

Simulator II Research References

“Two-year clinical and radiographic evaluation of Scheker Prosthesis (Aptis) distal radioulnar joint arthroplasty.”

Brannan PS, Ward WA, et al. Two-year clinical and radiographic evaluation of Scheker Prosthesis (Aptis) distal radioulnar joint arthroplasty. *J Hand Surg Am.* 2021; ■■■1.e1-e11
<https://doi.org/10.1016/j.jhsa.2021.04.034>

ABSTRACT

Purpose To evaluate the clinical and radiographic outcomes of patients who underwent semiconstrained distal radioulnar joint arthroplasty.

Methods A retrospective analysis was performed on a series of patients who underwent distal radioulnar joint arthroplasty with more than a 23-month follow up. The quantitative outcome variables included the visual analog scale for pain, Disability of the Arm, Shoulder, and Hand (DASH) score; Patient-Rated Wrist Evaluation (PRWE); and Mayo wrist score. The range of motion, grip strength, torque, and lifting capacity were measured at final follow up and compared with that of the nonsurgical extremity. Complications related to the prosthesis were assessed.

Results Twenty-one patients (mean age 57 years) were assessed at an average 41-month follow up (23e73 months). Fifteen underwent prior hand, wrist, or elbow procedures. Four patients required 5 reoperations. The postoperative median visual analog scale pain score was 0.6 at rest and 2.1 with activity. The median postoperative DASH score was 26.7, PRWE41, and Mayo wrist score was 65. Upon comparing the supination torque of the operative and intact sides, the operative side was found to average 87% of the intact side on a work simulator and 77% on the simulator’s D-ring. Eight of 20 patients had lysis around the collar of the ulnar component (40%), as detected using radiography. Three of 21 (14%) radial plates were malpositioned, with 2 resulting in a fracture. The overall complication rate was 29%.

Conclusions Distal radioulnar joint arthroplasty using the Scheker prosthesis demonstrated good patient pain scores and the restoration of supination strength. The collar lysis resulted in weaker supination and grip strength. Still, the patients experienced mild levels of pain and moderate disability. A moderate complication rate persisted, as reported by other authors. Accurate radial component placement is important.

Type of study/level of evidence Therapeutic IV.

Use: measure torque (isometric strength) of supinator and pronator muscles

“Sex-specific effects of muscle fatigue on upper body kinematics and discomfort during a repetitive point teak performed on a sit-stand stool.”

Yang C, Cote JN. Sex-specific effects of muscle fatigue on upper body kinematics and discomfort during a repetitive point teak performed on a sit-stand stool. *International J Industrial Ergonomics.* 2021; 85 103188. <https://doi.org/10.1016/j.ergon.2021.103188>

ABSTRACT

When performing repetitive work-like tasks while standing, people may develop leg discomfort and adapt their whole-body motion to arm fatigue. How these responses are affected when working while sitting on a sit-stand stool is unknown. Asymptomatic young adults (N = 29, 15 females) performed a repetitive pointing task sitting on a sit-stand stool, while whole-body kinematics was recorded. Results showed no

leg discomfort increase with fatigue. The upper body leaned more backwards and towards the non-reaching side. Variability increased at the seat (p = 0.002), shoulder (p = 0.001) and elbow (p = 0.005) but

was preserved at wrist ($p = 0.058$) and endpoint ($p = 0.088$). Participants who were more fatigable increased seat variability (males, $p = 0.01$) or seat range of motion (females, $p = 0.022$) after fatigue. The sit-stand stool contributed to the response to arm fatigue, although females and males developed different strategies. The maintained endpoint variability and leg discomfort suggest that the sit-stand stool could be recommended as an alternate workstation with minimal disruption to work performance or worker discomfort.

Use: provide static resistance in order kinematically measure maximum voluntary contractions

“New methods to assess forearm torque and lifting strength: reliability and validity.”

Axelsson P, Karrholm J. New methods to assess forearm torque and lifting strength: reliability and validity. *J Hand Surg Am.* 2018;1.e1-e10. <https://doi.org/10.1016/j.jhsa.2018.01.009>

ABSTRACT:

Purpose: To determine the repeatability and validity of new methods designed to objectively measure forearm torque and lifting strength in a clinical setting.

Methods: Twenty-eight healthy volunteers, 19 women and 9 men, were tested for lifting strength and forearm torque with the Kern and Baseline dynamometers. Two raters tested each participant on 3 occasions in the standing position. One of the raters also examined 15 subjects, 3 times, for forearm torque in the seated position and for lifting strength and forearm torque by the Work Simulator II, Baltimore Therapeutic Equipment (BTE II). Intraclass correlation coefficients (ICC) model 2,1 was used to calculate ICCs for intra- and interrater reliability. The same ICC model and Bland-Altman plots were used to analyze the validity and agreement between the new test methods and the BTE II equipment and for comparison between tests performed in the standing and seated positions.

Results: Intra- and interrater reliability for forearm torque measurements with both the Baseline and the BTE II demonstrated ICCs between 0.88 and 0.96. The comparison between the Baseline and the BTE equipment yielded lower ICCs of 0.74 to 0.88 but they were still substantial and in good agreement. The ICCs for torques recorded in the standing and seated position were 0.89 to 0.96. Lifting strength, measured in 3 different positions of forearm rotation, yielded ICC values between 0.84 and 0.96 for both raters and with both the Kern and the BTE II instruments. Similarly, comparisons between the Kern and the BTE II methods showed ICC values between 0.91 and 0.95.

Conclusions: Both the Baseline and the Kern dynamometers demonstrated excellent intra- and interrater repeatability. Except for forearm torque test in direction of pronation, which had a slightly lower ICC of 0.74, our new methods were valid when the BTE II was used as the reference standard. Assessments in the standing or seated position for torque measurements made little difference. Thus, we found the quality of measurements performed with our new methods sufficient for future studies of forearm torque and lifting strength.

Clinical relevance: Simple, yet reliable, methods to quantify torque and lifting strength in a clinical setting have the potential to improve evaluations of wrist and forearm disorders as well as their treatments.

Use of Simulator: as a reference standard to validate new strength dynamometers. “The Simulator was chosen because it is commonly used for strength assessments and has demonstrated high coefficients for test-retest reliability”. Forearm torque and lifting strength were tested.



“Comparison of portable handheld versus fixed isokinetic dynamometers in measuring strength of the wrist and forearm.”

Lucado A, Fraher L, Patel H, et al. Comparison of portable handheld versus fixed isokinetic dynamometers in measuring strength of the wrist and forearm. *Physiother Theory Pract.* 2018. DOI: 10.1080/09593985.2018.1455248.

ABSTRACT:

Purpose: The purpose of this study was to test the concurrent validity of using hydraulic dynamometers in comparison to the gold standard isokinetic dynamometers in measuring wrist and forearm strength.

Materials and methods: Healthy adults between the ages of 18–65 participated, including 24 participants, 8 men and 16 women. The examiner used a handheld dynamometer, forearm/wrist dynamometer, and an isokinetic dynamometer to measure force/torque production in forearm rotation and wrist flexion/extension using a standardized protocol of two handle types for each motion. Sequence of testing was randomized. The data were analyzed using Pearson correlation coefficients and paired t-tests.

Results: When matched for handle type, three of the four correlations between the strength measurements taken with the different dynamometers were moderate to high with Pearson product moment coefficients ranging from 0.72 to 0.96; the screwdriver handle demonstrated less than acceptable correlation ($r = 0.45, 0.67$ for wrist flexion and extension, respectively). There were significant differences in most of the force/torque values obtained by different handle types for wrist and forearm motions.

Discussion and conclusions: Overall, the dynamometers demonstrated acceptable correlations supporting concurrent validity for measuring forearm and wrist strength, except with the screwdriver handle. However, different tools, positions, and handle interfaces provided different absolute values, therefore the tools cannot be used interchangeably. It is recommended that repeated measurements to monitor patient progress are taken with the same tool and handle type.

Use of Simulator: as an established strength measurement device to which portable HHD and FWD measures will be compared in order to establish concurrent validity across devices. Various tools were used to measure maximum strength of wrist flexors and extensors and forearm supinators and pronators.



PLEASE NOTE THAT THE BTE SIMULATOR II DOES NOT HAVE AN ISOKINETIC MODE.

“Gender differences in sensorimotor characteristics associated with the performance of a manual dexterity task at shoulder height.”

Minn S, Cote JN. Gender differences in sensorimotor characteristics associated with the performance of a manual dexterity task at shoulder height. *J Electromyog Kinesiol.* 2018, doi: <https://10.1016/j.jelekin.2018.08.001>

ABSTRACT:

Women report more neck/shoulder musculoskeletal disorders in association to low-force, dexterous work. However, it is unclear if this may be due to gender differences in sensorimotor patterns while performing such tasks. Twenty-nine asymptomatic adult volunteers (15 men, 14 women) performed a neck/shoulder fatiguing task involving screwing and unscrewing bolts placed at shoulder height until scoring 8 on a Borg CR-10 scale. During the task, performance (bolts/minute) was measured, and electromyography (EMG) was recorded at eight neck/shoulder muscle sites to compute Root Mean Square (RMS), Motor Variability and Normalized Mutual Information (NMI). Before and after the task, Purdue pegboard and shoulder joint position sense were measured. Even though muscle fatigue was evidenced by neck/shoulder EMG results, shoulder proprioception was not affected by the fatiguing task while screwing bolts and Purdue pegboard performance actually improved ($p < 0.001$). Women displayed overall higher RMS and NMI values (e.g. 80% higher UT RMS, 42% higher AD RMS). Thus, although task performance and proprioception did not deteriorate and were not different between genders, gender differences in EMG measures may help understand the sex-specific muscle fatigue mechanisms associated to shoulder height dexterous work and may help explain the higher rates of neck/shoulder injuries in women.

Use of Simulator: musculoskeletal evaluation of the upper extremities of asymptomatic adults. Isometric mode was utilized to measure maximum strength of eight UE muscle sites.

“Comparison of the strength endurance parameters for the Baltimore Therapeutic Equipment (BTE) Simulator II and the Jamar Handgrip Dynamometer.”

Myers E, Trsicari R. Comparison of the strength endurance parameters for the Baltimore Therapeutic Equipment (BTE) Simulator II and the Jamar Handgrip Dynamometer. *Work*. 2017. doi:10.3233/WOR-172542.

ABSTRACT:

BACKGROUND: The purpose of this study was to provide evidence regarding the Baltimore Therapeutic Equipment (BTE) Work Simulator II's recommended grip endurance protocol. The grip endurance protocol of the BTE Simulator II has never been validated, though it has been used often for the rehabilitation of work-related injuries and other occupational dysfunctions. Without validation, the grip endurance protocol may or may not be providing skilled clinicians with appropriate evaluation results. This study evaluated a protocol comparing the BTE Simulator II to the Jamar Dynamometer to determine how the BTE compares to the Jamar device.

OBJECTIVE: To establish whether the recommended grip endurance protocol for the BTE Simulator II is comparable to the parameters established for the Jamar handgrip dynamometer.

METHODS: Data were gathered from 140 participants ages 18 to 40 at the time of the study. Participants completed protocols established for the BTE Simulator II and compared to a performance of a grip strength endurance protocol for the Jamar Handgrip Dynamometer. After establishing baseline strength levels for the participants, they were timed to see how long they could sustain a 30% maximum voluntary contraction (MVC) on each device. Sample t-tests were calculated to compare the results of the BTE Simulator II to the previously validated Jamar device.

RESULTS: A dependent sample t-test found no statistically significant difference between the times a participant sustained 30% of their maximum voluntary contraction (MVC) on the BTE Simulator II with attachment #162 versus the Jamar Dynamometer when comparing the differences of the means. This provides possible evidence of validity for the BTE endurance protocol. The independent sample t-test found no statistically significant difference between the grip endurance of the males versus the females, however, the means indicate men sustained 30% of their MVC longer than their female counterparts on the BTE.

CONCLUSIONS: The findings indicate that the 30% MVC may be a reliable baseline for grip strength endurance testing following the BTE Simulator II protocol. This suggests that the BTE Simulator II's endurance protocol may be a useful tool to document client progression during rehabilitation after sustaining an upper extremity dysfunction. Further research is needed to validate this protocol using different populations.

Use of Simulator: validation study of endurance protocol related to musculoskeletal evaluation of endurance of muscles involved with hand grip

“Differences in muscular and perceptual responses to a neck/shoulder fatiguing task between women and men.”

Otto A, Emery K, Cote JN. Differences in muscular and perceptual responses to a neck/shoulder fatiguing task between women and men. *J Electromyog Kinesiol*. 2018;43:140-147. <https://doi.org/10.1016/j.jelekin.2018.09.010>

ABSTRACT:

Fatigue is a risk factor for the development of work-related musculoskeletal disorders (WMSDs) of the neck/shoulder, and exertion is a state that connects the sensory/affective and physical aspects of fatigue. Relationships between ratings of perceived exertion (RPE) and electromyogram (EMG) signal characteristics have been identified. However, the sex-specific effects on these relationships are unclear and could be affected by personal factors such as skinfold thickness. 28 healthy young adults completed a fatiguing task with the arm held at shoulder height. Neck/shoulder EMG and RPE were collected at the

end of each minute. Males showed stronger correlations between RPE with anterior deltoid (AD, $r_s = 0.37$) and upper trapezius (UT, $r_s = 0.48$) EMG, whereas females showed a weak relationship between RPE and UT EMG ($r_s = 0.22$), and no relationship with AD EMG. Significant correlations were observed between biceps EMG and skinfold thickness in both males and females. Findings suggest that neck/shoulder perceived exertion is strongly associated to the activity of shoulder mobilizers (anterior deltoid) in men, whereas in women, it is rather associated to the activity of shoulder stabilizers (upper trapezius), and to a lesser extent. It is possible that in turn, these sex differences affect fatigue adaptation strategies. Skinfold thickness may be an important variable to consider when studying sex-specific characteristics of muscle fatigue.

Use of Simulator: musculoskeletal evaluation of the upper extremities of asymptomatic adults. Isometric mode was utilized to measure maximum voluntary muscle contractions while performing a unilateral shoulder shrug, shoulder flexion, and elbow flexion

“Early active rehabilitation after arthroscopic rotator cuff repair; a prospective randomized pilot study.”

Raschhofer R, Poulos N, Schimetta W, et al. Early active rehabilitation after arthroscopic rotator cuff repair; a prospective randomized pilot study. *Clin Rehabil.* 2017;31:1332-1339.

ABSTRACT:

Objective: To compare two different rehabilitation strategies, primary passive motion versus early isometric loading of the rotator cuff.

Design: Prospective randomized controlled observer-blinded pilot study.

Setting: Institute of Physical Medicine and Rehabilitation.

Subjects: Thirty patients after rotator cuff surgery.

Intervention: All participants were randomly assigned to one of the two outpatient treatment groups: primary passive motion versus early isometric loading of the rotator cuff. Both groups were treated for 12 weeks and performed additionally a home exercise program.

Main measures: The primary outcome measure for functional assessment was the Constant Murley score. The secondary outcome measures were the Disabilities of the Arm, Shoulder and Hand score (DASH), active range of motion, pain level and strength. Patients were assessed before, 6, 12 and 24 weeks after surgery.

Results: Repeatedly measured metric variables were compared by the Quade rank analysis of covariance and revealed substantially better Constant Murley scores in the early activated group at all 3 assessments (6 weeks: 41 [31;45] versus 30 [23;37]; 12 weeks: 68 [56;77] versus 59 [53;62]; 24 weeks: 79 [76;81] versus 66 [62;74]; data as median [25%;75%]). Postoperative changes of Constant score were in favor of the active group with the biggest difference at week 12 (28 [38;12] versus 9 [27;-4]). Maximal pain levels showed clear more reduction 6 and 24 weeks after surgery in the early activated group.

Conclusions: This pilot study with early isometric loading of the rotator cuff shows better function and less maximal pain. Further research is warranted to confirm our results.

Use of Simulator: musculoskeletal evaluation of the shoulders of patients post-arthroscopic repair of the supraspinatus tendon. Isometric mode was utilized to measure maximum strength of the external rotators, following the BTE Standard guidelines



“Near-normal shoulder function 10 years after complete acromionectomy. A case report.”

Rasmussen JF, Wing DW, Steiner ME. Near-normal shoulder function 10 years after complete acromionectomy. A case report. *Ortho J Sports Med.* 2017;5, 2325967117726072. DOI: 10.1177/2325967117726072

ABSTRACT:

The clinical history and outcomes of a 26-year-old man who underwent complete acromionectomy at the age of 16 years for pain secondary to an aneurysmal bone cyst (ABC) are presented. The findings demonstrate that the absence of the acromion may not significantly impair function, provided the deltoid is intact.

Use of Simulator: musculoskeletal evaluation of the shoulder musculature of male post-complete acromionectomy. Isometric and isotonic modes were utilized to measure maximum strength and power output of shoulder internal and external rotators, forward elevators, and abductors.

“Quantitative assessment of scalene muscle block for the diagnosis of suspected thoracic outlet syndrome.”

Braun RM, Shah KN, Rechnic M, et al. Quantitative assessment of scalene muscle block for the diagnosis of suspected thoracic outlet syndrome. *J Hand Surg Am.* 2015; article in press.

ABSTRACT:

Purpose: To measure changes in upper limb work and power capacity before and after anterior scalene muscle block (ASMB) to suggest thoracic outlet syndrome caused by costoclavicular space compression.

Methods: We evaluated 34 patients disabled by symptoms suggesting thoracic outlet syndrome. An ASMB was performed via a supraclavicular injection. The sternocleidomastoid muscle was injected as a control. We captured data obtained from work simulator measurements before and after ASMB. Each patient performed a push-pull test with the forearm at waist level (test 1), an overhead bar push-pull test with the arm elevated (test 2), and the extremity abduction stress test with repetitive hand gripping during static arm elevation (test

3). We measured the work product, time to fatigue, and power generation. Sensory testing was performed after ASMB to rule out improved performance associated with possible sensory nerve block.

Results: In contrast to sternocleidomastoid injection controls, symptomatic and functional improvement was noted in all patients (n = 34) after ASMB. Work product measurement improved 93%, 108%, and 104% for tests 1, 2, and 3, respectively. Time to fatigue and power output also increased after the block.

Conclusions: Temporary symptomatic improvement after ASMB may be anticipated in patients with TOS. This study documents a significant concurrent increase in upper limb motor function after the block. Increased work and power measurements after ASMB may draw diagnostic inference regarding a dynamic change in the scalene muscle and the costoclavicular space associated with symptomatic thoracic outlet syndrome.

Use of Simulator: musculoskeletal evaluation of the functional work capacity of patients with suspected thoracic outlet syndrome. Isotonic mode was utilized to measure dynamic endurance.

**“The effects of a group exercise program on the weight management of obese women in a publicly funded healthcare system.”**

Brewer W, Olson S, Roddey T, et al. The effects of a group exercise program on the weight management of obese women in a publicly funded healthcare system. *J Phys Ther Health Promotion.* 2014;2:29-39.

ABSTRACT:

Women from minority backgrounds have the highest prevalence rates of obesity and physical inactivity. A prospective cohort pilot study was conducted to investigate the effectiveness of a 12-week intervention that consisted of a group exercise program with educational reinforcement to enhance physical activity, physical fitness and physical self-worth. Twenty-three minority women completed the intervention. The participants were obese, had a neuromusculoskeletal impairment, chronic medical condition or disability that required outpatient physical therapy services. The results of this study revealed no significant

reduction in body-weight but improvement was made for functional cardiovascular endurance ($p < .005$), lower and upper body strength ($p < .006$ and $.042$, respectively), physical self-worth ($p < .0005$) and moderate physical activity ($p < .009$). Despite the absence of weight-loss for these participants, the exercise and education intervention provided improvements in levels of physical fitness, physical self-worth and engagement in health enhancing physical activity.

Use of Simulator: musculoskeletal evaluation of muscular strength of the upper and lower extremities of healthy females. Isometric mode was utilized to measure maximum strength capabilities of functional tasks including pushing and pulling with the upper extremities and squat and pull with the lower extremities pre- and post-exercise interventions.



“Pisiform excision for pisotriquetral instability and arthritis.”

Campion H, Goad A, Rayan G, et al. Pisiform excision for pisotriquetral instability and arthritis. *J Hand Surg.* 2014;39(7):1251-1257.

ABSTRACT:

Purpose: To evaluate wrist strength and kinematics after pisiform excision and preservation of its soft tissue confluence for pisotriquetral instability and arthritis.

Methods: We evaluated 12 patients, (14 wrists) subjectively and objectively an average of 7.5 years after pisiform excision. Three additional patients were interviewed by phone. Subjective evaluation included inquiry about pain and satisfaction with the treatment. Objective testing included measuring wrist flexion and extension range of motion, grip strength, and static and dynamic flexion and ulnar deviation strengths of the operative hand compared with the nonsurgical normal hand. Four patients had concomitant ulnar nerve decompression at the wrist.

Results: All patients were satisfied with the outcome. Wrist flexion averaged 99% and wrist extension averaged 95% of the nonsurgical hand. Mean grip strength of the operative hand was 90% of the nonsurgical hand. Mean static flexion strength of the operative hand was 94% of the nonsurgical hand, whereas mean dynamic flexion strength was 113%. Mean static ulnar deviation strength of the operative hand was 87% of the nonsurgical hand. The mean dynamic ulnar deviation strength of the operative hand was 103% of the nonsurgical hand.

Conclusions: Soft tissue confluence-preserving pisiform excision relieved pain and retained wrist motion and static and dynamic strength. Associated ulnar nerve compression was a confounding factor that may have affected outcomes.

Use of Simulator: musculoskeletal evaluation of wrist muscle performance in patients post-pisiform excision. Isometric and isotonic modes were utilized to measure maximum strength capabilities dynamic power output of the wrist flexors and extensors.

“Functional deficits in carpal tunnel syndrome reflect reorganization of primary somatosensory cortex.”

Maeda Y, Kettner N, Holden J, et al. Functional deficits in carpal tunnel syndrome reflect reorganization of primary somatosensory cortex. *Brain.* 2014;137:1741-1752.

ABSTRACT:

Carpal tunnel syndrome, a median nerve entrapment neuropathy, is characterized by sensorimotor deficits. Recent reports have shown that this syndrome is also characterized by functional and structural neuroplasticity in the primary somatosensory cortex of the brain. However, the linkage between this neuroplasticity and the functional deficits in carpal tunnel syndrome is unknown. Sixty-three subjects with carpal tunnel syndrome aged 20–60 years and 28 age- and sex-matched healthy control subjects were evaluated with event-related functional magnetic resonance imaging at 3 T while vibrotactile stimulation was delivered to median nerve innervated (second and third) and ulnar nerve innervated (fifth) digits. For

each subject, the interdigit cortical separation distance for each digit's contralateral primary somatosensory cortex representation was assessed. We also evaluated fine motor skill performance using a previously validated psychomotor performance test (maximum voluntary contraction and visuomotor pinch/release testing) and tactile discrimination capacity using a four-finger forced choice response test. These biobehavioral and clinical metrics were evaluated and correlated with the second/third interdigit cortical separation distance. Compared with healthy control subjects, subjects with carpal tunnel syndrome demonstrated reduced second/third interdigit cortical separation distance ($P < 0.05$) in contralateral primary somatosensory cortex, corroborating our previous preliminary multi-modal neuroimaging findings. For psychomotor performance testing, subjects with carpal tunnel syndrome demonstrated reduced maximum voluntary contraction pinch strength ($P < 0.01$) and a reduced number of pinch/release cycles per second ($P < 0.05$). Additionally, for four-finger forced-choice testing, subjects with carpal tunnel syndrome demonstrated greater response time ($P < 0.05$), and reduced sensory discrimination accuracy ($P < 0.001$) for median nerve, but not ulnar nerve, innervated digits. Moreover, the second/third interdigit cortical separation distance was negatively correlated with paresthesia severity ($r = -0.31$, $P < 0.05$), and number of pinch/release cycles ($r = -0.31$, $P < 0.05$), and positively correlated with the second and third digit sensory discrimination accuracy ($r = 0.50$, $P < 0.05$). Therefore, reduced second/third interdigit cortical separation distance in contralateral primary somatosensory cortex was associated with worse symptomatology (particularly paresthesia), reduced fine motor skill performance, and worse sensory discrimination accuracy for median nerve innervated digits. In conclusion, primary somatosensory cortex neuroplasticity for median nerve innervated digits in carpal tunnel syndrome is indeed maladaptive and underlies the functional deficits seen in these patients.

Use of Simulator: testing of psychomotor performance and tactile discrimination ability of patients with CTS. Isometric mode was used to measure maximum pinch strength and pinch and release between 2% and 25% of maximum voluntary contraction.

