Evidence-based Practice Initiative – Primus

**PrimusRS and PR30 specific references:**


**ABSTRACT:**

**Purpose/Background:** Hip external rotator (ER) and internal rotator (IR) muscle weakness is theorized to be associated with lower extremity injury in athletes including knee ligament tears and patellofemoral pain. Previous studies investigating hip musculature strength have utilized various sagittal plane hip positions for testing. The relationship between results at these different positions is unknown.

**Methods:** Eighty healthy, pain-free young adults participated in the study: 40 female, mean age 22.90 (± 2.32) years, and 40 male, mean age 23.50 (± 2.15) years. Peak isometric torque of bilateral hip ER and IR were tested at 90° and 0° of hip flexion with an instrumented dynamometer. Peak muscle forces were calculated. Peak forces were normalized by body mass. Mean normalized force was calculated for dominant and non-dominant limbs for ER and IR in both positions. Male and female data were analyzed separately with paired t-tests (2-tailed). Reference values for average muscle force and torque were calculated for dominant and non-dominant limbs for both hip positions.

**Results:** Hip IR normalized peak force was greater at 90° compared to 0° flexion position bilaterally in both genders (p < .01). Hip ER normalized peak force was greater at 90° compared to 0° flexion in dominant limbs of both genders and in non-dominant limbs of males (p < .01). Non-dominant hip ER normalized force in females was greater at 90° versus 0° flexion; however, it was not significant (p = .092). Post hoc analysis of normalized average force (average over 5-second contraction) yielded similar results.

**Conclusion:** Clinicians and researchers should use consistent positioning for testing of hip ER and IR strength. This will improve certainty of determining if a patient’s strength has changed or if differences between groups are present. Reference values reported will be useful in order to determine if weakness is present and to set goals, particularly in cases of bilateral involvement.

**Level of Evidence:** 2b

*Use of Primus: musculoskeletal evaluation of hip muscle strength (isometric). Reliability of measures established.*


**ABSTRACT:**
STUDY DESIGN: Cross-sectional laboratory study.
OBJECTIVES: To compare peak lower-limb, pelvis, and trunk kinematics and interjoint and intersegmental coordination in women with strong and weak hip muscle performance.
BACKGROUND: Persons with lower extremity musculoskeletal disorders often demonstrate a combination of weak hip musculature and altered kinematics during weight-bearing dynamic tasks. However, the association between hip strength and kinematics independent of pathology or pain is unclear.
METHODS: Peak hip extensor and abductor torques were measured in 150 healthy young women. Of these, 10 fit the criteria for the strong group and 9 for the weak group, representing those with the strongest and weakest hip musculature, respectively, of the 150 screened individuals. Kinematics of the hip, knee, pelvis, and trunk were measured during the stance phases of walking and rate-controlled hopping. Hip/knee and pelvis/trunk coordination were calculated using the vector coding technique.
RESULTS: There were no group differences in peak hip, knee, or pelvis kinematics. Participants in the weak group demonstrated greater trunk lateral bend toward the stance limb during hopping ($P = .002$, effect size $[d] = 1.88$). In the transverse plane, those in the weak group utilized less inphase coordination between the hip and the knee during walking ($P = .036$, $d = 1.45$) and more antiphase coordination between the hip and knee during hopping ($P = .03$, $d = 1.47$).
CONCLUSION: In the absence of pain or pathology, poor hip muscle performance does not affect peak hip or knee joint kinematics in young women, but is associated with significantly different lower-limb and trunk/pelvis coordination during weight-bearing dynamic tasks.

Use of Primus: musculoskeletal evaluation of hip strength.


ABSTRACT:
Study design: Case report.
Introduction: Reports of comprehensive rehabilitation following hand replantation are limited.
Purpose of the study: To describe hand therapy of a patient following hand replantation.
Methods: Right hand dominant 55 year-old male assessed 9 days following left hand replantation to treat distal forearm amputation. Patient presented with dorsal blocking orthotic. Initial status: AROM digits and thumb 0-20° extension, 0-40° flexion; absent light touch sensation; 0-1/5 hand strength. Patient underwent 70 hand therapy sessions over 13 months focusing on A/PROM, therapeutic exercise, neuromuscular re-education, and modalities to address functional limitations.
Results: Hand therapy discharge status: AROM digits and thumb form composite fist, thumb opposition to digit 3, light touch sensation (monofilament) 4.03 (digits 2, 4) and 4.17 (digits 1, 3, 5); 3- to 4-/5 hand strength.
Discussion: Hand therapy allowed for near complete functional return of the hand following
Conclusion: Comprehensive Hand therapy aided restoration of adequate sensation and strength for functional use of the replanted hand.

Level of evidence: 4

Use of Primus: **musculoskeletal treatment to increase muscle strength and function of the upper extremity.**

Davidge KM, Yee A, Kahn LC, Mackinnon SE: **Median to radial nerve transfers for restoration of wrist, finger, and thumb extension.** J Hand Surg. 2013;38A:1812-1827

ABSTRACT: Radial nerve injury results in loss of wrist, finger, and thumb extension. Traditionally, radial nerve palsies that fail to recover spontaneously have been reconstructed with tendon transfers or nerve grafts. Nerve transfers are a novel approach to the surgical management of Sunderland grade IV and V radial nerve injuries. We describe our technique for median to radial nerve transfers. In this procedure, the flexor digitorum superficialis nerve is transferred to the extensor carpi radialis brevis nerve for wrist extension, and the flexor carpi radialis nerve is transferred to the posterior interosseous nerve for finger and thumb extension. Our experience with these nerve transfers has demonstrated excellent outcomes up to 10 months after injury. Indeed, unlike tendon transfers, median to radial nerve transfers have the potential to restore normal radial nerve function, including independent finger motion. Tension-free nerve coaptation and postoperative motor re-education are critical factors to achieving these successful outcomes.

Use of Primus: **musculoskeletal/neuromuscular treatment for strengthening and functional training.**

Levanon Y: **The advantages and disadvantages of using high technology in hand rehabilitation.** J Hand Ther. 2013:26:179-183

ABSTRACT: A brief review of the history of occupational therapy shows that the relationship between health and activity was of great concern to the founders of the Occupational Therapy (OT) field, and continues to be of concern to today’s occupational therapists. Today, computers and Virtual Reality (VR) take the place of clay and the weaving loom. The goal of this article is to describe both known and innovative computerized equipment being used in interventions for hand rehabilitation and evaluations, as well as answer the question: ‘what are the advantages and disadvantages of using technology in hand rehabilitation?’ Our conclusion, based on clinical
experience and supported by the literature, appears to emphasize that advanced technology can enrich treatment and help patients who are unable to visit the clinic regularly, to get appropriate treatment. However, advanced technology has not been found to be superior to traditional treatment and cannot replace the occupational therapist.

**Use of Primus: musculoskeletal evaluation of the upper extremity.**


**ABSTRACT:**

**Background:** Age-related lower extremity weakness leads to difficulty with stair negotiation, gait, and balance. The purpose of this study was to evaluate and compare the impact of functional walking training on hip strength, balance, and functional mobility among community-dwelling working and retired older adults.

**Methods:** 12 healthy working adults (10 females and 2 males; mean age 66 years) were recruited from the campus community and 15 retired community-dwelling adults (13 females and 2 males; mean age 75 years) were recruited from a church. Subjects completed pre-post-test measurements: hip strength (flexion, abduction, and extension) were tested using hand held dynamometer; Timed Up and Go test, 30-Second Chair Rise test, and static and dynamic balance tested using the Xeno Walkway System. Subjects completed 8 sessions of functional walking using the BTE™ Primus RS. Subjects were connected to the Primus using cable attachment and waist belt. Primus was set in concentric-eccentric mode and resistance was applied. Subjects walked seven feet in four directions: forward; backward; sideways both directions a total of five times each. Resistance was increased each session.

**Results:** The working group had significant improvements (p= 0.02-0.0003) in Timed Up and Go, 30-Second Chair Rise test, and hip strength following the intervention. The retired group had significant (p=0.01-0.0002) improvements in Timed Up and Go, 30-Second Chair Rise, hip in static balance. Only the Timed Up and Go was significantly different in the amount of change between groups.

**Conclusion:** A resisted functional walking program resulted in significant improvements in function and strength in both working and retired older adults. Functional walking with resistance allows older adults to benefit without having them assume difficult exercise positions. This exercise protocol can be easily modified for the clinical setting and be used in falls prevention programs.

**Use of Primus: musculoskeletal and neuromuscular treatment for resisted walking that impacted hip strength, balance and functional mobility.**

**ABSTRACT:**

**Purpose:** Balance and gait ability determine to a large degree the level of independence of daily living which is an important goal of rehabilitation. This study was conducted in order to examine the effectiveness of an ankle proprioceptive control program on ankle muscle strength, balance, and gait of chronic stroke patients.

**Methods:** Thirteen chronic stroke patients more than six months post-stroke were recruited. All subjects received ankle proprioceptive control training for 30 minutes per session, two days per week, over a period of six weeks. Outcome measures were ankle strength (BTE-Primus), the Timed Up and Go test (TUG), and spatiotemporal parameters measured by a GAITRite instrument.

**Results:** Significant improvements in ankle dorsiflexor strength, TUG, gait speed and cadence, step length, and stride length were observed on the paretic side.

**Conclusion:** The results of this study provide evidence in support of incorporation of an ankle proprioceptive control program for effective improvement of both balance and gait ability of chronic stroke patients. The findings of this study suggest the feasibility and suitability of an ankle proprioceptive control program for chronic stroke patients.

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**ABSTRACT:**

**Background:** Studies of adult patients suggest that nonoperative treatment of clavicle fractures may result in functional disability, but this has not been demonstrated in adolescents. The purpose of this study was to determine the functional outcomes after nonoperative treatment of displaced, shortened, midshaft clavicle fractures in adolescents.

**Methods:** Adolescents ten to eighteen years of age with an isolated, completely displaced, shortened, midshaft clavicle fracture sustained between 2009 and 2011 were recruited for this study. Injury and final radiographs were assessed for displacement, shortening, and clavicle length. Maximal and endurance strength testing was performed with the Baltimore Therapeutic Equipment (BTE) machine, with use of the uninjured shoulder as an internal control. Shoulder range of motion and clavicle length were assessed clinically, and patient-oriented outcomes were obtained.

**Results:** Sixteen patients (four of whom were female) with an average age (and standard deviation) of 14.2 ± 2 years and a mean duration of follow-up of 2 ± 1 years were included in the study. Fifteen patients were right-hand dominant and one was ambidextrous, and thirteen of the fractures occurred in the nondominant limb. Compared with the uninjured limb, no differences were noted in range of motion or strength except for an 8% decrease in maximal shoulder
external rotation strength ($p = 0.04$) and a 11% loss of shoulder abduction endurance strength ($p = 0.04$). Radiographs demonstrated a 100% union rate but significant shortening compared with the uninjured clavicle ($p \leq 0.001$). SANE (Single Assessment Numeric Evaluation), QuickDASH (shortened version of the Disabilities of the Arm, Shoulder and Hand questionnaire), and Constant scores were similar between sides. Fifteen of the sixteen patients were satisfied with the appearance of the clavicle, and all returned to full activity, including the preinjury (or a higher) level of sports participation.

**Conclusions:** Regardless of patient age, sports participation, and final clavicle shortening, no differences in pain, strength, shoulder range of motion, or subjective outcome scores were found between the injured and uninjured limbs of adolescents treated nonoperatively for a displaced, shortened, midshaft clavicle fracture.

**Level of Evidence:** Therapeutic Level IV.

**Use of Primus:** musculoskeletal evaluation of muscle strength and endurance of shoulder.

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ABSTRACT: Landing mechanics have been documented as a risk factor for knee injuries in female athletes. This article aimed to determine the effect of hip abductor/external rotator fatigue and activity type on landing kinematics. Selected hip and knee landing kinematics were measured before and after a hip fatigue task in 45 healthy participants regularly performing either multiplanar or uniplanar activities. Across conditions, the multiplanar activity male group demonstrated less knee abduction than the uniplanar ($P = .001$) and multiplanar ($P = .018$) activity female groups. In addition, the uniplanar activity female group demonstrated greater knee abduction than the multiplanar activity female group ($P = .031$). Hip adduction during landing increased postfatigue ($P = .001$); however, fatigue did not affect knee kinematics. Landing kinematics may depend on activity participation, as well as gender. Therefore, it is important to classify research participants based on the type of activity in which they regularly participate.

**Use of Primus:** musculoskeletal testing of strength and endurance of hip musculature (isometric).

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ABSTRACT: This study investigates a method using novel hybrid diffuse optical spectroscopies (near-infrared spectroscopy (NIRS) and diffuse correlation spectroscopy (DCS)) to obtain continuous, noninvasive measurement of absolute blood flow (BF), blood oxygenation, and oxygen consumption rate (V\textsubscript{O2}) in exercising skeletal muscle. Healthy subjects (n = 9) performed a handgrip exercise to increase BF and V\textsubscript{O2} in forearm flexor muscles, while a hybrid optical probe on the skin surface directly monitored oxy-, deoxy-, and total hemoglobin concentrations ([HbO2], [Hb], and THC), tissue oxygen saturation (StO2), relative BF (rBF), and relative oxygen consumption rate (rV\textsubscript{O2}). The rBF and rV\textsubscript{O2} signals were calibrated with absolute baseline BF and V\textsubscript{O2} obtained through venous and arterial occlusions, respectively. Known problems with muscle-fiber motion artifacts in optical measurements during exercise were mitigated using a novel gating algorithm that determined muscle contraction status based on control signals from a dynamometer. Results were consistent with previous findings in the literature. This study supports the application of NIRS/DCS technology to quantitatively evaluate hemodynamic and metabolic parameters in exercising skeletal muscle and holds promise for improving diagnosis and treatment evaluation for patients suffering from diseases affecting skeletal muscle and advancing fundamental understanding of muscle and exercise physiology.

Use of Primus: musculoskeletal evaluation for muscle strength and endurance of UE.


ABSTRACT:
Hip abductors play an important role in maintaining trunk and pelvis stability during unipedal tasks. The purpose of the study was to compare postural stability between individuals with patellofemoral pain (PFP) and pain-free controls. A secondary purpose was to evaluate the effect of a hip stabilizing brace on postural stability. Twenty females with PFP (27.3 ± 6.3 years) and 19 controls (26.1 ± 4.5 years) participated. Each subject performed a unipedal step-down balance task with the stance leg on a force platform from which center of pressure (COP) excursion was recorded. Quantitative COP excursion patterns (mean and peak displacements) were used as measures of postural stability. For subjects with PFP, postural stability also was quantified following the application of a hip stabilizing brace. Hip abductor strength was significantly lower in PFP group compared to the control group (1.39 ± 0.4 vs. 1.62 ± 0.26 N/kg-BW, p = 0.046). Peak and mean medial–lateral COP displacements during the balance task were greater in the PFP group (39.8 ± 6.7 vs. 24.3 ± 3.8 mm, p < 0.001; 24.7 ± 16.3 vs. 13.5 ± 4.4 mm, p = 0.005). Application of the hip stabilizing brace reduced the peak and mean COP displacement (39.8 ± 6.7 vs. 24.7 ± 4.7 mm, p < 0.001; 24.7 ± 16.3 vs. 16.8 ± 15.1 mm, p = 0.02). Our results demonstrate that females with PFP exhibit impaired medial–lateral postural stability when compared to control subjects. Application of a hip stabilizing brace significantly improved stability to a level comparable to the controls.
ABSTRACT:

**Purpose:** To define the pronosupination arc for various types of forearm immobilization. We hypothesized that these methods of immobilization offer control of forearm pronosupination proportional to the loss of elbow motion, and that the Muenster cast may offer the most practical method of limiting forearm motion without eliminating elbow motion.

**Methods:** We enrolled 15 subjects in the study. We took measurements using computerized biometrics with the elbow free of immobilization and in a long-arm cast, a Muenster cast, a removable splint set to 90° elbow flexion, and a splint set to allow elbow flexion permissible by the Muenster cast. We recorded measurements for pronation and supination arcs.

**Results:** We obtained average pronosupination arcs for the unrestricted elbow (189°), long arm cast (11°), Muenster cast (35°), removable splint set to 90° (124°), and splint set to the flexion-extension arc of the Muenster cast (139°). We found statistically significant differences for pronation and supination for all comparisons between immobilization methods, with the exception of the splints compared with each other. The least motion was found in the long-arm cast, whereas the Muenster cast offered the only option allowing minimal pronosupination without strict elbow immobilization.

**Conclusions:** The Muenster cast offers reasonable immobilization of the forearm without fully immobilizing the elbow. The long-arm cast option offers significantly more forearm stability at the cost of any elbow motion. The 2 splints tested do not effectively immobilize the forearm compared with the other modalities tested.

**Clinical relevance:** This study provides good biomechanical support for using a Muenster cast when limiting forearm rotation is desirable.

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**ABSTRACT:**

**Purpose:** There is a decrease in quadriceps muscle strength in subjects with patellofemoral pain syndrome. Various types of strengthening exercises of the quadriceps are done as part of its management, but the effect of isotonic eccentric quadriceps muscle exercises on
patellofemoral pain syndrome has not been studied. Hence the aim of this exploratory pilot study was to evaluate the effect of eccentric quadriceps training in patients with patellofemoral pain.

Methods: Twenty patients (12 female and 8 male, mean ages, 27.50 +/- 6.6 years) with patellofemoral pain syndrome were treated. The eccentric training of the quadriceps was given using a Baltimore Therapeutic Equipment (BTE) Primus machine. The main outcome measures used were percentage time on target as shown by the BTE primus machine, SF-36 Health questionnaire and patellofemoral pain severity scale. Statistical analysis was performed using SPSS 13.

Results: All the outcome measures showed significant improvements ($P<0.05$). Percentage time on target improved with a mean difference of 23.6, the SF-36 questionnaire showed an improvement in physical component score, mental component score and bodily pain with a mean difference of 10.9, 2.6 and 29.2 respectively and pain score when taken using patellofemoral severity scale also improved with a mean difference of 3.4.

Conclusion: Isotonic eccentric training of quadriceps muscles was found to be effective in reducing pain and improving the functional status of patients with patellofemoral pain syndrome and can be suggested as part of the treatment.

Use of Primus: musculoskeletal/neuromuscular treatment using isokinetic concentric/eccentric quad exercise with visual feedback/target (CPM mode) is effective in reducing pain and improving strength and function.


ABSTRACT:
Context: Researchers have observed that medial knee collapse is a mechanism of knee injury. Lower extremity alignment, sex, and strength have been cited as contributing to landing mechanics.

Objective: To determine the relationship among measurements of asymmetry of unilateral hip rotation (AUHR); mobility of the foot, which we described as relative arch deformity (RAD); hip abduction–external rotation strength; sex; and medial collapse of the knee during a single-leg jump landing. We hypothesized that AUHR and RAD would be positively correlated with movements often associated with medial collapse of the knee, including hip adduction and internal rotation excursions and knee abduction and rotation excursions.

Design: Descriptive laboratory study.

Setting: Research laboratory.

Patients or Other Participants: Thirty women and 15 men (age = 21 ± 2 years, height = 171.7 ± 9.5 cm, mass = 68.4 ± 9.5 kg) who had no history of surgery or recent injury and who participated in regular physical activity volunteered.

Intervention(s): Participants performed 3 double-leg forward jumps with a single-leg landing. Three-dimensional kinematic data were sampled at 100 Hz using an electromagnetic tracking system. We evaluated AUHR and RAD on the preferred leg and evaluated isometric peak hip
abductor–external rotation torque. We assessed AUHR by calculating the difference between internal and external hip rotation in the prone position (AUHR = internal rotation – external rotation). We evaluated RAD using the Arch Height Index Measurement System. Correlations and linear regression analyses were used to assess relationships among AUHR, RAD, sex, peak hip abduction–external rotation torque, and kinematic variables for 3-dimensional motion of the hip and knee.

**Main Outcome Measure(s):** The dependent variables were joint angles at contact and joint excursions between contact and peak knee flexion.

**Results:** We found that AUHR was correlated with hip adduction excursion ($R = 0.36, P = .02$). Asymmetry of unilateral hip rotation, sex, and peak hip abduction–external rotation torque were predictive of knee adduction excursion (adjusted $R^2 = 0.47, P < .001$). Asymmetry of unilateral hip rotation and sex were predictive of knee external rotation excursion (adjusted $R^2 = 0.23, P = .001$). The RAD was correlated with hip adduction at contact ($R^2 = 0.10, R = 0.32, P = .04$) and knee flexion excursion ($R^2 = 0.11, R = –0.34, P = .03$).

**Conclusions:** Asymmetry of unilateral hip rotation, sex, and hip strength were associated with kinematic components of medial knee collapse.

**Use of Primus: musculoskeletal evaluation of hip muscle strength.**


**ABSTRACT:**

**STUDY DESIGN:** Controlled laboratory study using a cross-sectional design.

**OBJECTIVES:** To characterize ankle and hip muscle performance in women with posterior tibial tendon dysfunction (PTTD) and compare them to matched controls. We hypothesized that ankle plantar flexor strength, and hip extensor and abductor strength and endurance, would be diminished in women with PTTD and this impairment would be on the side of dysfunction.

**BACKGROUND:** Individuals with PTTD demonstrate impaired walking abilities. Walking gait is strongly dependent on the performance of calf and hip musculature.

**METHODS:** Thirty-four middle-aged women (17 with PTTD) participated. Ankle plantar flexor strength was assessed with the single-leg heel raise test. Hip muscle performance, including strength and endurance, were dynamometrically measured. Differences between groups and sides were assessed with a mixed-model analysis of variance.

**RESULTS:** Females with PTTD performed significantly fewer single-leg heel raises and repeated sagittal and frontal plane non–weight-bearing leg lifts, and also had lower hip extensor and abductor torques than age-matched controls. There were no differences between sides for hip strength and endurance measures for either group, but differences between sides in ankle strength measures were noted in both groups.

**CONCLUSION:** Women with PTTD demonstrated decreased ankle and hip muscle performance bilaterally.

**Use of Primus: musculoskeletal evaluation of hip (isolated and isometric for strength and
Palmer TG, Uhl TL: Interday reliability of peak muscular power outputs on an isotonic dynamometer and assessment of active trunk control using the chop and lift tests. J Athl Train. 2011;46(2):150-159

ABSTRACT:
Context: Assessment techniques used to measure functional tasks involving active trunk control are restricted to linear movements that lack the explosive movements and dynamic tasks associated with activities of daily living and sport. Reliable clinical methods used to assess the diagonal and ballistic movements about the trunk are lacking.
Objective: To assess the interday reliability of peak muscular power outputs while participants performed diagonal chop and lift tests and maintained a stable trunk.
Design: Controlled laboratory study.
Setting: University research laboratory.
Patients or Other Participants: Eighteen healthy individuals (10 men and 8 women; age 5 32 6 11 years, height 5 168 6 12 cm, mass 5 80 6 19 kg) from the general population participated.
Intervention(s): Participants performed 2 power tests (chop, lift) using an isotonic dynamometer and 3 endurance tests (Biering-Sørensen, side-plank left, side-plank right) to assess active trunk control. Testing was performed on 3 different days separated by at least 1 week. Reliability was compared between days 1 and 2 and between days 2 and 3. Correlations between the power assessments and the Biering-Sørensen test (r range, -0.008 to 0.017) were low. The side-plank tests were moderately correlated with the chop (r range, 0.528 – 0.590) and the lift (r range, 0.359 – 0.467) tests.
Conclusions: The diagonal chop and lift power protocol generated reliable data and appears to be a dynamic test that simulates functional tasks, which require dynamic trunk control.

Use of Primus: musculoskeletal and treatment of functional tasks that require trunk stability. Reliability of peak muscular power measure established.

ABSTRACT: A cross-sectional, quantitative study of clinical measurement utility. New technological advances can challenge the efficacy of even the most widely accepted and respected tests. For example, grip strength instruments offer digital or computerized displays, precision scoring, and varied interfaces that differ from traditional Jamar™ dynamometers (Lafayette, IN). This test case explores how the opportunity to view grip strength scores during testing can influence outcomes. One hundred forty-six healthy subjects, aged 18-24 years, were tested for grip strength under visual feedback and no visual feedback conditions, using the JTech Grip Dynamometer (Salt Lake City, UT). Participants achieved a small, yet statistically significant, 1.74 lb stronger grip score with visual feedback ($p < 0.002$). The order of grip testing conditions yielded no statistically significant differences ($p = 0.559$). These findings suggest the need to consider how new features, unavailable with the analog Jamar™ dynamometer and unaccounted for in existing clinical guidelines could potentially influence grip scores. Level of evidence: Not applicable.

Use of Primus: musculoskeletal evaluation of grip strength with visual feedback.


ABSTRACT:

Background: Recent studies have suggested that excessive hip internal rotation during dynamic tasks may be associated with patellofemoral pain. Although diminished hip-muscle strength and altered femoral morphologic characteristics have been implicated in abnormal hip rotation in persons with patellofemoral pain, no study has confirmed this hypothesis.

Hypothesis: Women with patellofemoral pain would demonstrate increased average hip internal rotation, decreased hip-muscle performance, and abnormal femoral shape compared with controls. Furthermore, measures of hip strength and femoral shape are predictive of average hip internal rotation during running.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: Nineteen women with patellofemoral pain and 19 pain-free controls participated. Lower extremity kinematics during running, hip-muscle performance, and femoral morphologic characteristics on magnetic resonance imaging were quantified. Independent $t$ tests were used to assess group differences. Stepwise linear regression was used to determine whether measures of strength and/or structure were predictive of average hip internal rotation during running.

Results: Participants with patellofemoral pain demonstrated significantly greater average hip internal rotation ($8.2° \pm 6.6°$ vs $0.3° \pm 3.6°$; $P < .001$), reduced hip-muscle strength in 8 of 10 hip strength measurements, and greater femoral inclination ($132.8° \pm 5.2°$ vs $128.4° \pm 5.0°$; $P = .011$) compared with controls. Stepwise regression revealed that isotonic hip extension endurance was the only predictor of average hip internal rotation ($r = -.451$; $P = .004$).

Conclusion: Abnormal hip kinematics in women with patellofemoral pain appears to be the result of diminished hip-muscle performance as opposed to altered femoral structure. The
results suggest that assessment of hip-muscle performance should be considered in the evaluation and treatment of patellofemoral joint dysfunction.

**Use of Primus: musculoskeletal evaluation of muscle strength (isometric) of the hip.**


**ABSTRACT:**

**Study Design:** Controlled laboratory study using a cross-sectional design.
**Objectives:** To determine whether females with patellofemoral pain (PFP) demonstrate differences in hip kinematics, hip muscle strength, and hip muscle activation patterns when compared to pain-free controls.
**Background:** It has been proposed that abnormal hip kinematics may contribute to the development of PFP. However, research linking hip function to PFP remains limited.
**Methods and Measures:** Twenty-one females with PFP and 20 pain-free controls participated in this study. Hip kinematics and activity level of hip musculature were obtained during running, a drop jump, and a step-down maneuver. Isometric hip muscle torque production was quantified using a multimodal dynamometer. Group differences were assessed across tasks, using mixed-design 2-way analyses of variance and independent t tests.
**Results:** When averaged across all 3 activities, females with PFP demonstrated greater peak hip internal rotation compared to the control group (mean ± SD, 7.6° ± 7.0° versus 1.2° ± 3.8°; \( P < .05 \)). The individuals in the PFP group also exhibited diminished hip torque production compared to the control group (14% less hip abductor strength and 17% less hip extensor strength). Significantly greater gluteus maximus recruitment was observed for individuals in the PFP group during running and the step-down task.
**Conclusion:** The increased peak hip internal rotation motion observed for females in the PFP group was accompanied by decreased hip muscle strength. The increased activation of the gluteus maximus in individuals with PFP suggests that these subjects were attempting to recruit a weakened muscle, perhaps in an effort to stabilize the hip joint. Our results support the proposed link between abnormal hip function and PFP.

**Use of Primus: musculoskeletal evaluation of muscle strength and function of the hip (isometric, isotonic and isokinetic).**

ABSTRACT: Early identification of weakness or strength imbalance at the hip is important. The literature suggests that proximal lower extremity strength deficits may result in hazardous positioning of the knee joint and that early identification of muscular weakness may decrease the incidence of injury. Based on that, the purpose of the article is to present techniques for measurement of hip strength. Three categories that differ in terms of complexity: primary, secondary, and tertiary are defined.

Use of Primus: musculoskeletal evaluation. Cites ability to measure isometric, isotonic, and isokinetic single joint torque associated with either concentric or eccentric contractions for the purpose of evaluation and treatment. Applications for rehab, sports, work through isolated joint and muscle assessment to integrated, functional movements.


ABSTRACT: The new generation of wounded Warriors is vastly different from those seen in the past, and military occupational therapists (OTs) must adapt to the challenges to meet the needs of these young men and women. Three case reports will be presented demonstrating the adaptability and flexibility of military OTs serving the combat wounded Warrior. The first case report reviews the rehabilitation process of a Sailor who was hit by an improvised explosive device (IED) and sustained an open shrapnel wound to his left upper extremity. The second case report presents the complex rehabilitation process of a Soldier who sustained an open distal radius and carpal fractures with soft tissue loss to his left hand from a gunshot wound after his helicopter was shot down. The final case report represents a Soldier who was injured using a table saw while in Iraq and sustained lacerations to his left hand thumb, index, and ring fingers. These case reports represent some of the demands and challenges that military OTs face when treating the war casualty.

Use of Primus: musculoskeletal treatment to increase muscle strength of the upper extremity. (Case #1)


ABSTRACT: An inverse linear relationship exists between torque and velocity in the mid-ranges of an isotonic maximal contraction in a single joint movement (such as the elbow and knee). We hypothesized that submaximal effort does not produce a linear torque-velocity relationship because replicating a submaximal isotonic contraction requires an enormous amount of
 proprioceptive feedback and the nervous system may not be able to accurately replicate both force and speed of contraction. If this hypothesis is true, the torque-velocity test of the BTE Primus would be an effective method for assessing sincerity of effort. The purpose of this study was to examine if differences exist in the linear torque-velocity relationship between maximal and submaximal grip strength effort. Due to the fact that a test is not valid unless it is reliable, an additional purpose was to calculate the test-retest reliability of velocity during isotonic contraction using the torque-velocity test of the BTE Primus’ grip tool. Participants included 32 healthy, right-hand dominant (16 male, 16 female) persons, aged 20-50 years (mean age 25±8.0), with no history of upper-extremity injury. The subjects participated in two days of grip-strength testing (approximately two weeks apart) and were instructed to exert maximal effort with both hands on one day, and to feign injury with one hand on the other day. Each day included two sessions of testing, which consisted of performing the “torque-velocity test” on the BTE Primus grip attachment (#162). We randomly assigned the feigning hand (dominant vs. nondominant) and the effort (maximal vs. submaximal). The test administrator was blinded to the level of effort. On each day, four isotonic grip strength tests were performed at loads of 20%, 30%, 40%, and 50% of isometric test scores. Three repeated isotonic grip strength trials were performed at each load and the average was plotted. One plot was generated for the maximal effort and another for the submaximal efforts. Average torque was plotted against the average velocity at each of the four loads and for each level of effort (maximal vs. submaximal). The linear relationship of the torque-velocity curve was examined by performing regression analysis, calculating the intercept, slope, correlation coefficient (r), and the coefficient of determination (r2) for each curve. Paired t-tests were used to compare the intercept, slope, and r2 between maximal and submaximal efforts. Bonferroni correction set the alpha level at 0.0167. Sensitivity and specificity values were calculated for linearity (r2) and a Receiver Operator Characteristic (ROC) curve was constructed to obtain the optimal sensitivity and specificity combination. In addition, test-retest reliability was determined for velocity of maximal isotonic effort using Intraclass Correlation Coefficient. Significant differences between maximal and submaximal efforts were found for the intercept (t = 5.069; p<0.001) and for linearity as expressed by r2 (t = 5.414; p<0.001). Mean r2 was 0.89 for maximal effort and 0.53 for submaximal effort. The slopes of maximal and submaximal efforts were not significantly different (t = 0.14; p = 0.888). The ROC curve revealed the optimal combination of sensitivity (0.69) and specificity (0.72) values. Test-retest reliability of maximal isotonic grip effort for velocity was r = 0.843. The differences in intercepts suggested that velocity was greater during maximal effort. Greater r2 values indicated greater linearity for maximal efforts than submaximal efforts. These findings suggest that the torque-velocity test of the BTE Primus can distinguish between maximal and submaximal efforts during grip-strength testing. However, the test misclassified 31% of submaximal effort and 28% of maximal error, for a total error of 59%. Therefore, this test does not possess adequate sensitivity and specificity values to justify its use in the clinic.

Use of Primus: musculoskeletal evaluation of grip strength. Reliability of measures established.

ABSTRACT: Radial head fractures are the most common fractures in the elbow, and the treatment of nondisplaced fractures is often straightforward. However, radial head fractures with concurrent injury to the elbow stabilizers may require complex treatment and therapy that are targeted at specifically restoring elbow stability. This treatment of complex radial head fractures has recently improved because of long-term follow-up studies, increased biomechanical research on elbow stability, and improved surgical techniques. With an open line of communication between the surgeon and the therapist, an appropriate therapy plan can be initiated to protect both simple and complex injuries. The therapist should have knowledge of specific tissue healing and treatment techniques, and the patient must be educated in possible outcomes, safe arcs of motions, positioning, and proper splint use. This article summarizes current advanced techniques in the surgical management and rehabilitation of radial head fractures. Comprehensive protocols for decision making and treatment are introduced for both simple and complex radial head fractures.

*Use of Primus: musculoskeletal evaluation of strength and treatment for strengthening and functional task training.*

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Davila SA, Johnston-Jones K: **Managing the stiff elbow: Operative, nonoperative, and postoperative techniques.** J Hand Ther. 2006;19:268-281

ABSTRACT: Elbow contracture may be caused by intrinsic or extrinsic limitations or a combination of both. Evaluation of the specific structures guides the development of an effective therapy treatment program. Intrinsic contractures are by definition due to joint/intra-articular incongruency, and therefore therapy and splinting cannot provide increase in joint motion. Nonoperative therapy treatment options include heat modalities, myofascial soft tissue mobilization, joint mobilization, muscle energy techniques, passive range of motion, active range of motion, extensive use of corrective splinting, and strengthening exercise. All operative candidates must participate in a preoperative therapy program of six to eight weeks to reduce extrinsic contractures as feasible and to assess patient compliance with an intensive postoperative therapy program. Corrective splinting may be needed for as long as six months to maintain gains made in surgery. The therapy following manipulation under anesthesia and open contracture release is similar. The therapist must know the details of the procedure. Operative treatment for the stiff elbow progresses in a sequential fashion to progressively release tissue structures limiting motion and reconstruct any structures as needed to provide joint stability. Postoperative therapy consists of continuous passive motion, corrective splinting, modalities, and specific exercise techniques to maintain passive gains achieved in surgery. The therapy is extensive and requires full participation from the patient to maximize motion and function. Complications of elbow contracture release include nerve palsy or nerve injury, seroma, joint instability, heterotopic ossification, and recurrence of elbow contracture.

*Use of Primus: musculoskeletal treatment for strengthening and improved function.*
Strzelecki MV: *Worth the DRIVE*. OT Practice. 2006; Feb:9-10. (And Thesis)

ABSTRACT: This research study, conducted over nine months, used the BTE PrimusRS as a tool with an individual who has a high-level SCI (at the cervical level). The primary goal of this study was to increase the individual's functional ability so that he may return to driving independently with the least amount of vehicle adaptations. This was the first time that the BTE PrimusRS had been used for this purpose. Other goals of the program were to return to driving in order to: maximize existing musculature; increase global functional ability; minimize necessary adaptations; increase independence, quality of life, return to work, and social participation; and improve health. Using targeted force CPM for steering and braking and accelerating hand control was able to improve work output significantly as well as endurance. Percent increase in work performed during exercise: CW steering = 333%, CCW steering = 205%, push/brake = 694%, and pull/accelerate = 330%. Percent increase in endurance for steering = 736% and for braking-accelerating = 68%. Improvement in ADL Performance Scale scores.

*Use of Primus: musculoskeletal/neuromuscular evaluation and treatment using isokinetic concentric/ eccentric UE exercise with visual feedback/target (CPM mode) is effective in improving strength, endurance, and function. Integrated functional movements/task simulations. Progress charting.*


ABSTRACT:

**Introduction:** Fractures of the radial head and associated elbow instability can be treated with operation with radial head prosthesis. In this study, we evaluate function 1–7 years after implantation and also function after removal of five prostheses.

**Material and methods:** Eighteen patients with radial head fracture and associated elbow instability were evaluated 3.7 years (1–7) after implantation of a radial head prosthesis. Pain at rest and during activity was measured with a visual analogue scale (VAS). Test of stability and neurological examination was done manually as well as measurement of the range of motion, using a goniometer. Activity of daily living (ADL) was estimated using five questions where the answers were graded between 1 and 3. The patients were asked to grade their general satisfaction according to the following scale; very satisfied, satisfied, not satisfied, disappointed. Plain X-rays were taken and 14 patients agreed to have their elbow strength evaluated using the validated BTE work simulator (Primus).

**Results:** Five prostheses had been extracted due to poor range of motion. All these patients improved after extraction. All elbows were stable. No patient with extracted prosthesis had VAS score >2. The mean extension defect for this group was 15° (5–25) compared to the mean extension defect for the 13 patients with the prosthesis still in place 15° (0–40). The highest VAS score for the patients with prosthesis was five but the mean as low as 0.8. In the whole group, 13 patients were pain free. ADL function was good in general. The X-rays of the
prostheses, still in place, showed radiolucent lines in 7 of the 13 patients. In the whole group, there was a significant decrease in supination, flexion and extension strength (P<0.01, P<0.01, P<0.05).

**Discussion:** Radial head prosthesis works as a spacer after fracture of the radial head and associated instability. If range of motion is much restricted post-operatively, the prosthesis can be removed with improved function as result.

*Use of Primus: musculoskeletal evaluation of active ROM of the elbow/forearm.*


**ABSTRACT:**

**Context:** Contralateral muscular imbalances have been suggested to increase the risk of lower extremity injury. Previous groups have assessed strength of the quadriceps and hamstring muscle groups; however, no previous authors have compared bilateral hip-abductor muscular performance.

**Objective:** To examine the strength and fatigability of the hip abductors in the dominant and nondominant legs.

**Design:** Single-group, repeated-measures design.

**Setting:** Musculoskeletal laboratory.

**Patients or Other Participants:** Forty-two healthy subjects (23 males, 19 females; age = 24.3 ± 2.7 years, height = 173.4 ± 9.8 cm, mass = 73.7 ± 11.6 kg).

**Intervention(s):** Subjects performed three 5-second maximal voluntary isometric contraction (MVIC) trials of the hip abductors with the dominant and nondominant legs. Following the maximal strength trials, subjects performed a submaximal (50% of MVIC) 30-second fatigue trial with each leg.

**Main Outcome Measure(s):** Peak torque (PT) was recorded from each MVIC trial. Surface electromyography was used to record muscle activity during the fatigue trials. Power spectral analysis was used to determine the median frequency of each 0.512-second portion of the fatigue trials. Median frequencies were plotted against time, and linear regression was used to determine the median frequency slope (MFslope). Data were analyzed using 2-tailed, paired t tests.

**Results:** Hip-abduction PT of the dominant leg (81.0 ± 23.7 Nm) was significantly larger than that of the nondominant leg (76.1 ± 9.9 Nm, P = 0.02). There was no difference in MFslope between the dominant (20.37 ± 0.29) and nondominant limbs (20.35 ± 0.34, P = 0.84). The PT and MFslope were not significantly correlated (r = 20.07, P = 0.53).

**Conclusions:** Hip-abduction strength differences exist between the dominant and nondominant legs. Measures of strength and fatigability were poorly related; therefore, clinicians may opt to assess hip strength and fatigability independent of each another.

*Use of Primus: musculoskeletal evaluation of hip muscle isometric strength and fatigability.*
PR10 and PR20 specific:


ABSTRACT: Visual analogue scale has been shown to reflect subjective feelings but rarely has it been used for musculoskeletal fatigue so in the present study VAS ratings were used to quantify musculoskeletal fatigue. A total of 20 students underwent a fatigue protocol (M age=21.3 yr., SD= 1.0). A series of randomized external loads at 0, 5, 10, 15, 25, 35, and 50% of the maximum voluntary contraction was generated by the BTE Primus and applied at the distal end of the dominant arm, which was sustained at the 90° forward flexion position. After 60 sec. of force exertion for each loading, the subject marked the scale to reflect their extent of fatigue at the shoulder muscle. Analysis showed fatigue scores were significantly correlated with the percentage of maximum load applied (r = .73, p 5.01). The correlation between higher external loads (25-50% maximum load) and fatigue scores was .57 (p 1.01) and that for lower external loads (0-15% maximum load) was .44 (p 2.01). The validity of using a visual analogue scale as a measure of musculoskeletal fatigue requires further study, particularly for a low load.

Use of Primus: musculoskeletal evaluation of muscle strength and endurance (isometric) of the shoulder.

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ABSTRACT: This study was designed to examine the reliability and validity of the newly designed grip tool of the BTE Primus and to investigate the effects of body position (sit versus stand), handedness, and fatigue on grip strength. The subjects performed maximal grip strength tests using the Jamar dynamometer and the BTE Primus. Intraclass correlation coefficients were calculated for test-retest reliability and criterion-related validity. A repeated measures analysis of covariance was conducted to reveal differences in grip strength between instruments, body positions, hands, and sessions. The BTE Primus grip tool was found to be reliable (r = 0.97 to 0.98) and valid (r = 0.95 to 0.96). There were no significant differences in grip strength scores between the Jamar and the BTE Primus or between sitting and standing. Grip strength scores of the right hand were significantly greater than those of the left hand, and grip strength scores in the first session were significantly greater than those of the second session. The results of this study indicate that clinicians can use the BTE Primus grip attachment at the second handle setting and know that it is reliable, valid, and comparable to the second handle setting of the Jamar dynamometer.

Use of Primus: musculoskeletal evaluation of grip strength. Reliability of measures established. Validity of attachments and measures established.

ABSTRACT: The purpose of this article is to familiarize therapists with the diagnosis, clinical presentations, surgical interventions, and therapy considerations for patients diagnosed with Madelung’s deformity. Madelung’s deformity is a deformity of the distal forearm and wrist caused by premature closing of the palmar and ulnar portion of the distal radius epiphysis. As the radial portion of the physis continues to grow, dorsal and radial bowing of the radius develops. A host of other changes follow, which alter the normal biomechanics of the distal radioulnar joint and carpus. Consequently, there typically is decreased range of motion for supination, ulnar deviation, and extension and decreased grip strength. The presenting complaint is usually pain, typically on the ulnar side of the wrist.1–3 A variety of surgical approaches exist for this deformity; many of these are discussed later. The cause and radiologic presentation of Madelung’s deformity also are reviewed.

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ABSTRACT:

**Objective:** To explore the degree of consistency in a subject’s performance in physical strength and endurance.

**Design:** Thirty healthy men, aged 19 to 26 yr, were recruited to participate in protocols to assess static strength and dynamic endurance tests on their upper limbs with the Baltimore Therapeutic Equipment Primus. Retests were conducted 7 days after the initial test.

**Results:** The intraclass correlation coefficients were 0.71 to 0.97 and 0.32 to 0.90 for static and dynamic endurance strengths, respectively. These results indicated that the consistency of the subjects’ performance across occasions was high for testing static strength, although it was more varied for testing endurance strength.

**Conclusions:** Higher consistency was observed among subjects in the assessment of static strength than dynamic endurance strength. The range of motion traveled by the limb, speed of performance, and ergonomic design of attachments seemed to confound the subjects’ performance on the instrument. Stringent assessment protocols, ergonomically designed hardware, and clear instructions and practice trials before the formal testing were essential to maximize the subjects’ consistency of performance. The results of this study were applicable and generalized to other performance-based instruments for physical and functional capacity evaluation and work simulators.

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**Use of Primus: musculoskeletal evaluation of upper extremity (isolated and integrated isometric, isotonic). Reliability of measures established.**

**ABSTRACT:**

**PURPOSE:** This study established a work profile and functional capacity for formwork carpenters (FCs) working at construction sites.

**METHOD:** Thirty male FCs aged 19-45 were recruited by convenient sampling from the construction training centres. All FCs participated in an interview/questionnaire and a standardized functional capacity evaluation (FCE) using the Baltimore Therapeutic Equipment Primus (BTE Primus) and Valpar Component Work Sample (VALPAR19). Thirty male adults (office workers) aged 19-45 participated in the exact FCE for comparison.

**RESULTS:** The results of the questionnaire indicated that the job demands of formwork carpenters were frequent lifting (46.7%), carrying (50.0%) and handling (60.0%). Significantly higher lifting and carrying capacities were revealed among the FCs, but not in their isometric strengths and the endurance of the upper limbs (chi2 = 6.48, df = 2, p < 0.05).

**CONCLUSIONS:** The dynamic and repetitive sub-maximal nature of the work of formwork carpentry induced an elevation of job-specific lifting and carrying capacities among the FCs. The job and functional capacity profiles would be useful for formulating guidelines for the rehabilitation of injured workers and the training of new workers in the trade.

*Use of Primus: musculoskeletal evaluation of muscle strength when performing functional/work-related tasks (as is required for an FCE).*

Shechtman O, MacKinnon L, Locklear C: **Using the BTE Primus® to measure grip and wrist flexion strength in physically active wheelchair users: An exploratory study.** Am J Occup Ther. 2001;55:393-400

**ABSTRACT:**

**Objective:** The purpose of this study was to establish test-retest reliability values for the newly designed grip and wrist attachments of the BTE Primus® and to determine criterion-related validity of the new grip attachment against the Jamar dynamometer. An additional purpose was to explore the difference in grip and wrist flexion strength between wheelchair users and control participants without disabilities and to examine the effect of body position on strength in persons without disabilities.

**Method:** Wheelchair users and matched controls (13 per group)) were tested for grip and wrist flexion strength on the BTE Primus and for grip on the Jamar dynamometer.

**Results:** The BTE Primus grip attachment was found to be valid and reliable. No significant differences were found in static and dynamic grip or wrist flexion strength between the two groups or in the sitting versus standing position for the control group.

**Conclusion:** The findings suggest that the BTE Primus may be used to assess grip and wrist flexion strength validly and reliably for both wheelchair users and persons without disabilities.

*Use of Primus: musculoskeletal evaluation of grip and wrist flexion strength. Reliability of measures established. Validity of attachments and measures established.*
ABSTRACT: Theories on the etiology of reflex sympathetic dystrophy (RSD) are reviewed and presented in three categories: peripheral, spinal, and supraspinal. The peripheral pathophysiology involves a prolonged inflammatory response to injury due to the axon reflex with release of vasoactive neuropeptides and sensitized nociceptors. The spinal component of RSD genesis involves nociceptive spinal cord neurons with lowered thresholds due to chronic pain input. These sensitized spinal neurons respond in turn by signaling pain reflexes through the sympathetic system. A physical-emotional diathesis may predispose individuals to respond to stress through autonomic arousal. Autonomic arousal, coupled with injury, signals the supraspinal influence on this syndrome. Since the puzzle of RSD remains to be solved, measurement and treatment strategies are suggested to provide intervention at each level. Measurement techniques should include a battery of static tests and stress tests. Static tests are used to quantify a physiological parameter at one point in time. Stress tests access physiological response to various neuro-vaso-motor challenges. A "hands off" treatment regime is presented that includes pain control, methods to reset sensory thresholds, vasomotor challenges, and an active motion program.

Use of Primus: musculoskeletal treatment of upper extremity using continuous passive mode (isokinetic mode) for gentle rocking, not stretching, of the least-involved extremity joints to enable early motion without pain.

Supporting Evidence:


ABSTRACT: The purpose of this study was to examine the effect of an 8-week concentric (CON) versus eccentric (ECC) isokinetic training program on the electromyography (EMG) signal amplitude of vastus medialis (VM), vastus lateralis (VL) and rectus femoris (RF). Also, the isometric (ISO) and dynamic maximum strength of the knee extensors were assessed. Eighteen physically healthy male subjects (age 22 ± 1 years, body height 177 ± 4 cm, body mass 73 ± 7 kg) performed four weeks of unilateral CON isokinetic training for the quadriceps of the dominant leg on a REV9000 dynamometer. At the end of the fourth week, the sample was divided into two groups, with one group performing additional four weeks of unilateral ECC training and the other continuing with CON training. The training sessions consisted of three sets of ten maximal repetitions at a velocity of 60ºs-1, three days per week for eight weeks. The results showed that CON and ECC groups improved the peak torque in all types of contractions. Also, both groups presented increases in the avgEMG for VL, VM and RF. The present investigation showed that CON training elicited increases of the ISO peak torque and VM avgEMG in the CON contraction. Additionally, significant gains were reported after the ECC training on the VM avgEMG in all contractions and RM avgEMG in CON contraction.
Chen CH, Chen TC, Jan MH, Lin JJ: **Acute effects of static active or dynamic active stretching on eccentric exercise-induced hamstring muscle damage.** Int J Sports Physiol Perform. 2014;Sep 17 (Epub)

**ABSTRACT**

**Objectives:** The purpose of this study was to examine whether an acute bout of active or dynamic hamstring stretching exercises to reduce the amount of muscle damage observed after a strenuous eccentric task and to determine whether the stretching protocols elicit similar responses.

**Design:** A randomized controlled clinical trial.

**Methods:** Thirty-six young male students performed 5 minutes of jogging as a warm-up and were allocated to one of three groups: 3 minutes of stretching (static active stretching (SAS), 3 minutes of dynamic active stretching (DAS), or control (CON). All subjects performed eccentric exercise immediately after stretching. Heart rate (HR), core temperature (CT), maximal voluntary isometric contraction (MVIC), passive hip flexion, passive hamstring stiffness (PHS), plasma creatine kinase (CK) activity, and myoglobin (Mb) were recorded at pre-stretching, at post-stretching, and on every day following the eccentric exercises for 5 days.

**Results:** After stretching, the change in hip flexion was significantly higher in the SAS (5°) and DAS (10.8°) groups than in the CON (-4.1°) group. The change in PHS was significantly higher in the DAS (5.6%) group than in the CON (-5.7%) and SAS (-6.7%) groups. Furthermore, changes in muscle damage markers were smaller in the SAS group than in the DAS and CON groups.

**Conclusions:** Prior active stretching application could be useful for attenuating the symptoms of muscle damage after eccentric exercise. SAS is recommended over DAS as a stretching protocol in terms of strength, hamstring ROM, and damage markers.

Farup J, Sorensen H, Kjolhede T: **Similar changes in muscle fiber phenotype with differentiated consequences for rate of force development: Endurance versus resistance training.** Human Movement Sci. 2014;34:109-119

**ABSTRACT:** Resistance training has been shown to positively affect the rate of force development (RFD) whereas there is currently no data on the effect of endurance training on RFD. Subjects completed ten weeks of either resistance training (RT, n = 7) or endurance cycling (END, n = 7). Pre and post measurements included biopsies obtained from m. vastus lateralis to quantify fiber phenotype and fiber area and isokinetic dynamometer tests to quantify maximal torque (Nm) and RFD (Nm/s) at 0–30, 0–50, 0–100 and 0–200 ms during maximal isometric contraction for both knee extensors and flexors. Both groups increased the area percentage of type IIa fibers (p < .01) and decreased the area percentage of type IIx fibers (p = .05), whereas only RT increased fiber size (p < .05). RT significantly increased eccentric, concentric and isometric strength for both knee extensors and flexors, whereas END did not. RT increased 200 ms RFD (p < .01) in knee flexor RFD and a tendency towards an increase at 100 ms (p < .1), whereas tendencies towards decreases were observed for the END group at 30, 50 and 100 ms (p < .1), resulting in RT having a higher RFD than END at post (p < .01). In
conclusion, resistance training may be very important for maintaining RFD, whereas endurance training may negatively impact RFD.


ABSTRACT:
Introduction: We quantified submaximal torque regulation during low to moderate intensity isometric hip flexion contractions in individuals with stroke and the associations with leg function.

Methods: Ten participants with chronic stroke and 10 controls performed isometric hip flexion contractions at 5%, 10%, 15%, 20%, and 40% of maximal voluntary contraction (MVC) in paretic, non-paretic, and control legs.

Results: Participants with stroke had larger torque fluctuations (coefficient of variation, CV), for both the paretic and non-paretic legs, than controls ($P<0.05$) with the largest CV at 5% MVC in the paretic leg ($P<0.05$). The paretic CV correlated with walking speed ($r^2=0.54$) and Berg Balance Score ($r^2=0.40$). At 5% MVC, there were larger torque fluctuations in the contralateral leg during paretic contractions compared with the control leg.

Conclusions: Impaired low-force regulation of paretic leg hip flexion can be functionally relevant and related to control versus strength deficits post-stroke.


ABSTRACT:
BACKGROUND: Torque and power-velocity relationships obtained during isokinetic evaluation can be useful for rehabilitation program. Nevertheless, their determination requires a substantial number of measures using different velocities, inducing time-consuming protocols.

OBJECTIVE: The aim of the present study was to assess the agreement between a short isokinetic protocol, including three angular velocities (P3) and a longer one including eight angular velocities (P8).

METHODS: Sixteen healthy male subjects performed isokinetic knee extensions at several preset velocities during two protocols. The first included eight velocities ranging from 60 to 270°/s (P8), whereas the second (P3) consisted of three velocities (90, 180 and 240°/s).

Mechanical parameters: theoretical maximal isometric torque ($T_0$), theoretical maximal velocity ($V_0$), and maximal power ($P_{max}$), were extrapolated from torque- and power-velocity relationships for both P8 and P3.
RESULTS: The torque- and power velocity relationships drawn from each protocol were in agreement since no significant differences were found for either each extrapolated mechanical parameters, between the slopes of the torque-velocity relationships, or between the polynomial regression coefficients of the power-velocity relationships resulting from P8 and P3.

CONCLUSION: The agreement between the short and long protocols allows reduction of fatigue and loss of motivation that may occur during full velocities testing particularly during rehabilitation program.


ABSTRACT:
OBJECTIVE: To analyse treatment effects of eccentric vs. concentric graded exercise in chronic tennis elbow.
DESIGN: Randomized controlled trial.
SETTING: Primary care in Uppsala County, Sweden.
SUBJECTS: A total of 120 subjects with tennis elbow lasting more than three months were recruited from primary care and by advertisement.
INTERVENTION: Eccentric (n = 60) or concentric exercise (n = 60), by lowering or lifting a weight, at home daily, for three months with gradually increasing load.
MAIN MEASURES: Pain during muscle contraction and muscle elongation, as well as strength, was assessed at baseline and after one, two, three, six, and 12 months. Function and quality of life was assessed at baseline and after three, six and 12 months.
RESULTS: The eccentric exercise group had faster regression of pain, with an average of 10% higher responder rate at all levels of pain reduction, both during muscle contraction and elongation, (p < 0.0001 and p = 0.006, respectively). Significant differences were found in Cox's analysis from two months onwards (HR 0.78, 95% confidence interval (CI) 0.63-0.96, p < 0.02). This represents an absolute pain reduction of 10% in the eccentric vs. the concentric group and a number-needed-to-treat of 10. The eccentric group also had a greater increase of muscle strength than the concentric (p < 0.02). The differences persisted throughout the follow-up period. There were no significant differences between the groups regarding function or quality of life measures.
CONCLUSION: Eccentric graded exercise reduced pain and increased muscle strength in chronic tennis elbow more effectively than concentric graded exercise.

ABSTRACT:

Background: Localized exercises are widely used in rehabilitation processes. The predominant options are exercises with an emphasis on either concentric or eccentric contractions. Eccentric exercises promote greater strength gains compared to classical concentric stimuli, but can cause muscle damage. The aim of present study was to compare strength training composed of 10 sessions with progressive loads between groups with a predominance of concentric versus eccentric contraction through an analysis of isotonic strength, pressure pain threshold, creatine kinase, tumor necrosis factor-alpha and cortisol.

Methods: One hundred twenty male subjects were divided into four groups: C1 and E1 – single session of maximum strength with emphasis on concentric and eccentric contraction, respectively; C10 and E10 – 10 sessions with progressive loads from 80% to maximum strength with emphasis on concentric and eccentric contraction, respectively.

Results: Isotonic strength increased by 10% in E10 following the ten training sessions. C1 and E1 exhibited a lower pressure pain threshold 48 hours after the sessions in comparison to C10 and E10, respectively. Creatine kinase was increased in C1 in comparison to baseline, with significant differences (p ≤ 0.05) in comparison to E1 at 48 and 96 hours as well as C10 at 48, 72 and 96 hours. No significant differences were found in TNF-α or cortisol among the groups or evaluation times.

Conclusion: Eccentric contraction training promotes functional adaptation. Moreover, both concentric and eccentric contraction training have a protective effect on the muscle in relation to a single session of maximum strength exercise.

Clark DJ, Patten C: Eccentric versus concentric resistance training to enhance neuromuscular activation and walking speed following stroke. Neurorehabil Neural Repair. 2013;27(4):335-344

ABSTRACT:

Background. Impaired voluntary neuromuscular activation of agonist muscles is a primary determinant of weakness and motor dysfunction following stroke.

Objective. To determine whether eccentric resistance training (ECC) resistance training is superior to concentric resistance training (CON) resistance training to enhance neuromuscular activation, strength, and walking speed after stroke.

Methods. A total of 34 adults post-stroke participated in a staged intervention comprising (1) either CON-only or ECC-only resistance training of the paretic leg followed by (2) gait training. Changes in voluntary neuromuscular activation and power were assessed for both the trained paretic and untrained non-paretic legs. Self-selected and fast walking speeds were also assessed.

Results. In response to resistance training, the ECC group experienced larger improvements in neuromuscular activation of paretic leg muscles, rectus femoris and vastus medialis (P < .005), and the largest gains in paretic leg power (+74% for ECC contractions, P < .0001). ECC also had greater cross-education of increased power to the untrained non-paretic leg (12%-14%, P = .006). Over the course of gait training, much of the gain in paretic leg activation in the ECC group was lost, such that the net change in agonist activation was comparable between the
CON and ECC groups when the full intervention was completed. Nevertheless, improvement in walking speed post-intervention was more prevalent in the ECC than CON group.

**Conclusion.** ECC resistance training was more effective for improving bilateral neuromuscular activation, strength, and walking speed following stroke. Future research should assess whether a longer duration ECC training program can provide further benefit.

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**ABSTRACT:**

**Background:** Neuromuscular alterations have been reported for patients with osteoarthritis of the hip joint; however, the underlying cause associated with altered gluteus medius muscle function has not been examined. This study assessed electromyographic amplitudes of the gluteus medius muscles during function in patients with unilateral end-stage osteoarthritis of the hip joint compared to controls.

**Methods:** Patients with unilateral end-stage hip joint osteoarthritis (n = 13) and asymptomatic control participants (n = 17) participated. Average root-mean squared muscle amplitudes represented as a percent of maximum voluntary isometric contraction for both the involved and uninvolved limb gluteus medius muscles were analyzed during step up, step down, and gait. The association between muscle activation and impact forces during stepping tasks was assessed.

**Findings:** Patients with hip osteoarthritis exhibited increased gluteus medius muscle electromyographic amplitudes bilaterally during stair ascent, stair descent, and gait compared to controls, regardless of which limb they led. Involved limb muscle activity was inversely related to impact force during step down onto the ipsilateral limb.

**Interpretation:** Patients with hip osteoarthritis demonstrated increased gluteus medius muscle activation levels during stepping tasks and gait when compared to controls. The increased activation is most likely a compensatory response to muscle weakness. Therefore, application of strengthening exercises which target the gluteal muscles should assist in neuromuscular control and result in improved strength for patients with hip joint osteoarthritis.

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**ABSTRACT:** *Eccentric* (ECC) exercise is classically used to improve muscle strength and power in healthy subjects and athletes. Due to its specific physiological and mechanical properties, there is an increasing interest in employing ECC muscle work for rehabilitation and
clinical purposes. Nowadays, ECC muscle actions can be generated using various exercise modalities that target small or large muscle masses with minimal or no muscle damage or pain. The most interesting feature of ECC muscle actions is to combine high muscle force with a low energy cost (typically 4- to 5-times lower than concentric muscle work) when measured during leg cycle ergometry at a similar mechanical power output. Therefore, if caution is taken to minimize the occurrence of muscle damage, ECC muscle exercise can be proposed not only to athletes and healthy subjects, but also to individuals with moderately to severely limited exercise capacity, with the ultimate goal being to improve their functional capacity and quality of life. The first part of this review article describes the available exercise modalities to generate ECC muscle work, including strength and conditioning exercises using the body's weight and/or additional external loads, classical isotonic or isokinetic exercises and, in addition, the oldest and newest specifically designed ECC ergometers. The second part highlights the physiological and mechanical properties of ECC muscle actions, such as the well-known higher muscle force-generating capacity and also the often overlooked specific cardiovascular and metabolic responses. This point is particularly emphasized by comparing ECC and concentric muscle work performed at similar mechanical (i.e., cycling mechanical power) or metabolic power (i.e., oxygen uptake, VO2). In particular, at a similar mechanical power, ECC muscle work induces lower metabolic and cardiovascular responses than concentric muscle work. However, when both exercise modes are performed at a similar level of VO2, a greater cardiovascular stress is observed during ECC muscle work. This observation underlines the need of cautious interpretation of the heart rate values for training load management because the same training heart rate actually elicits a lower VO2 in ECC muscle work than in concentric muscle work. The last part of this article reviews the documented applications of ECC exercise training and, when possible, presents information on single-joint movement training and cycling or running training programs, respectively. The available knowledge is then summarized according to the specific training objectives including performance improvement for healthy subjects and athletes, and prevention of and/or rehabilitation after injury. The final part of the article also details the current knowledge on the effects of ECC exercise training in elderly populations and in patients with chronic cardiac, respiratory, metabolic or neurological disease, as well as cancer. In conclusion, ECC exercise is a promising training modality with many different domains of application. However, more research work is needed to better understand how the neuromuscular system adapts to ECC exercise training in order to optimize and better individualize future ECC training strategies.


ABSTRACT: The prescription of an effective therapeutic exercise program requires the right dosage of the right exercise, at the right time for that patient. The therapist must understand and apply training principles effectively in the presence of pathology, injury, or otherwise unhealthy tissue. The intervention goal is to close the gap between current performance and the desired goal or capacity. Although there may be a preferred linear path from current performance to optimal outcome, complexities of the human body, internal factors, and external variables may create barriers to this direct path. Successful programs include key program design
considerations such as ensuring a stable baseline before progression, treating the right impairments and activity limitations, understanding contextual factors, considering the principles of specificity and optimal loading, and applying dosing principles. Program progression can be achieved through increases in total exercise volume and/or through manipulation of exercise challenges at the same exercise volume. Effective application of these principles will guide patients toward their goals as quickly and efficiently as possible.


ABSTRACT: This study investigated whether low-intensity eccentric contractions of the knee extensors would attenuate the magnitude of muscle damage induced by maximal eccentric exercise of the same muscle performed 7 days later using elderly individuals. Healthy older men (66.4 ± 4.6 years) were assigned to control or experimental (Exp) group (n = 13 per group). The control group performed six sets of ten maximal eccentric contractions (MaxECC) of the knee extensors of non-dominant leg. The Exp group performed six sets of ten low-intensity eccentric contractions of the knee extensors on a leg extension machine by lowering a weight of 10% maximal voluntary isometric knee extension strength (10%ECC) 7 days prior to MaxECC. Changes in maximal voluntary isokinetic concentric torque (MVC-CON), angle at peak torque, range of motion (ROM), upper thigh circumference, muscle soreness, plasma creatine kinase activity and myoglobin (Mb) concentration and B-mode ultrasound echo-intensity before and for 5 days after MaxECC were compared between groups by a mixed factor ANOVA. No significant changes in any variables were observed following 10%ECC. Following MaxECC, all variables changed significantly, and changes in all variables except for angle at peak torque were significantly different between groups. MVC-CON and ROM decreased smaller and recovered faster (P<0.05) for Exp than control group, and changes in other variables were smaller (P<0.05) for Exp group compared with control group. These results suggest that pre-conditioning knee extensor muscles with low-intensity eccentric contractions was effective for attenuating muscle damage induced by subsequent MaxECC of the knee extensors for elderly individuals.


ABSTRACT:
Purpose: the aim of this article was to review the clinical approach of quadriceps strengthening programmes.
Methods: a literature search was carried out from 1980 up to September 2011. Eligible studies
were those that: (1) evaluated the patients with patellofemoral pain syndrome (not healthy or asymptomatic subjects) (2) examined the effect of kinetic chain exercises (3) examined the effect of weight-bearing exercises (4) compared the effect of the combined exercises programme in the treatment of patients with patellofemoral pain syndrome.

Results and conclusion: patients with patellofemoral pain syndrome may tolerate a closed kinetic chain exercises programme better than open kinetic chain. Weight-bearing and non-weight-bearing quadriceps exercises can significantly improve subjective and clinical outcomes in patients with patellofemoral pain syndrome. Combining treatments as an initial approach to treating patellofemoral pain but developing individualized more functional, global treatments are essential.


ABSTRACT:
Introduction: We compared the effects of eccentrically biased (EB) and conventional (CONV) resistance training on muscle architecture, one-repetition maximum (1RM), isometric strength, isokinetic force–velocity characteristics, functional capacity, and pulse wave velocity in older men and women.

Methods: Twenty-eight older adults participated in the study (mean ± SD: age = 68 ± 5 yr). Of these, 13 were allocated to a waitlist control, 10 of whom progressed to training (CONV, n = 12; EB, n = 13). Training was twice a week for 16 wk. EB involved three sets of 10 concentric lifts at 50% of 1RM with the eccentric portion of repetitions performed unilaterally, alternating between limbs with each repetition. CONV involved two sets of 10 repetitions at 75% of 1RM. EB and CONV were matched for total work. Isokinetic knee extensor strength was assessed across a range of velocities (0–360°·s⁻¹). Functional capacity was assessed via a 6-m fast walk test, a timed up and go test, stair climb and descent power test, and vertical jump test. Vastus lateralis and gastrocnemius medialis architecture were assessed using ultrasonography.

Results: Both EB and CONV improved 1RM (Δ23%–35%, P < 0.01). Compared to the control group, both training regimens improved 6-m fast walk (Δ5%–7%, P < 0.01) and concentric torque at 60 and 120°·s⁻¹ (Δ6%–8%, P < 0.05). Significant improvements were evident in EB for isometric and concentric torque at 240 and 360°·s⁻¹ (Δ6%–11%, P < 0.05), vastus lateralis thickness (Δ5%, P < 0.05), and stair climb (Δ5%, P < 0.01). Timed up and go (Δ5%, P < 0.01), stair descent (Δ4%, P < 0.05), and vertical jump (Δ7%, P < 0.01) improved in CONV. Pulse wave velocity, pennation angle, and fascicle length remained unchanged in both training groups.

Conclusions: EB seems superior to CONV at increasing torque at high contraction velocities, whereas CONV seems more effective at improving some functional performance measures and vertical jump. This has important implications for preserving functional capacity.

**ABSTRACT:** Thirty-four untrained women participated in a 6-week program to investigate slow-speed versus “normal” speed resistance-training protocols. Subjects were divided into: slow-speed (SS), normal-speed/traditional-strength (TS), normal-speed/traditional muscular endurance (TE), and non-exercising control (C) groups. Leg press, squats, and knee extensions were performed 2 days/week for the first week and 3 days/week for the remaining 5 weeks (~2 min rest). The SS group performed 6–10 repetitions maximum (6–10RM) for each set with 10 s concentric (con) and 4 s eccentric (ecc) contractions. The TS and TE groups performed sets of 6–10RM and 20–30RM, respectively, at “normal” speed (1–2 s/con and ecc contractions). TE and SS trained at the same relative intensity (~40–60% 1RM), whereas TS trained at ~80–85% 1RM. Pre- and post-training muscle biopsies were analyzed for fiber-type composition, cross-sectional area (CSA), and myosin heavy chain (MHC) content. The percentage of type IIX fibers decreased and IIAX increased in all three training groups. However, only TS showed an increase in percentage of type IIA fibers. CSA of fiber types I, IIA, and IIX increased in TS. In SS, only the CSA of IIA and IIX fibers increased. These changes were supported by MHC data. No significant changes for any parameters were found for the C group. In conclusion, slow-speed strength training induced a greater adaptive response compared to training with a similar resistance at “normal” speed. However, training with a higher intensity at “normal” speed resulted in the greatest overall muscle fiber response in each of the variables assessed.


**ABSTRACT:**

**Purpose/Background:** Patellofemoral pain syndrome (PFPS) is one of the most common and clinically challenging knee pathologies. Historically, clinicians have used a myriad of interventions, many of which have benefited some but not all patients. Suboptimal outcomes may reflect the need for an evidence-based approach for the treatment of PFPS. The authors believe that integrating clinical expertise with the most current scientific data will enhance clinical practice. The purpose of this systematic review is to provide an update on the evidence for the conservative treatment of PFPS.

**Methods:** The PubMed, CINAHL, and SPORTDiscus databases were searched for studies published between January 1, 2000 and December 31, 2010. Studies used were any that utilized interventions lasting a minimum of 4 weeks for subjects with PFPS. Data were examined for subject sample, intervention duration, intervention type, and pain outcomes.

**Results:** General quadriceps strengthening continues to reduce pain in patients with PFPS. Data are inconclusive regarding the use of patellar taping, patellar bracing, knee bracing, and foot orthosis. Although emerging data suggest the importance of hip strengthening exercise,
ongoing investigations are needed to better understand its effect on PFPS.

**Conclusions:** Current evidence supports the continued use of quadriceps exercise for the conservative management of PFPS. However, inconsistent or limited data regarding the other interventions precluded the authors’ ability to make conclusive recommendations about their use. Future investigations should focus on identifying cohorts of patients with PFPS who may benefit from the other treatment approaches included in this systematic review.


ABSTRACT:
Previous studies attempted to compare the effectiveness of isokinetic and isotonic training. However, they have provided conflicting results. The purpose of this study was to compare the effects of isotonic versus isokinetic standardized concentric strength training programs of the knee extensors on the neuromuscular system. The standardization of these two training programs was ensured by the equalization of the total external amount of work performed and the mean angular movement velocity. Thirty healthy male students were randomly assigned to the isotonic (IT; n = 11), the isokinetic (IK; n = 11) or the control (C; n = 8) group. Both IT and IK groups trained their dominant lower leg 3 sessions/week for 8 weeks on a dynamometer. The IT group exercised using a preset torque of 40% of the maximal voluntary isometric torque at 70° (0° = leg in horizontal position). The IK group exercised at a velocity ranging between 150° and 180° s⁻¹. Isotonic, isokinetic and isometric tests were performed on a dynamometer before and after strength training. Surface electromyographic activity of vastus lateralis, vastus medialis, rectus femoris, semitendinosus and biceps femoris muscles was recorded during the tests. Significant strength increases in both dynamic and static conditions were noticed for IT and IK groups without any significant difference between the two trained groups. Agonist muscle activity also increased with training but no change in antagonist muscle co-activity was observed. The two training methods could be proposed by clinicians and athletic coaches to improve concentric muscle strength in dynamic and static conditions.


ABSTRACT:
**Background:** Concern has been expressed that preventive measures in older people might increase frailty by increasing survival without improving health. We investigated the impact of exercise on the probabilities of health improvement, deterioration and death in community-dwelling older people.

**Methods and Principal Findings:** In the Canadian Study of Health and Aging, health status
was measured by a frailty index based on the number of health deficits. Exercise was classified as either high or low/no exercise, using a validated, self-administered questionnaire. Health status and survival were re-assessed at 5 years. Of 6297 eligible participants, 5555 had complete data. Across all grades of frailty, death rates for both men and women aged over 75 who exercised were similar to their peers aged 65 to 75 who did not exercise. In addition, while all those who exercised had a greater chance of improving their health status, the greatest benefits were in those who were more frail (e.g. improvement or stability was observed in 34% of high exercisers versus 26% of low/no exercisers for those with 2 deficits compared with 40% of high exercisers versus 22% of low/no exercisers for those with 9 deficits at baseline).

**Conclusions:** In community-dwelling older people, exercise attenuated the impact of age on mortality across all grades of frailty. Exercise conferred its greatest benefits to improvements in health status in those who were more frail at baseline. The net effect of exercise should therefore be to improve health status at the population level.


**ABSTRACT:** The velocity-specificity principle in training is well established by studies applying isokinetic training devices. However, the contraction velocity during customary resistance training using barbells is rarely stable and can be manipulated in several ways. By manipulating load and intention of movement, the significance of contraction velocity during barbell training on gains in strength-related parameters was investigated. Twenty-seven subjects (divided into 3 experimental groups) performed standardized biceps curls 3 times a week for 3 weeks under the following conditions: high load and slow contraction velocity (HS), high load and fast contraction velocity (HF), and low load with fast contraction velocity (LF). Twelve subjects received no intervention, serving as controls (C). Elbow flexion strength was tested before and after the training period at both isometric and 4 isokinetic contraction velocities (30, 90, 240 and 300°/sec) using a dynamometer. Rate of force development (RFD) was calculated in 100 millisecond epochs from isometric torque curves. Increased maximal isometric strength was seen in HF (9.7%), whereas HS improved slow isokinetic strength (8.5%). There were no improvements in force performance for LF and C. In none of the groups were changes in RFD observed. These findings support the principle of training specificity, highlighting the importance of details concerning contraction velocity on the outcome of resistance training using free weights.

Knudson DV: **Correcting the use of the term “power” in the strength and conditioning literature.** J Strength Cond Res. 2009;23(6):1902-1908
ABSTRACT: Many strength and conditioning papers have incorrectly adopted the colloquial use of the term “power” as a measure of short-term, high-intensity muscular performance despite a long history of research and editorials critical of this practice. This has led to confusion, incorrect interpretations, and conflicting results in the literature. This paper summarizes the scientific evidence on external mechanical power as a short-term, high-intensity neuromuscular (anaerobic) performance or training variable. Many problems in the measurement and use of power in strength and conditioning research were identified, as well as problems in the use of the vertical jump as a field test of power. A critical review of the biomechanics, measurement, and training research does not support this colloquial use of the term “power.” More research is needed that improves our understanding of the domains of muscular strength or neuromuscular performance, as well as partial correlation and multiple regression analyses to document the unique associations between these domains, biomechanical variables, training effects, and sport performance. Strength and conditioning research should limit the use of the term power to the true mechanical definition and provide several specific and measurement details on this measurement.


ABSTRACT:

Context: Rehabilitation protocols involving eccentric resistance exercise performed with loading more than 100% concentric 1-repetition maximum are effective in increasing muscle function in both healthy and injured populations. The mode of eccentric exercise (isokinetic versus isotonic) may be an important factor in limiting symptoms of delayed-onset muscle soreness and in improving muscle function after training.

Objective: To compare functional and symptomatic responses after an eccentric-only (ECC) isotonic exercise protocol and after a combined concentric-eccentric (CON-ECC) isokinetic exercise protocol matched for total exercise volume.

Design: Observational study.

Setting: Controlled research laboratory.

Patients or Other Participants: Twenty-four healthy, untrained, college-aged men (n = 12) and women (n = 12).

Intervention(s): Participants were randomly assigned to the ECC isotonic or CON-ECC isokinetic exercise group and performed a single bout of resistance exercise involving the elbow flexors.

Main Outcome Measure(s): Measurements of elbow flexion and extension, isometric strength, and muscle point tenderness were obtained before exercise (baseline) and during follow-up sessions (days 2, 4, 7, and 14). Separate 1-way analyses of variance and repeated-measures analyses of variance were used to determine outcome differences. Tukey post hoc testing was performed when indicated.

Results: At baseline, no differences were present between groups for any measure. The ECC isotonic exercise protocol resulted in a 30% to 36% deficit in muscle strength, a 5% to 7%
reduction in elbow flexion, and a 6% to 8% reduction in elbow extension at follow-up days 2
and 4 (P < .01). The CON-ECC isokinetic exercise protocol did not alter muscle strength or
range of motion at any time when compared with baseline. Muscle point tenderness increased
from baseline on days 2 and 4 in both groups (P < .05) but was not different between groups
throughout the recovery period.

Conclusions: Our results indicated more pronounced functional deficits occurred after a
single bout of ECC isotonic exercise than with a CON-ECC isokinetic exercise protocol
matched for training volume.

versus concentric resistance training on muscle strength and mass in healthy

ABSTRACT: The aim of this systematic review was to determine if eccentric exercise is superior
to concentric exercise in stimulating gains in muscle strength and mass. Meta-analyses were
performed for comparisons between eccentric and concentric training as means to improve
muscle strength and mass. In order to determine the importance of different parameters of
training, subgroup analyses of intensity of exercise, velocity of movement and mode of
contraction were also performed. Twenty randomised controlled trials studies met the inclusion
criteria. Meta-analyses showed that when eccentric exercise was performed at higher intensities
compared with concentric training, total strength and eccentric strength increased more
significantly. However, compared with concentric training, strength gains after eccentric training
appeared more specific in terms of velocity and mode of contraction. Eccentric training
performed at high intensities was shown to be more effective in promoting increases in muscle
mass measured as muscle girth. In addition, eccentric training also showed a trend towards
increased muscle cross-sectional area measured with magnetic resonance imaging or
computerised tomography. Subgroup analyses suggest that the superiority of eccentric training
to increase muscle strength and mass appears to be related to the higher loads developed
during eccentric contractions. The specialised neural pattern of eccentric actions possibly
explains the high specificity of strength gains after eccentric training. Further research is
required to investigate the underlying mechanisms of this specificity and its functional
significance in terms of transferability of strength gains to more complex human movements.

Meier W, Mizner R, Marcus R, Dibble L, Peters C, LaStayo PC: Total knee
arthroplasty: Muscle impairments, functional limitations, and recommended

ABSTRACT: Synopsis: The number of total knee arthroplasty (TKA) surgeries performed each year is
predicted to steadily increase. Following TKA surgery, self-reported pain and function improve, though individuals are often plagued with quadriceps muscle impairments and functional limitations. Postoperative rehabilitation approaches either are not incorporated or incompletely address the muscular and functional deficits that persist following surgery. While the reason for quadriceps weakness is not well understood in this patient population, it has been suggested that a combination of muscle atrophy and neuromuscular activation deficits contribute to residual strength impairments. Failure to adequately address the chronic muscle impairments has the potential to limit the long-term functional gains that may be possible following TKA. Postoperative rehabilitation addressing quadriceps strength should mitigate these impairments and ultimately result in improved functional outcomes. The purpose of this paper is to describe these quadriceps muscle impairments and to discuss how these impairments can contribute to the related functional limitations following TKA. We will also describe the current concepts in TKA rehabilitation and provide recommendations and clinical guidelines based on the current available evidence.

Level of Evidence: Therapy, level 5.

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ABSTRACT: The purpose of this study was to examine the age and sex associated differences in the eccentric/concentric functional ratio for the knee. Isokinetic concentric and eccentric knee extension and flexion was measured at 0.52 rad · s⁻¹ and 3.14 rad · s⁻¹ in 121 subjects. Other than mass there were no significant age-by-sex interaction effects for all variables examined. A significant velocity-by-age group effect was demonstrated for ECCKF/CONKE with higher ratios at 3.14 compared to 0.52 rad · s⁻¹. Females' CONKE/ECCKF was significantly lower than males at both velocities. Adults demonstrated significantly lower CONKE/ECCKF than the teenagers at 0.52 rad · s⁻¹ and lower than the prepubertal and teenager groups at 3.14 rad · s⁻¹. However, for ECCKF/CONKE at 3.14 rad · s⁻¹, prepubertal ratios were significantly lower than teenagers and adults. The results of the current study suggest that functional rather than conventional ratio should be used when examining knee stability. During fast velocity movements, prepubertal children have a lower capacity for generating eccentric compared to concentric torque. The lower CONKE/ECCKE ratio in adults appears to be due to a greater ability to generate large eccentric torques at all slow and fast movement velocities. The lower CONKE/ECCKE ratio in females is a product of lower concentric torque as opposed to high eccentric torque producing capability as previously thought.

ABSTRACT:

Context: Isokinetic and isotonic resistance training exercises are commonly used to increase strength during musculoskeletal rehabilitation programs. Our study was designed to examine the efficacy of isokinetic and isotonic muscle actions using surface electromyographic (EMG) amplitude-to-work ratios (EMG/WK) and to extend previous findings to include a range of isokinetic velocities and isotonic loads.

Objective: To examine work (WK), surface EMG amplitude, and EMG/WK during concentric-only maximal isokinetic muscle actions at 60, 120, 180, 240, and 300°/s and isotonic muscle actions at 10%, 20%, 30%, 40%, and 50% of the maximal voluntary isometric contraction (MVIC) torque during leg extension exercises. Design: A randomized, counterbalanced, cross-sectional, repeated-measures design.

Setting: A university-based human muscle physiology research laboratory.

Patients or Other Participants: Ten women (mean age = 22.0 ± 2.6 years) and 10 men (mean age = 20.8 ± 1.7 years) who were apparently healthy and recreationally active.

Intervention(s): Using the dominant leg, each participant performed 5 maximal voluntary concentric isokinetic leg extension exercises at randomly ordered angular velocities of 60, 120, 180, 240, and 300°/s and 5 concentric isotonic leg extension exercises at randomly ordered loads of 10%, 20%, 30%, 40%, and 50% of the isometric MVIC.

Main Outcome Measure(s): Work was recorded by a Biodex System 3 dynamometer, and surface EMG was recorded from the superficial quadriceps femoris muscles (vastus lateralis, rectus femoris, and vastus medialis) during the testing and was normalized to the MVIC. The EMG/WK ratios were calculated as the quotient of EMG amplitude (μVrms) and WK (J) during the concentric phase of each exercise.

Results: isotonic EMG/WK remained unchanged (P -> .05) from 10% to 50% MVIC, but isokinetic EMG/WK increased (P < .05) from 60 to 300°/s. isotonic EMG/WK was greater (P < .05) than isokinetic EMG/WK for 50% MVIC versus 60°/s, 40% MVIC versus 120°/s, and 30% MVIC versus 180°/s; however, no differences were noted (P -> .05) between 20% MVIC versus 240°/s or 10% MVIC versus 300°/s. An 18% decrease in active range of motion was seen for the isotonic muscle actions, from 10% to 50% MVIC, and a 3% increase in range of motion for the isokinetic muscle actions from 60 to 300°/s was also observed. Furthermore, the peak angular velocities for the isotonic muscle actions ranged from 272.9 to 483.0°/s for 50% and 10% MVIC, respectively.

Conclusions: When considering EMG/WK, peak angular velocity, and range of motion together, our data indicate that maximal isokinetic muscle actions at 240°/s or controlled-velocity isotonic muscle actions at 10%, 20%, or 30% MVIC may maximize the amount of muscle activation per unit of WK done during the early stages of musculoskeletal rehabilitation. These results may be useful to allied health professionals who incorporate open-chain resistance training exercises during the early phases of rehabilitation and researchers who use isotonic or isokinetic modes of resistance exercise to examine muscle function.

**ABSTRACT:** Acute and long-term hormonal and neuromuscular adaptations to hypertrophic strength training were studied in 13 recreationally strength trained men. The experimental design comprised a 6-month hypertrophic strength-training period including 2 separate 3-month training periods with the crossover design, a training protocol of short rest (SR, 2 minutes) as compared with long rest (LR, 5 minutes) between the sets. Basal hormonal concentrations of serum total testosterone (T), free testosterone (FT), and cortisol (C), maximal isometric strength of the leg extensors, right leg 1 repetition maximum (1RM), dietary analysis, and muscle cross-sectional area (CSA) of the quadriceps femoris by magnetic resonance imaging (MRI) were measured at months 0, 3, and 6. The 2 hypertrophic training protocols used in training for the leg extensors (leg presses and squats with 10RM sets) were also examined in the laboratory conditions at months 0, 3, and 6. The exercise protocols were similar with regard to the total volume of work (loads 3 sets 3 reps), but differed with regard to the intensity and the length of rest between the sets (higher intensity and longer rest of 5 minutes vs. somewhat lower intensity but shorter rest of 2 minutes). Before and immediately after the protocols, maximal isometric force and electromyographic (EMG) activity of the leg extensors were measured and blood samples were drawn for determination of serum T, FT, C, and growth hormone (GH) concentrations and blood lactate. Both protocols before the experimental training period (month 0) led to large acute increases \( p < 0.05-0.001 \) in serum T, FT, C, and GH concentrations, as well as to large acute decreases \( p < 0.05–0.001 \) in maximal isometric force and EMG activity. However, no significant differences were observed between the protocols. Significant increases of 7% in maximal isometric force, 16% in the right leg 1RM, and 4% in the muscle CSA of the quadriceps femoris were observed during the 6-month strength-training period. However, both 3-month training periods performed with either the longer or the shorter rest periods between the sets resulted in similar gains in muscle mass and strength. No statistically significant changes were observed in basal hormone concentrations or in the profiles of acute hormonal responses during the entire 6-month experimental training period. The present study indicated that, within typical hypertrophic strength-training protocols used in the present study, the length of the recovery times between the sets (2 vs. 5 minutes) did not have an influence on the magnitude of acute hormonal and neuromuscular responses or long-term training adaptations in muscle strength and mass in previously strength trained men.

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**ABSTRACT:**

**Objectives:** To determine whether variation in resistance exercise volume affects muscle function and physical performance response in older adults.
Design: A randomized trial with subjects assigned to a single-set (1-SET) or three-set (3-SET) exercise group.

Setting: An exercise facility at the University of Queensland.

Participants: Twenty-eight community-dwelling men and women aged 65 to 78.

Intervention: Progressive resistance training consisting of seven exercises targeting the major muscle groups of the upper and lower body performed on exercise machines twice weekly for 20 weeks at eight-repetition maximum (RM) intensity.

Measurements: Muscle function included isotonic muscle strength (1-RM) of the seven exercises, isokinetic and isometric knee extensor strength, and muscle endurance for the chest press and leg press exercises. Physical performance included timed chair rise, usual and fast 6-m walk, 6-m backwards walk, 400-m walk, floor rise to standing, and stair climbing ability. In addition, body composition was determined using dual energy x-ray absorptiometry.

Results: Isotonic muscle strength increased in both exercise groups for all seven exercises ($P<.01$), with the gain in the 3-SET group greater ($P<.05$) for the seated row, triceps extension, and knee extension (analysis of covariance). Similarly, muscle endurance gains were greater for the 3-SET than the 1-SET group ($P<.01$), with no significant difference between groups for isokinetic and isometric knee extensor strength. Both groups improved ($P<.05$) in the chair rise (1-SET, 10.1%; 3-SET, 13.6%), 6-m backwards walk (1-SET, 14.3%; 3-SET, 14.8%), 400-m walk (1-SET, 3.8%; 3-SET, 7.4%), and stair climbing test (1-SET, 7.7%; 3-SET, 6.4%), with the only difference between groups for the 400-m walk ($P<.05$). There was no difference between groups for change in body composition.

Conclusion: Resistance training consisting of only single-set exercises is sufficient to significantly enhance muscle function and physical performance, although muscle strength and endurance gains are greater with higher-volume work. These findings have application in designing time-efficient exercise regimens to enhance neuromuscular function in older adults.