at the end of the day, leave the monitor and printer turned on. When you turn the SIMULATOR II power switch to the OFF position, these components will be turned off as well. If you leave the component switches ON, when you turn the system on the next day, these components will turn on automatically with the SIMULATOR II. The CPU must be turned on separately.

The SIMULATOR II program can be controlled with the mouse or via the optional touch screen.

Mouse Operation Tips:

In some instances, you may find it easier to use the mouse instead of the touch-screen control. If you are unfamiliar with computers and mouse operation, here are some tips to remember as you read through this manual and are using the mouse:

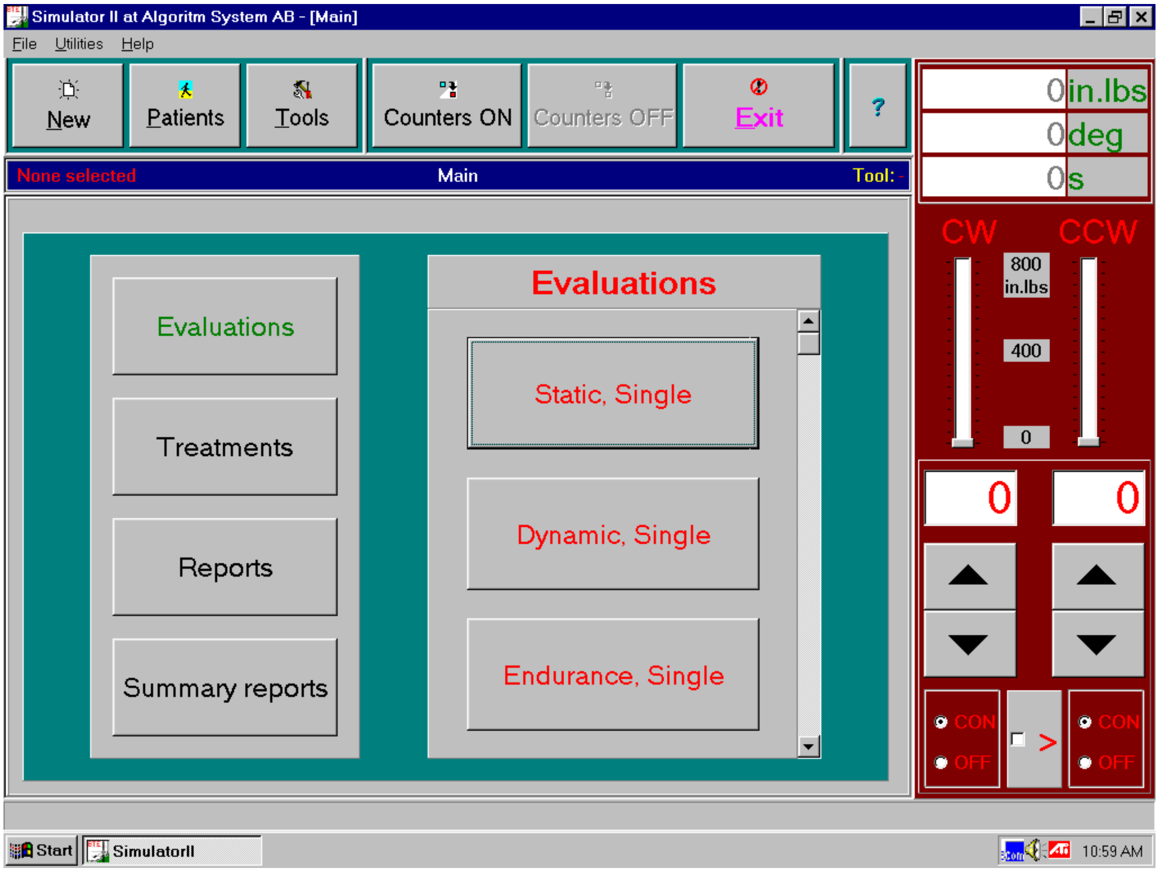
If instructed to "select" or "click", move the pointer on the screen to the desired selection and quickly press and release the left button on the mouse.

If instructed to "double click" an item on the screen, move the pointer to the desired selection and press and release the left mouse button twice in rapid succession.

If instructed to "right click", move the pointer on the screen to the desired selection and press and release the right button on the mouse. This usually pops up a menu with additional choices to select from.

To "drag" something on the screen, move the pointer to the selection, then press and hold the left mouse button. Move the pointer by moving the mouse while still holding the left button. When you get to the desired location, release the mouse button.

When the Windows desktop appears, double click the **SIMULATOR II** icon on the desktop to start the program.

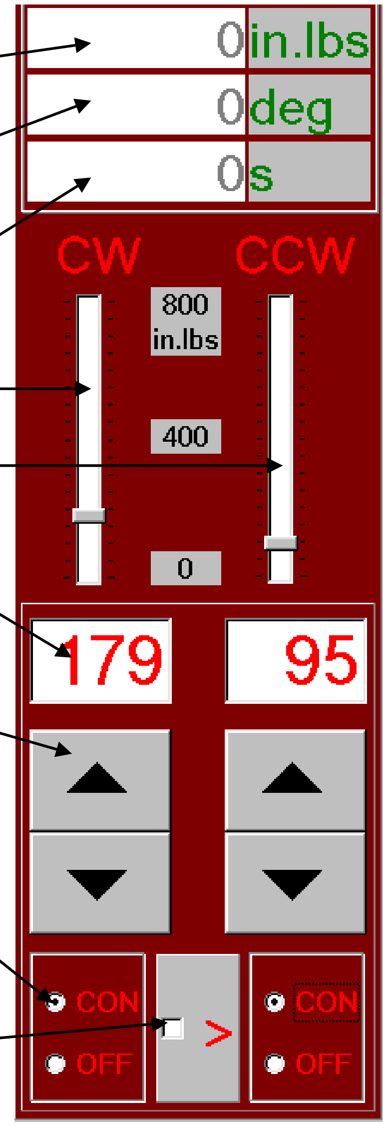


The start-up screen, above, has a number of options for starting a session. If you are planning to set up an exercise program that will be repeated on a regular basis, or if you are performing an evaluation, you will need to create a Patient record for the patient. However, if you need to perform a trial exercise or wish to use the system without creating a patient record, you may do so by using the control panel on the right side of the screen.

The right side control panel gives you the ability to use the SIMULATOR II with a minimum of set-up steps. Simply insert the desired attachment, then select the resistance level using the vertical slide bars. You may drag the bar with the mouse or use the touch screen to move the bar.

The chart on the next page explains each field and control on the Control Panel.

SIMULATOR II Control Panel



The top field (force) shows the "real time" force that the patient is exerting.

The second field (degrees) shows the total degrees of motion the patient has moved the tool against resistance.

The third field (seconds) shows the time elapsed in seconds since the patient started the exercise.

The left vertical slide bar controls the clockwise resistance.

The right vertical slide bar controls the counterclockwise resistance.

You may also enter the resistance by selecting the force setting field and typing in the desired force value.

The UP ARROW and DOWN ARROWS may also be used to make force adjustments. These are useful to make small adjustments while the exercise is in progress.

At the bottom of the Control Panel, you have the option to turn off the resistance in either direction. If you want resistance, click the ○ CON marker. If you do not want resistance in a certain direction, click the ○ OFF marker.

If you want the same resistance in both directions, click the center ☑ > symbol to "synchronize" the clockwise and counterclockwise force settings.

Because each direction has its own control bar, different resistance levels can be set in each direction. If you want the same force in both directions, simply click the “Synchronize” box. Then, when you change resistance using the left (clockwise) slide bar, the right (counterclockwise) bar will shadow it, and both clockwise and counterclockwise directions will have the same resistance setting.

Exercise data is reported at the top of the screen. To begin collecting data on an exercise, select the **Counters ON** box at the top of the screen. If you do not want to collect data on the exercise, select **Counters OFF**.

The data includes the total distance the tool has been moved against resistance, and the time of the exercise. This data is not saved, so make a note of it if you want it for the patient’s record. To clear these fields, left click on a field you wish to reset to "0".

Please note that using the Control Panel will not allow you to save any data collected. If you want to save an exercise session, go to the Treatment Chart Set-up and create an exercise protocol for that patient, then use that protocol each time the patient used the SIMULATOR II (see Section 4). This will give you the option to save the exercise sessions to be reviewed later or to generate progress graphs.

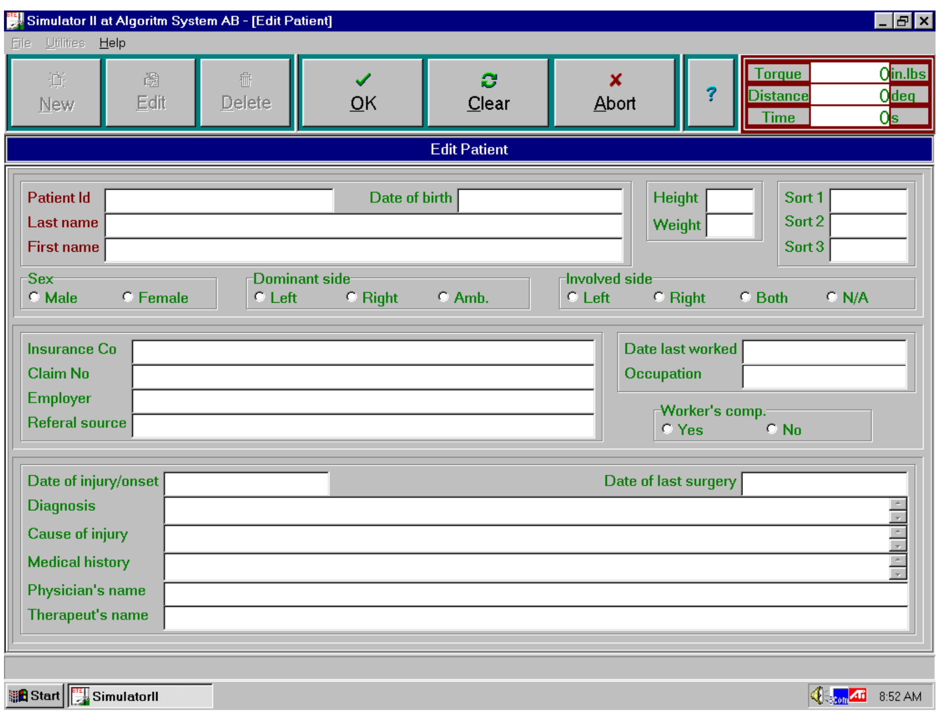
Patient Records

If you want to save any test or treatment information, you must create a patient record for each patient. The SIMULATOR II software uses the patient record to track all test and treatment information, and to generate reports and summaries.

Information entered into the patient record screen will be printed on the Evaluation Report if desired.

To create a new patient record, select **NEW** at the start-up screen.

There are three fields that must be entered before you will be allowed to save a new record. These fields are designated by the red type and include ID Number, Last Name and First Name. All other fields are optional and may also be entered at any time after creating the record using the EDIT option.



When all desired information is entered, select **OK** and the record will be saved.

To Edit A Record

To make changes or add information to a Patient's record, perform the following steps:

Select **Patients** from the main screen.

Select **Show Patient List** and select the patient from the list.

Select **Edit** and make the desired changes.

When finished, select **OK**.

Select **OK** or **Abort** to return to the main screen.

To Delete A Record

To permanently delete a Patient record from the database, perform the following steps:

Select **Patients** from the main screen.

Select **Show Patient List** and select the patient from the list.

Select **Delete**.

Select **OK** when prompted. You will be asked to confirm your selection to help prevent the accidental deletion of a patient record.

Select **OK** or **Abort** to return to the main screen.

Working With A Specific Patient

If you want to save a Treatment Chart or Evaluation for a specific patient, you must select the patient and tool prior to the completion of the treatment session or evaluation.

To select a patient, select **Patients**, then enter the **ID** number and click **OK**. If you do not know the ID number, select **Show Patient List** and highlight the desired patient on the list. Select **OK** to make the selection.

Help Levels

There are three help levels available in the on the SIMULATOR II - Low, Medium, and High. The help level you select determines whether or not "help prompts" appear when you make certain selections, such as saving data, clearing data and starting trials. Low Help level gives you the fewest prompts and High Help level gives you reminder prompts just about everywhere. For experienced operators, it is most efficient to set the Help Level to the medium or low setting.

To set the Help Level, select **Help** at the top of the screen, then **Help Level**, then click on the level of help you wish to use.

Turning the *SIMULATOR II* OFF

Once the SIMULATOR II is turned ON, it is ok to leave it on all day. At the end of the day, you should turn the system OFF. To do so:

Select **EXIT** from the Main Screen.

Select **START** on the Windows desktop.

Select **Shut Down**, then **Shut down the computer**.

After the CPU has turned itself off, you may then turn off the SIMULATOR II Main Power Switch located on the power supply box. Leave the power switches on the monitor and printer in the ON position.

Warning: Make sure you follow the above steps to properly shut down the SIMULATOR II! Failure to do so may produce errors on the hard drive and corrupt files in Windows and/or other software running on your system.

Section 3
EXERCISE HEAD AND ATTACHMENTS

Exercise Head Description

The exercise head is the mechanism that creates the resistance for the exercises. It has two adjustments to place the tool in the desired position for an exercise. The entire head may be raised or lowered by pushing the up-down switch.

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 vertically to any one of seven positions from straight up, to 45^{o} below horizontal. Push the lever back down to lock the exercise head when one the desired position is found.

CAUTION: Be sure this lever is locked into one of the seven positions before proceeding with an exercise.

The shaft on the exercise head has a knurled nut with a center hole for inserting the SIMULATOR II attachments (Fig. A - next page). Inside there is a square hole that matches the square shaft end found on all attachments. When an attachment is inserted, slowly rotate it while lightly pushing in until it slides in place. The squares must be aligned before the attachment can be completely seated. Once it is seated, hold the attachment and turn the knurled nut clockwise as tight as possible. If properly inserted, the attachment will be locked into the shaft. To make sure the tool is locked in securely (especially with attachment #191), we recommend that you use the spanner wrench (Fig. B), enclosed with the exercise head. To use, insert the small round tip of the spanner into one of the two small holes in the knurled nut. While again holding the attachment, use the spanner to tighten the nut.

When releasing an attachment, back the knurled nut off (counterclockwise) only enough to pull the attachment out. If the nut is very tight and difficult to loosen, increase the resistance in the counterclockwise direction so the exercise shaft will be held in place by the higher resistance. Now you can use both hands on the spanner wrench to turn it counterclockwise, releasing the tight nut.

FIGURE A
EXERCISE SHAFT

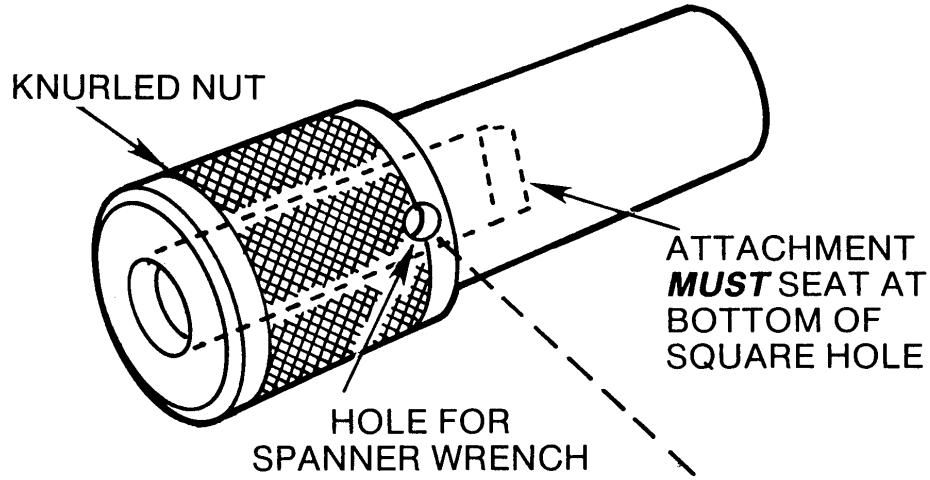
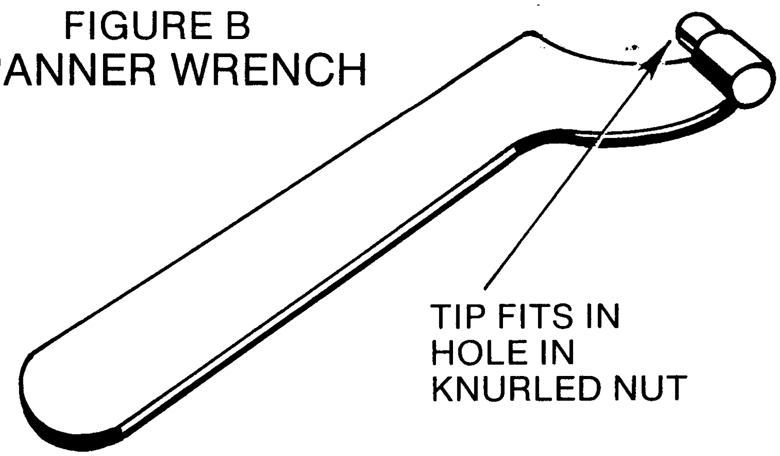


FIGURE B
SPANNER WRENCH



PLEASE NOTE

It is a normal mechanical process for heat to build up whenever resistance is turned on at the exercise head. This heat will <u>not</u> harm your BTE SIMULATOR II.

ATTACHMENTS

All attachments have a three-digit number on them. This standard numbering is a handy reference when discussing the various uses for each attachment. It is also useful in recording and documenting patients exercise and progress.

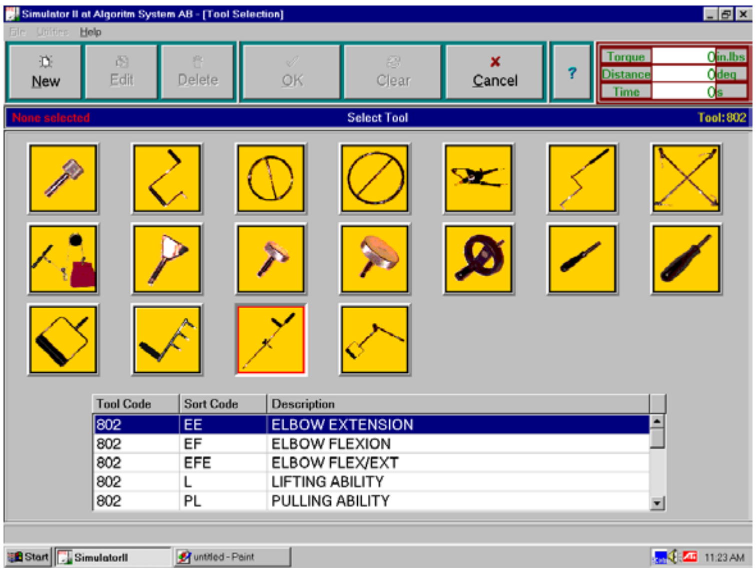
A sample of uses for each attachment is given in this section. Keep in mind that the examples stated represent only sample applications for each attachment. The actual total number of applications is limited only by your creativity. We suggest that you experiment on your own, with each attachment used in as many different positions as you can come up with (i.e., tilt the exercise head through all seven positions and raise and lower the telescope for an assortment of heights - also try sitting in a chair).

If cleaning/disinfecting the attachments becomes necessary, use an alcohol-based solution. Dampen a cloth with the solution and wipe down the attachments.

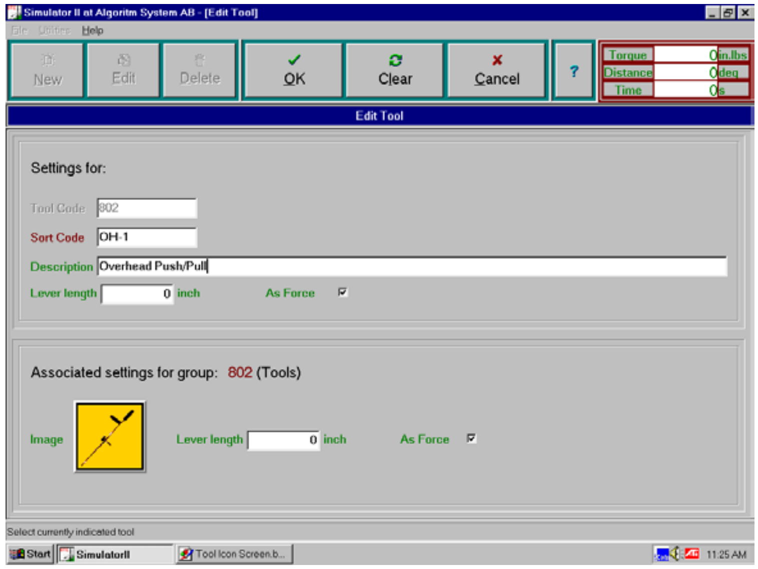
Tool Setup

To select the attachment you will be using, select **Tools**, then select the picture of the attachment you would like to use. Once the picture is selected, choose from the list of functional descriptions at the bottom of the screen.

If you would like to add a description to the list, select the tool you would like to add a functional description, then select **NEW**. You must assign a Sort Code and Description. Select **OK** when done.



The Sort Code provides a secondary ranking system for tool descriptions.



To change or edit the name of a saved description, select the description you want to change, then select **EDIT**. In the **Description** field, type in the new name for that tool description. You must also enter a **Sort Code**. Select **OK** when done.

If you want to have the results for this tool description to be displayed as force (pounds) instead of torque (inch-lbs.), make sure the **As Force** box on the top half of the screen located just under the Description field is checked ☑. With this box checked, if you enter the **Lever Length** of the tool you are using in the appropriate field at the test screen setup window, your results will be in pounds instead of inch-pounds.

You may also choose to default this description to force readings whenever *this description* is selected for any patient. To do this, at this screen, enter the lever length in the field labeled **Lever Length** on the top half of the screen and make sure the **As Force** box is checked. If both these fields are entered, the results will default to force for this tool and description.

You may apply these settings whenever you add a **New** description to a tool, or by selecting the **Edit** option to change the name or settings for an existing description.

It is not necessary to change or enter any information on the bottom half of this screen. These fields are not used with the default settings of the SIMULATOR II.

Attachment Use Suggestions

The following pages offer usage suggestions for each tool. These functions may be entered into the SIMULATOR II tool description lists by using the above described steps.

Attachment Description and Uses

102 - One Inch Diameter Knurled Knob

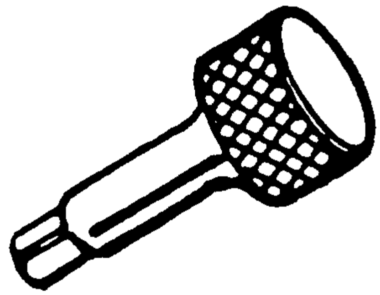
Fine finger manipulation (rotational)

To simulate:

twist top bottles
machine adjustments

Uses:

fingertip desensitization
pinch strengthening



202 - Key Shape

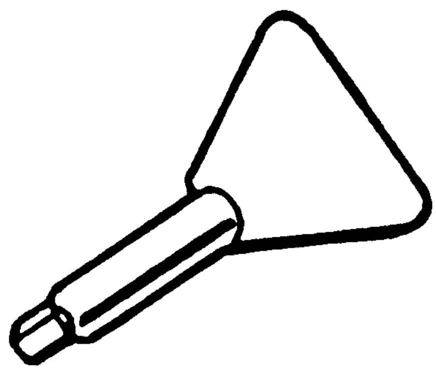
Finger pinch (rotational)

To simulate:

keys of all types

Uses:

fingertip desensitization
lateral pinch strengthening
pulp to pulp pinch strengthening
supination/pronation (with finger pinch)



301/302 - 301-Two Inch Diameter Knurled Knob
302-Three Inch Diameter Knurled

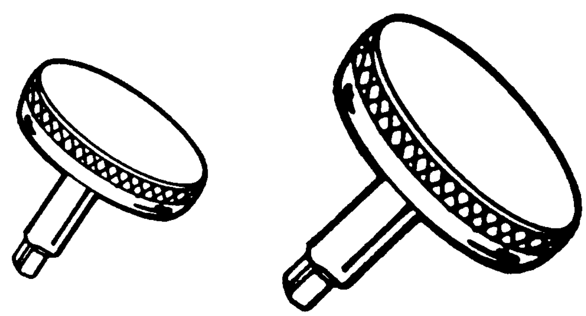
Spherical grasp (rotational) knob

To simulate:

door knobs
jar lids
machine adjustments
small valve wheels

Uses:

rotational grip strengthening
(static grip while turning)
fingertip and palmar
desensitization
radial/ulnar wrist deviation

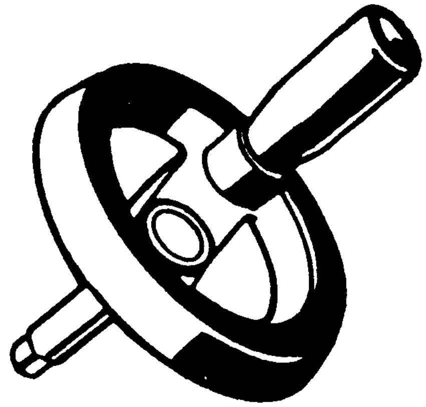


400 - Small Wheel with Short Crank

Finger pinch with compound wrist motion
(rotational) handle

To simulate:
- machine controls
- pencil sharpener
- hand drill
- lathe or milling machine crank

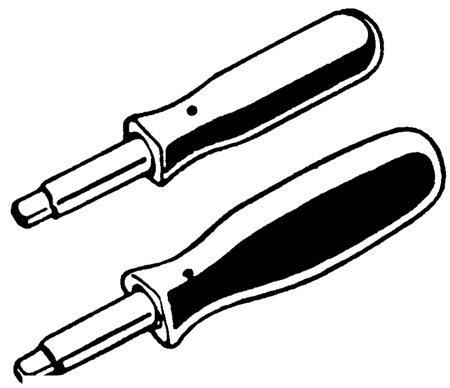
Uses:
- pinch strengthening
- compound wrist motion
- prosthetic training



501/502/504 - 501-small screwdriver handle
502-medium screwdriver handle
504-large screwdriver handle

Cylindrical Hand Grasp (rotational)

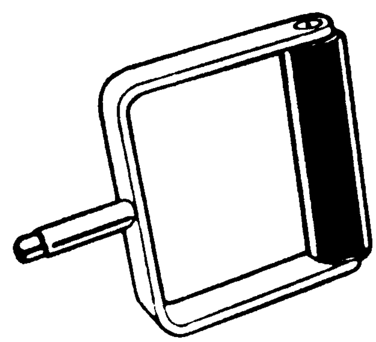
To simulate:
- screwdrivers of various sizes
- pipes
- wrist curls
- supination/pronation
  (with ulnar wrist deviation)
- wrist flexion/extension
- palmar desensitization
- grip strengthening
- increase of finger flexion



601 - Cylindrical Handle

Hand grasp for supination/pronation

Uses:
- supination/pronation
- radial and ulnar deviation

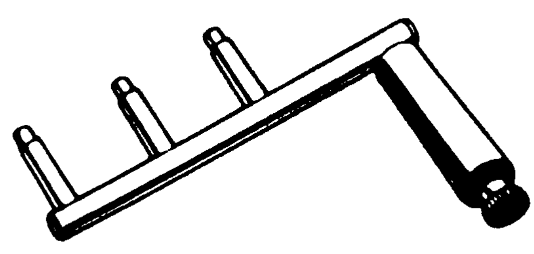


701 - Medium Crank Handle With Alternate SquareHandle

Hand grasp (rotational)
three position crank handle

To simulate:
- machine control
- car window crank

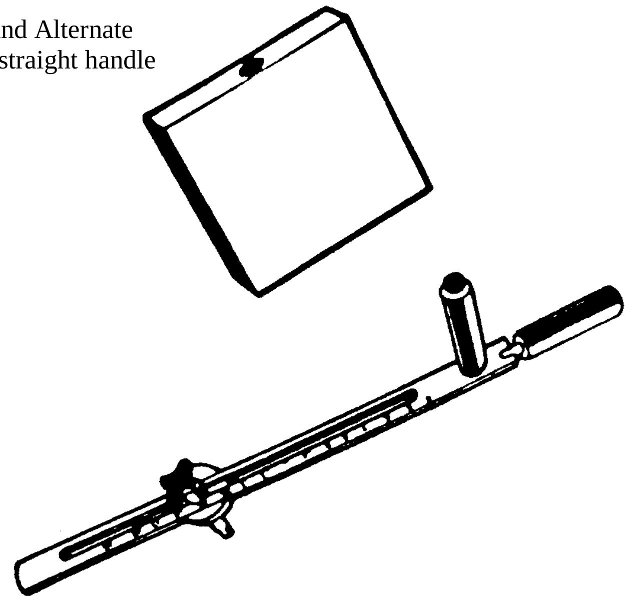
Uses:
- wrist flexion/extension (with arm support)
- pushing/pulling
- total upper extremity ROM
- prosthetic training



802 - Large Crank Handle With Two Position Hand Grip and Alternate
Square Handle, Multi-position crank handle and/or straight handle

To simulate:
- lifting (from various positions)
- crowbar
- drill press
- wrenches, etc.

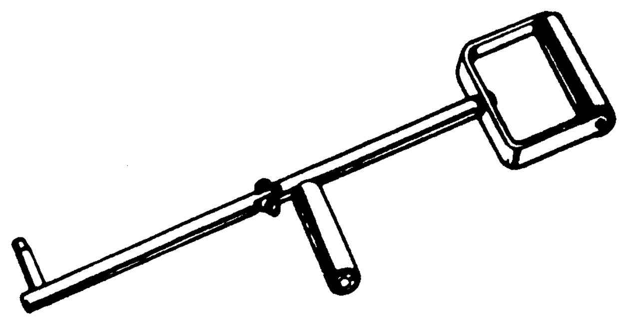
Uses:
- elbow flexion/extension
- internal/external shoulder rotation
- shoulder abduction/adduction
- shoulder flexion/extension
- pushing/pulling (overhead or horizontal)
- amputee and prosthetic training
- whole upper torso motion



901 - End/Side Handle With Articulating Joint
One or two handed grasp (linear motion)

To simulate:
- saw
- shovel
- lifting

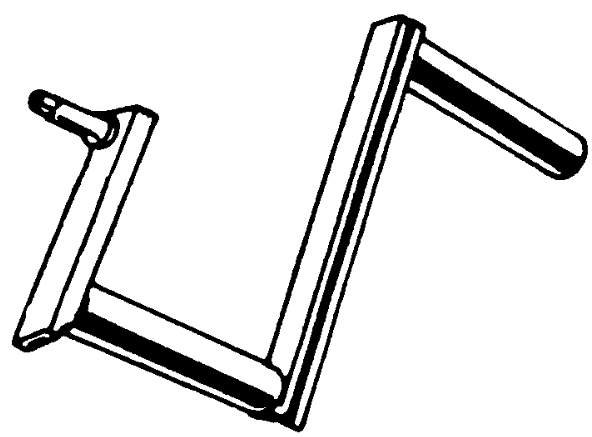
Uses:
- pushing/pulling
- bilateral upper torso motion
- elbow and shoulder flexion/extension



122 - Two Handled Reciprocating Crank (Rotational)

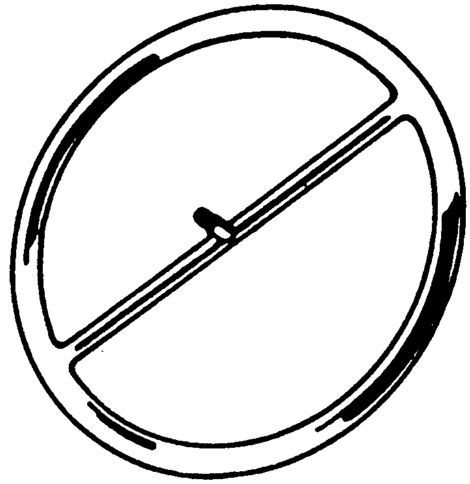
To simulate:
- auger drill
- upper extremity ergometer

Uses:
- upper body conditioning
- cardiac and pulmonary stress testing
- prosthetic training
- stroke and paraplegic
- rehabilitation



131/141 - 141-Large Steering Wheel (21" Diameter)

To simulate:
- driving
- valve wheels
- machine controls



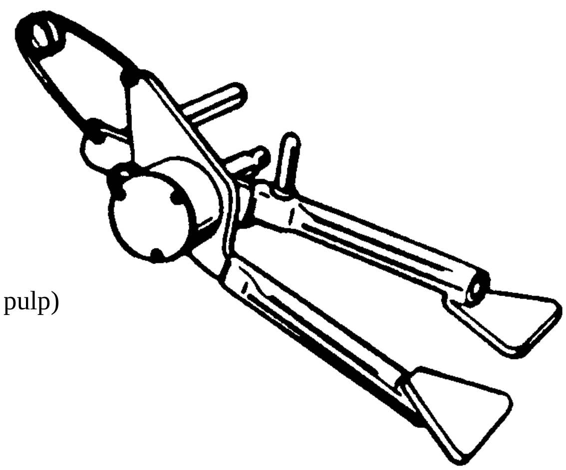
Uses:
- bilateral ROM
- driver training
- stroke and paraplegic rehabilitation
- prosthetic and amputee training

162 - Grip and Pinch Tool

pliers type handles

To simulate:

pliers	machine adjustments
scissors	pistol grip with trigger
shears	car door handle, etc.
stapler	



Uses:
- grip strengthening (various positions)
- pinch strengthening (lateral and pulp to pulp)
- fingertip and palmar desensitization
- improving finger flexion

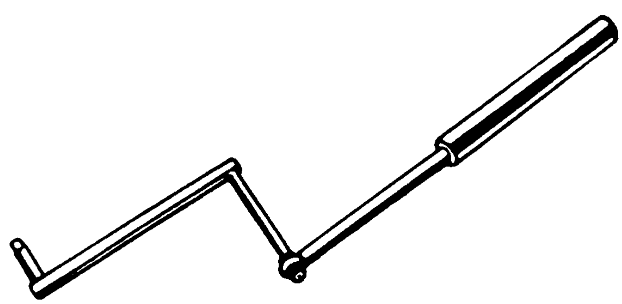
171 - Straight Handle with Articulating Joint

Cylindrical grasp (linear motion)

To simulate:

shovel	broom
knife	baseball bat

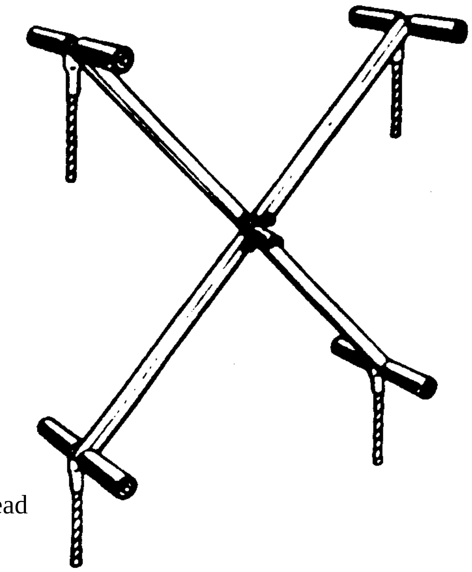
clothes iron scraper
tennis racket vacuum cleaner
hammer, etc. trowel



Uses:
- cylindrical grip strengthening while lifting
- pushing/pulling
- radial/ulnar wrist deviation
- whole upper torso motion

181 - Multiple Handle Crossbar

thirty-two inch diameter crossbar with four handles and ropes



To simulate:

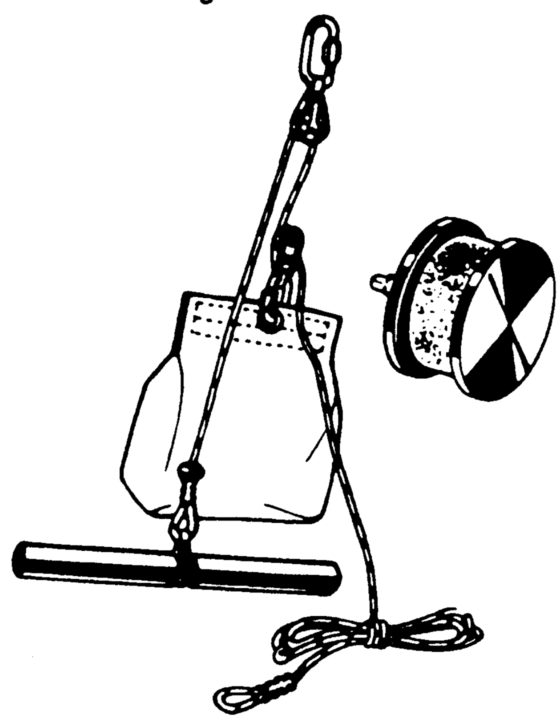
climbing ladder
pulling ropes

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 - Dynamic Linear Motion Attachment

rope, pulleys, handle - lifting range from floor to seven feet overhead



To simulate:

rowing
bowling
baseball bat
tennis racket, etc.

Uses:

unlimited uses and positioning
total body exercising
lift, push, pull in any direction
possible weight adjustment up
to <u>150</u> <u>pounds</u>

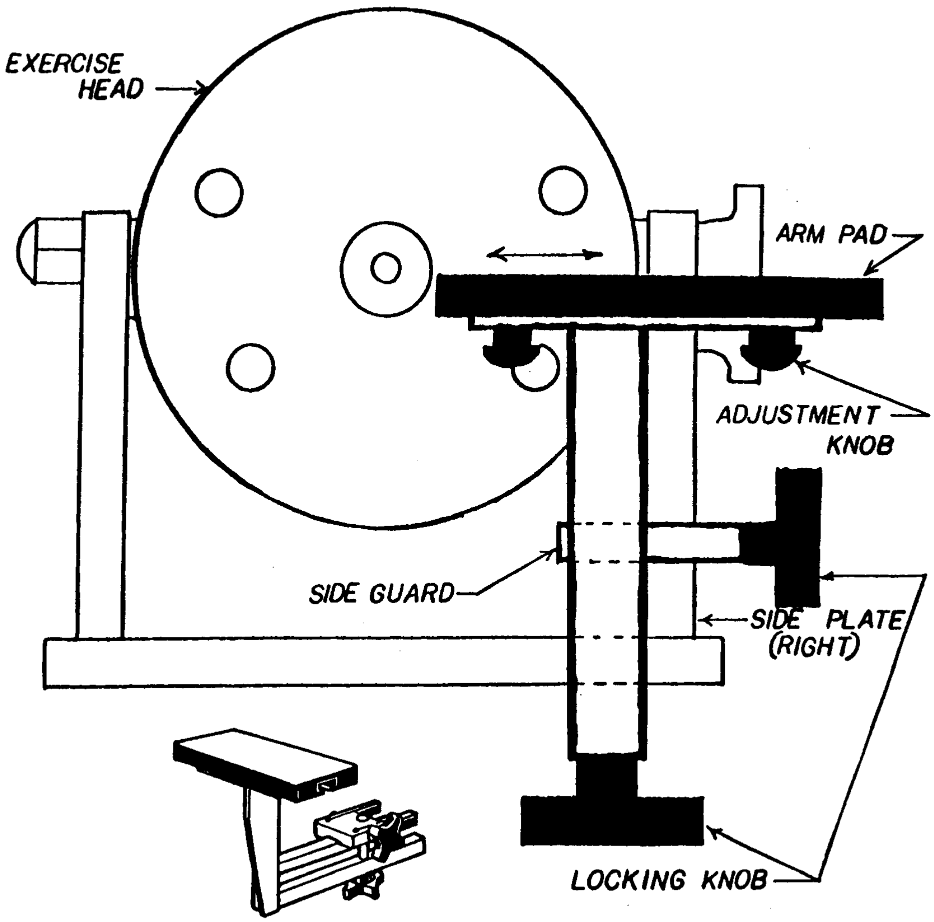
191B - Extension pole

See instruction, page xx in this section.

001 - Range-Of-Motion Limiter

002 - Arm Support For Wrist Flexion/Extension
(See Next Page)

ARM REST



ARM REST Set-up

To Use:

1) Loosen the LOCKING KNOBS.
2) Be sure armrest is against the right or left SIDE PLATE of the exercise head.
3) Push armrest all the way until the SIDE GUARD of the armrest is seated around the SIDE PLATE of the exercise head.
4) Tighten both LOCKING KNOBS.
5) Loosen ADJUSTMENT KNOBS to position ARM PAD.

HELPFUL SUGGESTIONS FOR INSERTING, REMOVING and USING TOOL #162

To insert, position the attachment in the exercise head. Then, apply light pressure to the center of the round hub while **slowly** squeezing the handles together several times, until the tool slides into place. The square end of the tool shaft will only align with the exercise head in four positions, and it is necessary to align these components for a secure fit. Once the tool slides in as far as it will go, tighten the knurled nut by turning it clockwise until it is snug. Before beginning any exercise with this tool, make sure the “Synchronize” button is checked.

To remove, increase the resistance in the exercise head by sliding the counterclockwise torque adjustment bar up. This will hold the shaft in place, allowing you to loosen the knurled nut by turning it counter-clockwise with either your hand or the spanner wrench. Once the knurled nut turns freely, pull the tool straight out. Lower the resistance back down.

The size of the handle opening can be adjusted to one of six different sizes. To change the grip size, insert one of the two "fast pins" into one of the three holes provided on tool 162.

For repeatability of patient performance, it is IMPORTANT that the patient always position his or her hand at the same location on tool 162 each time it is used. To help in positioning, there is a one-inch long stud sticking up on the top handle. This is provided as a stop against which patients should put the web space between the thumb and index finger when using this tool for grip strengthening.

Instructions for Assembly of the 191 Cable System

Step 1: Raise the exercise head to 54” as shown on the height scale.

Step 2: Straighten out the rope assembly so there are no tangles. Place the handle to the left, near the left eyebolt, and the bag to the right.

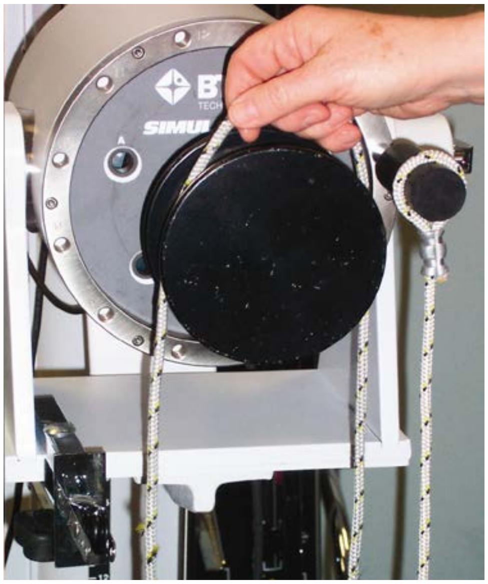
Step 3: Fasten the “rapid link” and large pulley to the left eyebolt and close the threaded sleeve. (DO NOT close it too tightly or it will be difficult to remove.)

Step 4. Screw in range-of-motion limiter (#001) at the 3 o’clock position. Screw it down tightly.

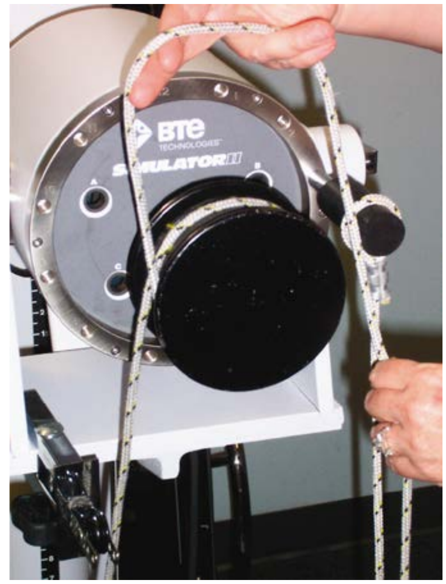
Step 5: Attach large black spool (#191) to exercise shaft. You MUST use your spanner wrench to tighten it securely.

Step 6. Attach guide pulley (#191C) at the left side of the exercise head.

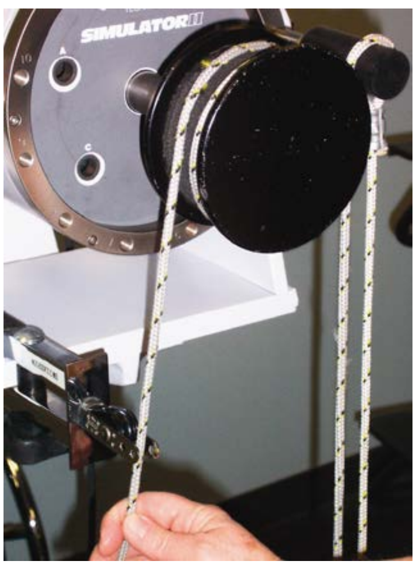
Step 7. Place the end loop of the rope on the range-of-motion limiter. Keep the loop on the outer edge of the black rubber.



Step 8. Grab the rope halfway between the handle and bag and drape it over the 191 spool, then let go.

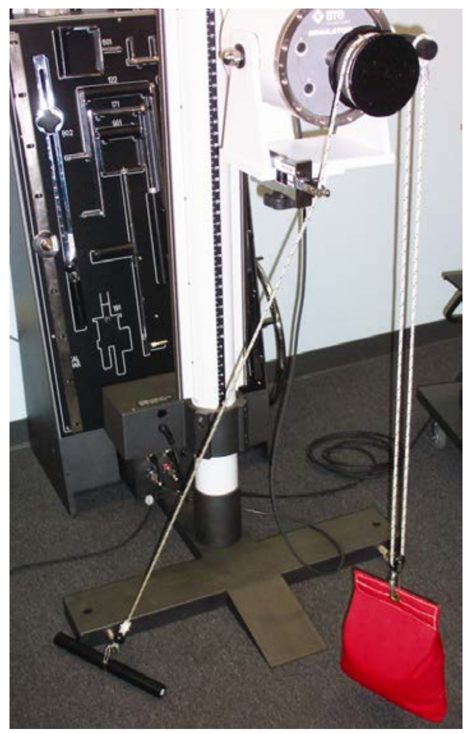


Step 9. With both hands, grab the middle section of the rope, which runs from the 191 spool down to the bag, and wrap it around the 191 spool one time.



Step 10. Place the left section of rope between the side supports of the guide pulley.

Step 11. In the software, set the resistance to OFF in the clockwise (CW) direction.



Complete Assembly: (you may reverse the setup if you wish to use the right side eyebolt.)

Step 12. With the resistance at 0 it is VERY IMPORTANT that you pull the handle through one COMPLETE travel until the bag has been raised up as high as it can go. Then return the handle ALL THE WAY back, to the starting point. This step is essential in order to pull the tangle out and “seat” the rope on the spool properly.

Notes: The bag should NEVER touch the floor during an exercise.
This attachment should be used ONLY in Manual Dynamic Mode.

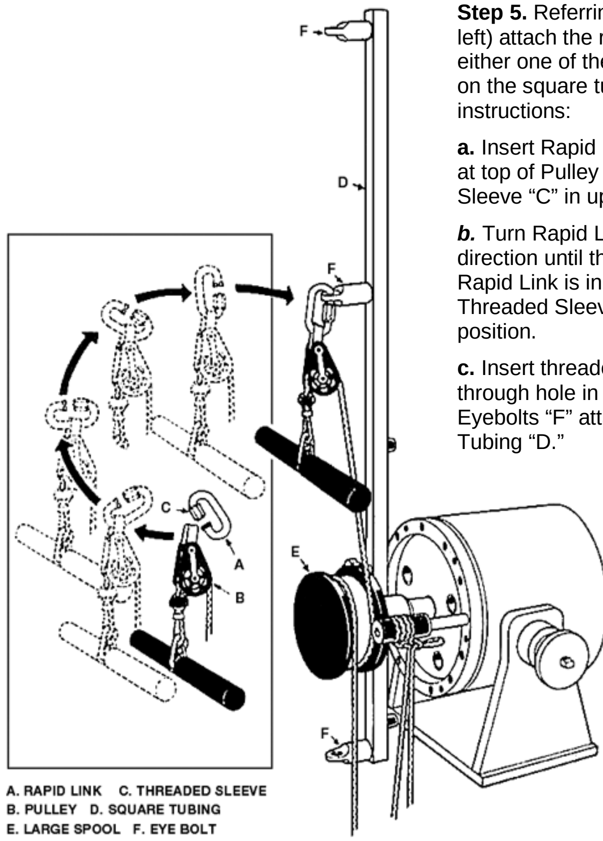
Instructions for installing attachment #191-B to the BTE Simulator II

CAUTION: Do not use attachment #191-B for isometric exercises or at a force above 150 lbs (300 in/lbs).

IMPORTANT: Attachment #191-B **MUST NOT** be used unless the SimulatorII has been bolted securely to the floor (or a 4’x6’ sheet of plywood as explained in the first section if the instruction manual). When using this attachment above chest height, there is a strong **DANGER** of tripping the machine over if it is not bolted down.

Repeat steps 1-3 from 191 setup procedure.

Step 4. Attach the square tubing to the exercise head using the two black knobs provided. Be sure to tighten both knobs securely so that the square tubing is snug against the chrome ring on the exercise head. (Note: the tubing can be attached with either the long end pointing up or down, as you will notice in the accompanying photos).



A. RAPID LINK C. THREADED SLEEVE
B. PULLEY D. SQUARE TUBING
E. LARGE SPOOL F. EYE BOLT

Step 5. Referring to illustration (at left) attach the rope and pulley to either one of the upper two eyebolts on the square tubing. Follow these instructions:

a. Insert Rapid Link “A” through loop at top of Pulley “B” with Threaded Sleeve “C” in upper position.

b. Turn Rapid Link in clockwise direction until threaded portion of Rapid Link is in upper position and Threaded Sleeve “C” in lower position.

c. Insert threaded part of Rapid Link through hole in either of the two top Eyebolts “F” attached to the Square Tubing “D.”

d. Turn Threaded Sleeve Clockwise, attaching it to threads on Rapid Link.

Step 6. Pull the end of the rope up and over the range-of-motion limiter (001) so that the bag is lifted off the floor. You must pull all of the slack out of the line and be sure that the handle is pulled snugly against the pulley as shown in the above illustration. Now wrap the excess rope around the 001 several times in a counter-clockwise direction. IMPORTANT: The bag should never touch the floor during an exercise.

Step 7. In the software, set the resistance to OFF in the clockwise (CW) direction. With the exercise level set at 0, pull the handle through one complete travel of the rope and then return the handle all the way to the starting point. This will seat the rope properly on the large spool so that it will then work freely during an exercise. Now you’re ready to set the exercise level at the desired resistance and begin your exercise.

USING ATTACHMENT 191

Dynamic Evaluations

To begin a lifting (or pushing or pulling) evaluation, set the resistance at the lowest level. After completion of each repetition, have your subject pause for a moment, and if he/she agrees, increase the resistance by 5 - 10 pounds. Continue this process until the subject is not willing to try any additional weight, or is unable to complete the full range you have selected (floor to knuckle, knuckle to shoulder, etc.).

Please note that attachments 191 and 191B are not designed to be used in the Isometric Mode. They are intended for dynamic use ONLY. Also, do not exceed 264 inch-lbs. of torque when using these attachments. 264 inch-lbs. is the equivalent of 150 lbs.

Suggestions for Using Attachment 191

1) Use the conversion chart to convert inch-lb. readings to pounds for attachment 191 only. To convert for other attachments, please refer to the TORQUE definition on page 901.

2) Do not allow your subject to drop the handle too quickly. Doing so allows the rope to go slack and the bag will drop uncontrollably, causing the handle to jerk out of his or her hands. Do not lower the handle faster than the bag is able to lower.

3) The distance reading will not be accurate if the subject lifts too quickly or jerks the handle. Use smooth motions for the most accurate readings.

4) Always use the spanner wrench to tighten the knurled nut onto the 191 spool (see page 302). Tightening the nut by hand for this attachment is not sufficient and it WILL come loose.

5) To remove any tangles, slowly pull the handle through one complete repetition, then returning the handle to the starting point.

6) Do not allow the bag to touch the floor during use. If it does, slack may appear in the rope and cause it to tangle or come off the spool.

7) You may raise or lower the exercise head to any height you desire as long as there is no slack in the rope as described in step 6 of "Instructions for installing Attachment 191B to the BTE SIMULATOR II" on page 313.

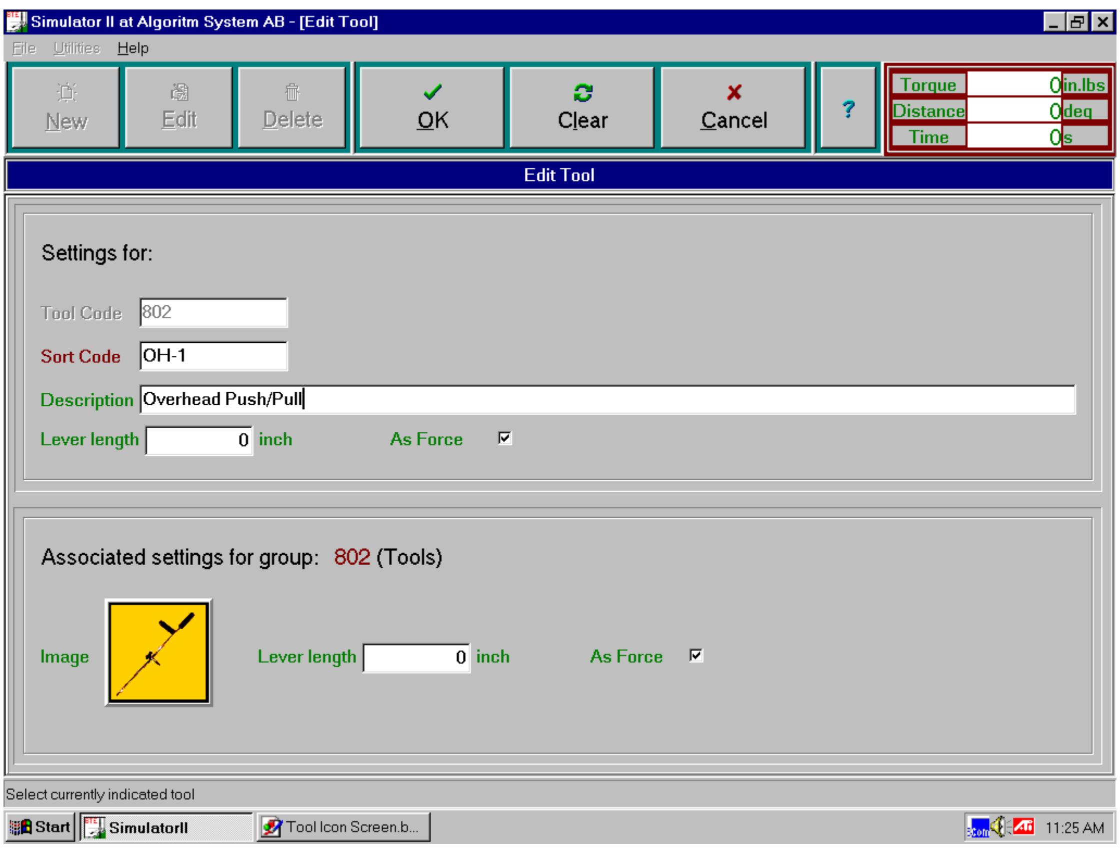
8) You can replace the black handle with any type of handle or object you want. To do so, just insert an eyebolt (1/4" or larger), through the object and place a nut on the end.

Then just clip the end of the rope to the eyebolt and you're ready to go. Some examples include:

3/4" plywood box
rake or shovel handle
knives
hammer handles
sports equipment
milk crate
flat board
heavy denim (lifting a bag)

Adding or Editing a Tool Description

If you would like to add a description to the list, select the tool you would like to add a functional description, then select **NEW**.



If you want to have the results for this tool description to be displayed as force (pounds) instead of torque (inch-lbs.), make sure the **As Force** box on the top half of the screen located just under the Description field is checked ☑. With this box checked, if you enter the **Lever Length** of the tool you are using in the appropriate field at the test screen setup window, your results will be in pounds instead of inch-pounds.

You may also choose to default this description to force readings whenever *this description* is selected for any patient. To do this, at this screen, enter the lever length in the field labeled **Lever Length** on the top half of the screen and make sure the **As Force** box is checked. If both these fields are ente, the results will default to force for this tool and description.

Section 4
Daily Treatment Program

■ Developing a Treatment Program

INTRODUCTION

Before you begin initial treatment on the BTE SIMULATOR II, we recommend that you take a few minutes to plan a treatment program. This involves first determining the nature of the patient's physical impairment, 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. Included in this manual are forms and examples that may be useful during this process.

GETTING STARTED

The first step is a functional activity evaluation to establish diagnosis and cause of injury. Then, 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 SIMULATOR II begins.

JOB/TASK ANALYSIS

The second step is a job and/or task analysis, depending on whether you are dealing with a work related injury or are trying to improve the patient's ADL functioning. These two analyses are essentially the same process. A completed JOB/TASK ANALYSIS form is on the next page. There is a blank copy at the end of this section for you to copy if desired.

With the aid of the task analysis form, any job can be quickly broken down into its individual functions, regardless of your familiarity with the job. Most information can be obtained from the patient during a 15 to 20 minute interview process.

"Occupational Title" is the starting point. Once you have established the correct title with the patient, ask him to state a list of his duties. The column entitled **"Task"** is a broad heading for a group of functions which may form one job duty. These tasks will form the basis for the functional goals for this patients rehab program. As each duty 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 job task is completely explored, proceed on to the next duty.

Task Analysis Form

Client Name: Ellen Jones Date:________________

Occupation: Automobile Mechanic___________________________________

Task	Function/Movement	Tool No:
Engine Tune-up	Open garage door	191
	Remove spark plugs – socket wrench	3/8" drive wrench
	Change parts – screwdriver	504
	- pliers	162
	Test drive car – steering	131
	- shift gears	802
	- open and close the door	162
Rebuild transmission	Place car on hoist – push hoist arms into place	802
	Tool use overhead – wrenches, sockets	601
	- pry bar	802
	- plastic hammer	171
Break repair	Jack up car	802
	Lift off tires – impact wrench	601
	- lifting	191
	- screwdriver	504
	- small pliers	162
ADL activities	Open doors	301
	Open bottles and jars	302
	Cut meat/chop vegetables	171
	Iron clothes	171
	Put groceries away	191

A completed task analysis form will have several job tasks and numerous individual functions listed. ADL functions can be listed in a similar manner. The third column, "Tool No.", is reserved for relating all individual functions to appropriate BTE attachments, once the interview is over.

BEGINNING TREATMENT

Once you have analyzed this information and decided which BTE attachments will be used, list the selected tools and exercises on the **"SIMULATOR II Master Chart."** (There is a blank copy at the end of this section for you to copy as needed.) Use this chart to organize the exercises into the order you want the patient to go through them, and add notes and other reminders for yourself and the patient to refer to if there is a question about an exercise. This serves as a guide for which attachments will eventually be used, with the "Comments" section as a reminder of why each attachment was chosen. Depending on the ability of the patient and his state of recovery, you may or may not be able to begin using all the chosen attachments on the first day. Do not attempt to push the patient beyond a level of exercise that he/she can comfortably perform. You, as a therapist, must determine when your patient has reached the fatigue point. Signs/symptoms to watch for include increased edema, altered sensation, substitution patterns, etc.

■ Daily Exercise

SETUP

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

At the Main Menu screen, select TREATMENT from the left side of the menu, then CHART SET-UP from the right side of the menu. Proceed as described below. You may select the subject ID at any time during the set-up or before you exit the Daily Treatment Set-up chart.

CREATING A TREATMENT CHART

Select the Subject record for which you would like to create a treatment program.

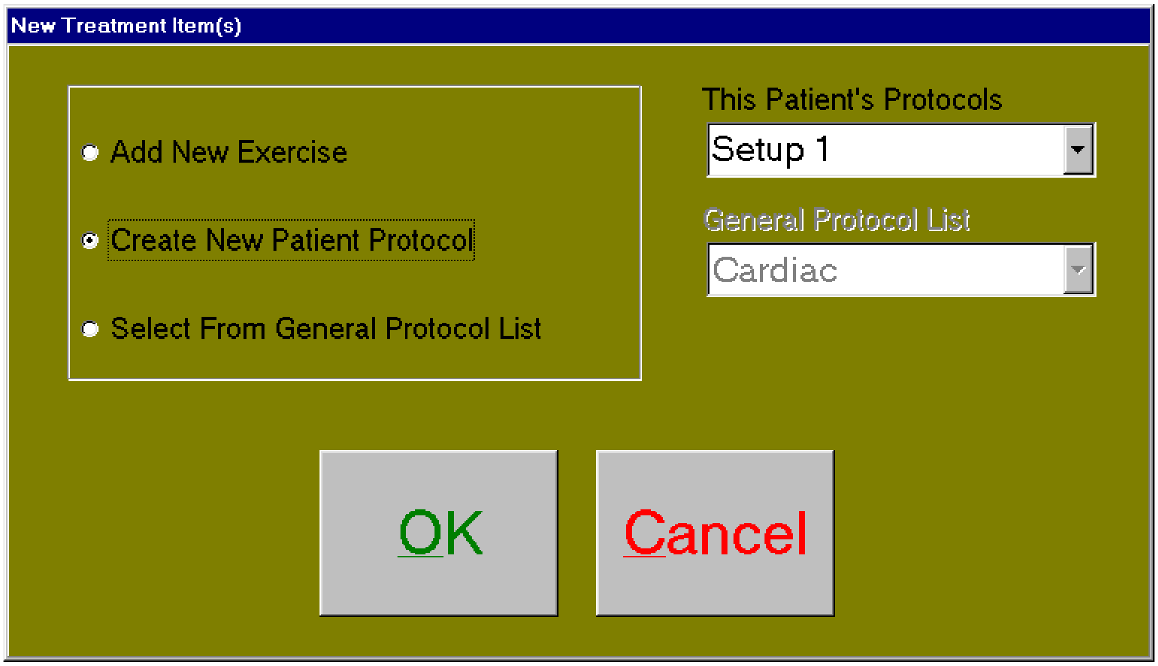
At the main screen, select **Treatments** on the left side column, then **Chart Setup** on the right side column. You will be presented with a screen like the example on the next page.

At this screen, you have three options:

○Add New Exercise

⦿ Create New Patient Protocol

○ Select From General Protocol List



Add New Exercise:

Select this option if you want to add an exercise to the currently displayed **existing** chart for this patient. The exercise will be added to the currently selected session.

IMPORTANT: If you want to add an exercise to a new chart (i.e. entering the first exercise on a new patient's chart), select **Create New Patient Protocol** and enter a name for this chart in the **This Patients Protocols** field (see next paragraph).

Create New Patient Protocol:

Select this option if you want to start a new chart for a patient or create a protocol or series of exercises that you can select and use for this or any other patient. If you select this option, make sure you also type in the name you want to give this protocol in the "**This Patient's Protocol**" field.

Example: You want to create a set of exercises you wish to use with all your patients with a carpal tunnel release. Select **Create New Patient Protocol** and name the protocol "Carpal Tunnel Release Exercises". Click OK, then add exercises (using the **Add New Exercise** option) you feel are appropriate for patients that have had a carpal tunnel release. Click **READY**, then **Save in General Protocol List**. Whenever you set up a new patient exercise chart, you will have the option of inserting this set of exercises into that patient's chart by selecting **Select From General Protocol List**.

Select From General Protocol List:

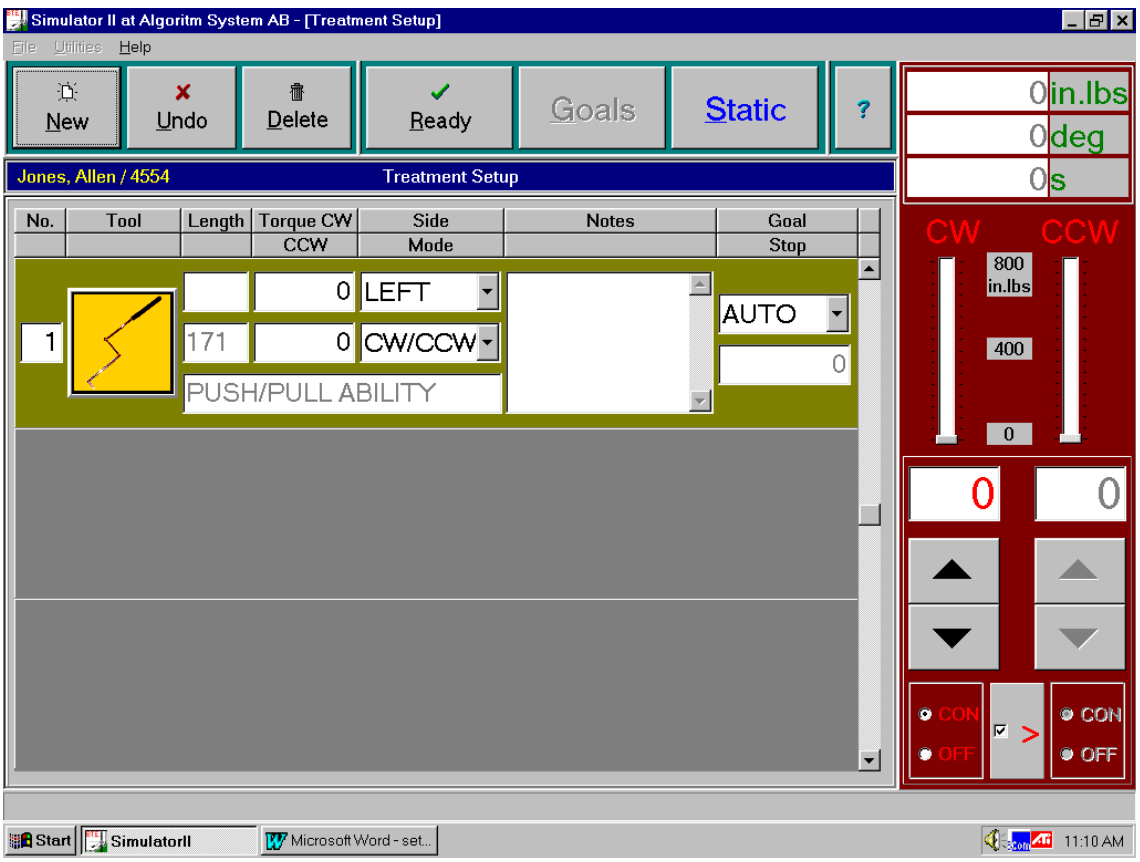
Select this option if you want to insert a pre-set protocol into this patient's setup chart. After you select this option, you may select from the "**General Protocol List"**. You still must name this protocol for this patient. The exercises from your selected General Protocol will be inserted into this new protocol you are creating and naming for this patient.

After you have made your choices, select **OK**.

NOTE: The name for the Protocol selected will not be retained for the patients protocol list. The exercises will be inserted into the existing chart or newly names chart and will be saved as part of that chart.

If you selected Add New Exercise or Create New Patient Protocol, The next step is to select the attachment you want to use from the **Tool Icons** screen, and the Functional description. Double click the functional description, or highlight it and select **OK.**

The screen will change to the Setup Chart pictured below:



Setup Chart Fields

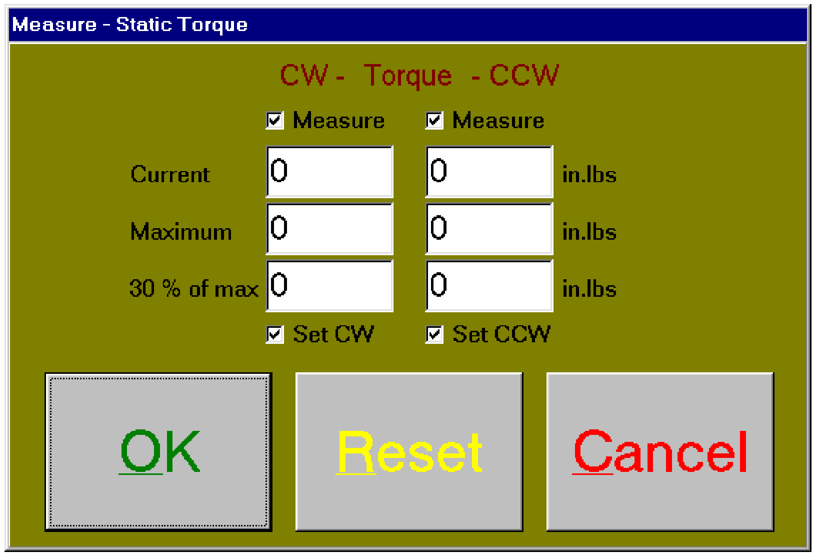
No. **-** This is the order of the exercises. You may change the sequence by typing in a new number

Tool - select the tool icon if you wish to change the attachment used for this exercise.

Length - Enter the lever length for this tool. Lever length refers to the distance from the point where the tool attaches to the exercise head to the point where the patient's hand is applying force to the tool. When a lever length is entered, the force values will be in pounds if "☑ As Force" is selected on the tool setup screen.

Torque CW/CCW - If the desired resistance is known, you may enter it in the field for resistance. To establish initial torque settings, it is recommended that you begin at a low level with each attachment, then gradually increase the resistance as the patient is exercising. It may take several sessions for the patient to become accustomed to his or her new exercise protocol, and starting at a low level is less likely to aggravate the injury on the first day of treatment. Begin each attachment at a fairly easy level, and while the patient is exercising, slowly increase the resistance level by clicking on the up-arrow (the exercise resistance can be adjusted at any time during an exercise). The object 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 he/she begins to fatigue. When you sense the patient has reached the fatigue point, stop the exercise. **Don't overdo it!** It is not necessary to enter a goal for the first session, since you do not know how much the patient can do. Wait until the second or third session before establishing a goal value.

Another commonly accepted method used for establishing the appropriate resistance level for an exercise routine is to first test the patient isometrically to determine his or her maximum strength. Then, set the exercise resistance at 30% of the isometric maximum. To use this method, at the setup chart, select **Static** from the top menu bar. A window will pop up with the option to perform an isometric trial.

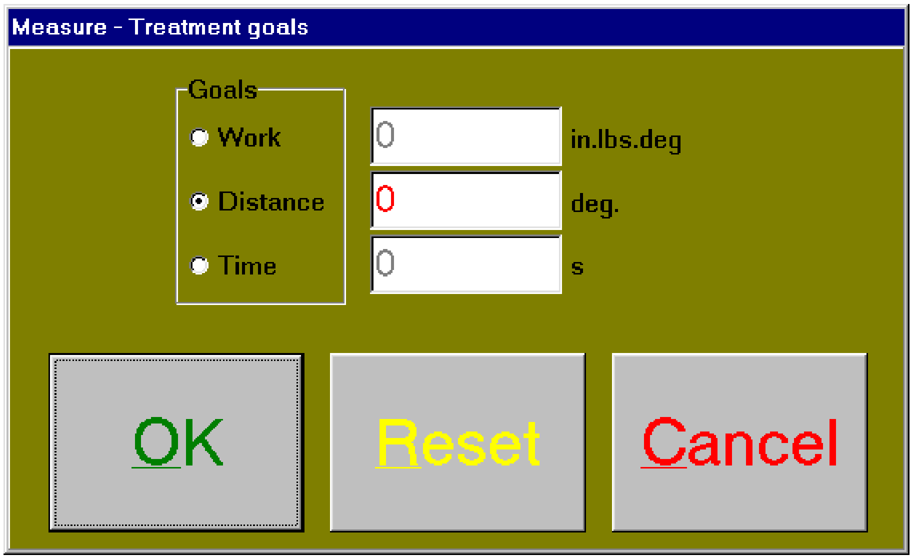


Place a click on the ☐ **Measure** label to select or deselect the **CW** or **CCW** directions. Set up the attachment and have the subject perform an isometric trial. The **30% of max** field will automatically fill in as a suggested starting resistance. The first trial is usually considered a practice trial, so click on **Reset** and let the subject have a second trial. This value will be inserted into the Setup Chart when you select **OK**. (**NOTE**: You may also perform this step after you go the Daily Treatment Section and the patient is ready to perform the exercise. The **STATIC** option will also appear when you select **Set-up**.)

Side/Mode - Click on the top ▼ symbol to select RIGHT, LEFT or BOTH Click on the bottom ▼ symbol so select the resistance direction mode. Remember that you have the ability to set different resistance levels in each direction if you use the CC/CCW mode.

Notes - Enter any additional set-up notes in the Notes field. These notes may include height of the exercise head, angle of the head, foot and hand placement, etc…

Goal/Stop - Select the ▼ symbol to select between the automatic stop, work, distance or time goal. If you select work, distance or time, you may them select the lower field to enter the desired goal. You may also select the Goals option on the upper menu bar and have the patient perform the exercise to set the current performance level and use that as the beginning goal. The window pictured below will pop up and allow the patient to perform the exercise, with the work, distance and time results captured for the goal option. **NOTE: Make sure you have the desired resistance set before you select this option.**



To add another exercise, select **New** and follow the same sequence to add additional tools to this patient's Setup Chart (see page 404 for options). When all applicable exercises are added, select **Ready** from the top menu bar. You will be presented with the following options:

⦿ **Save Patient Protocol** - Select this option and the exercises added will be applied to this patient's treatment plan.

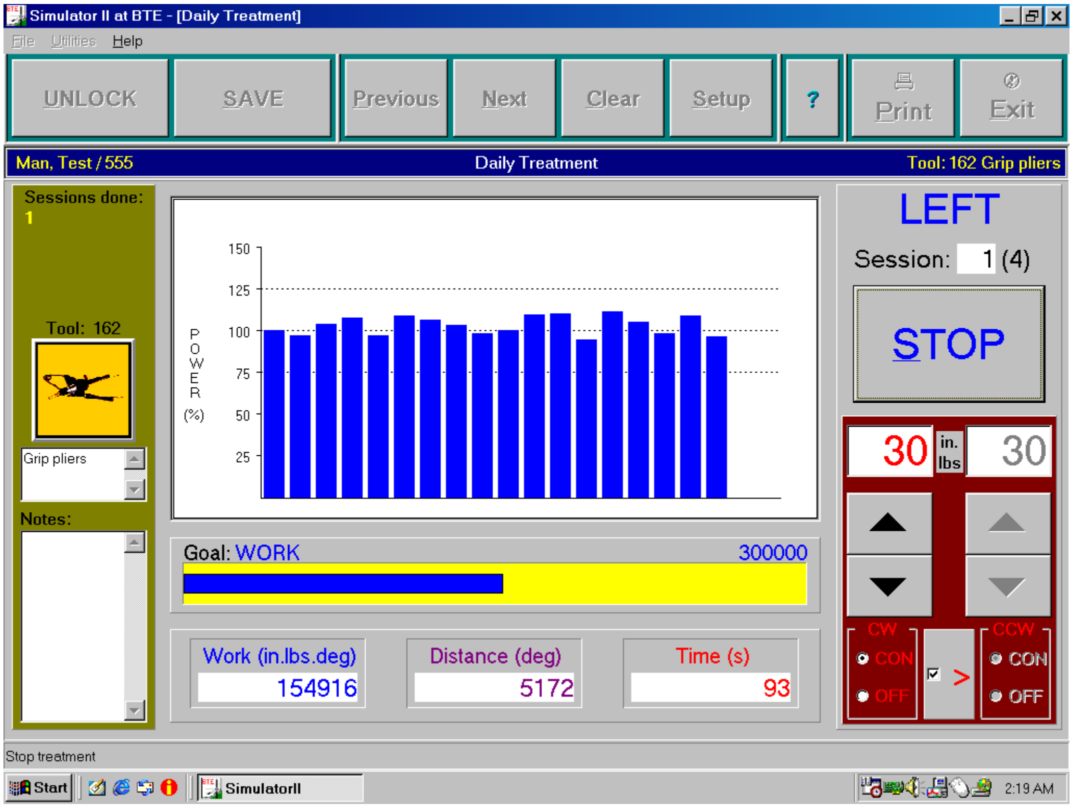
○ **Save Only in General Protocol List** - Select this option if you want to make these exercises available to other patient setup charts, but *not* inserted into the current patient's chart.

○ **Save For This Patient and General Protocol List** - Select this option and the exercises added will be added to this patient's treatment plan *and* saved as a protocol that can be selected for other patients treatment plans.

○ **Discard changes** - Select this option to exit without saving any changes to the chart.

To perform the exercises that have been set up in a patient's chart, select Daily Treatment at the Main Menu. You will be given the option to select a specific protocol that you set up for this patient. You can create a number of different groups of exercises for each patient following the procedure outlined above .

After selecting the desired treatment protocol, the first exercise that comes up will be the first one on the set-up chart. You may move to different exercises with the **Previous** and **Next** buttons at the top of the screen. Adjustments to the exercise resistance and goals may be made at this screen at any time.



Click **START** to begin the exercise. As the exercise progresses, vertical bars will appear every five to six seconds. These bars represent the patient's performance. If the patient is working consistently, the bars should be approximately the same height. The pace of the exercise is set by the first five seconds of the exercise. After that, each five to six seconds will be displayed as a percentage of the first. This feedback is very helpful in determining the patient's fatigue level because you are always comparing current performance to initial performance. If a goal was entered, a horizontal bar will be displayed to show progression towards the set goal.

The exercise will end if you click on **STOP**, if the power output drops to below 50% for two cycles in a row, or if the patient reaches a set goal. A result comparison window will pop up if this exercise has been completed at least once before. This comparison window shows how well the patient did as compared to the last time they did this exercise.

When all exercises are completed, click **SAVE** to save results, then **Exit** to return to the main menu. If the exercises were completed, you will be asked if you want to enter a Progress Report. This report will print the progress for all exercises on this protocol for this patient.

To delete a protocol from the General Protocol List or a specific patient protocol:

General Protocol

If a protocol that was saved is no longer needed, it can be removed from the list by deleting all the exercises from the protocol.

1. Make sure there is no patient name selected ("None Selected" should be displayed in the blue bar that goes across the screen). To clear a patient name, select Daily Treatment, then exit Daily Treatment. You will be asked if you want to continue with the same patient - respond NO. You can also clear the name by exiting the SIMULATOR II software, then restarting the program.

2. Select Chart Setup

3. Choose Select from General Protocol List. Then select the Protocol you wish to delete.

4. Click **Delete** until the last exercise is removed. You will be prompted to save changes to General Protocol - Select YES.

The selected protocol will be removed from the list.

Specific Patient Protocol

Follow the same procedure as outlined above, except make sure the correct patient *is selected* before you go to Chart Setup.

Task Analysis Form

Client Name:_______________________________ Date:__________

Occupation:____

Task	Function/Movement	Tool No:

SIMULATOR II Master Chart

Client Name:_________________________________ **Job Title**: _________________________ Date: _____________

Tool No.	Function or Task Simulated	Comments

Section 5
Evaluations

There are numerous methods for conducting evaluations on the BTE SIMULATOR II. Evaluation techniques for each of the two modes of resistance the SIMULATOR II uses (isometric and isotonic) will be discussed in this section.

Precede testing with a warm-up exercise or practice to familiarize the patient with the motion and equipment, and to warm up the muscle before maximal effort is exerted.

The type of evaluation procedure you choose for each subject will be dependent on your objective for doing the evaluation. Presented here are several test types with their associated objectives. These will be discussed in greater detail throughout this section.

- Standard Protocol
  - measure maximum strength, power and endurance
  - compare right side to left side for percentage of deficit
  - initial baseline strength evaluation
  - discharge evaluation for determining amount of improvement

- Lift/Push/Pull Tests
  - evaluate maximum lifting ability (or pushing/pulling)
  - evaluate repetitive lifting ability (or pushing/pulling)

- Consistency of Effort Test (isometric testing)
  - How do you know if the patient is trying her best?
  - coefficient of variation analysis

To access the evaluation options, at the main menu screen, select the **Evaluations** box on the left side of the screen. This will bring up the following testing options on the left side of the screen:

Static, Single - Isometric trials for one side or a bilateral (two handed) test.

Dynamic, Single - Dynamic test measuring power for one side or a bilateral (two handed) test.

Endurance, Single - Dynamic test measuring endurance for one side or a bilateral (two handed) test.

Static, Compare - Isometric trials for a comparison of right to left side strength or opposing muscle group strength (i.e. flexion vs. extension). Test the non-injured side first.

Dynamic, Compare - Dynamic test measuring power output for a comparison of right to left side strength or opposing muscle group strength (i.e. flexion vs. extension). Test the non-injured side first.

Endurance, Compare - Dynamic test measuring endurance for a comparison of right to left side strength or opposing muscle group strength (i.e. flexion vs. extension). Test the non-injured side first.

Line Graph - Isometric test showing force generated in line graph form. For testing a single side or a bilateral (two handed) test. The Line Graph screen can also be used as patient feedback during an isometric exercise.

Lift, Repetitive - Dynamic test using the 191 attachment to look at repetitive lifting ability. Can be used for any setup of the 191 attachment.

Lift, Maximum - Dynamic test using the 191 attachment to look at a person's maximum lifting capacity. Can be used for any setup of the 191 attachment.

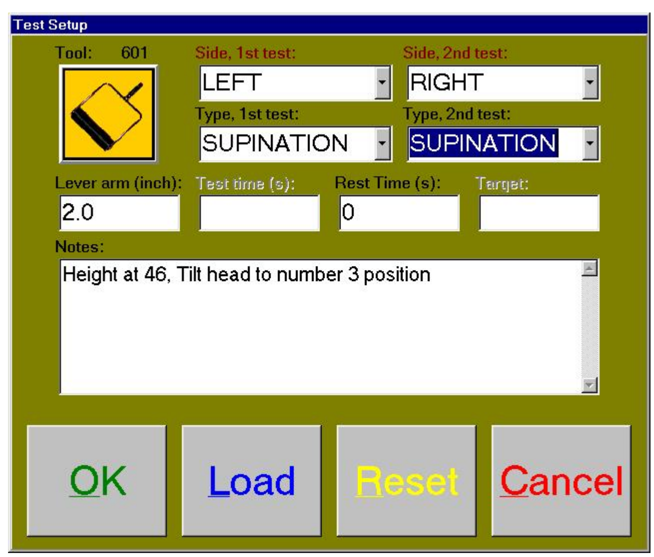
Test Basics

At each test screen, you will see a series of buttons across the top of the screen. These buttons provide the following options:

New - Prompts you to create a new patient record. If you have not already created a record for the patient you will be testing, use this option to enter a new patient into the database.

Patients - Select from the existing list of patients.

Tools - Select the attachment and functional description for this test.



At the top of each test screen, you will have options to accept or reject a specific trial. If you wish to reject a trial, click on the **Previous** or **Next** button at the top of the screen until the trial you want to reject is highlighted. Then click **Clear** to remove that trial.

Setup - Whenever you go into a test selection, you will be prompted to enter setup notes. The last tool selected will be recalled for the test. If this is not the tool you wish to use, simply click in the tool icon and select the desired attachment and functional description. If a previous test was completed, you may reselect to set-up parameters by clicking **Load**. This will present you with a list of previously completed test setups for this patient and this type of test. Selecting a past test from this list will recall that setup data.

On the Setup screen, you can enter the side or function. You may type in your own title for this test, or select one of the names provided.

Another option on the Setup box is to enter the **Lever arm** of the attachment you are using. Entering this value will change the display from torque measured in inch-lbs. to force measured in pounds (newton-meters to kilograms). It is very important to get this value correct as it directly impacts the final result of the test. The lever arm is the distance from the point where the tool attaches to the exercise head to the point where the subject is applying force to the tool.

Additional **Notes** may be entered to help you remember the setup of the attachment and patient positioning information.

At the completion of any test, you will have the option to **Save** the results, **Print** a report, **Clear** the test to do it over again, and **Exit** back to the main screen. If you Save or Print the results, you will be given the option to type notes or comments to be included with the report.

ISOMETRIC (STATIC)

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

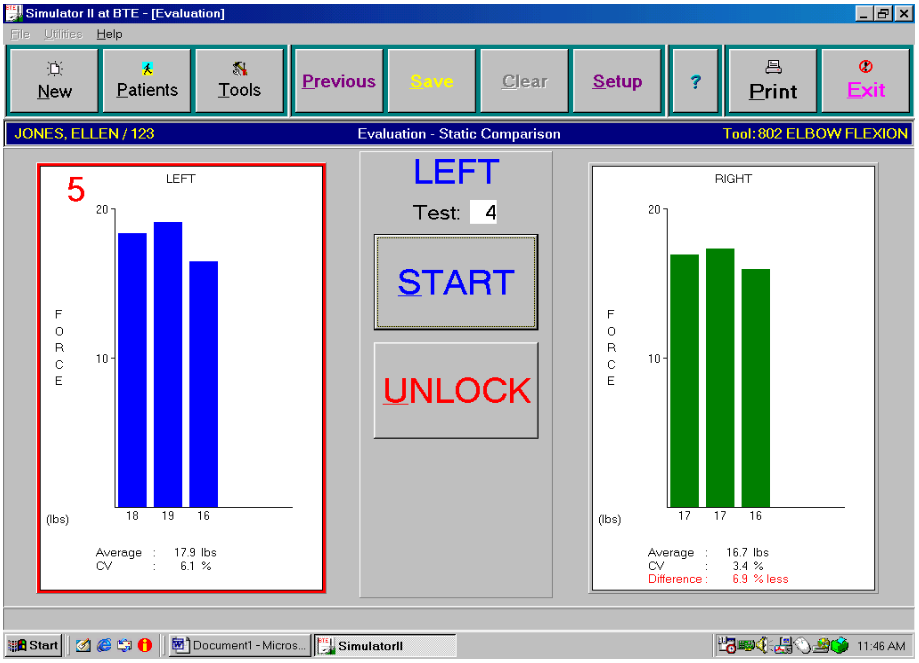
There are three different isometric tests available in the SIMULATOR II; Static Trials, Static Compare and Line Graph test.

Static Single and Compare

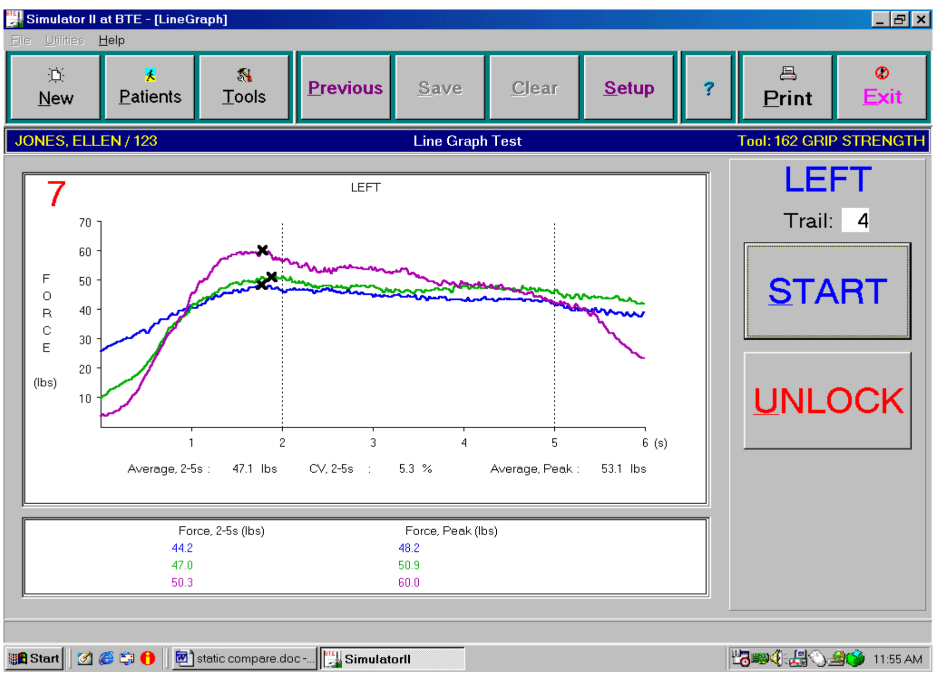
Isometric testing is a set of trials in which you measure the peak effort exerted by the patient. **Static Single** is for a single side or set of trials (one hand or bilateral**). Static Compare** is a set of trials for both right and left sides separately or opposing muscle groups. If the comparison is selected, the results will also report a percent difference between the two sets of trials.

The **Isometric Compare** test can also be used for consistency of effort testing (See Clinical Applications Manual, Section 3). It provides a great deal of flexibility to perform a number of isometric protocols. Two specific examples include 1) Directional Strength Trials based on Matheson's testing technique, and 2) the rapid exchange test to compare right to left hand strength and calculate the coefficient of variation (typically performed with a hand dynamometer). In addition, the flexibility lets you create your own testing protocols.

The results of the static single side or comparison test include peak force, average force, coefficient of variation, and percent difference (comparison only).



Static Comparison Example



Isometric Line Graph Example

Isometric Line Graph

The Isometric Line Graph shows the level of effort the patient is applying throughout a designated time trial. A key feature is the presentation of the trials in an overlay format. Real time curves are displayed as the patient exerts maximum effort. The default time for each trial is six seconds as recommended by Chaffin (1975). One to ten trials may be performed, however three is the recommended number of trials for testing since more trials may introduce fatigue, and can alter the consistency of the trials.

The graph displays peak force, average force from the beginning of the 3rd second to the end of the 5th second and the coefficient of variation of the 3 to 5 second averages. (See the example on the previous page.)

You may also change the time of the trials to up to 60 seconds and set a target force goal to use this screen as an isometric exercise feedback screen. The target force goal will appear as a dashed line "window" where the middle line represents the target goal, while the upper and lower lines represent ± 10% of the target goal.

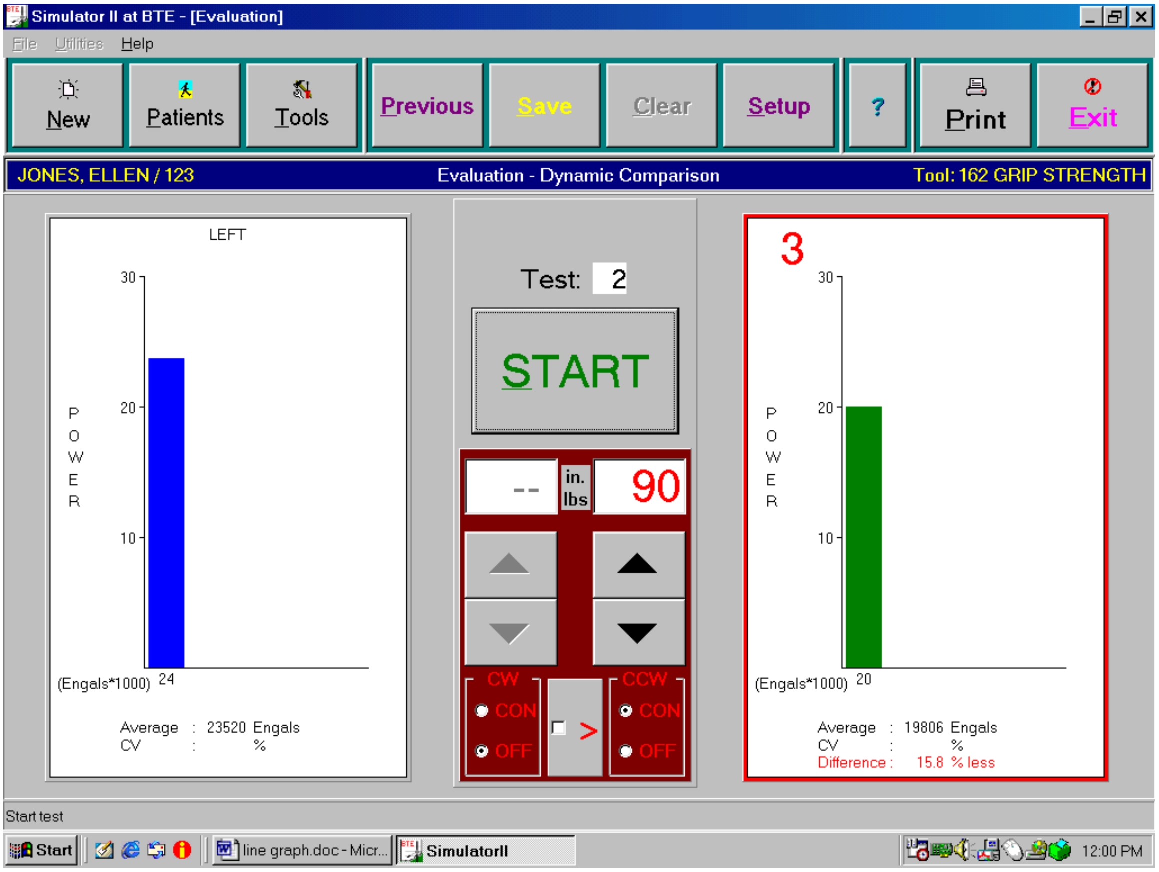
■ DYNAMIC TESTS

There are different options for performing dynamic evaluations with the SIMULATOR II. The test you select will depend on the goal of the evaluation – what you are trying to measure. To make the most appropriate selection, please review the following description of each test option.

Dynamic Test

The dynamic test is a simple way to record dynamic power output. Power is a measure of efficiency, or “how well” a patient is able to use their strength.

You may select **Dynamic Single** (one hand or bilateral) or a **Dynamic Comparison** (right and left sides separately or opposing muscle groups). If the comparison is selected, the results will also report a percent difference between the two sets of trials.

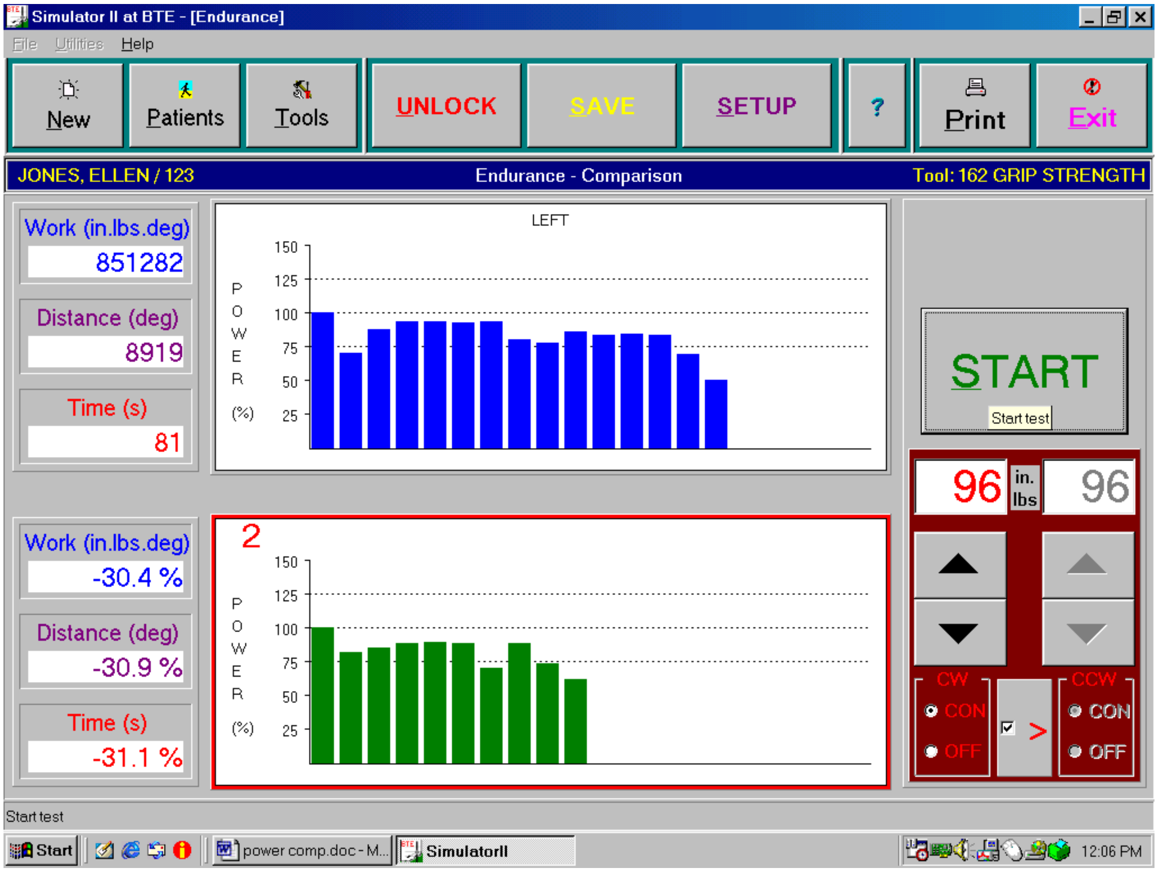


Dynamic Comparison Example

The information presented at the end of the test includes the average power, percent difference (comparison only) and percent CV (three or more trials only).

Endurance Test

The endurance test allows you to measure and document a patient's endurance while performing a specific task. Endurance is quantified by the amount of work performed when the force and rate are held constant. You may select Endurance Single (one hand or bilateral) or Endurance Comparison (right and left sides separately or opposing muscle groups). If the comparison is selected, the results will also report a percent difference between the two sets of trials.



Endurance Comparison Example

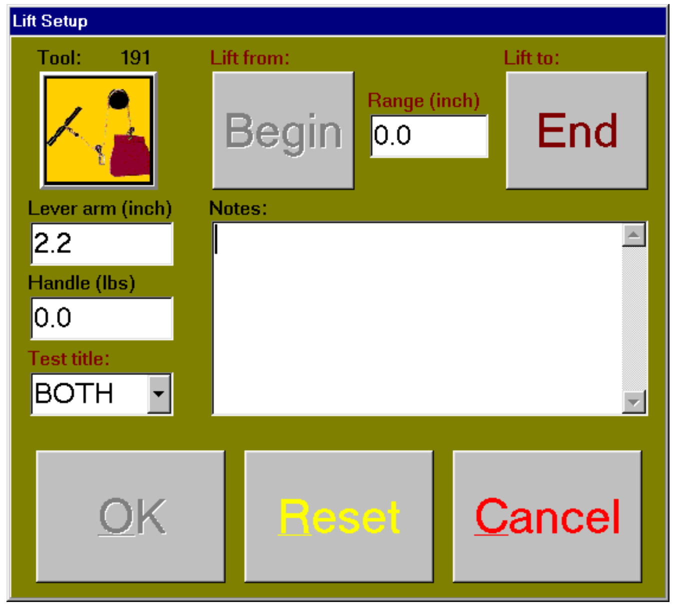
The results of this test include total work output, total distance and total time. In a comparison test, the percent difference will be displayed for each of these results in terms of a percent less than the opposite test. The percent difference alternates with the results for the lesser of the two sides.

Lifting/Pushing/Pulling (Attachment 191)

With these dynamic test options, you are able to determine a patient's maximum weight handling ability. They are designed specifically for attachment 191 and 191B. You must enter the range of motion through which the patient will be lifting (or moving) the handle, and a performance (power) score is provided at the end of every repetition to help document the patient's performance.

There are two options for this test; maximum ability testing and repetitive ability testing. As you enter each test, you will be presented with a set-up screen where you must set the range of motion and other options. This screen is as presented on the next page. *Before you can start entering this information, you must have the 191 attachment set up and ready to use.*

Set-Up Window Fields:



Lever Length - Entering the lever length will show the results in pounds (kilograms) instead of inch-lbs (Nm). This value should fill in automatically if you have the lever length entered on the tool set-up screen (See Section 3).

Handle - Enter the weight of the handle you are using. The standard handle provided with the SIMULATOR II weighs one lb. The handle weight will be included in the results if entered.

Test Title - Select which side is being tested.

Notes - Enter additional setup information. This may include a description of the lift technique, body mechanics, or anything else you wish to note.

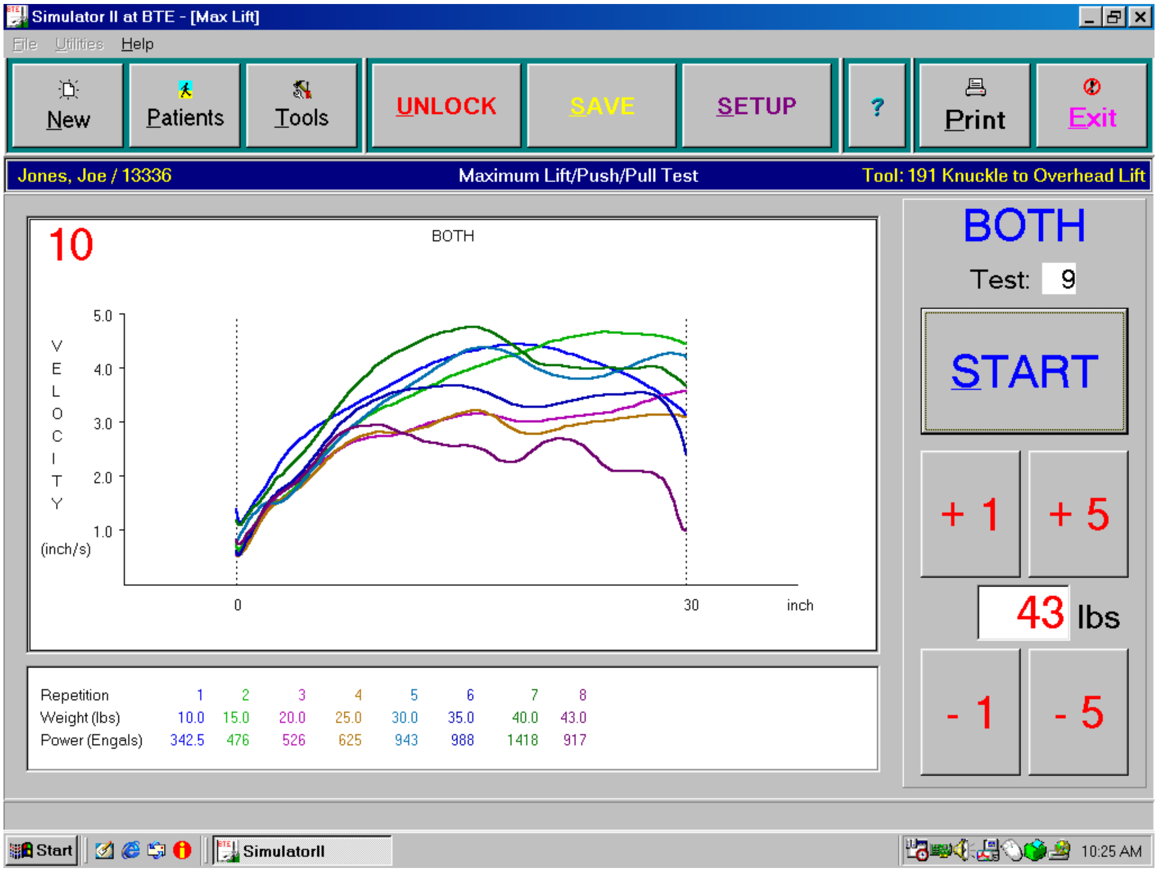
There are boxes labeled **Begin** and **End** at the top of this window. Use these selections to set the range of motion for the test. With the tool already set up and ready to go, move the handle to the END of the range of motion. Click **End** to capture that position. Now move the handle to the BEGINNING of the range of motion. Click **Begin** to capture that position.

When all desired and required fields are set, click OK to go on to the test screen.

Maximum Lift Capacity Test

This test will document the maximum load a patient can handle through a specific range of motion using the 191 attachment. It provides a means for setting a range for which the subject must move the handle, and generates real time velocity graphs for each repetition. Results of each repetition include the weight lifted and power of each lift.

With each repetition, increase the weight using the +1 and +5 buttons (use -1 and -5 to decrease the weight).



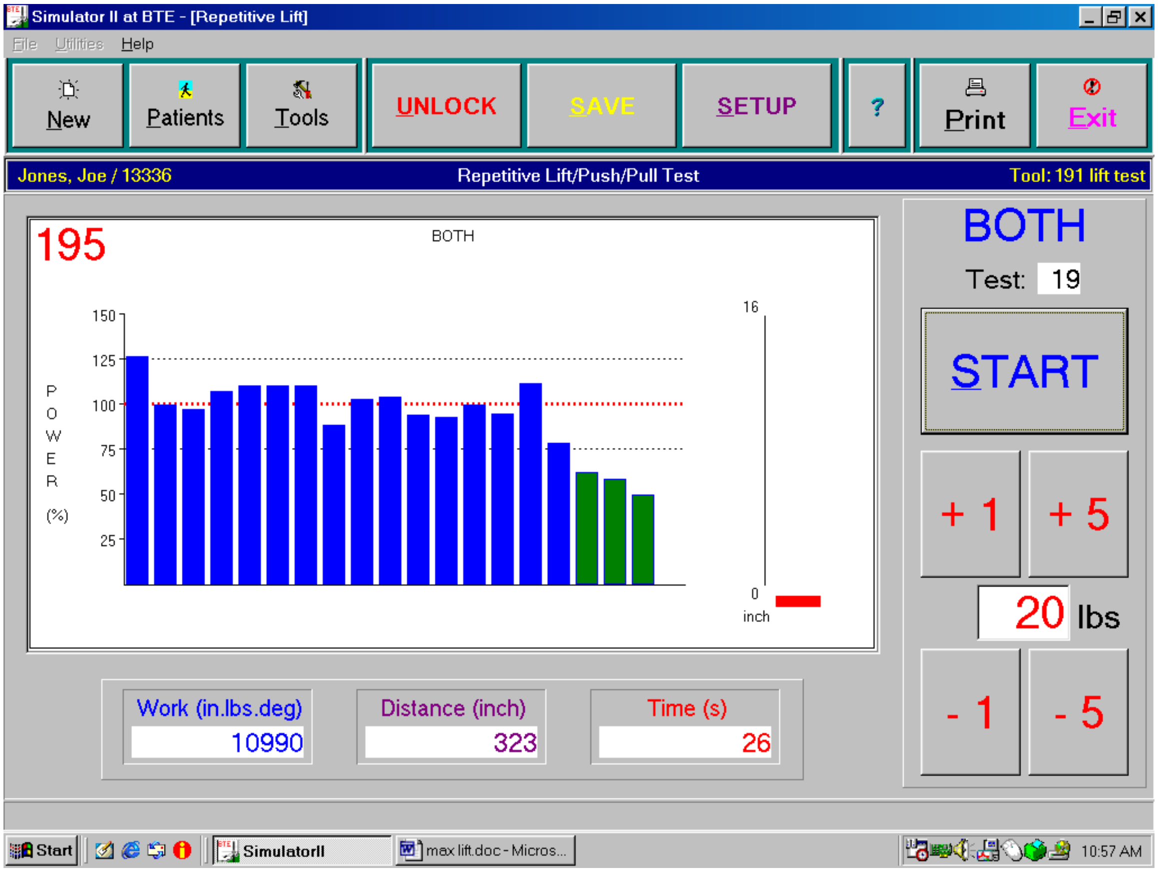
The line graphs represent the velocity of each repetition. This information is helpful in analyzing body mechanics and movement patterns.

Weight refers to the force exerted to move the handle through the range of motion.

Power indicates the power generated for each repetition. This number should increase at a predictable rate with each repetition if the weight increases and the subject's technique remains constant. If the number increases or decreases dramatically, the subject may be moving differently (substituting, poor body mechanics, jerking the handle, etc…) and he or she may have exceeded their safe lifting capacity.

Repetitive Lift Test

This test will document how many times a person can perform a lift (or other linear movement) using the 191 attachment, providing objective information for determining a fatigue point. You can also use it as a range of motion feedback screen for performing exercise with the 191 attachment. The test screen looks like the one on the next page.



With each repetition, a blue bar will appear showing the power generated for that repetition. This is an excellent way to document the fatigue rate of the patient. The second repetition will set the "100%" performance level. This means that the power for every other repetition will be compared to that rep and graphed as a percentage. As she begins to fatigue, the power per lift will drop. If the displayed power bar is green, it indicates that the patient did not complete the full range of motion that was set at the beginning of the evaluation.

The red bar at the far right of the screen indicates the patient's position for the current repetition in relation to the set ending and starting points.

■ Standard Evaluation Protocol

The best method for determining impairment is to compare the individual's injured extremity to his or her non-injured extremity. The testing procedure explained here allows you to do three types of comparison with each selected attachment. These tests will help you determine maximum strength, dynamic power, and dynamic endurance.

The Standard Evaluation Protocol has been used clinically for many years and has been documented in published research. It is the most often used form of muscle performance testing administered on this device and is effective for general strength testing as well as determining strength deficits.

Isometric testing is always the starting point for this evaluation. The resistance settings for both the dynamic power and endurance tests are based on the results of the isometric test. In isometric testing, the subject is given three trials. The peak force achieved is presented for each trial, and then averaged. Consistency of effort is quantified by the coefficient of variation (CV) score. The CV is a statistical measure of the amount of fluctuation between a set of scores. ("It should be possible in physical capacity testing to achieve a coefficient of variation of less that 15%." Work Practice Guide for Manual Lifting – NIOSH pub. no. 81-122)

The following are descriptions of this testing procedure and the test selections to accomplish these results. However, you may use these tests options for other testing procedures as well. For additional information on the Assessment of Maximum Muscle Performance you may also review section four of the Clinical Applications Manual.

MAXIMUM STRENGTH TEST (ISOMETRIC)

This is always the first step in the Standard Protocol testing. It is a measure of the patient's peak isometric strength applied against static resistance.

Select the tool and function to be tested by clicking on the **Tools** button at the top of the main screen. Select the patient to be tested by clicking on the **Patients** button at the top of the main screen.

Select Evaluations form the left side of the Main Menu.

From the right side, select **Static Single** to perform a single side test. Select **Static Comparison** to see the difference between the injured and non-injured sides. Input the set-up parameters and desired notes (height, tool position, head position, etc…) to get to the test screen.

Insert the selected attachment and position the patient appropriately.

If a comparison, test the non-injured side first. Allow a practice trial. Clear the practice trial, then instruct the patient to exert maximum effort against the tool. The peak score will appear as a bar graph for each trial. The trial automatically ends when the force drops to zero. To change the test screen from side to side, click in the test box for each side before beginning the trial for that side.

Perform three trials with the non-injured side, then three trials with the injured side.

DYNAMIC POWER TEST

Dynamic power is a means of quantifying dynamic strength. It is a way of measuring the patient's ability to rapidly perform a specific task during a set period of time. Power is a measure of “how well” a person can use their strength (power is a ‘quality’ value).

After you have completed the Isometric Test, select **Dynamic Single** or **Dynamic Compare.** The force level(s) should be set to 50% of the patients average peak isometric trail results for each extremity. This is usually a very challenging level for the patient. You may change the force if you wish to do so. The time of the trial should be set to ten (10) seconds. Make sure the resistance is set in the correct direction before beginning the test trial.

Test the non-injured side first.

Allow the patient to perform two or three practice trials so he/she can feel the amount of resistance. Remember to erase this trial set before beginning the actual test.

Instruct the patient to perform as many repetitions as possible within a 10-second trial time. Experience has shown that a person begins to fatigue 7-9 seconds when working at half of their maximum.

Repeat with the non-injured side if testing both sides.

DYNAMIC ENDURANCE TEST

Dynamic endurance is a means of measuring how long the patient can continue to perform a given task. The endurance test reports “work” which is a measure of “how much” the patient can do before he or she reaches the fatigue point (work is a ‘quantity’ value).

After completing the Power test, select **Endurance Single** or **Endurance Compare**. The force level should be set to 50% of the average peak of the weaker of the extremities (if a comparison test is being performed). If you wish, you may change this force level.

Test the non-injured side first.

To gauge a person's endurance, it is important that your control the rate (speed) at which the patient works, and be sure 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 patient is to perform one complete repetition for each cycle. Set a rate that duplicates a specific job task, or one that is comfortable for the patient. Usually two, three, or four seconds is appropriate.

The patient should be instructed to perform to the speed of the cycle timer. If the patient performs at the proper pace, the performance bars will reach the middle line of the feedback screen. Fatigue can be defined as the point when the performance bars fall below the bottom line two or three times in a row.

Additional Suggestions

1) It may be helpful to repeat the tests periodically to determine how well the patient is progressing.

2) 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 can cause changes in test results.

3) Patients who may experience edema should have volumetric measurements taken of both hands before and after testing.

4) The patient 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 exactly.

5) The display screens should not be visible to the patient.

6) When the test is repeated, week after week, it is best to look at the change in percentage of difference between injured and non-injured to determine how well the patient is progressing.

7) Test results should not be discussed with the patient until completed.

Section 6
Report Options

Introduction

All data saved into the database can be retrieved through the Reports option. There are two options for displaying and printing data: Reports and Summary Report.

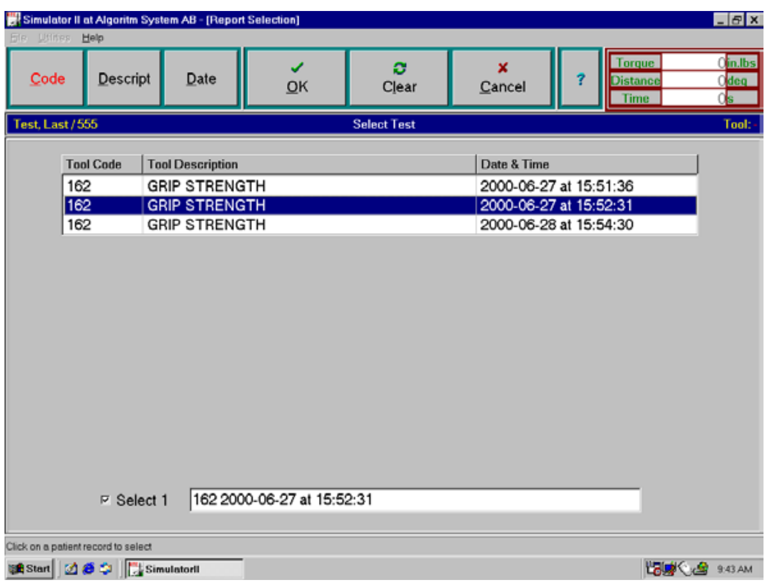
Reports - Select this option if you would like to review a completed evaluation. All data and graphic information will be presented as it was when you completed the test with the option to print the report.

Summary Reports - This option will give you a comparison of two or more dates in a treatment program or evaluation. The results will be generated as a Microsoft Word document. You can then open this document and edit it using Microsoft Word if desired.

Reports

To select a specific test to review or print:

Select **Reports** from the Main Menu screen. You will be presented with the option to select from static, dynamic, endurance, line graph, maximum and repetitive lift tests. After selecting the type of test you wish to review, you will be presented with a screen like the one below, listing all the tests of that type completed. Use the Code, Description and Date buttons to sort the list.



Highlight the test you wish to review, then click **OK**. Once the test results are on the screen, you may select the Print option.

To exit this screen, select **Cancel**.

■ Summary Reports

Summary Reports gives you the ability to generate a comparison of two or more treatment or evaluation dates in Microsoft Word format. This report can easily be modified and printed to send to the doctor, referral source, or place in the patient's chart.

To generate a Report Summary:

Select Summary Reports from the Main Menu. You may then select from the following:

Evaluation, Tools - sorts the report by the attachments used for evaluations. Tests completed with the same tool code will be grouped together.

Evaluation, Test - sorts the report by the tests that were completed. Test results will be grouped by type of test.

Treatment Graphs - reports treatment results in a line graph format. Includes percent change for the date range selected.

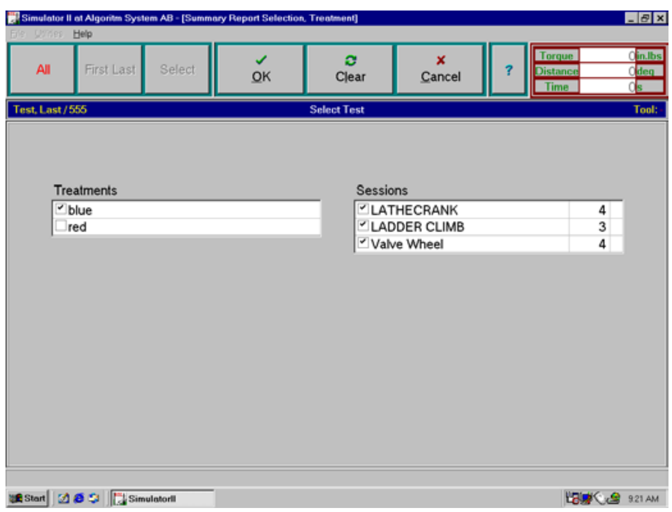
Treatment Values - reports treatment results in numeric format. Reports only results without any comparisons.

Once you select the desired type of evaluation or treatment summary, the following options will be presented. To select a specific date range, select:

> **All** - includes all dates.
>
> **First Last** - includes the first and last test dates.
>
> **Select** - choose the beginning and ending dates.

Treatment

On the left side of the screen you may select from the treatment protocols this patient has used. The right side of the screen lets you select which exercises from that protocol you would like to include on the report. Left click on the ☐ to place a ✓ next to the tools you want to include. If the tool is already marked with a ☑ and you do not want

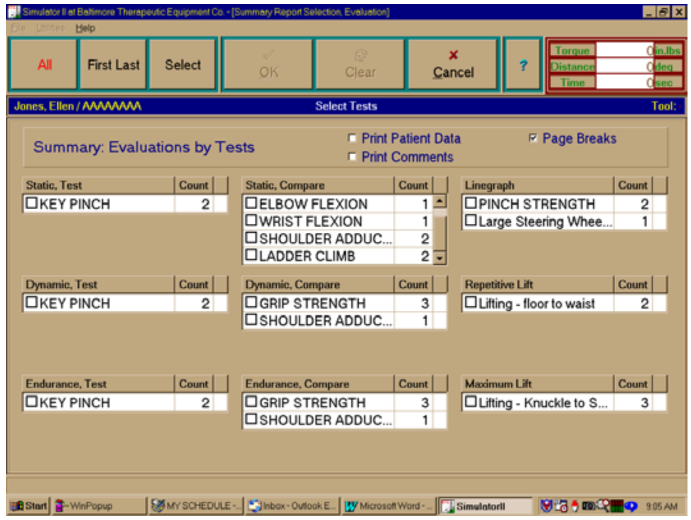


to include that tool, left click on the box to remove the check.

Evaluation

Left click on the ☐ to place a ✓ next to the tools you want to include for each test type. If the tool is already marked with a ☑ and you do not want to include that tool, left click on the box to remove the check.

On the Evaluation summary options, you also can select:



Print Patient Data - Prints the completed fields from the Patient data screen on the first page of the report.

Print Comments - Prints the comments from the last completed test with the respective test.

Page Breaks - places each test type on separate pages. (Default setting when Evaluation, Tests is selected.)

When you are satisfied with your selections, click OK. A pop-up window will appear with a blank area where you can type additional comments to be included on the report. (You may also add comments after you create and save the report) Then select **Print**, **File** or **Cancel**.

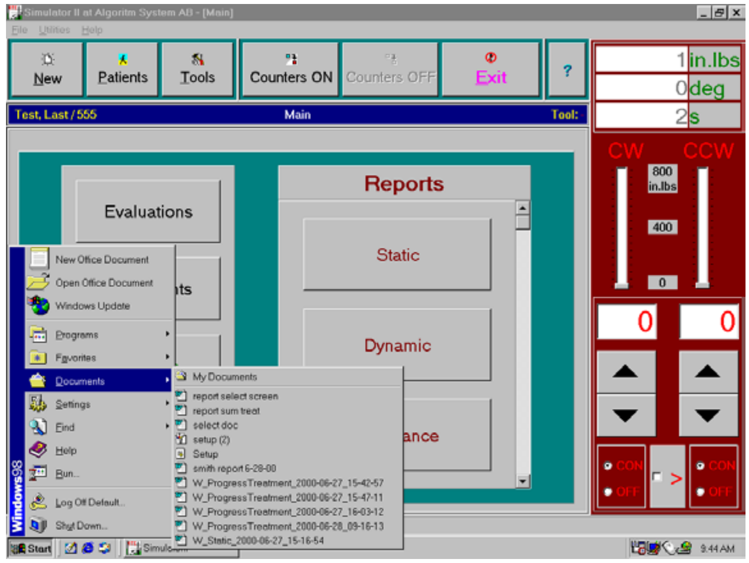
> **Print** - This selection will send the report to the printer and save it to the patient's folder.
>
> **File -** This option will only save the report to the patient's folder.
>
> **Cancel** - This option will cancel the requested report. No report will be generated.

The report generator will begin and create the report in Word format. When the report is complete the report will be saved with a date and time stamp and the Word window will close. To exit this screen, select **Cancel**.

To view, edit or print the report, retrieve the document using the following steps:

Select START at the lower left corner of the screen.

Slide the cursor up to the Documents option. A new menu will appear listing all the documents that have recently been created or accessed.



Select from this list the document with the date and time of the report you wish to retrieve. To do this, highlight the document with the cursor and left click. This will open Word and the document selected. You may now add, delete and edit anything on this report. You may change the name of the document when you resave it. To do this, when you are ready to exit and save the report, select **File**, then **Save As**. In the **File Name** field, type the new name for this report. You may also change the location it will be saved to if desired, however we suggest you keep the report in the patient's database folder, which is the default location..

Section 7
Maintenance and Utilities

The BTE SIMULATOR II has been designed to be a state-of-the-art rehabilitation tool, with very low maintenance required on the part of the user. This design concept will help keep the SIMULATOR II in your center operational, with a minimum of "down-time" if you do need repairs. If you begin experiencing difficulties with your SIMULATOR II, please refer to Section 8 "Trouble Shooting", find the problem you are experiencing, and follow the solution described. If you are still unable to clear up the problem, please call BTE using the toll free number 1-800-331-8845.

Periodically inspect all of the components of the SIMULATOR II, including the attachments, for any unusual wear or damage. If you feel a part or attachment is not as it should be, please call BTE to discuss your options for repair or replacement of that part. To keep your SIMULATOR II operational, please follow these maintenance suggestions. Doing so will greatly reduce service requirements and "down-time".

■ Cleaning the Attachments

If it should become necessary to clean or disinfect the attachments, use an alcohol-based solution. Dampen a cloth with the solution and wipe down the attachment. As you clean each attachment, inspect it for unusual wear or damage.

■ Computer System

The computer system is basically a maintenance free component. However, since it is a computer system, it is subject to operating problems due to static electricity discharges. To minimize the occurrence of static electricity, we recommend that you spray the area around the SIMULATOR II once per month with an anti-static spray. This can be purchased at any computer store or Radio Shack (stock #26-515).

■ Exercise Head

The exercise head is a very low maintenance component. The only thing you need to do is occasionally wipe the threads on the inside of the knurled nut and exercise head shaft and place a drop of light oil (i.e. 3-in-1 oil, sewing machine oil), on the threads of the shaft under the knurled nut. To do this, completely unscrew the collar and wipe the threads clean with a paper towel or rag. Then place two or three drops of the light oil on the threads of the shaft. **DO NOT** place any oil on the inside of the knurled nut. Replace the knurled nut. Repeat this about once per month and the attachments will remain secure when properly inserted. **NEVER PLACE ANY OIL OR OTHER LUBRICANT INSIDE THE EXERCISE HEAD!**

■ Base

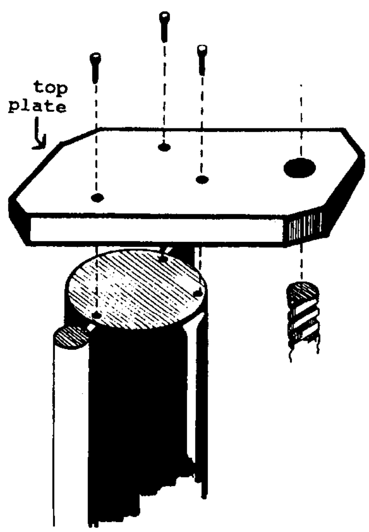
To protect the chrome vertical shafts on the ST20, spray a light lubricant such as WD-40 on a rag, then wipe the shafts on both sides of the center black column. Performing this procedure will help prevent corrosion of the shafts.

Also for the ST20, the ACME screw on the back of the main column may occasionally need additional grease applied. If the mechanism seems to make more noise than usual when the lift is activated, observe the following instructions and diagrams to apply grease to the unit:

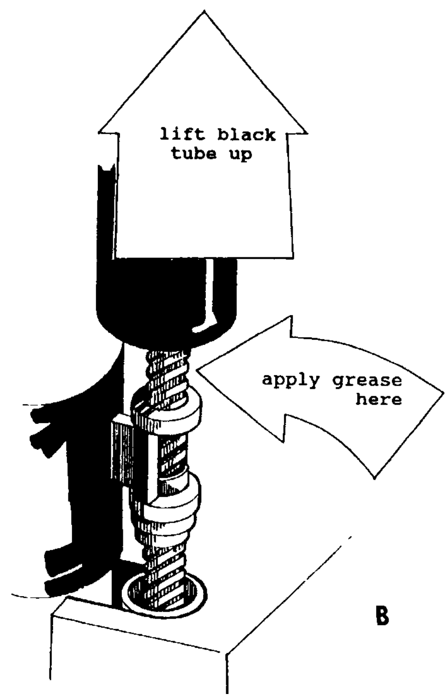
1) Lower the exercise head as low as it will go.

2) Using the 5/32" hex wrench included in the ST20 tool kit, remove the three screws on the top of the main column (figure A - below).

3) Remove the top plate (figure A). If there is enough clearance between the top of the SIMULATOR II and the ceiling, remove the black tube on the back of the main column by sliding it up over the screw. If not, lift the black tube as high as you can, exposing as much of the screw as possible.



A



B

4) Using the paint brush included with the grease kit (supplied by BTE upon request), apply grease to the threads of the ACME screw, just above the exercise head arm (figure B).

5) Run the exercise head up and down until the grease is evenly distributed. Apply additional grease if necessary.

6) Replace the black plastic tube and top plate.

7) Replace and tighten the three hex screws on the top of the main column.

■ Calibration

Calibration refers to making sure the SIMULATOR II is accurately measuring torque and setting the desired resistance. You should recalibrate about once every month and document for your records that you have calibrated the system.

To recalibrate, you must use the SIMULATOR II calibration kit. This consists of a long graduated bar and a cylindrical 20 pound weight on a long rod with a hook on the end.

To calibrate the system, select **Utilities**, then **Calibration**, then **System**. You will be presented with the option to calibrate.

Click on "Calibrate" and follow the onscreen instructions.

*Note, the onscreen instructions direct you to attach the hub from the 802 tool to the calibration bar. This no longer applies with new systems due to a design improvement with the calibration bar. Insert the calibration bar into the head.

■ Database Management

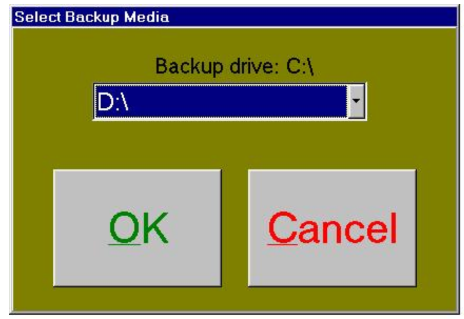
To keep your system operating at peak efficiency and your database a manageable size, you should use the database only for currently active patients. Once a patient has been discharged, you should either delete that patient, or archive them to a CD-RW, then delete them.

To use the backup and archive functions, you should use a CD-RW (read/write) that is DirectCD formatted. This allows you to erase old backup and archived files so the disk can be reused. A CD-RW was included with your system. Additional CD-RW's can be purchased at any computer store and formatted with the DirectCD format utility installed on your computer.

Archiving/Unarchiving

Archiving refers to backing up a single patient's records to an alternate storage device. BTE strongly suggests using a DirectCD formatted CD-RW for archiving. A 3.5" diskette will be too small for most records, and archiving to the hard drive will not gain you any advantage if the hard drive fails.

Before you archive a subject, check to see that the back-up media is pointing to the desired drive. The CD drive (D:) or floppy disk drive(A:) is recommended. To do this, select **File** from the top menu bar, then select **Select Backup Media**. The following window will appear:



Click on the ▼ and select the desired drive. Then click OK.

Once you have done this, select the patient you wish to archive from the patient list.

To archive that patient, Select **File** from the top menu bar, then **Archive Single Subject**. You will be prompted to confirm the selection and the archive destination location. Click OK to continue.

Once the archive process is complete, you may delete that patient from the database. If you need to replace that patient into the database, insert the disk that contains the archived record into the appropriate drive. Select **File** from the Top menu bar, then **Unarchive Single Subject**. Click on the ▼ to see a list of patient archived to that disk (listed by ID number). Select the desired record. Click OK to continue.

Backing up your database

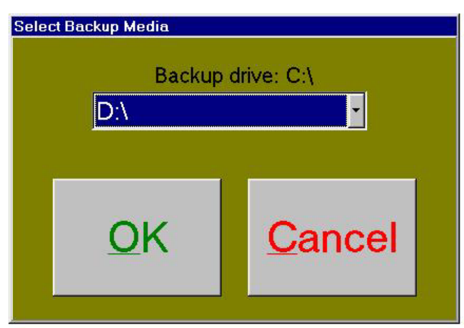
Whenever you select "save" at the end of a test or treatment session, the data just generated is placed in the database under the patient's ID number. This way it will be available to print, compare to another session or review at a later date.

To protect this data from being lost or accidentally destroyed, you should make a backup of your database at the end of **every day you use the SIMULATOR II.** By doing so, you are protecting your data from loss in the event your computer is damaged, stolen, or the files become corrupt. **If you do not make a backup copy of your database, you may loose all patient data in the event of a system failure**.

To backup your database to a CD-RW:

Insert the DirectCD formatted CD-RW into the CD drive.

Before you select the Backup option, make sure that the back-up media is pointing to the CD drive (D:). You may also elect to backup to the C: drive if a CD-RW is unavailable. To do this, select **File** from the top menu bar, then select **Select Backup Media.** The following window will appear:



Click on the ▼ and select the desired drive.

Then click OK.

To make a backup of your database:

Select **File** from the top menu bar.

Select **Backup Database**.

Click on **OK**.

You may use the same CD-RW each time you make a backup copy of your database. Each backup will be saved with a different date stamp. If the disk becomes full, you may use Windows Explorer delete older backup files from the CD to make room for new ones.

To further insure against loss of data due to a damaged CD, BTE recommends you make your daily backups using a different CD for each day of the week. For this method, you will need five CD-RW's. Label each one with a day of the week (Monday, Tuesday, Wednesday, etc…). Then on each respective day of the week, use the CD labeled for that day. You will end up reusing each CD once per week. This method helps protect your database from being lost if the backup CD becomes lost or damaged.

To restore your database from CD-RW:

Insert the CD-RW into the CD drive.

Select **File** from the top menu bar.

Select **Restore Database**.

If more than one backup exists on the CD, click on the ▼ to select the desired backup. They are sorted with the most recent at the top of the list.

Click on **OK**.

If you have any questions, please do not hesitate to call us at 800-331-8845 or 410-850-0333.

Environmental Protection

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

- Dispose of batteries in accordance with all local, state, and federal laws.

Section 8
Troubleshooting

Use the following chart if you encounter a problem with your SIMULATOR II. If the solution cannot be found here, please call our service department at 800-331-8845 or 410-580-0333.

PROBLEM	SOLUTION
Attachment broken	Call BTE for a replacement.
Exercise head gets very warm	This is not uncommon and is caused by leaving the TORQUE turned up high for long periods, or by leaving the SIMULATOR II in the isometric mode for extended periods of time. The high temperature will not damage the exercise head. To prevent a heat buildup, exit to the start-up screen when the SIMULATOR II is not in use, and make sure the slide bars are set to zero force.
Exercise head squeaks excessively	Squeaks are normal occurrences because of the friction material in the exercise head. If yours seems to squeak excessively and is annoying, call BTE. <u>DO NOT</u> for any reason, put oil or any other lubricant in the exercise head.
No resistance at tool	Make sure the force is set to the desired level for each direction. Make sure the tool is inserted correctly
Power won't come on	Make sure the SIMULATOR II is plugged in to an electrical outlet. Check all the SIMULATOR II connections to be sure they are properly connected. Make sure the computer components are turned on. Check your facilities circuit breaker to confirm power is going to the outlet the SIMULATOR II is plugged into.

Printer activates but nothing prints	Print heads may be clogged – clean print heads according to the instructions under the printer cover or in the printer manual Ink cartridges may be empty – replace with correct ink cartridges according to the printer manual.
Lift Mechanism	The silver cylindrical shafts that run the length of both sides of the main column should be periodically treated with a light oil. Use a lubricant such as WD-40 and a rag to spread a very light coating on the plain metal shafts only. Such a coating will prevent corrosion of the shafting.
Excessive noise when raising the exercise head	Apply grease for the screw in the back of the column (see maintenance – page 702)

NOTE:

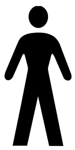
Oil or any other lubricant should NEVER be applied to the inside of the exercise head.

BTE will make available upon request, circuit diagrams, component parts lists, descriptions and other information which will assist appropriately qualified technical personnel to repair those components that are designated by BTE as repairable.

For any mechanical problems, don't hesitate to call BTE toll-free at 1-800-331-8845.
Most problems can be resolved with a phone call.

Section 9
Definitions and Bibliography

Definitions



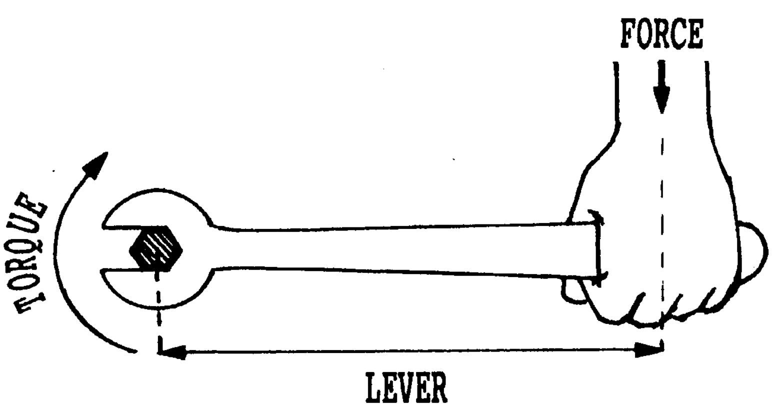
IEC Publication 878-02-02: TYPE B EQUIPMENT

<u>TORQUE</u>
The torque measure on the BTE SIMULATOR II 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 to turn a screw, and open or close a jar lid, and use a wrench to tighten or loosen a bolt (example below). Torque can cause rotation of a shaft, or it can just set up a twisting force in a shaft that refuses to rotate. Applying torque to a shaft does not necessarily mean that the shaft will move.

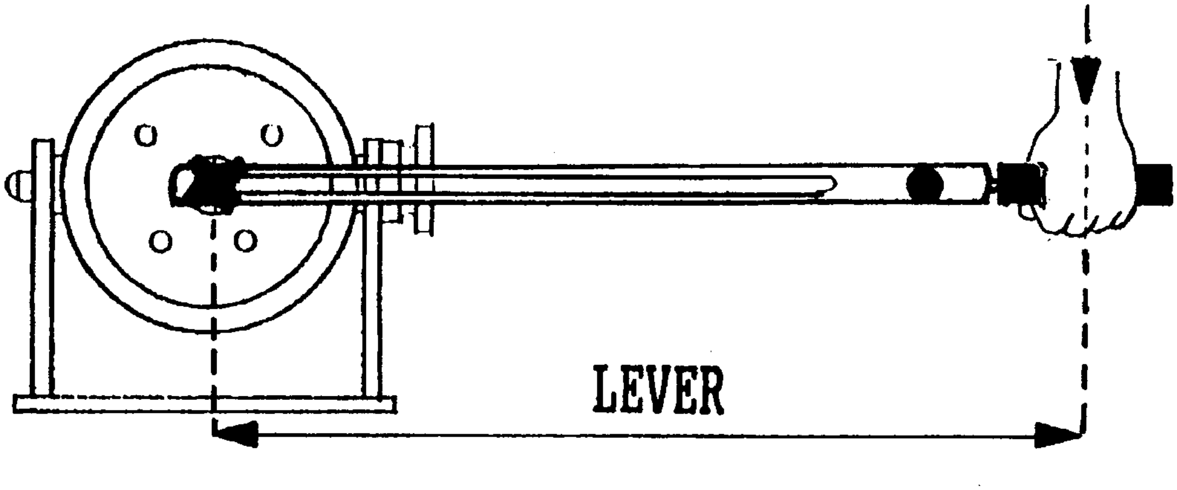
Torque is usually expressed in units of foot-pounds or inch-pounds. The BTE SIMULATOR II uses inch-pounds because it is a very small unit of measure which can easily be applied to human performance. Inch-pounds can be converted to foot-pounds - there are 12 inch-pounds in every foot-pound.

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.

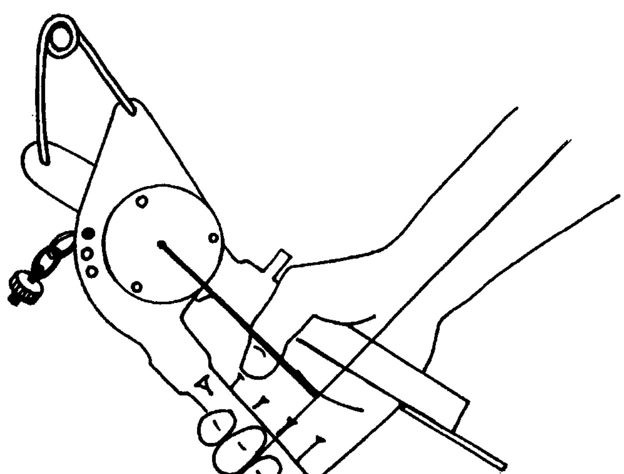
$$\frac{\text{100 inch pounds}}{\text{10 inches}} = \text{10 pounds}$$



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 times 10 pounds which equals 100 inch-pounds.



When using the BTE SIMULATOR II, an understanding of this basic principle will allow you to relate these numbers better to everyday activities. All you need to do is measure the distance from the centerline of the SIMULATOR'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.



WORK

Work is defined as force times distance. Whenever any amount of weight or force is moved any amount of distance, work has been done. Any task in the world that involves movement can be described in units of work.

The units of work on the SIMULATOR II are derived from a product of torque (which is measured in inch-pounds) times distance (which is measured in degrees of shaft rotation). If 48 inch-pounds of force is moved 1000 degrees of distance during an exercise, the patient has then completed 48,000 inch-pound-degrees of work. As the patient accumulates more degrees of distance, he or she will continue to do more work.

Units of work are useful in that they allow you to quantify how much exercise the patient is performing. This unit permits you to combine two variables, force and distance, into one number that can help indicate if a patient is making progress.

By quantifying the amount of work required to perform any real-life task, it then becomes possible not only to duplicate the task on the SIMULATOR II, but also to determine if a patient is able to produce the units of work which are required to accomplish that task. (The inch-pound-degree units of work shown on the SIMULATOR II can be converted to other units that may be more understandable. See the end of this section.)

POWER

Power is the rate at which work is done, or in other words, the amount of work done per unit of time. It shows how efficiently a patient is performing. As a patient works more efficiently it is an indication that his dynamic strength and endurance is improving.

> Example:
>
> If a patient performs 48,000 inch-pound-degrees of work in 30 seconds, his power number is 48,000/30 = 1600. This is an indication that the patient is performing at an average rate of 1600 units of work per second. If tomorrow the patient performs the same amount of total work, but in less time, they will be working more efficiently and therefore their power number will increase. Let's assume he uses only 20 seconds. 48,000/20 = 2,400. In this second example, the larger power number shows that they are performing more work per second because he has taken less time (20 seconds instead of 30) to perform the same amount of work.

Any change in the work or time numbers will result in a power change. If the patient were to exercise for 30 seconds, as they did the first day, but produce more than 48,000 units of work, they would be performing at a higher power rate.

Example: $\frac{\text{75,000 units of work}}{\text{30 seconds}}$ = 2,500 units of power

As you can see, power is useful because it takes three different variables, force, distance, and time, and computes them into one number. This one number can then be used as a measure of dynamic strength and endurance as a measure of patient progress from day to day, or a comparison to the actual power requirements of performing any real life task.

Power can be stated in a variety of units, such as horsepower, watts, etc. The SIMULATOR II gives power in units of watts and also engals. Watts is a standard unit with which you may already be familiar. Engals, however, are units that are used only on the SIMULATOR II.

An engal is defined as the effort required to move a load of one inch-pound one degree in one second. It still does, however, use the standard definition of power, which is force x distance/ time.

$$\text{engals} = \frac{\text{force (inch-pounds) x distance (degrees of rotation)}}{\text{time (seconds)}}$$

COEFFICIENT OF VARIATION

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:

$$\text{CV} = \frac{\text{Standard Deviation}}{\text{Mean}}$$

where standard deviation is:

$$\sigma = \sqrt{\frac{\Sigma(x-x)^2}{n}}$$

EXAMPLE:

Say your isometric test results were: 132, 112 and 128

n is: 3

The mean is: 124

Subtract the mean
<u>from the data:</u> <u>then square the difference:</u>

132 - 124 = 8 8^2 = 64
112 - 124 = -12 -12^2 = 144
128 - 124 = 4 4^2 = 16

Add the products, 64 + 144 + 16 = 224; and divide by 3 (n): 224/3 = 74.7

The square root of 74.7 (8.64), is the standard deviation.

The standard deviation (8.64), divided by the mean (124) times 100 equals the coefficient of variation.

8.64 / 124 x 100 = 6.97 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 own opinions based on all the data you have available to you.

■ CONVERSIONS

1 engal = .00197 watts
1 engal = .00000264 horsepower
1 horsepower = 378,000 engals
1 foot-pound = 12 inch-pounds

■ 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. Wenger & Hellerstein state that for a given 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, a cardiologist gave an exercise prescription 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.

CONVERSION

To perform the conversion the following accepted conventions will be used:

1. VO_2/min = oxygen uptake per minute
2. VO_2/min at rest = 3.5mlO_2/kg/min = 1 MET (for the normal adult population)[1]
3. kcal/min = (4.825)(VO_2/min)[2]
4. 1 kcal/min = 72 watts[3]

Resting VO_2/min levels can be calculated for the "**average adult**" using formula 2 from above:

VO_2/min for 70kg male = 245ml/min at rest (3.5*70)
VO_2/min for 55kg female = 193ml/min at rest (3.5*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, VO_2/min can be converted to kcal/min:

For males: kcal/min = (4.825*.245) = 1.182 kcal/min
For females: kcal/min = (4.825*.193) = 0.931 kcal/min

Now using formula 4 from above we can convert kcal/min to watts:

For males: 72*1.182 = 85.1 watts
For females: 72*0.931 = 67.0 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 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 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

EMC Guide

Guidance and manufacturer's declaration – electromagnetic emissions		
Simulator II is intended for use in the electromagnetic environment specified below. The customer or the user of Simulator II should assure that it is used in such an environment		
Emissions test	Compliance	Electromagnetic environment - guidance
RF Emissions CISPR 11	Group 1	Simulator II uses RF energy only for its internal function. The RF emissions from the Simulator II are very low and not likely to cause interference in nearby electronic equipment.
RF Emissions CISPR 11	Class A	Simulator II is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic Emissions IEC 61000-3-2	Class A	
Voltage Fluctuations/flicker emissions 61000-3-3	Complies	

Guidance and manufacturer's declaration – electromagnetic immunity			
Simulator II is intended for use in the electromagnetic environment specified below. The customer or the user of Simulator II should assure that it is used in such an environment.			
Immunity test	IEC 60601 test level	Compliance Level	Electromagnetic environment guidance
Electrostatic discharge (ESD) IEC 61000-4-2	± 6 kV contact ± 8 kV air	± 6 kV contact ± 8 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30 %.
Electrical fast transient/burst IEC 61000-4-4	± 2 kV for power supply lines ± 1 kV for input/output lines	± 2 kV for power supply lines ± 1 kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	±0.5 kV to ±1 kV differential mode ±0.5 kV to ±2 kV common mode	±0.5 kV to ±1 kV differential mode ±0.5 kV to ±2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Power Frequency, Magnetic Fields IEC 61000-4-8	3A/m	3A/m	Magnetic field levels should be at levels characteristic of a typical location in a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	<5 % U_T (>95 % dip in U_T) for 0.5 cycle 40 % U_T (60 % dip in U_T) for 5 cycles 70 % U_T (30 % dip in U_T) for 25 cycles <5 % U_T (>95 % dip in U_T) for 5 s	<5 % U_T (>95 % dip in U_T) for 0.5 cycle 40 % U_T (60 % dip in U_T) for 5 cycles 70 % U_T (30 % dip in U_T) for 25 cycles <5 % U_T (>95 % dip in U_T) for 5 s	Mains power quality should be that of a typical commercial or hospital environment.

<table>
<tr><th colspan="4">Guidance and manufacturer’s declaration – electromagnetic immunity</th></tr>
<tr><td colspan="4">Simulator II is intended for use in the electromagnetic environment specified below. The customer or the user of Simulator II should assure that it is used in such an environment.</td></tr>
<tr><td>Immunity test</td><td>IEC 60601 test level</td><td>Compliance Level</td><td>Electromagnetic environment guidance</td></tr>
<tr><td>Conducted RF
IEC 61000-4-6

Radiated RF
IEC 61000-4-3</td><td>3 Vrms
150 kHz to 80 MHz

3 V/m
80 MHz to 2.5 GHz</td><td>3 Vrms

3 V/m</td><td>Portable and mobile RF communications equipment should be used no closer to any part of Simulator II, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter.

Recommended separation distance
d =1.2 eP
d =1.2 eP 80 MHz to 800 MHz
d = 2.3 eP 800 MHz to 2.5GHz
where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in meters (m).

Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey, [1] should be less than the compliance level in each frequency range.[2]

Interference may occur in the vicinity of equipment marked with the following symbol:
</td></tr>
<tr><td colspan="4">NOTE 1 At 80 MHz and 800 MHz, the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.</td></tr>
<tr><td colspan="4">[1] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which Simulator II is used exceeds the applicable RF compliance level above, Simulator II should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating Simulator II.

[2] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.</td></tr>
</table>

<table>
<tr><th colspan="4">Recommended distance between portable/mobile RF communication equipment and Simulator II</th></tr>
<tr><td colspan="4">Simulator II does not need to be used in a radiated RF controlled environment. Customers or users of Simulator II shall maintain the minimum safe distance between portable/mobile RF communication equipment (transmitter) and Simulator II to prevent electromagnetic interference. The minimum distance shall be accordance with the maximum output of the communication equipment as recommended below.</td></tr>
<tr><td rowspan="2">Rated Maximum output power of transmitter

W</td><td colspan="3">Separation distance according to the frequency of the transmitter</td></tr>
<tr><td>150Khz to 80Mhz

d = 1.2 eP</td><td>80Mhz to 800Mhz

d = 1.2 eP</td><td>800Mhz to 2.5 GHz

d = 1.2 eP</td></tr>
<tr><td>0.01</td><td>0.12</td><td>0.12</td><td>0.23</td></tr>
<tr><td>0.1</td><td>0.38</td><td>0.38</td><td>0.73</td></tr>
<tr><td>1</td><td>1.2</td><td>1.2</td><td>2.3</td></tr>
<tr><td>10</td><td>3.8</td><td>3.8</td><td>7.3</td></tr>
<tr><td>100</td><td>12</td><td>12</td><td>23</td></tr>
<tr><td colspan="4">For transmitters rated at a maximum output power not listed above, the recommended separation distance d in meters (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE 1 At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.</td></tr>
</table>

CLINICAL

APPLICATIONS

MANUAL

A clinically-oriented reference manual for
users of the BTE ***Simulator II***.

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TABLE OF CONTENTS

CLINICAL APPLICATIONS FOR THE BTE *SIMULATOR II*

When discussing how the BTE Simulator II 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 Simulator II 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 Simulator II.

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 upper extremity 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 Simulator II 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 - i.e. 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 neurologic 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 *Simulator II* Uses With Upper Extremity Injuries/Conditions

The following represents suggested areas of assessment and uses of the BTE Simulator II 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
#202 - key shape
#400 – lathe crank
#162 – grip/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
#301 & #302 – small and large knobs
#501, #502, #504 – small, medium and large screwdriver handles
#601 - cylindrical handle
#701 - small lever
#802 - large lever
#171 – linear motion handle
#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
#802 - elbow flexion and extension
- shoulder internal and external rotations
- shoulder flexion and extension
- shoulder 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:

#162 – grip, pulp to pulp pinch, 3-jaw chuck, lateral pinch
#701 - wrist flexors and extensors
#302, #601 - radial and ulnar deviators of wrist
#601 - supination and pronation
#802 - elbow flexion and extension
- shoulder flexion and extension
- shoulder abduction and adduction
- shoulder internal and external rotations
#191 - elbow flexion and extension
- shoulder flexion and extension
- shoulder abduction and adduction
- shoulder internal and external rotations

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:

#122 – upper extremity ergometer
#131, #141 - repetitive arm movement similar to turning a steering wheel.
#181 - 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:

#400 – combined static pinch with wrist circumduction
#802 - 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)
#171 – simultaneous static grasp with wrist, elbow and shoulder motions
#122 – simultaneous static grip with bilateral wrist, elbow and shoulder performing reciprocal motions

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. Performing isolated joint motions, i.e. wrist

flexion/extension or a specific repetitive task, can assess this tolerance.

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, #171
- arm lift - #191, #802, #901
- reaching (static and dynamic at various heights) - #802, #191, #181, #131, #141, #701, #901, #103, #122
  (using wrenches), #504/502/501, #302, #601
- static grip - #302, #301, #501, #502, #504, #601, #701, #802, #901, #122, #131, #141, #162, #171
- static pinch - #102, #202, #162, #400

BTE *Simulator II* Uses with Back Injuries/Conditions

The following represents suggested areas of assessment and uses of the BTE Simulator II 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; i.e. 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
#131/141 - steering wheel
#181 - multiple handle crossbar
#171 – linear motion handle

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 Simulator II, back strength is measured functionally.
The isometric and dynamic power testing protocols are applicable for this assessment, except when tool 191 is in use; the 191 tool can be used dynamically only.

Appropriate tools to be used to assess strength both statically and dynamically include:

#802 - 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 kinesiophysical 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, #171 - 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

#122 – upper extremity ergometer 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:

#122 – upper extremity ergometer
#181 - which is equivalent to climbing a ladder but with the upper extremities
#191 - for repetitive lifting tasks
#802 - for repetitive push/pull
#131, #141 - for repetitive bilateral upper extremity exercise

Biomechanics
Evaluation of, instruction in, and practice in body mechanics can be accomplished using the Simulator II.

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, #171
lifting (at various heights) - #191, #802, #901, #181
reaching (static and dynamic at various heights) - #802, #191, #181, #122, #131, #141, #701, #901
static grip - #301, #302, #501, #502, #504, #162, #601, #701, #802, #901, #122, #131, #141, #171
repetitive grip - #162
static pinch - #102, #202, #162, #400
dynamic pinch - #162

Various work postures can be addressed indirectly using the Simulator II. 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 *Simulator II* Uses with Patients S/P CVA

The following represents a list of suggested uses of the BTE Simulator II 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:

#122 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, pulp to pulp, 3-jaw chuck and lateral pinches
#701 for wrist flexors and extensors
#802 for elbow flexors and extensors
shoulder flexors and extensors
shoulder abductors and adductors
shoulder internal and external rotators
#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.

#141 is most appropriate for this task

Passive Range of Motion
Passive range of motion of the "involved" upper extremity can be provided by Ace wrapping the hand to tools that are used bilaterally.

#131 and #141
#122
#181

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
#131, 141 - steering wheel
#122 – UE ergometer

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
#122 for bilateral and reciprocal UE motions

Balance and Weight-Shifting Activities

Performing “whole body” tasks such as pushing and pulling can practice Balance and weight-shifting activities.

Appropriate tools for performance of such activities include:

- #802 - large lever
- #131, 141 - steering wheel
- #901 - end/side handle
- #171 – linear motion handle
- #191 - three-dimensional motion attachment

BTE *Simulator II* Uses with Patients with Arthritis

The following represents suggested areas of uses of the BTE Simulator II 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 Simulator II 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
- #400 – lathe crank
- #162 – grip/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/pinch tool
#301, 302 – medium/large knob
#501, 502, 504 - screwdriver handles
#601 - D-handle
#701 - small lever
#802 - large lever
#171 – linear motion handle
#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
#302, 601 - wrist radial and ulnar deviations
#601 - forearm supination and pronation
#802 - shoulder flexion and extension,
shoulder abduction and adduction,
elbow flexion and extension,
shoulder internal and external rotations,

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/pulp to pulp pinch, 3-jaw chuck, lateral pinch
#701 - wrist flexors and extensors
#302, 601 - wrist radial and ulnar deviators
#601 - forearm supinators and pronators
#802 - elbow flexors and extensors,
shoulder abductors and adductors,
shoulder internal and external rotators,
knee flexors and extensors (limited use)

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:

#131/141 -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 Simulator II.

Appropriate tools that can be incorporated into an ADL evaluation using the Simulator II include:

#102 - as a bottle top, small knob
#202 - as a key
#301/302 - as a jar lid
#400 – as a pencil sharpener, window crank, fishing reel

#501, 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
#171 - as an iron, vacuum cleaner, broom or brush, shovel;
#901 - for one-handed lifting, as a shovel
#131/141 - turning a steering wheel, turning a valve

Many others as need 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 - #171, #802, #901, #191
pushing, pulling (at various heights) - #171, #802, #191, #701, #901,
lifting (at various heights) - #191, #802, #901
reaching (at various heights) - #802, #191, #181, #122, #131, #141, #701, #901
static grip - #301, #302, #501, #502, #504, #162, #601, #701, #802, #901, #122, #131, #141, #171
repetitive grip - #162
static pinch - #102, #202, #162
dynamic, repetitive pinch - #162

TREATMENT

The BTE *Simulator II* in an Exercise Program

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 Simulator II 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".[1] This statement reinforces the benefits obtained when using the Simulator 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 must 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 Simulator II.

The second step involves performing a task analysis. With the aid of the **Task Analysis Form**, 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 Simulator II, 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 workday.

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 the Section 5 entitled "Task Analysis and Measurement".

When recording information on the Task Analysis Form, list job tasks, ADL's, and avocational 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 Simulator II, visualize the task, and then review the various attachments available. Keep the attachments out where they are visible; do not place them in drawers or closets. If possible, hang the poster of the various work, ADL, and leisure simulations on a wall near the Simulator II. 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 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.

Once the list is condensed, enter the attachments to be used on the **Simulator II Master Chart**. 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 Simulator II 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 duration of treatment for these specific injuries/conditions.

After having completed the Task Analysis and Master Chart, you are ready to initiate treatment. Documentation of daily performance is important in all rehabilitation programs. To make this easy when using the Simulator II, all daily treatment results are recorded automatically and can be saved at the end of the exercise session. Set-up parameters, goals, and daily performance results for each attachment can be recorded per session.

When the treatment begins, set-up parameters must be established and entered in the NOTES Section. They include the position of the exercise head, height of the exercise shaft, tool positioning, 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 accomplish only 3 to 5 attachments on the first day.

When introducing the patient to the Simulator II, 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 can be calculated from these variables. Explain to the patient that he will be taught how to use the Simulator II so that he or she can work independently.

To begin the first session using the Simulator II, go to the Chart Set-up screen and add the desired exercises. You may begin with zero resistance, a pre-selected starting resistance level, or use the STATIC option to perform an isometric trial where 30% of this value will be inserted into the chart as the beginning exercise level. When the Chart Set-up is completed, go to Daily Treatment to perform the exercises. 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, it is recommended that you use the AUTOMATIC goal stop mode. You may 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 to produce the most efficient rates of patient progress.[2]

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, and ability to follow commands, personality, and other traits that may influence progress.

At the end of the first or second day of treatment, select one of the goal options and enter the stop value based on the results of the first or second day. 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, set the resistance direction, position the exercise head, and adjust the height of the exercise shaft. Instruct the patient that he/she need only be concerned with the screen buttons that begin the exercise and advance to the next exercise. By the 3rd or 4th attachment, have the patient insert the tool and set up the Simulator II.

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. Have the patient exercise while trying to match or slightly exceed the goal recorded during the initial treatment session. Provided that the distance is the same or greater than the first recording, the patient will perform more work during the second treatment session. This is because he is exercising at a constant level of resistance, rather than starting at a resistance of zero and gradually increasing it. Force, distance, work, power and time will be saved for documenting progress.

On the third day, review the set-up procedures with the patient and be available to provide verbal cues as needed. Goals should be set by taking the result of the preceding treatment session and rounding them off appropriately. The work goal provides a result that is a combination of the distance (repetitions) and the resistance (torque) set. This is the most appropriate goal to use because it takes two performance variables into consideration, and quantifies how much the patient has done. 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. Time may be appropriate for endurance exercises using the 122 or 181 tools, similar to setting a time goal on a stationary bike.

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 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.

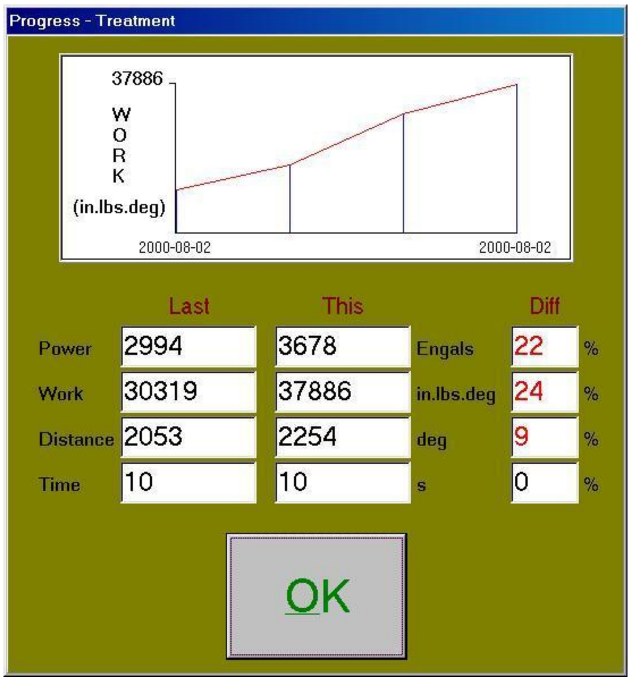
When deciding to increase exercise goals, regardless of which goals are being altered, it is important that adjustments be made appropriately. When making subsequent increases in resistance, use the method previously described in this section (the self-estimated "challenging but comfortable" level). 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. Another method is to use a percentage as a guide for making increases. Once the patient can comfortably complete an exercise, increase the goal by 10%. Following is a suggestion for increasing output using 10% increases to the work goal:

Exercise Session	Goal Change
Day 1	Establish base (force and work)
Day 2	Increase work 10%
Day 3	Increase work 10%
Day 4	Increase work 10%
Day 5	Increase force 20% - keep work the same
Day 6	Increase work 10%

Note: the above chart is a suggestion. Patients progress at different rates. Adjust your changes to each patients treatment program according to individual capabilities.

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 graph presented at the end of an exercise (see example below) represents the work done per attachment (shown on the vertical axis) during each treatment session (shown on the horizontal axis). When looking at the overall trend line, peaks and valleys may be noted; however a general trend towards higher work numbers should be observed. Increases in work indicate an increase in the quantity of exercise completed. An increase of the power number indicates an increase in the efficiency of the patient. Changes in the power numbers may suggest the need for changes in the treatment program or be indicative of an adjustment that was just made.



Work Graph - Represents the change on work from the first session to the just completed session. It includes a point for all sessions with this attachment.

Power - The *quality* of the patient's performance.

Work - The *quantity* of exercise performed.

Distance - Total degrees moved against resistance.

Time - The time in seconds the patient took to complete the exercise.

The difference (**Diff**.) column represents the change in performance from the last session completed to the session just completed. Increases are indicated by a red number, decreases are represented by a negative number.

The treatment method described above is endorsed by many clinicians. One study, specific to the BTE Simulator by Blackmore S, Beaulieu D, et. al.[2] has been published, lending support to this approach. Certainly the efficacy of progressive resistive exercise programs is well documented in the literature.

[1]Joynt RL: Therapeutic Exercise. In Delisa JA (ed.): Rehabilitation Medicine: Principles and Practice. Philadelphia: J.B. Lippincott, pp. 346-371, 1988
[2]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 Work Simulator. 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 (more on this formula later). With this in mind, a number pr protocols cam be performed with the BTE Simulator II isometric tests *Static Compare* and *Line Graph Test*.

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 are not part of an isometric trial so they 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.[1-4] 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 cutpoints.

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.[3] 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.[1,3,5] This test method can be easily accomplished using the Simulator II using the *Static Compare* option.

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.[3,5-8] 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.[5,9]

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[5]. 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.[3,5] 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.[1,3,5,11-13] 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 serial trials in order to be calculated. CV's are automatically calculated by the Simulator II; however, they can also be calculated using a scientific calculator. (Refer to page 312 for instructions). There are two different formulas used to determine standard deviation: one is representative of the complete population of test scores (Formula #1) and the other of a sampling of the population of scores (Formula #2).[14] For the purpose of this test, the first formula is most appropriate.

Formula #1	Formula #2
$\sigma = \sqrt{\dfrac{\Sigma(x-\mu)^2}{n}}$	$s = \sqrt{\dfrac{\Sigma(x-\mu)^2}{n-1}}$

If you are using a scientific calculator, be sure to check the instruction manual to assure use of the correct one formula (formula #1).

What Test Procedure Should I Follow?

Based on this information, there are two ways of testing consistency of effort using the Simulator II. The first method involves measuring peak isometric strength only. Using *Static Compare (or Singles)* allows you to document the maximum strength capabilities of a particular muscle group. Utilizing *Static Compare*, multiple trials can be performed by one extremity, then the other, or you may alternate between right and left sides (or flexion and extension, supination and pronation, etc…). If performing a bilateral activity, *Static Single* would be chosen. CV's are calculated in all cases.

Testing of opposing muscle groups while alternating directions between trials decreases chances of consistent sub-maximal performance, as has been suggested by various authors.[1,3,5] This would be the option of choice when testing a patient suspected of giving sub-maximal effort.

The second method of testing consistency of effort is based on work by Chaffin and others.[10,11] 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 between the end of the 2nd 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* 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. For example, if testing grip strength using #162, instruct the individual to place the thumb-index web space against the perpendicular peg located on the top handle. If using another 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 metacarpals 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 or a large piece of plywood laid beneath the Simulator II can be used 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 Simulator II 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 unbreakable object 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 308-311 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?

Coefficients of variation provide 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 cutpoints, 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 cutpoints 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%."**[11] 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% cutpoint was found to be liberal.[3] As a result of this study, individual cutpoints 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 cutpoints falling below 10%.[13] The variations that exist between the cutpoints 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 Simulator alone.[3] Additional tests using various instruments are also 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 Simulator II have CV's higher than the established cutpoints[12, 15]. King and Berryhill[1] 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 cutpoints, 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 supports 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. Other tools which also allow for this type of cross-validation include, but are not limited to, #301 and #302, the large and medium knobs, and #162, which has multiple positions for grip testing.

Can This Test Method Be Modified?

This method of testing consistency of effort is 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. includes the use of the Simulator as a tool for evaluating consistency of effort.[3,5,12,15] 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, again, the exception of #701. This test protocol yields 20 coefficient of variations that 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,[1] examined the Work Simulator and the Jamar hand-held dynamometer. The attachments chosen for the Simulator were #302, #502, and #162. Although the CV cutpoints 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 generated on the Simulator II 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.

[1]King JW, Berryhill BH: Assessing maximum effort in upper extremity functional testing. WORK 1(3): 65-76, 1991

[2]Niemeyer LO, Jacobs K: Work Hardening - State of the Art. New Jersey: Slack, Inc., pp 100-103, 1989

[3]Niemeyer LO, Matheson LN, Carlton RS: Testing consistency of effort: BTE Simulator II. Industrial Rehab. Quarterly 2(1): 5-32, 1989

[4]Khalil TM, Goldberg ML, et al: Acceptable maximum effort (AME): A psychophysical measure of strength in back pain patients. Spine 12(4): 772-776, 1987

[5]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

[6]Battie MC, Bigos SJ, et al.: Isometric lifting strength as a predictor of industrial back pain reports. Spine 14(8): 851-56, 1989

[7]Mayer TG, Barnes MA, et al.: Progressive isoinertial lifting evaluation: I. a standardized protocol and normative database. Spine 13(9): 993-997, 1988

[8]Zeh J, Hansson T, et al.: Isometric strength testing: recommendations based on a statistical analysis of the procedure. Spine 11(1): 43-46, 1986

[9]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

[10]Chaffin DB, Andersson G: Occupational Biomechanics. New York: John Wiley & Sons, Inc., 1984

[11]NIOSH: Work Practices Guide for Manual Lifting. Akron, OH: American Industrial Hygiene Association, 1983

[12]Matheson LN: Use of the BTE Simulator II to screen for symptom magnification syndrome. Industrial Rehab. Quarterly 2(2): 5-28, 1989

[13]Jacobs JL, Vermette JE: BTE National Database-Supination/Pronation. Unpublished

[14]Koosis DJ: Statistics (3rd ed.). New York: Wiley Press, p. 77, 1985

[15]Barren N, Gant A, et al.: The Validity of the ERIC Maximal Voluntary Effort Protocol in Distinguishing Maximal form Submaximal Effort on the Baltimore Therapeutic Equipment Work Simulator. NARPPS Journal & News, 7(6): 223-8, 1992

Procedure/Description:

The Employment and Rehabilitation Institute of California (E.R.I.C.) has developed a Maximum Voluntary Effort Test Battery that includes the use of the Simulator as a tool for evaluating consistency of effort. It involves isometric testing of both hands in clockwise and counterclockwise directions using five different attachments (#302, #502, #503, #601, and #701). This 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 "Static Compare" from the Evaluations menu.

2. Place the exercise head in the horizontal position with the shaft facing forward (position #3).

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, #503, 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 Simulator II. 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 #503, medium and large screwdrivers: 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, three position crank: insert the tool at its shortest position, so that it is parallel to the floor and the handle is positioned toward the side on which the patient is standing. 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 that, 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. Enter the desired parameters in the Set-Up window.

9. 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.

10. 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. Clear that trial before continuing with the test.

    NOTE: Allow the patient to see the console during the practice trial so that he/she can see that his/her effort is being recorded.

11. Turn the monitor so that the patient can not see it.

12. Making sure that the tool is securely attached, the patient properly positioned, and the correct side/direction is selected, click START 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.

13. Proceed through three trials, alternating back and forth in both clockwise and counterclockwise directions. Begin by instructing the patient to apply maximum effort against the tool while supinating. When maximum is reached, 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. Remember to select the opposite side of the screen to change to the appropriate test box after each trail.

    NOTE: Be sure the patient's position has NOT change and 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.

14. You have now collected data from two out of the 20 tests performed when following this procedure. The Simulator II will automatically calculate the coefficient of variation for each test. Save and print the results.

15. Continue with all five attachments in order as they are listed above, always beginning with the dominant or uninjured side and alternating directions between trials.

Use the following or similar chart to document the results of all 20 tests:

BTE MAXIMUM VOLUNTARY EFFORT TESTING –

TOOL	FUNCTION	Hand	CV Score	CUTPOINTS MALE	FEMALE	Failed Scores
302	**Supination**	Dom.		12.2	16.3	
		Non-Dom.		10.5	13.0	
	Pronation	Dom.		11.9	12.4	
		Non-Dom.		9.3	8.8	
502	**Supination**	Dom.		11.8	11.5	
		Non-Dom.		13.8	12.7	
	Pronation	Dom.		12.1	13.6	
		Non-Dom.		10.2	9.9	
504	**Supination**	Dom.		8.7	13.3	
		Non-Dom.		11.4	13.2	
	Pronation	Dom.		9.6	14.1	
		Non-Dom.		8.6	9.8	
601	**Supination**	Dom.		9.9	11.7	
		Non-Dom.		8.9	12.7	
	Pronation	Dom.		11.2	12.3	
		Non-Dom.		9.4	12.4	
701	**Elbow Flexion**	Dom.		10.4	11.0	
		Non-Dom.		9.9	7.6	
	Elbow Extension	Dom.		8.5	10.3	
		Non-Dom.		10.1	12.4	

Of the 20 tests completed, __________of the coefficients are above the designated cutpoints, indicating **full/less than full** participation in testing of this type.

Niemeyer LO, Matheson LN, Carlton RS; Testing Consistency of Effort: BTE Work Simulator: Ind. Rehab Quarterly, Vol. 2 num. 1, Spring 1988

Barren N, Gant A, Ng F, Silver P, Wall J; The Validity of the ERIC Maximal Voluntary Effort Protocol in Distinguishing Maximal Effort on the BTE Work Simulator: NARPPS J & News, Vol. 7 num. 6, 1992

CALCULATING THE COEFFICIENT OF VARIATION

Coefficient of Variation (CV) = $\frac{\text{Standard Deviation}}{\text{Mean}}$

where standard deviation is:

$$\sigma = \sqrt{\frac{\Sigma(x-\mu)^2}{n}}$$

Example:

Recorded isometric test results (X) were: 83, 75, and 91

$n = 3$
mean (μ) = 83

Subtract the mean from the data ($X-\mu$):
83 - 83 = 0
75 - 83 = -8
91 - 83 = 8

then square the difference:
$0^2 = 0$
$-8^2 = 64$
$8^2 = 64$

Add these numbers ($\sum x^2$): 0 + 64 + 64 = 128;

and then divide by 3 (n): 128 ÷ 3 = 42.7

The square root (√) of 42.7 = 6.5, giving you the standard deviation (σ).

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 levels and/or limitations, and to establish a baseline against which progress can be measured. Although there are numerous methods for conducting evaluations on the Simulator II, the following procedure is the one recommended for general testing. It allows the evaluator to test the three components of function mentioned above: 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.[2,3,4,5] 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.[5-10] 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.[10] 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.[10]

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).[3,4] 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 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[5] as a conservative measure; however, Chaffin[3] 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,[11] 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.[6] 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.[12] The standard protocol for testing peak isometric strength presented in this manual has been used in a number of studies.[13-17] 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.[3,4] 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 evaluator controls the individual’s body position and joint angles, 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.[3] 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%.[4] 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.[4,15,18,19] 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 Simulator II. Quantifying an individual's power output allows for comparison against 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 duration of ten seconds. 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,[6,13-17] and it has also been recommended in the BTE Simulator II 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 the lesser of the two peak strength measurements to set the force, 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 Simulator II 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 Simulator II. It can be converted to pounds by dividing the inch-pound reading by the length of the lever arm in inches. 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:

$$\boxed{\frac{\text{inch-pounds}}{\text{inches}} = \text{pounds}}$$

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 relaxed. Distance is recorded as degrees of rotation on the Simulator II, where 360^{o} 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 Simulator II.

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:

WORK	**POWER**
(force)distance = work	$\frac{\text{work}}{\text{time}}$ = power

On the Simulator II, work is inch-pound-degrees and power is inch-pound-degrees per second. The effort it takes to move a one inch-pound load one degree in one second has been identified as an ***engal*** by the inventors of the Simulator II. This unit of measure is felt to be more appropriate to human output than other standard measures of power. Watts and horsepower, which measure power output that far exceed human output, result in very small numbers when used to calculate human power. It was felt that numbers used to record human power should be more realistic and perhaps more motivating. Surely, one would rather see that he/she has increased their power by 500 engals rather than by 0.985 watts.

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 (engals). This number is derived using the following method:

$$\frac{\text{60,000 units of work}}{\text{30 units of time.}} = \text{2,000 units of power (engals)}$$

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 engals. This is because the same amount of work has been done in a shorter period of time, resulting in the generation of greater power.

$$\frac{\text{60,000 units of work}}{\text{20 units of time.}} = \text{3,000 units of power (engals)}$$

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 work, 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.

$$\frac{\text{75,000 units of work}}{\text{30 units of time}} = \text{2,500 units of power (engals)}$$

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 engals because it has taken more time to do the same amount of work.

$$\frac{\text{60,000 units of work}}{\text{60 units of time.}} = \text{1,000 units of power (engals)}$$

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 set on the console 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. nondominant, 2) injured vs. noninjured, 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/Nondominant - Injured/Noninjured

Comparisons of dominant to nondominant and injured to noninjured 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 nondominant or injured side as a percent lesser or greater than the "normal or baseline" measurement. The formula for calculating this percentage is as follows:

$$\frac{\text{nondominant score}}{\text{dominant score}} - 1 \bullet 100 = \_\_\_\_\_\_\% \text{ OR } \frac{\text{injured score}}{\text{noninjured score}} - 1 \bullet 100 = \_\_\_\_\_\_\%$$

The " - 1 " in this formula allows for the calculation of a negative number. This indicates that the nondominant or the injured score is a certain percent "less than" the dominant or noninjured score. A review of the literature indicates conflicting data when searching for a "normal" percent difference between extremities.

Agonist/Antagonist

Comparisons of agonists 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 Simulator II, the best method for determining impairment is still to compare the individual's injured extremity to his/her non-injured.[11] 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.[4]

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 torque recorded for the test dates being compared. Changes in dynamic power can be calculated using the engal 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 judgement.

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PRESENTATION OF BTE SIMULATOR II DATA

GRIP STRENGTH (#162)

Maximum Strength (Isometric test) in inch-lbs.:

Test Date	Right	Left	Percent Difference
9/15/99	84	269	Right is 69% less than Left
9/17/99	161	383	Right is 58% less than Left
9/18/99	162	375	Right is 57% less than Left

Dynamic Power Test in engals:

9/15/99	1105	5199	Right is 79% less than Left
9/17/99	2064	7258	Right is 72% less than Left
9/18/99	1725	6900	Right is 75% less than Left

Dynamic Endurance Test in seconds:

9/15/99	41	216	Right is 81% less than Left
9/17/99	63	162	Right is 61% less than Left
9/18/99	56	193	Right is 71% less than Left

GRIP STRENGTH (#162)

Maximum Static Force (inch-lbs.):

Test Date	Right	Left	Percent Difference
1/03/00	162	33	L = 80% less
7/12/00	152	110	L = 28% less

Comparison - pre-op post-op
-6% +233%

Dynamic Power Test (engals):

1/03/00	5246	2763	L = 47% less
7/12/00	5032	4675	L = 7% less

Comparison - -4% +69%

Dynamic Endurance Test (seconds):

1/03/00	180	40	L = 78% less
7/12/00	148	70	L = 53% less

Comparison - -18% +75%

Presentation of Simulator II Data, continued

GRIP STRENGTH (162A)	**Right**	**Left**
Maximum Isometric Force	202 inch-lbs.	441 inch-lbs.
Maximum Dynamic Power	2384 engals	6776 engals

Injured extremity was 54% less than noninjured, isometrically.
Injured extremity was 65% less than noninjured, dynamically.

OPENING JAR (302 cc)

Maximum Isometric Torque	66 inch-lbs.	97 inch-lbs.
Maximum Dynamic Power	145 engals	1112 engals

Injured extremity was 32% less than noninjured, isometrically.
Injured extremity was 87% less than noninjured, dynamically.

BTE SIMULATOR II:

The BTE tool #802 is used to simulate pushing and pulling of objects on a horizontal surface while using both upper extremities.

Static test: N/A
Dynamic test:
Force: 186 inch-lbs.
Distance: 3056 degrees
Time: 120 seconds
Power: 4621 engals

Above represents approx. 47% of actual work requirements.

Comments: Pt. c/o increased pain in left shoulder, neck, and low back.

BTE SIMULATOR II EVALUATION TERMINOLOGY

Maximum Isometric Force (BTE Simulator II)
The client's maximum strength applied against a static resistance measured in inch-pounds (in-lbs.). This number represents the average of three consecutive trials.

Dynamic Power Test (BTE Simulator II)
Maximum power measured in engals (378,000 engals = 1 horsepower). For this test, the resistance (torque) is typically set at one half of the client's maximum isometric force for each upper extremity,

respectively. The client is instructed to perform the exercise as rapidly as possible for a 10 second duration.

Dynamic Endurance
This is a measure of a client's ability to work for an extended period of time. The resistance level is usually set for one half of the client's maximum strength capability of the injured or weaker extremity. The work rate is kept constant for the duration of the test. The fatigue point is determined when the client can no longer maintain the pace. Endurance is measured in seconds or by the amount of work performed.

Percentage Difference
The data obtained from each extremity or test is compared, with the variation expressed as a percentage.

Percentile Ranking (% Rank)
This number represents how the client's test results compare to available normative data.

Coefficient of Variation
A percentile representation of the fluctuation of the scores for a test repeated in a short period of time. It is the result of the standard deviation of a set of scores divided by the mean.

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),[1] 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,[2,3,4] and a significant percentage of these injuries have been caused by lifting activities.[5,6] 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.[4,6,7]

Test Methods

Various methods are currently used for evaluating load handling capacities; they include the psychophysical, biomechanical, physiological, and kinesiophysical approaches to strength testing.[7,12,16-18] These approaches define who is in control of the test. The psychophysical approach to testing places the patient in control of determining the maximum. Whereas 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.[1,7,8] 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;[1,7,8] however, the validity and the safety of this technique have been questioned.[5,9] Back injuries have been reported as a result of performing isometric lift evaluations,[8,10] possibly due to overexertion caused by the poor ability to judge the amount of effort being applied.[11] 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.[3,7]

Isokinetic test methods, by contrast, tend to "accommodate" the patient's effort.[3,8,11] 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.[2,3,13] No restrictions are posed on velocity or acceleration, making either method more 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 that 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 Simulator II 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.[7,8,12,18] 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.[7,8,12] 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.[18]

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.[6,7,9] 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.[2] 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.[2] 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.[3,4,14-16] Although this approach has been criticized for having a subjective end-point and questionable validity and reproducibility, studies have shown high reliability.[3,6,9,12,16] It has also been praised for being characteristic of "real world" lifting.[2] Due to complete freedom when lifting, coordination and agility variables are not compromised, leading to a higher true lifting capacity[11] and the best estimate of the maximum load a person is willing to handle.[3]

The test method described by Isernhagen[18], 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 judgement 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 Simulator II. Dynamic lifting, pushing, and pulling can be accomplished by utilizing attachments #191 or #191B. The protocol suggests that the three standard dynamic lift ranges identified by NIOSH[1] 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 773 through 789. Included in these written procedure are details on subject positioning information, verbal instructions, and important highlighted notes.

When Do I Stop the Test?

In addition to obtaining objective data from the Simulator II, 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 exceeds 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 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.[3] Noticing movements, such as jerking or ballistic movements, stalling, decreasing speed, and/or hesitancies 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 variables of a lift, force, distance and time, are recorded by the Simulator II and reported as a “power per lift” score. Watching this number will also give indication as to whether or not the subject has reached or exceeded his or her *safe* lift capacity. As one proceeds with each subsequently heavier load, you can expect the power score to increase at a fairly predictable rate. The heavier load in an increase in force. The distance is constant, as the range of the lift is the same for each repetition. The time is also relatively constant. Most people will lift an object with about the same velocity as long as they are within a comfortable weight range. If distance and time remain constant, and force increases, then power should increase. If the load should become unmanageable for the subject (too heavy), he will compensate by either slowing way down (struggling with the load) or lifting balistically (throwing the load to it’s destination. When either of these situations occur, the evaluator will see a break in the power score pattern. If the subject is struggling, power will drop. If the subject throws the load, the power score will increase at a much greater proportion than previous increases for each lift load. If either of these situations occur, the test should be discontinued, as the subject is no longer lifting safely.

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.[5] 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".[5] 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?

Assorted tools other than #191 and #191B 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 various test instruments 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 Simulator II, the evaluator must adapt the Simulator II to simulate the boxes. Comparing the results obtained using the standard handle on the Simulator II to those recorded using boxes 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 standard handle provided by the BTE rope and pulley 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. Or perhaps a person may be required to handle loads with one hand rather than two, also indicating the need to modify the handle. The following suggestions are but a few examples to help facilitate the seemingly endless options available when using the rope and pulley system on the Simulator II.

If one handed tasks are being tested using #191 or #191B, the standard handle can be removed and replaced with #601 (D-handle). Simply thread the rope through the handle and clip it back onto itself. Insert the shaft of #601 into the hole of the clip for stability (see Figures 1a - c). This may be used to simulate lifting a bucket, pulling down a garage door, or pushing a sliding door.

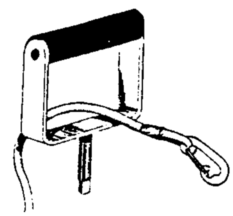

Fig. 1a

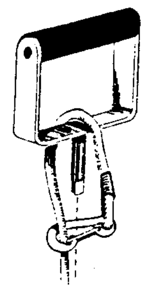

Fig. 1b

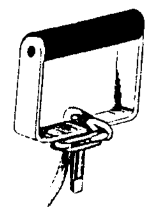

Fig. 1c

If it is necessary to simulate lifting a box or box-shaped object such as a cinderblock, 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 Simulator II, 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).

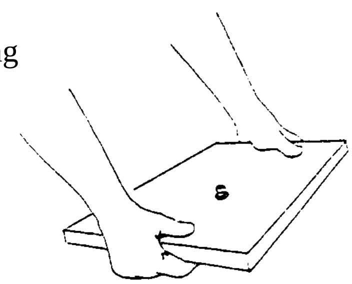

Fig. 2a

Another way to simulate the handling of boxes or crates is by attaching an actual milk crate to the rope and pulley system. This is done by removing the standard handle, threading the rope through the center of the bottom of the crate, and reattaching the handle to the rope inside the crate. The reason the handle is reattached is to distribute the pressure evenly over the bottom of the crate when force is applied. If a plastic crate is used and the rope 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 rope threaded up through the inside of the crate, and the handle re-attached across the bottom on the outside of the crate.

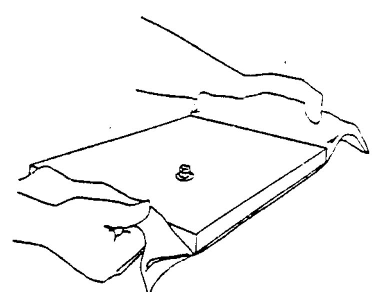

Fig. 2b

It is important when adapting any attachment on the Simulator II 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 and #191B, 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.

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[12]Mital A: The psychophysical approach in manual lifting - A verification study. Human Factors 25(5): 485-491, 1983 [13]Kroemer KHE: An isoinertial technique to assess individual lifting capability. Human Factors 25: 493-506, 1983

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[15]Foreman TK, Baxter CE, Troup JDG: Ratings of acceptable load and maximal isometric lifting strengths: The effects of repetition. Ergonomics 27: 1283-1288, 1984

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[17]Isernhagen SJ: Return to work testing. Ortho Phys Ther Clinics 1(1): 83-98, 1992

[18]Isernhagen SJ: Work Injury - Management and Prevention. Rockville, MD: Aspen Publishers, 1988

PROCEDURE/DESCRIPTION For Lifting
And Other Evaluations Using The 191 Attachment

1. Choose "Lift Maximum" at the Evaluations menu.

2. Set up #191 or #191B according to the Operator's Manual, using #191 for lifting and #191B for pushing and pulling. When using #191B, be sure to adjust the height of the exercise head and choose the appropriate eyebolt in order to achieve the desired starting height 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/pull;
   - you will be instructed in 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 lift/push/pull being tested and the proper positioning for that activity. This may be specific to a simulated job task 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 zero, 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 lift/push/pull 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 lift/push/pull being tested, enter the set-up parameters and lift range and begin the test.

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 load with the patient's approval.

NOTE: Gradually increase the load lifted/pushed/pulled by 5 to 10 pounds.

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.

e. the power score drops even though the weight lifted increased.

TASK ANALYSIS AND MEASUREMENT

As the demand for work hardening, functional and work capacity assessments, and 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 visit allows the therapist to recognize the physical demands of a job and construct a comprehensive rehabilitation program for an injured worker. Using the data obtained from the job site permits the clinician to accurately assess the current level of a worker's physical abilities to perform that job and design a treatment program that is geared toward meeting the physical demands of the job. Upon completion of the rehabilitation course, an intelligent decision can be made about the worker's return to work status. Questions such as "can he/she do the job", "is light-duty indicated", "are job modifications necessary", can be accurately answered.

We recognize that proficiency comes with experience but basic knowledge is a necessary element. It is therefore our purpose to provide information to assist you in the process of job 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 and job site visits.

Why Do A Job Site Visit?

When looking at an individual's ability to perform a particular job or job-related 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. 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.

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,[1] 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.

Benefits

Numerous benefits are obtained from a job site visit. Knowing the details of each job task allows the clinician to assess the client's performance specific to the job 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 the job.

For the therapist, the visit serves to educate him or her and allow for development of a realistic rehabilitation program that 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. Realistic work simulations allow him or her to "practice" the tasks, thereby improving his work skills and increasing his confidence level. This also allows the worker 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 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 that 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 that 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 torque 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 early in the work hardening phase of treatment. The valuable information gained allows the therapist to design more realistic work 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 job site visit. Priorities would probably be placed on those jobs involving repetitive motion tasks (ie. 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. (You may also count strides.)

CAMERA/VIDEO: Cameras and video-recorders allow you to record actual work environments, work positions, and job activities. **Make sure you obtain permission 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 even find that he has the strength to perform the job.

General Normative Date

Muscle performance Evaluation (Standard Protocol)

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.

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.

GUIDELINES FOR TESTING GRIP STRENGTH

Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #3).

2. Place the pin <u>without</u> the rubber washer in hole #1 (the hole closest to the spring and farthest from the handles) (see Fig. 1). No other changes need to be made to this tool and doing so will make normative comparisons invalid. Insert the tool into the exercise shaft and secure it tightly using the spanner wrench.

3. Insert tool #162 with the support arm placed in hole A, the top left hole on the face of the exercise head. Tighten it securely with the spanner wrench.

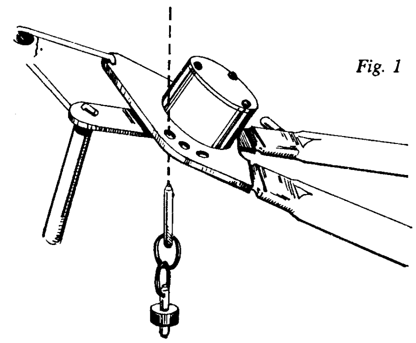


Fig. 1

4. Demonstrate to the subject the motion being tested (cylinder grip), and the proper positioning as described below.

5. Position the subject to the right side of and facing the exercise head (see fig. 3). The upper arm should be in the neutral position (not internally or externally rotated) and resting at the subject's side. The attachment should be directly in front of the arm being tested.

   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 comfortably grasp the tool while placing the thumb/index web space against the perpendicular peg on the top handle (see Fig. 2). Enter the height in the set-up parameters. The height should be the same for both static and dynamic tests.

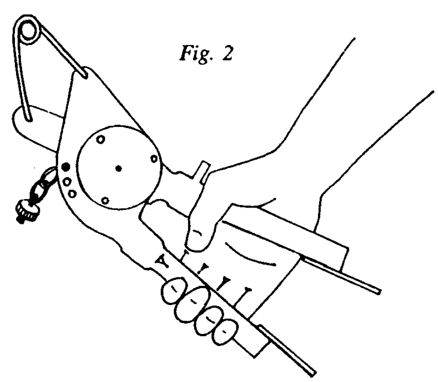


Fig. 2

   NOTE: Do NOT test with the elbow in 90 degrees of flexion as this places the wrist in a severely deviated position and compromises grip strength.

7. 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 and the wrist should be in neutral with the wrist having 0 to 15 degrees of extension and zero (0) degrees of deviation (see Fig. 3).

NOTE: Do NOT allow the subject to use substitution patterns.

8. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.

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.

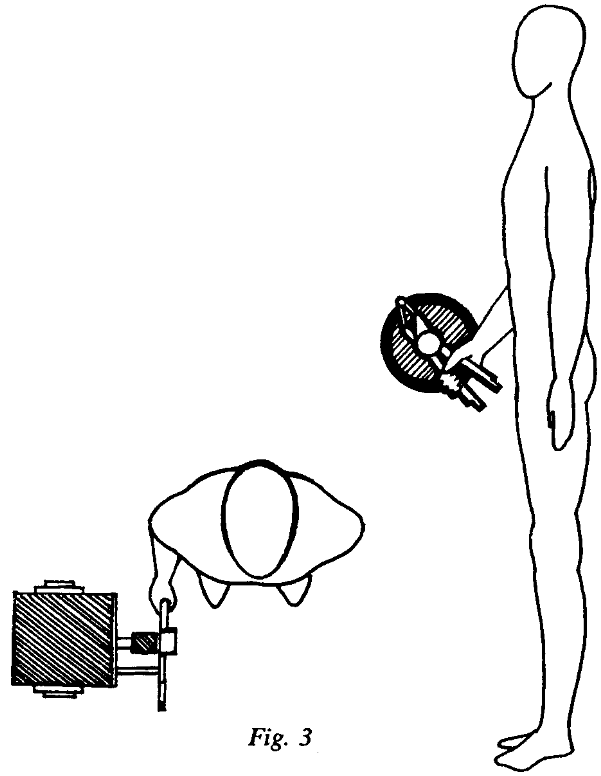


Fig. 3

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. Delete this trial before proceeding with the actual test trials.

11. Turn the computer monitor so that the subject cannot see the display.

12. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** to begin each trial

    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. The number of seconds allowed for each trial is counted in the upper part of the test box for each side. Maximum effort should be reach 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 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 grip strength testing of the nondominant or involved side (the tool should NOT be repositioned) and repeat Steps 12 and 13.

15. Write down the average torque/force for each side for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (gross grasp) and the proper positioning as described above.

   NOTE: Tool set up and subject positioning for dynamic testing should NOT change from that used during isometric testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 15 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. <u>Double check</u> the torque setting.

5. 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.

6. Reposition the subject as stated in Steps 4 through 7 under Isometric Testing procedures.

7. Before selecting START, 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.

NOTE: Do NOT allow the subject to use substitution patterns.

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side (the tool should NOT be repositioned) and repeat Steps 4 through 8.

If you wish to convert inch-pounds to pounds, measure the distance from the center of the shaft to the center of the point of pressure applied to the tool and divide that measurement (length of lever arm) into the average torque number.

$$\frac{\text{average torque (in-lbs)}}{\text{length of lever arm (inches)}} = \text{pounds of force}$$

GRIP (POSITION II)

DESCRIPTIVE STATISTICS:

MALES:

N = 31
Age – minimum = 24
maximum = 75
mean = 41.7
S. D. = 12.6
Dominance – right-handed = 29
left-handed = 2
ambidextrous = 0

TEST STATISTICS:

GRIP						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	**168.0**	**0.9**	**2523.0**	**140.0**	**0.6**	**2474.0**
Maximum	**592.0**	**10.1**	**9470.0**	**544.0**	**13.1**	**8442.0**
Mean	**408.6**	**4.6**	**6678.1**	**378.8**	**4.8**	**5877.2**
S. D.	**106.1**	**2.8**	**1631.8**	**93.0**	**3.2**	**1414.9**

FEMALES – N = 21
Age – minimum = 25
maximum = 46
mean = 35.5
S. D. = 7.3
Dominance – right-handed = 20
left-handed = 1
ambidextrous = 0

TEST STATISTICS:

	GRIP					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	**18.0**	**1.2**	**1206.0**	**115.0**	**1.3**	**1326.0**
Maximum	**400.0**	**16.9**	**5076.0**	**424.0**	**13.5**	**5636.0**
Mean	**199.9**	**6.6**	**3396.0**	**192.1**	**5.6**	**3193.3**
S. D.	**80.1**	**4.4**	**1117.0**	**70.9**	**3.5**	**1371.6**

TOTAL SAMPLE POPULATION –
N = 52
Age – minimum = 24
maximum = 75
mean = 39.2
S. D. = 11.1
Dominance – right-handed = 49
left-handed = 3
ambidextrous = 0

TEST STATISTICS:

	GRIP					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	**18.0**	**0.9**	**1206.0**	**115.0**	**0.6**	**1326.0**
Maximum	**592.0**	**16.9**	**9470.0**	**544.0**	**13.5**	**8442.0**
Mean	**322.4**	**5.5**	**5292.3**	**306.7**	**5.1**	**5229.4**

S. D.	140.9	3.6	2170.5	124.7	3.3	1808.5

RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients –

GRIP			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.962	**0.901**	**0.958**	**0.894**

PERCENTILE CHARTS:

	ALL MALES (24 – 75)				N = 31		
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
GRIP - # 162							
	Static/Isometric Torque (in-lbs.)						
Dominant	161	272	337	409	480	545	656
Nondominant	162	259	316	379	442	498	595
	Dynamic Power (engals)						
Dominant	2876	4581	5577	6678	7780	8775	10480
Nondominant	2580	4059	4922	5877	6832	7695	9174

	ALL FEMALES (25 – 46)				N = 21		
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
GRIP - # 162							
	Static/Isometric Torque (in-lbs.)						
Dominant	13	97	146	200	254	303	387
Nondominant	27	101	144	192	240	283	357
	Dynamic Power (engals)						
Dominant	793	1961	2642	3396	4150	4831	5999
Nondominant	NA	1377	2213	3139	4065	4902	6335

GUIDELINES FOR TESTING 3-JAW CHUCK

Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #3).

2. Place the pin <u>with</u> the rubber washer in position #1 (the hole closest to the spring and farthest from the handles) (see Fig. 1). No other changes need to be made to this tool and doing so will make normative comparisons invalid.

3. Insert tool #162 with the support arm placed in hole D, the bottom right hole on the face of the exercise head. Tighten it securely with the spanner wrench.

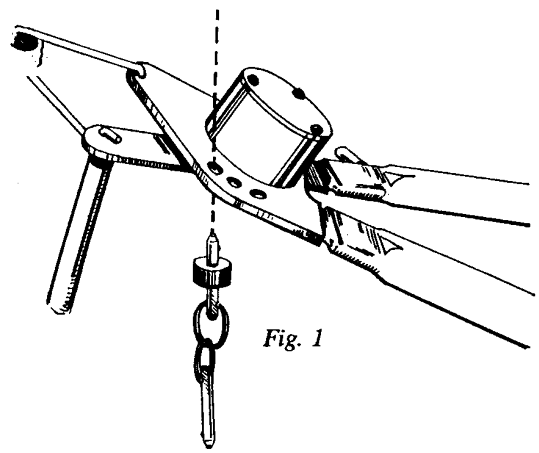


Fig. 1

4. Demonstrate to the subject the motion 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. (see fig. 2) **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.

   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 Fig. 2).

NOTE: Do NOT allow the subject to use substitution patterns.

9. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.

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.

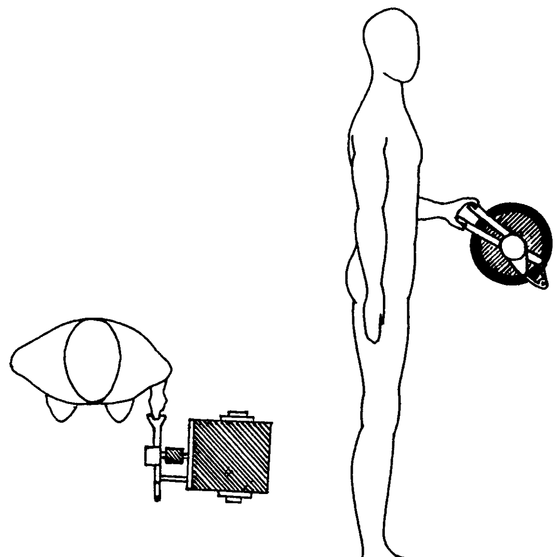


Fig. 2

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. Delete this trial before proceeding with the actual test trials.

12. Turn the computer monitor so that the subject cannot see the display.

13. Making sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** 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. The number of seconds allowed for each trial is counted in the upper portion of the screen. Maximum effort should be reach 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 nondominant or involved side (the tool should NOT be repositioned) and repeat Steps 13 and 14.

16. Write down the average torque/force for each side for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (3-jaw chuck), and the proper positioning as described above.

   NOTE: Tool set up and subject positioning for dynamic testing should NOT change from that used during isometric testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 16 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. Double check the torque setting.

5. 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.

6. Reposition the subject as stated in Steps 5 through 8 under Isometric Testing procedures.

7. Before selecting START, 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.

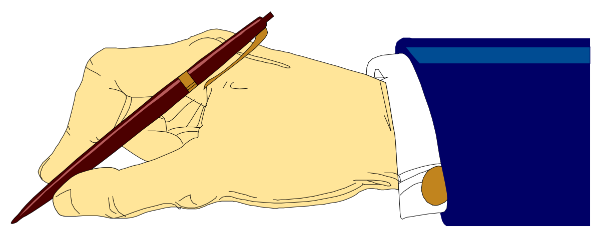
   NOTE: Do NOT allow the subject to use substitution patterns.

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side (the tool should NOT be repositioned) and repeat Steps 4 through 8.

If you wish to convert inch-pounds to pounds, measure the distance from the center of the shaft to the center of the point of pressure applied to the tool and divide that measurement (length of lever arm) into the average torque number.

$$\frac{\text{average torque (in-lbs)}}{\text{length of lever arm (inches)}} = \text{pounds of force}$$



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
ambidextrous = 0

TEST STATISTICS:

3 – Jaw Chuck	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	**89.0**	**0.6**	**885.0**	**109.0**	**0.5**	**909.0**
Maximum	**292.0**	**10.4**	**3108.0**	**284.0**	**12.7**	**3630.0**
Mean	**181.1**	**4.4**	**2023.1**	**181.1**	**5.1**	**1907.3**
S. D.	**46.2**	**2.8**	**555.3**	**45.1**	**3.0**	**567.1**

FEMALES – N = 21

Age – minimum = 25

maximum = 46

mean = 35.5

S. D. = 7.3

Dominance – right-handed = 20

left-handed = 1

ambidextrous = 0

3 – Jaw Chuck						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	60.0	0.9	657.0	68.0	1.6	780.0
Maximum	160.0	11.7	1975.0	154.0	14.8	1559.0
Mean	116.5	4.1	1191.8	111.4	5.9	1056.3
S. D.	28.0	2.6	339.9	24.4	3.4	228.6

TOTAL SAMPLE POPULATION –

N = 52

Age – minimum = 24

maximum = 75

mean = 39.2

S. D. = 11.1

Dominance – right-handed = 49

left-handed = 3

ambidextrous = 0

3 – Jaw Chuck						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	60.0	0.6	657.0	68.0	0.5	780.0

Maximum	**292.0**	**11.7**	**3108.0**	**284.0**	**14.8**	**3630.0**
Mean	**155.5**	**4.3**	**1700.8**	**155.0**	**5.4**	**1599.5**
S. D.	**50.9**	**2.7**	**630.2**	**51.3**	**3.2**	**625.9**

RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients –

3 – Jaw Chuck			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.681	**0.774**	**0.966**	**0.855**

PERCENTILE CHARTS:

ALL MALES (24 – 75) N = 31 3 – Jaw Chuck - # 162							
Percentiles	***1***	***10***	***25***	***50***	***75***	***90***	***99***
	Static/Isometric Torque (in-lbs.)						
Dominant	73	122	150	181	212	240	289
Nondominant	76	123	151	181	212	239	286
	Dynamic Power (engals)						
Dominant	729	1310	1648	2023	2398	2737	3317
Nondominant	586	1179	1525	1907	2290	2636	3229

ALL FEMALES (25 – 46) N = 21 3 – Jaw Chuck - # 162							
Percentiles	***1***	***10***	***25***	***50***	***75***	***90***	***99***
	Static/Isometric Torque (in-lbs.)						
Dominant	51	81	98	117	135	152	182
Nondominant	55	80	95	111	128	143	168
	Dynamic Power (engals)						
Dominant	400	755	962	1192	1421	1629	1984

Nondominant	524	763	902	1056	1211	1350	1589

Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #3).

2. Place the pin with the rubber washer in position #1 (the hole closest to the spring and farthest from the handles, as in Fig. 1). No other changes need to be made to this tool and doing so will make test results invalid.

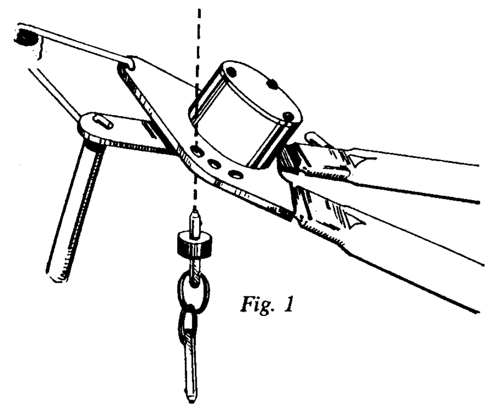


Fig. 1

3. Insert tool #162 with the support arm placed in hole B, the top right hole on the face of the exercise head. Tighten it securely with the spanner wrench.

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 (see fig. 2). **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.

   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 Fig. 2).

NOTE: Do NOT allow the subject to use substitution patterns.

9. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.

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.

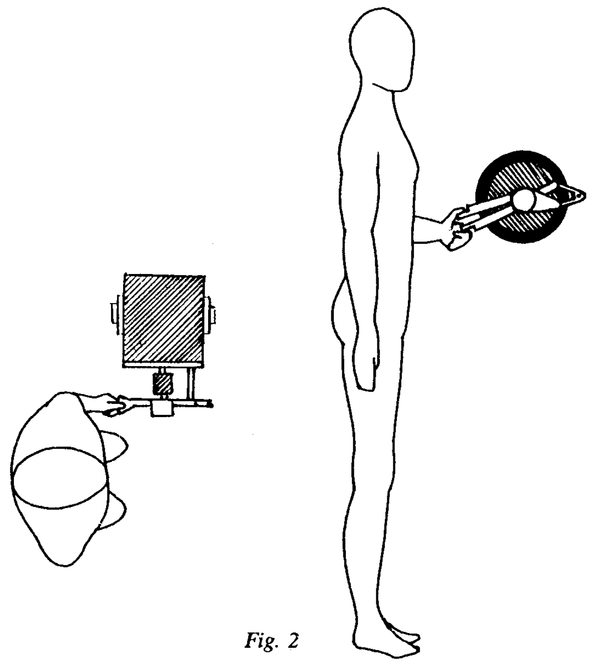


Fig. 2

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. Delete this trial before proceeding with the actual test trials.

12. Turn the computer monitor so that the subject cannot see the display.

13. Making sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** 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. The number of seconds allowed for each trial is counted in the upper portion of the screen. Maximum effort should be reach 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 nondominant or involved side (the tool should NOT be repositioned) and repeat Steps 13 and 14.

16. Write down the average torque/force for each side for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (lateral pinch), and the proper positioning as described below.

   NOTE: Tool set up and subject positioning for dynamic testing should NOT change from that used during isometric testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 16 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. <u>Double check</u> the torque setting.

5. 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.

6. Reposition the subject as stated in Steps 5 through 8 under Isometric Testing procedures.

7. Before selecting START, 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.

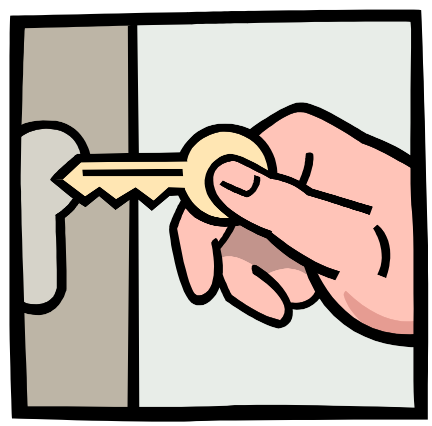
NOTE: Do NOT allow the subject to use substitution patterns.

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side (the tool should NOT be repositioned) and repeat Steps 4 through 8.

If you wish to convert inch-pounds to pounds, measure the distance from the center of the shaft to the center of the point of pressure applied to the tool and divide that measurement (length of lever arm) into the average torque number.

$$\frac{\text{average torque (in-lbs)}}{\text{length of lever arm (inches)}} = \text{pounds of force}$$



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
ambidextrous = 0

TEST STATISTICS:

LATERAL/KEY PINCH						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	**11.0**	**0.2**	**557.0**	**108.0**	**1.3**	**567.0**

Maximum	**199.0**	**7.6**	**1711.0**	**202.0**	**11.2**	**1705.0**
Mean	**152.5**	**3.1**	**1091.6**	**152.5**	**4.3**	**1054.3**
S. D.	**34.6**	**5.7**	**310.7**	**34.6**	**2.2**	**300.8**

FEMALES – N = 21

Age – minimum = 25
maximum = 46
mean = 35.5
S. D. = 7.3

Dominance – right-handed = 20
left-handed = 1
ambidextrous = 0

TEST STATISTICS:

LATERAL/KEY PINCH						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	**77.0**	**0.0**	**309.0**	**73.0**	**1.3**	**363.0**
Maximum	**147.0**	**10.5**	**1046.0**	**143.0**	**8.6**	**992.0**
Mean	**102.9**	**3.3**	**703.5**	**100.5**	**4.2**	**662.7**
S. D.	**18.5**	**2.7**	**196.6**	**19.8**	**2.1**	**195.1**

TOTAL SAMPLE POPULATION –

N = 53

Age – minimum = 24
maximum = 75
mean = 39.2
S. D. = 10.9

Dominance – right-handed = 49
left-handed = 4
ambidextrous = 0

TEST STATISTICS:

LATERAL/KEY PINCH						
	DOMINANT			NONDOMINANT		

	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
Minimum	**11.0**	**0.0**	**309.0**	**73.0**	**1.3**	**309.0**
Maximum	**199.0**	**10.5**	**1711.0**	**202.0**	**11.2**	**1705.0**
Mean	**132.4**	**3.2**	**934.7**	**133.1**	**4.3**	**894.1**
S. D.	**37.9**	**2.2**	**329.9**	**35.7**	**2.1**	**324.9**

RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients –

LATERAL/KEY PINCH			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.829	**0.950**	**0.974**	**0.965**

PERCENTILE CHARTS:

ALL MALES (24 – 75) N = 32 LATERAL PINCH - #162							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
Dominant	73	122	150	181	212	240	289
Nondominant	108	122	135	153	175	188	202
	Dynamic Power (engals)						
Dominant	368	692	882	1092	1301	1491	1816
Nondominant	353	668	851	1054	1257	1441	1755

ALL FEMALES (25 – 46) N = 21 LATERAL PINCH - #162							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
Dominant	60	79	90	103	115	127	146
Nondominant	54	75	87	101	114	126	147

	Dynamic Power (engals)						
Dominant	245	451	571	704	836	956	1162
Nondominant	208	412	531	663	794	913	1117

GUIDELINES FOR TESTING WRIST FLEXION AND EXTENSION

Isometric Testing

1. Place the exercise head in the horizontal position with the shaft facing forward (position #3).

2. Insert the tool, using the shaft closest to the handle, and secure it tightly using the spanner wrench.

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.

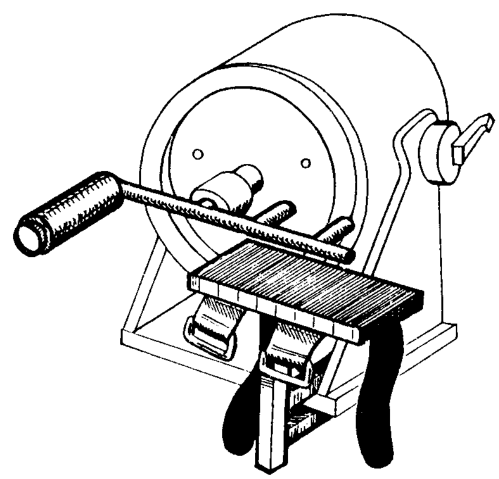


Fig. 1

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).

NOTE: Do NOT allow the subject to use substitution patterns.

10. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.

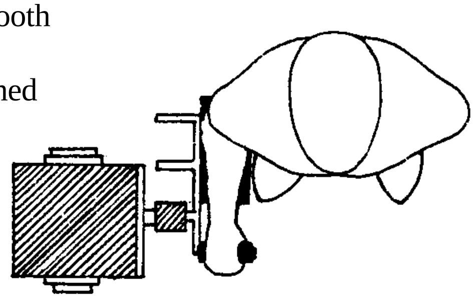
10. Verbally describe the procedure:
- exert maximum effort during the test,
- the tool will not move, we are only measuring effort applied,
- do not jerk the tool,
- effort should be applied in a smooth but rapid manner, and
- maximum effort should be reached in 2 to 3 seconds.

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. Delete this trial before proceeding with the actual test trials.

12. Turn the computer monitor so that the subject cannot see the display.

13. Making sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** to begin trial 1.



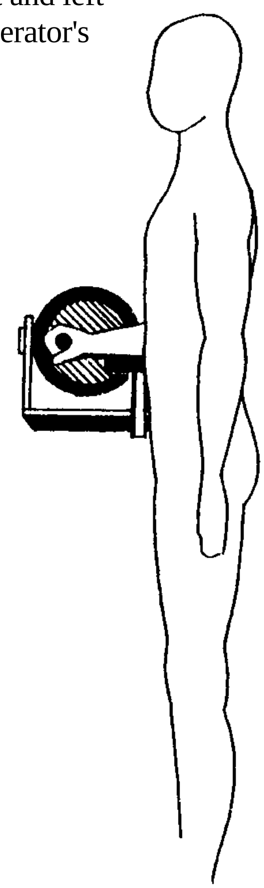


Fig. 2

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. The number of seconds allowed for each trial is counted in the upper portion of the screen. Maximum effort should be reach 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 13 and 14.

16. Write down the average torque/force for each side for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (either wrist flexion or extension), and the proper positioning as described below.

   NOTE: Except for the starting position of the wrist being tested, tool set up and subject positioning should NOT change for dynamic testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 16 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. Make sure the correct direction of resistance is selected. Double check the torque setting.

5. 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.

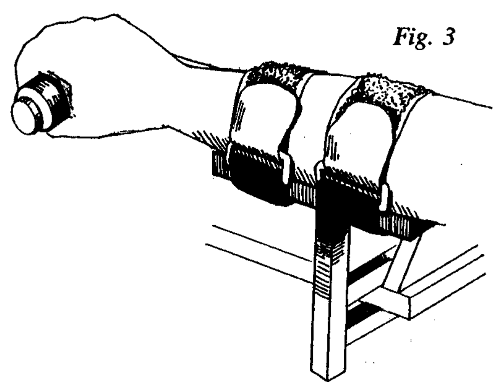


Fig. 3

6. 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 wrist flexion,** the wrist should be positioned in extension. **When testing wrist extension,** the wrist 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: Secure the forearm of the side being tested to the black platform of the armrest using the black straps as illustrated (see Fig. 3).

7. Before selecting START, 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.
NOTE: Do NOT allow the subject to use substitution patterns.

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side and repeat Steps 3 through 8.

If you wish to convert inch-pounds to pounds, measure the distance from the center of the shaft to the center of the point of pressure applied to the tool and divide that measurement (length of lever arm) into the average torque number.

$$\frac{\text{average torque (in-lbs)}}{\text{length of lever arm (inches)}} = \text{pounds of force}$$

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
ambidextrous = 0

TEST STATISTICS:

	WRIST FLEXION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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**
	WRIST EXTENSION					
	DOMINANT			**NONDOMINANT**		
	Isometric	**(C. V.)**	**Dynamic**	**Isometric**	**(C. V.)**	**Dynamic**
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
ambidextrous = 0

TEST STATISTICS:

	WRIST FLEXION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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**		

	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
ambidextrous = 0

TEST STATISTICS:

	WRIST FLEXION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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**
	WRIST EXTENSION					
	DOMINANT			**NONDOMINANT**		
	Isometric	**(C. V.)**	**Dynamic**	**Isometric**	**(C. V.)**	**Dynamic**
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 –

WRIST FLEXION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.930	**0.984**	**0.938**	**0.974**
WRIST EXTENSION			
DOMINANT		**NONDOMINANT**	

Isometric	Dynamic	Isometric	Dynamic
0.811	**0.646**	**0.966**	**0.650**

PERCENTILE CHARTS:

ALL MALES (24 – 75) N = 31 WRIST FLEXION - #701							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
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**
WRIST EXTENSION - #701							
	Static/Isometric Torque (in-lbs.)						
Dominant	**48**	**75**	**90**	**108**	**125**	**140**	**167**
Nondominant	**37**	**67**	**84**	**103**	**123**	**140**	**170**
	Dynamic Power (engals)						
Dominant	**2416**	**3412**	**3993**	**4637**	**5280**	**5861**	**6857**
Nondominant	**1874**	**2843**	**3409**	**4035**	**4661**	**5226**	**6195**

ALL FEMALES (25 – 46) N = 21 WRIST FLEXION - #701							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
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**	**5700**	**6673**	**7553**	**9059**
WRIST EXTENSION - #701							
	Static/Isometric Torque (in-lbs.)						
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**	**2647**	**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 #3).

2. Insert the tool and secure it tightly using the spanner wrench.

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 Fig. 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 in the set-up parameters. The height should be the same for both the supination and pronation tests.

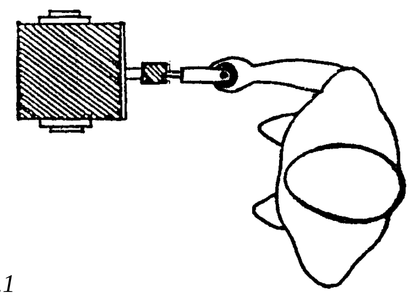


Fig.1

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.

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.

9. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.

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. Delete this trial before proceeding with the actual test trials.

12. Turn the computer monitor so that the subject cannot see the display.

13. Making sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** 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. Maximum effort should be reach 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 13 and 14.

16. Record the average torque/force for each side for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (either supination or pronation), and the proper positioning as described below.

    NOTE: Except for the starting position of the extremity being tested, tool set up and subject positioning should NOT change for dynamic testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 16 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. <u>Double check</u> the torque setting.

5. 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 if he experiences any unusual pain or discomfort.

6. 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 supination,** the forearm should be positioned in pronation. **When testing pronation,** the forearm should be positioned in supination.

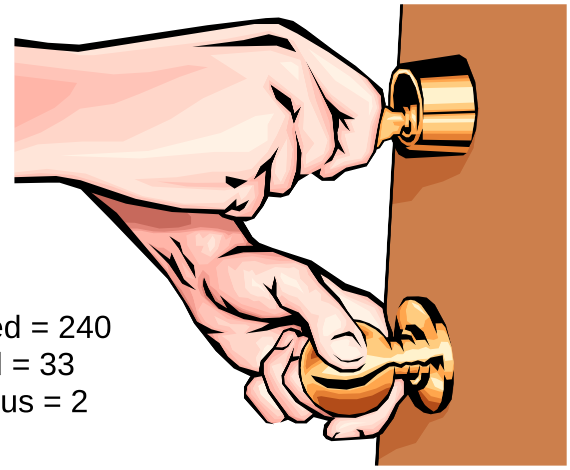
   NOTE: Starting positions should be at the maximum range of motion possible from which the subject is able to initiate movement of the tool without the use of substitution patterns.

7. Before selecting START, 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. **Do NOT allow the subject to use substitution patterns.**

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side and repeat Steps 3 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:

SUPINATION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
PRONATION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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:

SUPINATION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
PRONATION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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 –

SUPINATION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.916	0.883	0.909	0.816
PRONATION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.897	0.829	0.891	0.794

PERCENTILE CHARTS:

ALL MALES (17-78) N = 275							
SUPINATION - #601							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
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 - #601							
	Static/Isometric Torque (in-lbs.)						
Dominant	**35**	**62**	**79**	**104**	**129**	**150**	**224**
Nondominant	**34**	**62**	**80**	**100**	**122**	**147**	**225**
	Dynamic Power (engals)						
Dominant	**2100**	**4360**	**6415**	**8640**	**10695**	**12540**	**18640**
Nondominant	**2840**	**4220**	**6178**	**7950**	**9915**	**12510**	**17010**
ALL FEMALES (17-64) N = 325							
SUPINATION - #601							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
Dominant	**24**	**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 - #601							
	Static/Isometric Torque (in-lbs.)						
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**

SUPINATION AND PRONATION – ATTACHMENT 601
MALES (by age)

PERCENTILE CHARTS

MALES 17 – 29 SUPINATION – 601											N = 101
Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
Dominant	52	67	80	91	96	100	104	110	114	127	146
Nondominant	36	620	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	6280	6650	7380	8280	9170	9580	10870	12800	16880
PRONATION – 601											
	Static/Isometric Force (in-lbs.)										
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	17130

MALES 30-39 SUPINATION – 601											N = 106
Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
Dominant	32	66	75	82	87	94	100	107	115	129	150
Nondominant	31	64	72	78	87	92	98	104	114	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 – 601											
	Static/Isometric Force (in-lbs.)										
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	7750	6840	7530	8620	9210	10080	11540	12900
17190	2830	4710	5970	6520	7090	8000	9010	9950	10550	12540	15690

MALES 40-49 N = 44

SUPINATION – 601

Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
Dominant	51	60	72	80	84	89	104	107	113	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 – 601

Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
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	9840	12440	16750

MALES 50-59 N = 17

SUPINATION – 601

Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
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		2790	4730	5590	6570	6840	7590	8030	8890	12320	15160
Nondominant		4290	4750	5250	6540	7000	7820	8710	10440	11550	12230

PRONATION – 601

Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
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		3720	4250	4980	6030	7170	9040	9730	10130	11470	12040
Nondominant		3550	4390	6060	7510	8510	8650	9210	9320	9760	11850

MALES 60-78 SUPINATION – 601											N = 7
Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
Dominant		51	54	56	59	64	67	71	81	96	109
Nondominant		45	49	55	56	57	66	75	78	84	87
	Dynamic Power (engals)										
Dominant		1020	1170	2470	2980	3790	4230	4550	4830	5490	6800
Nondominant		1080	1460	2380	3300	3330	3360	4050	4750	6180	7230
PRONATION – 601											
	Static/Isometric Force (in-lbs.)										
Dominant		81	84	87	91	96	99	102	109	124	131
Nondominant		64	68	70	72	81	85	90	97	105	111
	Dynamic Power (engals)										
Dominant		3660	3970	4080	4360	4710	4830	4860	5070	7790	8700
Nondominant		3550	3730	3820	3890	3960	4070	4220	6950	7430	7610

SUPINATION AND PRONATION – ATTACHMENT 601
FEMALES (by age)

PERCENTILE CHARTS

FEMALES 17 - 29 SUPINATION – 601											N = 163
Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
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	4270	4900	5410	6090	9680
Nondominant	1060	2130	2680	3150	3490	3870	4280	4560	5140	5880	9800
PRONATION – 601											
	Static/Isometric Force (in-lbs.)										
Dominant	18	33	37	43	47	50	57	63	72	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 30-39 SUPINATION – 601											N = 113
Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
Dominant	23	32	27	42	47	50	53	55	58	63	81
Nondominant	20	30	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	2760	3210	3470	3990	4310	4760	5680	8450
PRONATION – 601											
	Static/Isometric Force (in-lbs.)										
Dominant	18	33	36	41	46	50	55	58	69	80	104
Nondominant	18	30	34	37	41	46	50	56	64	74	103
	Dynamic Power (engals)										
Dominant	680	1820	2470	2680	3170	3490	3750	4410	5170	5770	8600
Nondominant	620	1640	2090	2630	2970	3290	3860	4290	4870	5530	9120

FEMALES 40-49 SUPINATION – 601							N = 34				
Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
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 – 601											
	Static/Isometric Force (in-lbs.)										
Dominant	19	35	39	41	47	52	55	58	63	76	96
Nondominant	18	29	34	41	49	51	53	56	59	68	76
	Dynamic Power (engals)										
Dominant	1210	1700	2250	2490	2730	3320	3840	4010	4750	5340	6820
Nondominant	1160	1470	1580	2290	2610	3140	3490	4230	4620	4750	4950

FEMALES 50-64 SUPINATION – 601											**N = 15**
Percentiles	1	10	20	30	40	50	60	70	80	90	99
	Static/Isometric Force (in-lbs.)										
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 – 601											
	Static/Isometric Force (in-lbs.)										
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	4370
Nondominant		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 #3).

2. Attach the cylindrical attachment to the perpendicular handle of tool #802. Insert the tool into the exercise shaft and secure it tightly using the spanner wrench.

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 the set-up parameters. 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 proper length has been set, securely tighten the star-shaped adjustment knob and **record** the length of the tool on the data collection sheet for consistency in future set-ups. The length will remain the same for both isometric and dynamic elbow flexion and extension tests.

7. Position the #802 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 Fig. 1, next page).

   NOTE: Do NOT allow the subject to use substitution patterns.

9. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.

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.

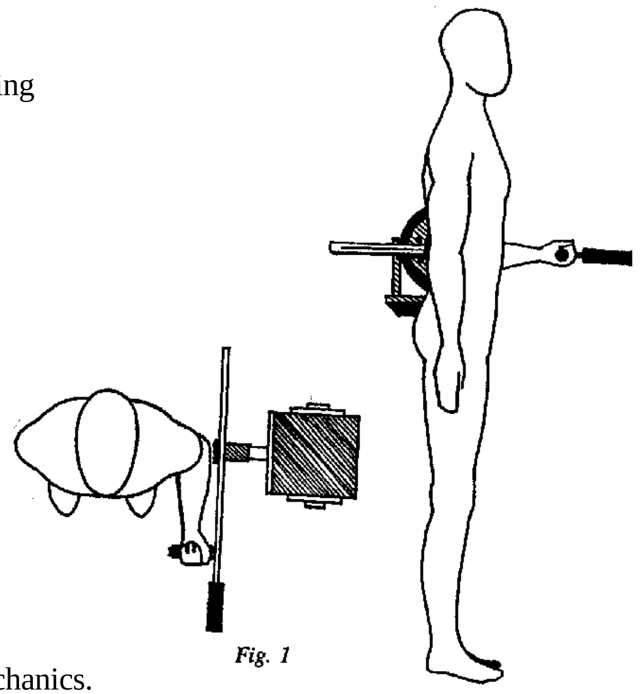


Fig. 1

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. Delete this trial before proceeding with the actual test trials.

12. Turn the computer monitor so that the subject cannot see the display.

13. Making sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** 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. The number of seconds allowed for each trial is counted in the highlighted box at the upper center portion of the screen. Maximum effort should be reach 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. In order to test the nondominant or injured extremity, the tool must be rotated 180 degrees. Then reposition the subject for the same test, repeating Steps 13 and 14.

16. Record the average torque/force for each side for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (either elbow flexion or extension), and the proper positioning as described below.

   NOTE: Except for the starting position of the elbow being tested, tool set up and subject positioning should NOT change for dynamic testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 16 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. <u>Double check</u> the torque setting.

5. 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.

6. 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.

7. Before selecting START, 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.

   NOTE: Do NOT allow the subject to use substitution patterns.

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side and repeat Steps 3 through 8.

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
ambidextrous = 0

TEST STATISTICS:

ELBOW FLEXION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
ambidextrous = 0

TEST STATISTICS:

ELBOW FLEXION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
ambidextrous = 0

TEST STATISTICS:

ELBOW FLEXION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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

Pearson Product-Moment Correlation Coefficients –

ELBOW FLEXION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.958	0.883	0.978	0.942
ELBOW EXTENSION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.725	0.876	0.869	0.929

PERCENTILE CHARTS:

				ALL MALES (24 – 75)			N = 31
			ELBOW FLEXION - #802				
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
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**
			ELBOW EXTENSION - #802				
	Static/Isometric Torque (in-lbs.)						
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**	**16512**	**21075**	**26524**	**31972**	**36896**	**45331**

				ALL FEMALES (25 – 46)			N = 21
			ELBOW FLEXION - #802				
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
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**
			ELBOW EXTENSION - #802				
	Static/Isometric Torque (in-lbs.)						
Dominant	**67**	**134**	**173**	**216**	**259**	**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 #3).

2. Attach the square block attachment and the black strap from the arm rest to the perpendicular handle of tool #802 as illustrated (see Fig. 1).
   Insert the tool into the exercise shaft and secure it tightly using the spanner wrench.

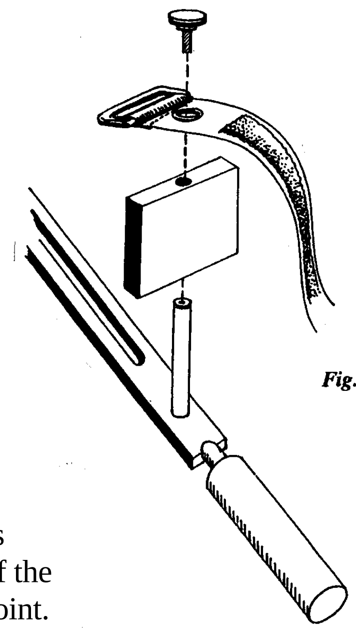


Fig. 1

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 set-up parameters. The height should be the same for both shoulder flexion and extension tests.

6. Adjust the length of the tool. Loosen the black, star-shaped adjustment knob and slide the tool so that the perpendicular handle, on which the block is attached, is resting on the dorsum of the forearm at mid-forearm level (see Fig. 2). When proper length has been set, securely tighten the star-shaped adjustment knob.

   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 (see Fig. 2).

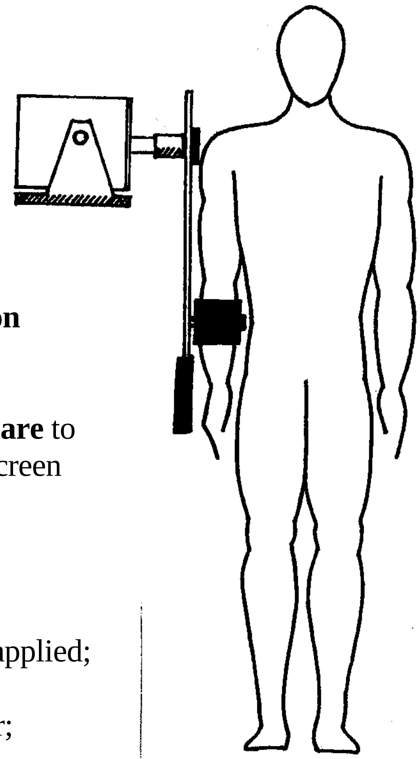


Fig. 2

NOTE: Do NOT allow the subject to use substitution patterns.

8. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.

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;
- 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. Delete this trial before proceeding with the actual test trials.

12. Turn the computer monitor so that the subject cannot see the display.

13. Making sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** 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. Maximum effort should be reach 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. In order to test the nondominant or injured extremity, the tool must be rotated 180 degrees. Then reposition the subject for the same test, repeating Steps 13 and 14.

16. Record the average torque for each side for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (either shoulder flexion or extension), and the proper positioning as described above.

   NOTE: Except for the starting position of the shoulder being tested, tool set up and subject positioning should NOT change for dynamic testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 16 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. <u>Double check</u> the torque setting.

5. 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.

6. 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 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: Secure the forearm of the side being tested to the block attachment using the black strap as illustrated (see Fig. 3).

7. Before selecting START, 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.

   NOTE: Do NOT allow the subject to use substitution patterns.

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side and repeat Steps 3 through 8.

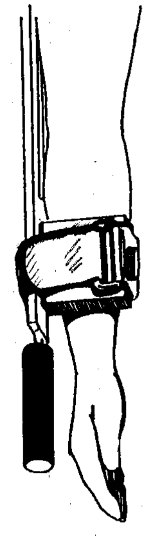


Fig. 3

If you wish to convert inch-pounds to pounds, measure the distance from the center of the shaft to the center of the point of pressure applied to the tool and divide that measurement (length of lever arm) into the average torque number.

$$\frac{\text{average torque (in-lbs)}}{\text{length of lever arm (inches)}} = \text{pounds of force}$$

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
ambidextrous = 0

TEST STATISTICS:

SHOULDER FLEXION	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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

SHOULDER EXTENSION	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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

FEMALES – N = 21

Age – minimum = 25
maximum = 46
mean = 35.5
S. D. = 7.3

Dominance – right-handed = 20
left-handed = 1
ambidextrous = 0

TEST STATISTICS:

SHOULDER FLEXION	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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

SHOULDER EXTENSION	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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

TOTAL SAMPLE POPULATION –

N = 52
Age – minimum = 24
maximum = 75
mean = 39.2
S. D. = 11.1
Dominance – right-handed = 49
left-handed = 3
ambidextrous = 0

TEST STATISTICS:

SHOULDER FLEXION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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**

SHOULDER EXTENSION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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 –

SHOULDER FLEXION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.963	**0.925**	**0.965**	**0.939**

SHOULDER EXTENSION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.952	**0.960**	**0.933**	**0.919**

PERCENTILE CHARTS:

Percentiles	1	10	25	50	75	90	99
ALL MALES (24 – 75) N = 31							
SHOULDER FLEXION - #802							
Static/Isometric Torque (in-lbs.)							
Dominant	**269**	**387**	**456**	**532**	**609**	**677**	**795**
Nondominant	**249**	**375**	**449**	**530**	**612**	**686**	**812**
Dynamic Power (engals)							
Dominant	**17917**	**18062**	**23984**	**30537**	**37090**	**43012**	**53157**
Nondominant	**16833**	**17032**	**22986**	**29574**	**36162**	**42116**	**52315**
SHOULDER EXTENSION - #802							
Static/Isometric Torque (in-lbs.)							
Dominant	**347**	**469**	**539**	**618**	**696**	**766**	**888**
Nondominant	**415**	**512**	**569**	**631**	**694**	**750**	**847**
Dynamic Power (engals)							
Dominant	**8184**	**8564**	**11817**	**13529**	**16051**	**21061**	**25902**
Nondominant	**8356**	**84144**	**10482**	**13112**	**15617**	**19907**	**25041**

Percentiles	1	10	25	50	75	90	99
ALL FEMALES (25 – 46) N = 21							
SHOULDER FLEXION - #802							
Static/Isometric Torque (in-lbs.)							
Dominant	**107**	**169**	**205**	**245**	**285**	**321**	**382**
Nondominant	**68**	**145**	**190**	**240**	**289**	**334**	**412**
Dynamic Power (engals)							
Dominant	**2506**	**7369**	**10207**	**13349**	**16490**	**19329**	**24192**
Nondominant	**1837**	**6558**	**9314**	**12364**	**15413**	**18169**	**22890**
SHOULDER EXTENSION - #802							
Static/Isometric Torque (in-lbs.)							
Dominant	**117**	**238**	**308**	**386**	**464**	**535**	**656**
Nondominant	**118**	**230**	**296**	**368**	**440**	**506**	**618**
Dynamic Power (engals)							
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 #3).

2. Attach the square block attachment and the black strap from the arm rest to the perpendicular handle of tool #802 as illustrated (see Fig. 1).
   Insert the tool into the exercise shaft and secure it tightly using the spanner wrench.

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.

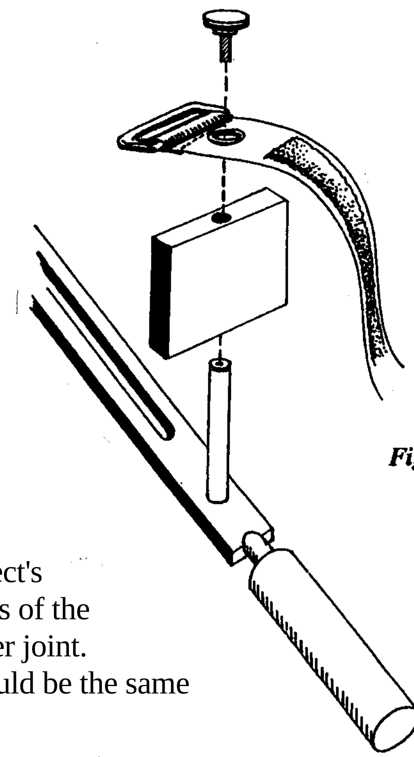


Fig. 1

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 set-up parameters. The height should be the same for both shoulder abduction and adduction tests.

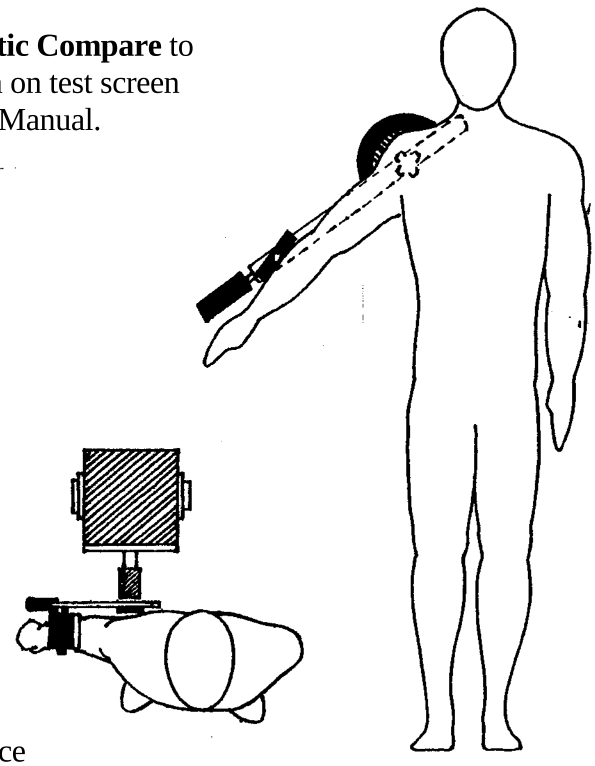
6. Adjust the length of the tool. Loosen the black, star-shaped adjustment knob and slide the tool so that the perpendicular handle, on which the block is attached, is resting on the dorsum of the forearm at mid-forearm level. When proper length has been set, securely tighten the star-shaped adjustment. 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 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.

7. Position the #802 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 (see Fig. 2).

NOTE: Do NOT allow the subject to use substitution patterns.

Fig. 2



9. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.

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. Delete this trial before proceeding with the actual test trials.

12. Turn the computer monitor so that the subject cannot see the display.

13. Making sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** 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 using the instructional prompts provided by **Quest**. The number of seconds allowed for each trial is counted in the highlighted box at the upper center portion of the screen. Maximum effort should be reach 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. In order to test the nondominant or injured extremity, the tool must be rotated 180 degrees. Then reposition the subject for the same test, repeating Steps 13 and 14.

16. Record the average torque for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (either shoulder abduction or adduction), and the proper positioning as described above.

   NOTE: Except for the starting position of the shoulder being tested, tool set up and subject positioning should NOT change for dynamic testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 16 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. <u>Double check</u> the torque setting.

5. 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.

6. 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 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: Secure the forearm of the side being tested to the block attachment using the black strap as illustrated (see Fig. 3).

7. Before selecting START, 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.

   NOTE: Do NOT allow the subject to use substitution patterns.

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side and repeat Steps 3 through 8.

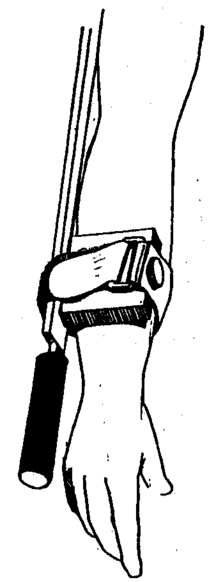


Fig. 3

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
ambidextrous = 0

TEST STATISTICS:

	SHOULDER ABDUCTION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
ambidextrous = 0

TEST STATISTICS:

	SHOULDER ABDUCTION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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	375.5	4.6	18722.5	370.4	5.1	17879.8
S. D.	165.7	2.6	10596.0	166.8	3.6	9836.5
	SHOULDER ADDUCTION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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

TOTAL SAMPLE POPULATION –

N = 52
Age – minimum = 24
maximum = 75
mean = 39.2
S. D. = 11.1
Dominance – right-handed = 49
left-handed = 3
ambidextrous = 0

TEST STATISTICS:

	SHOULDER ABDUCTION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
	SHOULDER ADDUCTION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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 –

SHOULDER ABDUCTION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.983	0.788	0.984	0.973
SHOULDER ADDUCTION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.981	0.965	0.919	0.859

PERCENTILE CHARTS:

				ALL MALES (24 – 75)		N = 31
			SHOULDER ABDUCTION - #802				
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
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**
			SHOULDER ADDUCTION - #802				
	Static/Isometric Torque (in-lbs.)						
Dominant	**400**	**498**	**555**	**618**	**681**	**738**	**836**
Nondominant	**362**	**473**	**539**	**611**	**683**	**748**	**860**
	Dynamic Power (engals)						
Dominant	**15222**	**22716**	**27091**	**31932**	**36772**	**41147**	**48641**
Nondominant	**16633**	**23472**	**27464**	**31881**	**36298**	**40290**	**47129**

				ALL FEMALES (25 – 46)		N = 21
			SHOULDER ABDUCTION - #802				
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
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**
			SHOULDER ADDUCTION - #802				
	Static/Isometric Torque (in-lbs.)						
Dominant	**139**	**214**	**301**	**367**	**433**	**492**	**595**
Nondominant	**144**	**250**	**312**	**380**	**448**	**510**	**616**
	Dynamic Power (engals)						
Dominant	**2988**	**9432**	**13194**	**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 #5).

2. Attach the cylindrical attachment to the perpendicular handle of tool #802. Remove the star-shaped knob and attach the black strap from the armrest as illustrated (see Fig. 1). Insert the tool into the exercise shaft and secure it tightly using the spanner wrench.

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.

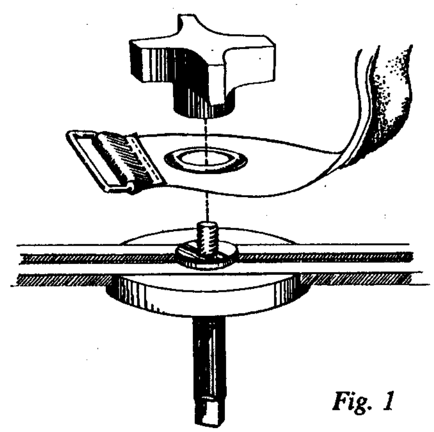


Fig. 1

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. Enter the height in the set-up parameters. The height should be the same for both shoulder internal and external rotation tests.

6. Adjust the length of the tool. Loosen the black, star-shaped adjustment 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.

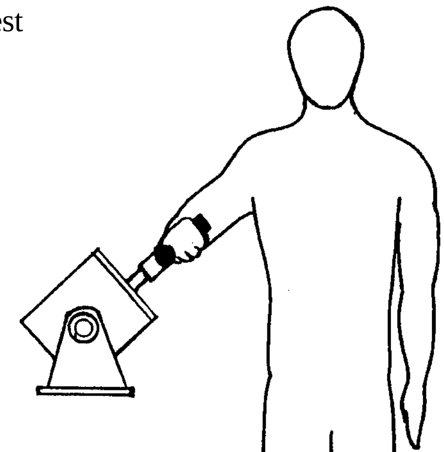
   The length will remain the same for both isometric and dynamic shoulder internal and external rotation tests.

7. Position the #802 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 (see Fig. 2).

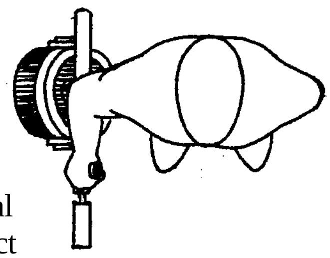
   NOTE: Do NOT allow the subject to use substitution patterns.

9. Select the **Evaluation** option, then select **Static Compare** to test both right and left hands. For information on test screen set-up, please see Section 5 of the Operator's Manual.



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.



12. 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. Delete this trial before proceeding with the actual test trials.

Fig. 2

12. Turn the computer monitor so that the subject cannot see the display.

13. Making sure that the tool is securely attached, the subject properly positioned, and the test side is selected. Select **START** 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. Maximum effort should be reach 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. In order to test the nondominant or injured extremity, the tool must be rotated 180 degrees.

Then reposition the subject for the same test, repeating Steps 13 and 14.

16. Record the average torque for each side for use in dynamic power testing.

Dynamic Testing

1. Demonstrate to the subject the motion being tested (either shoulder internal or external rotation), and the proper positioning as described above.

   NOTE: Except for the starting position of the shoulder being tested, tool set up and subject positioning should NOT change for dynamic testing.

2. From the **Evaluation** menu, select **Dynamic Compare** test application and enter the set-up information.

3. Make sure the proper force value is entered for the direction of the movement being tested (CW vs. CCW) and the trial time is set to 10 seconds.

4. Set the resistance to one-half (1/2) the average isometric strength noted in step 16 above. Each side should be tested using a different torque unless the average isometric strength on both sides is equal. <u>Double check</u> the torque setting.

5. 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.

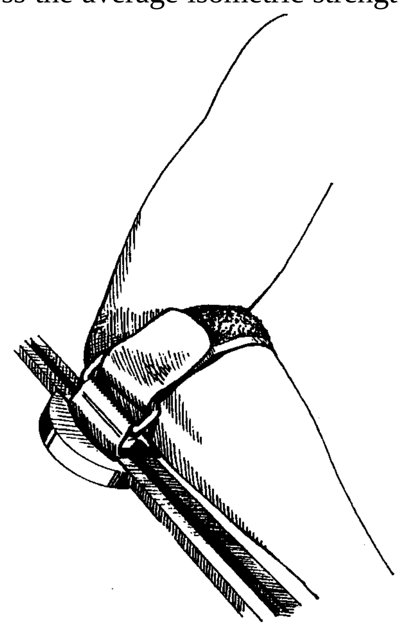


Fig. 3

6. Except for the starting position of the side being tested, position the subject as stated in Steps 4 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.

   NOTE: Secure the forearm of the side being tested to the star-shaped black knob

using the black strap as illustrated (see Fig. 3).

7. Before selecting START, 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.

   NOTE: Do NOT allow the subject to use substitution patterns.

8. Make sure that the tool is securely attached, the subject properly positioned, and the test side is selected on the screen. Select **START** to begin each trial.

9. Reposition the subject for the same test using the nondominant or involved side and repeat Steps 3 through 8.

If you wish to convert inch-pounds to pounds, measure the distance from the center of the shaft to the center of the point of pressure applied to the tool and divide that measurement (length of lever arm) into the average torque number.

$$\frac{\text{average torque (in-lbs)}}{\text{length of lever arm (inches)}} = \text{pounds of force}$$

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
ambidextrous = 0

TEST STATISTICS:

SHOULDER INTERNAL ROTATION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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**
SHOULDER EXTERNAL ROTATION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
ambidextrous = 0

TEST STATISTICS:

SHOULDER INTERNAL ROTATION						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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						
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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
ambidextrous = 0

TEST STATISTICS:

	SHOULDER INTERNAL ROTATION					
	DOMINANT			NONDOMINANT		
	Isometric	(C. V.)	Dynamic	Isometric	(C. V.)	Dynamic
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**		
	Isometric	**(C. V.)**	**Dynamic**	**Isometric**	**(C. V.)**	**Dynamic**
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**	**5344.9**	**93.0**	**2.1**	**5397.0**

RELIABILITY STATISTICS:

Pearson Product-Moment Correlation Coefficients –

SHOULDER INTERNAL ROTATION			
DOMINANT		NONDOMINANT	
Isometric	Dynamic	Isometric	Dynamic
0.966	**0.951**	**0.985**	**0.962**
SHOULDER EXTERNAL ROTATION			
DOMINANT		**NONDOMINANT**	
Isometric	**Dynamic**	**Isometric**	**Dynamic**
0.983	**0.973**	**0.981**	**0.934**

PERCENTILE CHARTS:

ALL MALES (24 – 75) N = 33 SHOULDER INTERNAL ROTATION - #802 *Percentiles*	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
Dominant	**191**	**299**	**363**	**433**	**503**	**567**	**676**
Nondominant	**195**	**304**	**367**	**437**	**507**	**571**	**679**
	Dynamic Power (engals)						
Dominant	**4699**	**16064**	**22698**	**30039**	**37380**	**44015**	**55380**
Nondominant	**5418**	**16260**	**22589**	**29592**	**36595**	**42924**	**53766**
SHOULDER EXTERNAL ROTATION - #802							
	Static/Isometric Torque (in-lbs.)						
Dominant	**105**	**182**	**227**	**277**	**327**	**372**	**449**
Nondominant	**100**	**178**	**224**	**274**	**325**	**370**	**449**
	Dynamic Power (engals)						
Dominant	**3021**	**8166**	**11170**	**14493**	**17816**	**20820**	**25965**
Nondominant	**2630**	**7700**	**10660**	**13935**	**17210**	**20170**	**25241**

ALL FEMALES (25 – 46) N = 21 SHOULDER INTERNAL ROTATION - #802 *Percentiles*	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Static/Isometric Torque (in-lbs.)						
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 - #802							
	Static/Isometric Torque (in-lbs.)						
Dominant	**15**	**76**	**111**	**150**	**189**	**225**	**285**
Nondominant	**12**	**72**	**107**	**146**	**185**	**220**	**280**
	Dynamic Power (engals)						
Dominant	**1070**	**3986**	**5688**	**7571**	**9454**	**11156**	**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 as described in section 3 of the operator's manual. Place the range of motion stopper in either the 10 o'clock or 3 o'clock position and connect the pulley on the opposite side of the Simulator ii using the eyebolt on the floor.

   NOTE: To insure that the rope will not slip on the spool when testing at increased loads, wrap the rope around the spool twice.

   NOTE: Remember to pull the handle through one full travel until the red bag has been raised as far as it will go in order to properly "seat" the rope on the spool.

2. Demonstrate to the subject the motion being tested (floor to knuckle height lift), and the proper positioning as described below (see Fig. 1).

3. Position the subject on the same side as the handle facing the exercise head.

4. 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, 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 at each end of the standard handle of attachment #191 using a cylinder grip.

   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.

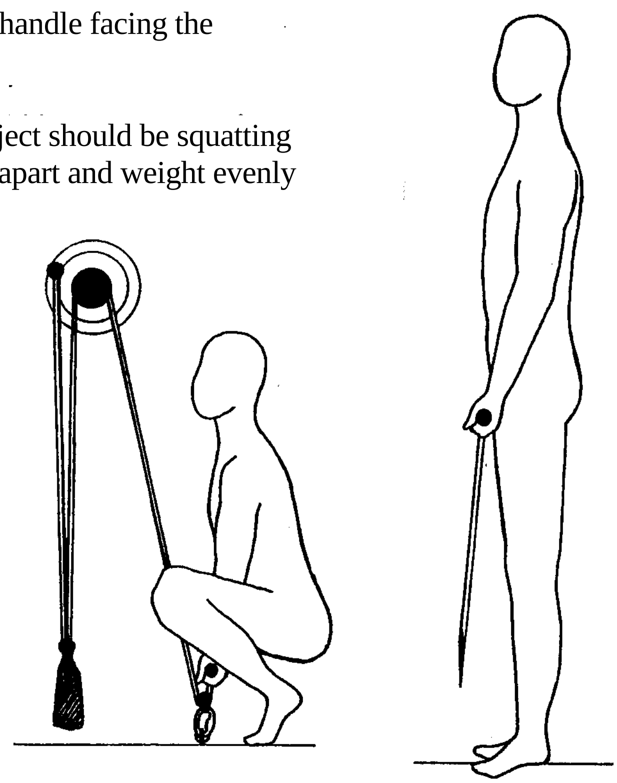


Fig. 1

NOTE: Do NOT allow the subject to use substitution patterns.

NOTE: Be sure to position the subject close to the Simulator II 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.

5. Select the **Evaluation** option, then select **Lift, Maximum**. For information on test screen set-up, please see Section 5 of the Operator's Manual (page 508).

At the setup window -

6. Make sure you enter the lever length (2.2 inches) and the handle weight. (The standard handle weighs one pound.)

7. Determine the lifting range. Instruct the patient to move the handle to the end point of the range and select the END button. Then, have the patient move the handle to the beginning of the range. Select BEGIN.

8. Click OK to bring up the test screen.

9. 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 floor after each lift,
   - do not let go of the handle or allow it to fall rapidly, and
   - do not begin until I say "go".

   NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.

10. Allow the subject one trial with the resistance set a zero (0) so that he/she knows what to expect once 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, and the starting weight is set. Select **START** to begin the test.

    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. Instruct the patient to lift the handle through the set range, then return the handle to the start position and pause for the rest time.

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. After each trial, increase load the by five to ten pounds.

15. The number of seconds allowed for each trial is counted in the upper left portion of the screen. Allow a minimum of 15 seconds rest between each trial.

NOTE: Depending on the condition of the patient, more that 15 seconds rest between trials may be necessary. If this is the case, be sure that the rest periods remain consistent.

16. Continue the sequence of having the subject complete the lift followed by the evaluator increasing the load on the Simulator II. 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
ambidextrous = 0

TEST STATISTICS:

FLOOR TO KNUCKLE LIFT		
	Maximum Lift	Safe Recommended Lift
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
ambidextrous = 0

TEST STATISTICS:

FLOOR TO KNUCKLE LIFT		
	Maximum Lift	Safe Recommended Lift
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
ambidextrous = 0

TEST STATISTICS:

FLOOR TO KNUCKLE LIFT				
	Maximum Lift		Safe Recommended Lift	
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 –

FLOOR TO KNUCKLE LEFT - #191	
Maximum Load	Recommended Safe Load
0.895	**0.898**

PERCENTILE CHARTS:

ALL MALES (24 – 75) FLOOR TO KNUCKLE LEFT - #191 N = 31							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Maximum Lift (lbs.)						
Dominant	25	72	100	131	162	189	237
Nondominant	24	69	95	124	154	180	225

ALL FEMALES (25 – 46) FLOOR TO KNUCKLE LEFT - #191 N = 21							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Maximum Lift (lbs.)						
Dominant	25	48	61	76	91	104	127
Nondominant	18	42	56	71	87	101	125

KNUCKLE TO SHOULDER HEIGHT

1. Set up attachment #191 as described in section 3 of the operator's manual. Place the range of motion stopper in either the 10 o'clock or 3 o'clock position and connect the pulley on the opposite side of the Simulator II using the eyebolt on the floor.

   NOTE: Remember to pull the handle through one full travel until the red bag has been raised as far as it will go in order to properly "seat" the rope on the spool.

2. Demonstrate to the subject the motion being tested (knuckle to shoulder lift), and the proper positioning as described below (see Fig. 2).

3. Position the subject on the same side as the handle facing the exercise head.

4. 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 at each end of the standard handle of attachment #191 using a cylinder grip.

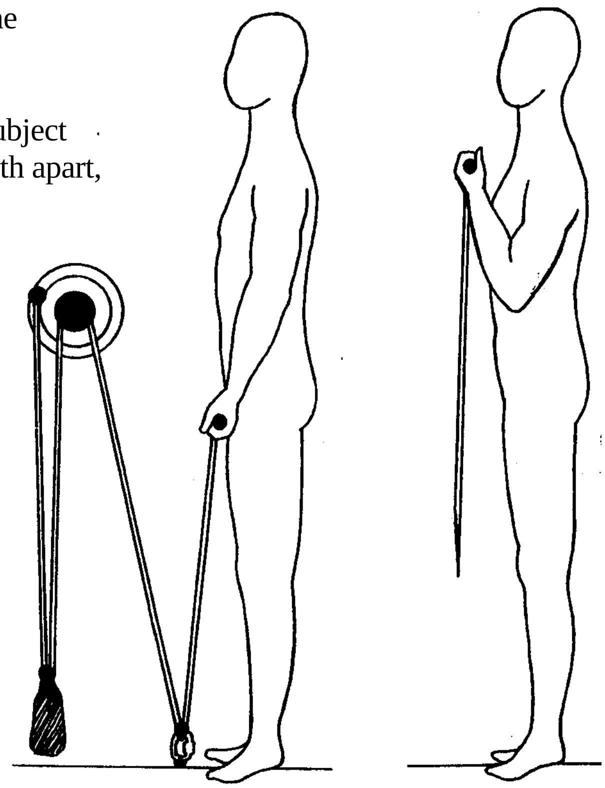
   

   Fig. 2

   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.

   NOTE: Do NOT allow the subject to use substitution patterns.

   NOTE: Be sure to position the subject close to the Simulator II 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.

5. Select the **Evaluation** option, then select **Lift, Maximum**. For information on test screen set-up, please see Section 5 of the Operator's Manual (page 508).

At the setup window -

6. Make sure you enter the lever length (2.2 inches) and the handle weight. (The standard handle weighs one pound.)

7. Determine the lifting range. Instruct the patient to move the handle to the end point of the range and select the END button. Then, have the patient move the handle to the beginning of the range. Select BEGIN.

8. Click OK to bring up the test screen.

9. Verbally describe the procedure:
   - lift the handle from knuckle to shoulder 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 or allow it to fall rapidly, and
   - do not begin until I say "go".

   NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.

10. Allow the subject one trial with the resistance set a zero (0) so that he/she knows what to expect once 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, and the starting weight is set. Select **START** to begin the test.

    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. Instruct the patient to lift the handle through the set range, then return the handle to the start position and pause for the rest time.

    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. After each trial, increase load the by five to ten pounds.

15. The number of seconds allowed for each trial is counted in the upper left portion of the screen. Allow a minimum of 15 seconds rest between each trial.

NOTE: Depending on the condition of the patient, more that 15 seconds rest between trials may be necessary. If this is the case, be sure that the rest periods remain consistent.

16. Continue the sequence of having the subject complete the lift followed by the evaluator increasing the load on the Simulator II. 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
ambidextrous = 0

TEST STATISTICS:

FLOOR TO KNUCKLE LIFT		
	Maximum Lift	**Safe Recommended Lift**
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
ambidextrous = 0

TEST STATISTICS:

KNUCKLE TO SHOULDER LIFT				
	Maximum Lift		Safe Recommended Lift	
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 = 55
Age – minimum = 24
maximum = 75
mean = 38.8
S. D. = 11.0
Dominance – right-handed = 53
left-handed = 2
ambidextrous = 0

TEST STATISTICS:

KNUCKLE TO SHOULDER LIFT				
	Maximum Lift		Safe Recommended Lift	
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 –

KNUCKLE TO SHOULDER LIFT	
Maximum Load	Recommended Safe Load
0.982	**0.996**

PERCENTILE CHARTS:

ALL MALES (24 – 75) N = 31 KNUCKLE TO SHOULDER LIFT - #191							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Maximum Lift (lbs.)						
Dominant	45	59	67	76	85	93	107
Nondominant	45	58	66	75	84	92	105

ALL FEMALES (25 – 46) N = 21 KNUCKLE TO SHOULDER LIFT							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Maximum Lift (lbs.)						
Dominant	17	26	31	37	42	47	56
Nondominant	16	25	30	36	42	47	56

SHOULDER TO OVERHEAD

1. Set up attachment #191 as described in section 3 of the operator's manual. Place the range of motion stopper in either the 10 o'clock or 3 o'clock position and connect the pulley on the opposite side of the Simulator II using the eyebolt on the floor.

   NOTE: Remember to pull the handle through one full travel until the red bag has been raised as far as it will go in order to properly "seat" the rope on the spool.

2. Demonstrate to the subject the motion being tested (shoulder to overhead lift), and the proper positioning as described below (see Fig. 3).

3. Position the subject on the same side as the handle facing the exercise head.

4. 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 at each end of the standard handle of attachment #191 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.

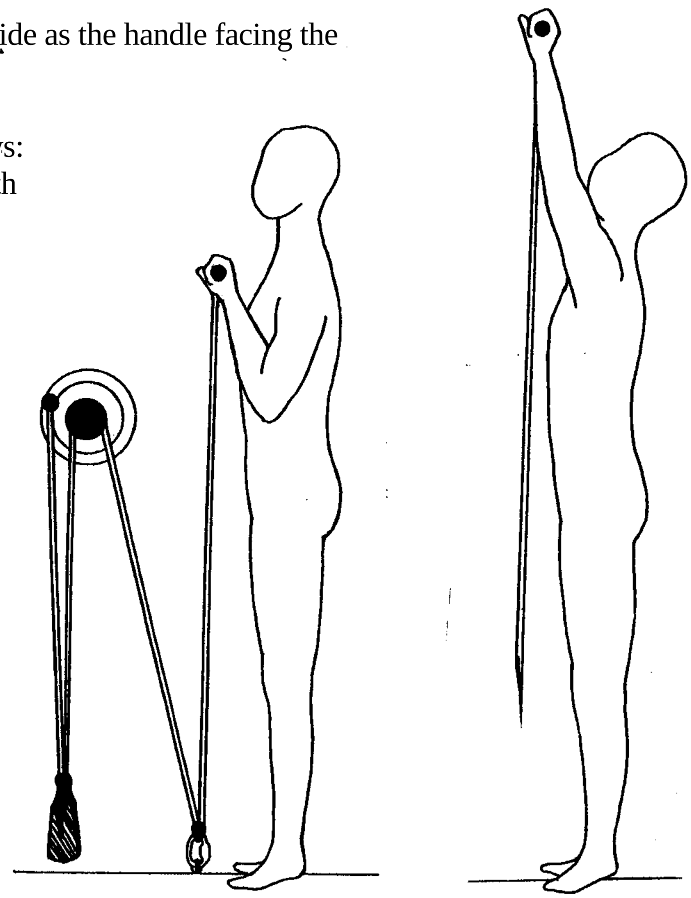


Fig. 3

   NOTE: Do NOT allow the subject to use substitution patterns.

   NOTE: Be sure to position the subject close to the Simulator II 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.

5. Select the **Evaluation** option, then select **Lift, Maximum**. For information on test screen set-up, please see Section 5 of the Operator's Manual (page 508).

At the setup window -

6. Make sure you enter the lever length (2.2 inches) and the handle weight. (The standard handle weighs one pound.)

7. Determine the lifting range. Instruct the patient to move the handle to the end point of the range and select the END button. Then, have the patient move the handle to the beginning of the range. Select BEGIN.

8. Click OK to bring up the test screen.

9. Verbally describe the procedure:
   - lift the handle from shoulder to overhead,
   - 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 or allow it to fall rapidly, and
   - do not begin until I say "go".

   NOTE: Remind the subject to stop immediately if he/she experiences any unusual pain or discomfort.

10. Allow the subject one trial with the resistance set a zero (0) so that he/she knows what to expect once 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, and the starting weight is set. Select **START** to begin the test.

    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. Instruct the patient to lift the handle through the set range, then return the handle to the start position and pause for the rest time.

    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. After each trial, increase load the by five to ten pounds.

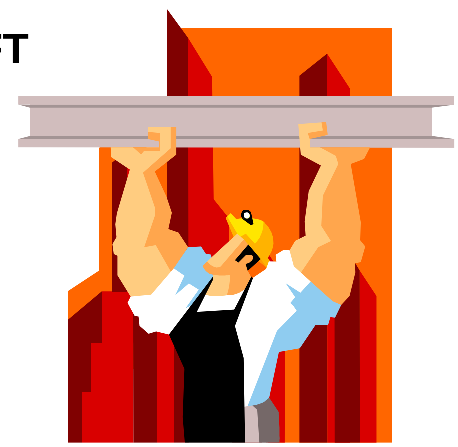
15. The number of seconds allowed for each trial is counted in the upper left portion of the screen. Allow a minimum of 15 seconds rest between each trial.

NOTE: Depending on the condition of the patient, more that 15 seconds rest between trials may be necessary. If this is the case, be sure that the rest periods remain consistent.

16. Continue the sequence of having the subject complete the lift followed by the evaluator increasing the load on the Simulator II. 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 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
ambidextrous = 0

TEST STATISTICS:

SHOULDER TO OVERHEAD LIFT		
	Maximum Lift	Safe Recommended Lift
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

ambidextrous = 0

TEST STATISTICS:

SHOULDER TO OVERHEAD LIFT		
	Maximum Lift	Safe Recommended Lift
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

ambidextrous = 0

TEST STATISTICS:

SHOULDER TO OVERHEAD LIFT		
	Maximum Lift	Safe Recommended Lift
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 –

SHOULDER TO OVERHEAD LIFT	
Maximum Load	**Recommended Safe Load**
0.974	**0.980**

PERCENTILE CHARTS:

ALL MALES (24 – 75)				N = 31			
SHOULDER TO OVERHEAD LIFT							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Maximum Lift (lbs.)						
Dominant	37	49	55	63	70	77	89
Nondominant	37	47	54	61	68	74	85

ALL FEMALES (25 – 46)				N = 21			
SHOULDER TO OVERHEAD LIFT							
Percentiles	*1*	*10*	*25*	*50*	*75*	*90*	*99*
	Maximum Lift (lbs.)						
Dominant	19	26	30	34	39	43	50
Nondominant	18	25	29	34	38	43	50