Eccentron Research References

"Comparison of high vs low eccentric-based resistance training frequencies on short-term muscle function adaptations."

Crane JS, Thompson B, Harrell DC, et al. Comparison of high versus low eccentric-based resistance training frequencies on short-term muscle function adaptations. *J Strength Cond Res*. 2022;36:332-339

ABSTRACT
Eccentric resistance training is beneficial for improving a number of performance and health metrics. However, the recommendations on eccentric training frequency have not been established. This study investigates the effects of volume-matched resistance training frequency comparing 1 vs. 3 training days per week of isokinetic multiple-joint eccentric training on strength and lower-body function adaptations during a 4-week training period. Thirty subjects were assigned to either 3 days per week (high-frequency [HF]) or 1 day per week (low-frequency [LF]) training conditions for 4 weeks. An eccentric dynamometer was used for the training and testing. Eccentric strength and vertical jump (VJ) measures were taken at Pre, Mid (2 weeks), and Post (4 weeks) intervention. Soreness (visual analog scale [VAS]) and rate of perceived exertion (RPE) were taken throughout the training period. There was no group × trial interaction for eccentric strength ($p = 0.06$) or VJ ($p = 0.87$). For eccentric strength, all trials were significantly different ($p < 0.001$) from each other. For VJ, there was a main effect for trial such that VJ increased from Pre to Post ($p < 0.001$) and Mid to Post ($p < 0.01$). High frequency reported lower RPE ($p < 0.01$) and soreness ($p = 0.04$) compared with LF. Both HF and LF protocols elicited large (36.8 and 27.4% strength increases, respectively) and rapid neuromuscular adaptations for improved strength. Eccentric-based workload may be dispersed across a given period to allow for reduced soreness and perceived exertion levels without compromising neuromuscular adaptations. Some eccentric training transfer to functional (VJ) task may also be observed, independent of training frequency.

Use of Eccentron: eccentric-based training and measurement of strength gains

"Potential benefits of a minimal dose eccentric resistance training paradigm to combat sarcopenia and age-related muscle and physical function deficits in older adults."

Harper SA, Thompson BJ. Potential benefits of a minimal dose eccentric resistance training paradigm to combat sarcopenia and age-related muscle and physical function deficits in older adults. *Frontiers in Physiol.* 2021; 12. https://doi.org/10.3389/fphys.2021.790034

ABSTRACT
The ability of older adults to perform activities of daily living is often limited by the ability to generate high mechanical outputs. Therefore, assessing and developing maximal neuromuscular capacity is essential for determining age-related risk for functional decline as well as the effectiveness of therapeutic interventions. Interventions designed to enhance neuromuscular capacities underpinning maximal mechanical outputs could positively impact functional performance in daily life. Unfortunately, < 10% of older adults meet the current resistance training guidelines. It has recently been proposed that a more "minimal dose" RT model may help engage a greater proportion of older adults, so that they may realize the benefits of RT. Eccentric exercise offers some promising qualities for such an approach due to its efficiency in overloading contractions that can induce substantial neuromuscular adaptations. When used in a minimal dose RT paradigm, eccentric-based RT may be a particularly promising approach for older adults that can efficiently improve muscle mass, strength, and functional performance. One approach that may lead to improved neuromuscular function capacities and overall health is through heightened exercise tolerance which would favor greater exercise participation in older adult populations. Therefore, our perspective article will discuss the implications of using a minimal dose, submaximal (i.e., low

intensity) multi-joint eccentric resistance training paradigm as a potentially effective, and yet currently underutilized, means to efficiently improve neuromuscular capacities and function for older adults.

Use of Eccentron: minimal dosing of eccentric-based resistance training to increase muscle mass, strength, and functional performance of older adults

"Going Backward": Effects of age and fatigue on posterior-directed falls in Parkinson disease."

Papa EV, Patterson RM, et al. "Going Backward": Effects of age and fatigue on posterior-directed falls in Parkinson disease. *NeuroRehabilitation*. 2021;49:151-159

ABSTRACT
Background: Nearly half of persons with Parkinson disease (PD) report fatigue as a factor in their fall history. However, it is unknown whether these self-reported falls are caused by a sensation of fatigue or performance fatigue.
Objective: We sought to investigate the influences of performance fatigue and age on postural control in persons with PD.
Methods: Individuals with PD (*n* = 14) underwent postural control assessments before (T0) and immediately after (T1) fatiguing exercise. Biomechanical data were gathered on participants completing a treadmill-induced, posterior-directed fall. Performance fatigue was produced using lower extremity resistance exercise on an isokinetic ergometer. Repeated measures ANCOVAs were used with age as a covariate to determine the effects of performance fatigue on biomechanical variables.
Results: After adjustment for age, there was a statistically significant difference in peak center of pressure (COP) latency during the support phase of recovery. Pairwise comparisons demonstrated a decrease in peak ankle displacement from T0 to T1. Age was also found to be significantly related to reaction time and peak knee displacement while participants were fatigued.
Conclusions: The decreased peak COP latency, along with decreased ankle angular displacement, suggest that persons with PD adopt a stiffening strategy in response to backward directed falls. Postural stiffening is not uncommon in persons with PD and could be a risk factor for falls. Older individuals with PD demonstrate slower mobility scores and decreased reaction times in the setting of fatigue, suggesting a combined effect of the aging and fatigue processes.

Use of Eccentron: measure lower extremity muscle endurance/fatiguability people with Parkinson's disease

"Isokinetic eccentric exercise substantially improves mobility, muscle strength and size, but not postural sway metric in older adults, with limited regression observed following a detraining period."

Kay AD, Blazevich AJ, Fraser M, et al. Isokinetic eccentric exercise substantially improves mobility, muscle strength and size, but not postural sway metric in older adults, with limited regression observed following a detraining period. *Euro J Allied Physiol*. 2020;120:2382-2395.

ABSTRACT
Introduction: Eccentric exercise can reverse age-related decreases in muscle strength and mass; however, no data exist describing its effects on postural sway. As the ankle may be more important for postural sway than hip and knee joints, and with older adults prone to periods of inactivity, the effects of two 6-week seated isokinetic eccentric exercise programmes, and an 8-week detraining period, were examined in 27 older adults (67.1 ± 6.0 years).

Methods: Neuromuscular parameters were measured before and after training and detraining periods with subjects assigned to ECC (twice-weekly eccentric-only hip and knee extensor contractions) or ECCPF (identical training with additional eccentric-only plantarflexor contractions) training programmes. **Results**: Significant ($P < 0.05$) increases in mobility (decreased timed-up-and-go time [− 7.7 to − 12.0%]), eccentric strength (39.4–58.8%) and vastus lateralis thickness (9.8–9.9%) occurred after both training programmes, with low-to-moderate weekly rate of perceived exertion (3.3–4.5/10) reported. No significant change in any postural sway metric occurred after either training programme. After 8 weeks of detraining, mobility (− 8.2 to − 11.3%), eccentric strength (30.5–50.4%) and vastus lateralis thickness (6.1–7.1%) remained significantly greater than baseline in both groups.
Conclusions: Despite improvements in functional mobility, muscle strength and size, lower-limb eccentric training targeting hip, knee and ankle extensor muscle groups was not sufficient to influence static balance. Nonetheless, as the beneficial functional and structural adaptations were largely maintained through an 8-week detraining period, these findings have important implications for clinical exercise prescription as the exercise modality, low perceived training intensity, and adaptive profile are well suited to the needs of older adults.

Use of Eccentron: exercise modality at low perceived intensity in older adults to increase lower extremity muscle strength and size and improve functional mobility

"Effects of lower extremity eccentric-based training on muscle strength and physical function in older adults: a randomized controlled pilot trial."
Kim DY, Oh SL, Song W, et al. Effects of lower extremity eccentric-based training on muscle strength and physical function in older adults: a randomized controlled pilot trial. *Exerc Sci*. 2019;28:346-354.

ABSTRACT:
Purpose: Reduced muscular strength is a key player in loss of physical function and quality of life in older adults. It has been reported that eccentric training has positive effects on the preservation of eccentric strength, produces less delayed onset muscle soreness, and has a lower metabolic cost for older individuals. Therefore, the present study investigated the effects of eccentric-based training on skeletal muscle strength and physical function in older adults.
Methods: Sixteen healthy older subjects (over the age of 65) participated either in eccentric training group (ETG, n=8) or in conventional resistance training group (CTG, n=8) twice a week for eight weeks. The ETG group performed motorized eccentric training, and the CTG group performed a leg press using air pressure. Physical function and muscular strength assessments were performed before and after 8 weeks. The primary outcomes for physical function included gait speed, stair climbing, and the chair stand test, and the secondary outcomes included muscle strength and power.
Results: The ETG group demonstrated significant improvements in physical function (gait speed and stair climbing) and muscle strength (isokinetic strength and power in knee tests) ($p<.05$) compared to the CTG group after 8 weeks. There were no significant differences for chair stand test ($p>.05$) after 8 weeks.
Conclusions: Motorized eccentric-based training was more effective in improving muscle strength and physical function in aged individuals than conventional resistance training, which s suggests that eccentric training is may be more beneficial for older individuals to improve overall physical function.

Use of Eccentron: eccentric strength training to improve lower extremity strength of healthy older adults

"Muscle quality improves with extended high-intensity resistance training after hip fracture."
Briggs RA, Houck JR, Drummond MJ, et al. Muscle quality improves with extended high-intensity resistance training after hip fracture. *J Frailty Aging*. 2018;7:51-56. http://dx.doi.org/10.14283/jfa.2017.31

ABSTRACT:
Background: Muscle mass deficits endure after hip fracture. Strategies to improve muscle quality may improve mobility and physical function. It is unknown whether training after usual care yields muscle quality gains after hip fracture.
Objectives: To determine whether muscle quality improves after hip fracture with high-intensity resistance training and protein supplementation.
Design: Case series. Setting: University of Utah Skeletal Muscle Exercise Research Facility.
Participants: 17 community-dwelling older adults, 3.6+/-1.1 months post-hip fracture, recently discharged from usual-care physical therapy (mean age 77.0+/-12.0 years, 12 female), enrolled. Intervention: Participants underwent 12 weeks (3x/week) of unilaterally-biased resistance training.
Methods/Materials: Participants were measured via a 3.0 Tesla whole-body MR imager for muscle lean and intramuscular adipose tissue (IMAT) of the quadriceps before and after resistance training. Peak isometric knee extension force output was measured with an isokinetic dynamometer. Muscle quality was calculated by dividing peak isometric knee extension force (N) by quadriceps lean muscle mass (cm2). In addition, common physical function variables were measured before and after training.
Results: Surgical and nonsurgical lean quadriceps muscle mass improved among participants (mean change: 2.9 cm2+/-1.4 cm2, and 2.7 cm2+/-1.3 cm2, respectively), while IMAT remained unchanged. Peak force improved in the surgical limb by 43.1+/-23N, with no significant change in the nonsurgical limb. Significant gains in physical function were evident after training.
Conclusion: Participants recovering from hip fracture demonstrated improvements in muscle mass, muscle strength, and muscle quality in the surgical limb after hip fracture. These were in addition to gains made in the first months after fracture with traditional care. Future studies should determine the impact that muscle quality has on long-term functional recovery in this population.

Use of Eccentron: eccentric strength training to improve lower extremity strength of community-dwelling older adults post-hip fracture

"High intensity multimodal resistance training improves muscle function, symmetry during a sit-to-stand task, and physical function following hip fracture."

Briggs RA, Houck JR, LaStayo PC, et al. High intensity multimodal resistance training improves muscle function, symmetry during a sit-to-stand task, and physical function following hip fracture. *J Nutr Health Aging.* 2018;22:431-438.

ABSTRACT:
Objectives: Post rehabilitation, older adults with hip fracture display low vertical ground reaction force (vGRF) on the involved lower extremity during a sit-to-stand task and low physical function. The purpose of this study was to test whether muscle performance, involved side vGRF during a sit-to-stand task, and physical function improved following multimodal high-intensity resistance training, when initiated after usual care (2 to 6 months after hip fracture).
Design: Case series study, 12 weeks extended high-intensity strength training intervention following hip fracture.
Setting: University hospital outpatient facility.
Participants: Twenty-four community-dwelling older adults (mean age 78.4 years (SD 10.4), 16 female/8 male), 3.6 (SD 1.2) months post-hip fracture and discharged from physical therapy participated.
Intervention/Measurement: All participants performed sit-to-stand tasks, muscle performance tests, and modified physical performance test (mPPT) before and after 12 weeks (3x/wk) of training. Variables were compared using paired t-tests.
Results: The vGRF rate of force development (RFD) and magnitude of discrepancy between limb loading during rising phase of sit-to-stand task (AREA) variables improved post-training (RFD ratio = Pre: 0.78 – Post: 0.82, AREA ratio = Pre: 0.79 – Post: 0.86). Surgical leg extension power gains were large (~65%) while strength gains were moderate (~34%); yielding improved symmetry in both strength (Pre: 0.74 –

Post: 0.88) and power (Pre: 0.75 – Post: 0.82). Physical function improved pre-training 25 (SD 5.2) to post training 30 (SD 4.3), ($p < 0.001$).
Conclusion: Unique to this study, participants recovering from hip fracture demonstrated improved symmetry in sit-to-stand vGRFs, muscle function, and physical function after training. However, a high percentage of patients continued to experience persistently low vGRF of the involved side compared to previous studies of healthy elderly controls. Developing alternative strategies to improve involved side vGRF may be warranted.

Use of Eccentron: eccentric strength training to improve lower extremity strength of community-dwelling older adults post-hip fracture

"Effects of isokinetic eccentric versus traditional lower body resistance training on muscle function: examining a multiple-joint short-term training model."
Gordon JP, Thompson BJ, Crane JS, et al. Effects of isokinetic eccentric versus traditional lower body resistance training on muscle function: examining a multiple-joint short-term training model. Appl Physiol Nutr Metab. 2018. www.nrcrearchpress.com

ABSTRACT:
Early adaptations of eccentric training show several advantages over concentric training. The purpose of this study was to quantify the effects of 4-weeks of multi-joint eccentric versus traditional leg press (TLP) training on muscle strength, rate of torque development (RTD), and jump and sprint performance adaptations. Twenty-six resistance trained adults performed either and eccentric or a TLP resistance training program twice per week for 4 weeks. Single-joint isometric maximum and rapid strength (peak torque and RTD, respectively) and isokinetic strength of the knee extensors and flexors, multi-joint eccentric strength, leg press strength (1-RM), 40-m sprint, and vertical and long jump were measured before (Pre), at the midpoint (Mid), and after (Post) a 4-week training period. Four weeks of isokinetic multi-joint eccentric training elicited greater test-specific strength gains (ES=1.06) compared to TLP (ES=0.11). The eccentric group (ES=0.51 and 0.54) also yielded moderate improvements in the early-middle phase RTD (RTD100-200) whereas the TLP group showed small-moderate improvements (ES=0.37). The majority of the single-joint strength variables showed negligible improvements. Performance tests showed no (broad jump) to small (vertical jump; sprint for the leg press) improvements. Eccentric multi-joint training induced significant improvements for lower body strength in a short amount of time in a trained population. These accelerated adaptations and also the lowered energy requirements of eccentric exercise may be useful for clinicians or practitioners when prescribing training programs for those who are injured, sedentary, or elderly, who are in need of time efficient muscle function improvements.

Use of Eccentron: eccentric strength training to improve lower extremity strength of college-aged men and women

"Effect of an 8-week eccentric training program on strength and balance in older adults."
Johnson SL, Fuller DK, Donnelly B, et al. Effect of an 8-week eccentric training program on strength and balance in older adults. *Intl J Exerc Sci*. 2018;11:468-478.

ABSTRACT:
The purpose of the current study was to determine changes in balance and strength following an eccentric resistance training program in community-dwelling older adults who reported no history of falling. Participants (N = 14, 8 female, 6 male; age = 63.5 ± 2.0 years) completed an 8-week eccentric exercise training intervention on a commercially available eccentric step machine. Training included 2 training sessions per week, with a duration of 5 to 10 minutes and an intensity of 30 to 50% maximal eccentric strength. Single leg stance, 30-second repeated chair stand, timed up-and-go, and maximal

eccentric strength were assessed at baseline, mid-point, and within one week of the final training session. In addition, total negative work and rating of perceived exertion were recorded for each exercise session. Negative work completed in training increased approximately three times, while rating of perceived exertion plateaued at the mid-point of training. The results indicated that significant improvements were observed in the 30-second repeated chair stand ($p < .001$), the timed up-and-go ($p < .001$), and maximal eccentric strength ($p < .001$), while there was no significant change in single leg stance time based on post-hoc analyses. The eccentric training was sufficient to yield improved performance on balance and strength tasks. These improvements, in community-dwelling individuals reporting no previous falls, indicate eccentric training may be a viable modality for older individuals aiming to minimize future fall-risk and prolong physical independence.

Use of Eccentron: eccentric strength training to improve lower extremity strength of community-dwelling older adults

"Effect of two types of muscle contraction training on muscle thickness, strength, and delayed onset of muscle soreness in persons with chronic stroke."

Lim SY, Lee WH. Effect of two types of muscle contraction training on muscle thickness, strength, and delayed onset of muscle soreness in persons with chronic stroke. *Phys Ther Rehabil Sci.* 2018;7:154-163.

ABSTRACT:
Design: Randomized controlled trial.
Methods: Thirty persons with chronic stroke were randomly assigned to the ECT or the CCT group. The ECT was performed in a specially designed system of eccentric contraction of both legs and, the CCT was performed using a traditional stepper system for concentric contraction of both legs. The training was performed for 30 min/times, 3 times/wk for 6 weeks. Rehabilitation ultrasound imaging was used to measure MT of the vastus medialis/lateralis (VL), and soleus (SOL), a digital muscle tester was used to measure MS, and a visual analog scale was used to assess DOMS.
Results: In the ECT group, MT was significantly improved except for SOL resting ($p<0.01$). In the CCT group, the MT was significantly
improved except for VL contraction ($p<0.05$). The MS was significantly improved in both groups, especially in the ECT group ($p<0.01$). In the ECT group, muscle soreness was highest in the first week after training but gradually decreased, and in the CCT group, it was highest in the second week of training but gradually decreased ($p<0.01$).
Conclusion: ECT can improve lower limb MT, MS, and DOMS of chronic stroke survivors. Therefore, it is recommended that ECT be used in the rehabilitation of persons with chronic stroke.

Use of Eccentron: eccentric strength training to improve lower extremity strength of individuals post-stroke

"Aging-related effects of bed rest followed by eccentric exercise rehabilitation on skeletal muscle macrophages and insulin sensitivity."

Reidy PT, Lindsay CC, McKenzie AI, et al. Aging-related effects of bed rest followed by eccentric exercise rehabilitation on skeletal muscle macrophages and insulin sensitivity. *Exp Gerontol.* 2018;107:37-49.

ABSTRACT:
The pro- and anti-inflammatory macrophages are associated with insulin sensitivity and skeletal muscle regeneration. Infiltrating macrophages in skeletal muscle during a period of physical inactivity and subsequent reloading/rehabilitation in older adults is unknown, but may provide insight into mechanisms related to the development of metabolic disease and changes in muscle cell size. The purpose of this study was to determine if skeletal muscle macrophage infiltration is modulated differently between young

and older adults after bed rest and exercise rehabilitation and if these responses are related to muscle and insulin sensitivity changes. 14 young and 9 older adults underwent 5-days of bed rest followed by 8-weeks of lower limb eccentric exercise rehabilitation (REHAB). Dual-energy X-ray absorptiometry, magnetic resonance imaging and myofiber analysis were used to identify muscle morphology and CLIX-IR and CLIX-β were used to assess insulin sensitivity. Skeletal muscle macrophages, CD68 (pan), CD11b (M1), CD163 (M2), CD206 (M2), were characterized using immunohistochemistry and gene expression. Insulin sensitivity, independent of age, decreased ~38% following bed rest and was restored following REHAB. We found robust age-related differences in muscle atrophy during bed rest, yet older and younger adults equally hypertrophied during REHAB. Interestingly, there were age-related differences in macrophage content (CD68+CD11b+ and CD68+CD11b− cells) but both young and old similarly increased macrophages with REHAB. Satellite cell changes during rehab corresponded to macrophage content. Muscle tissue resident macrophages and gene expression, were not associated with changes in insulin sensitivity following bed rest and REHAB. These data suggest that muscle macrophages are modulated as a result of exercise rehabilitation following bed rest and may more associated with muscle regrowth/hypertrophy rather than insulin sensitivity in young or older adults.

Use of Eccentron: eccentric strength training to improve lower extremity strength and hypertrophy of healthy community dwelling individuals aged 18–35 and 60-75 years of age post 5 days of continuous bed rest. A 3 x per week exercise rehabilitation protocol was incrementally increased over 8 weeks was used to maintain intensity.

"Ambulation and physical function after eccentric resistance training in adults with incomplete spinal cord injury: a feasibility study."

Stone WJ, Stevens SL, Fuller DK, et al. Ambulation and physical function after eccentric resistance training in adults with incomplete spinal cord injury: a feasibility study. *J Spinal Cord Med*. 2018. DOI: 10.1080/10790268.2017.1417804.

ABSTRACT:
Background: Strengthening the lower extremities has shown to positively influence walking mechanics in those with neurological deficiencies. Eccentric resistance training (ERT) is a potent stimulus for the development of muscular strength with low metabolic demand. Thereby, ERT may benefit those with incomplete spinal cord injuries (iSCI) seeking to improve ambulatory capacity.
Design: This study was aimed to determine the effect of ERT on walking speed, mobility, independence, and at home function following iSCI.
Methods: Individuals with longstanding iSCI trained twice a week for 12 weeks on an eccentrically biased recumbent stepper.
Outcome measures: Walking speed (10 meter walk test; 10MWT), mobility (timed up and go), independence (Walking Index for Spinal Cord Injury; WISCI), and at home function (Spinal Cord Independence Measure; SCIM) were assessed at baseline, after 6 weeks, and after 12 weeks of ERT.
Results: There were improvements in walking mobility (158.36 + 165.84 seconds to 56.31 + 42.42 seconds, P = .034, d = 0.62), speed (0.34 + 0.42 m/s to 0.43 + 0.50 m/s, P = .005, d = .23), and independence (8 + 7to13+ 7, P = .004, d = .73) after 12 weeks of ERT. At home function remained unchanged (22 + 10 to 24 + 10, P = .10, d = .12).
Conclusions: Improving lower extremity strength translated to walking performance and independence in those with iSCI. Additionally, ERT may diminish therapist burden in programs designed to improve ambulatory capacity or strength in those with iSCI.

Use of Eccentron: eccentric strength training to improve lower extremity strength and reciprocal limb activation of individuals with incomplete spinal cord injury

“Strength and step activity after eccentric resistance training in those with incomplete spinal cord injuries.”

Stone WJ, Stevens SL, Fuller DK, et al. Strength and step activity after eccentric resistance training in those with incomplete spinal cord injuries. *Top Spinal Cord Inj Rehabil*. 2018. DOI: 10.1310/sci17-00052

ABSTRACT:
Background: Individuals with spinal cord injuries (SCIs) often experience general weakness in the lower extremities that undermines daily step activity.
Objective: To investigate the efficacy of eccentrically biased resistance training on lower extremity strength and physical activity of individuals with spinal injuries.
Methods: Individuals with long-standing incomplete SCIs (N = 11) capable of completing a 10-meter walk assessment. All participants who completed the familiarization period finished the training. Individuals trained two times per week for 12 weeks on a lower body eccentric resistance training machine. It was hypothesized that the outcome variables (eccentric strength, isometric strength, and daily step physical activity) would improve as a result of the training intervention.
Results: Eccentric strength [$F(1.27, 12.71) = 8.42$, $MSE = 1738.35$, H-F $p = .009$] and isometric strength [$F(1.97, 19.77) = 7.10$, $MSE = 11.29$, H-F $p = .005$] improved as a result of the training while daily step activity remained unchanged [$F(2.00, 18.00) = 2.73$, $MSE = 216{,}836.78$, H-F $p = .092$].
Conclusions: Eccentric resistance training improves eccentric and isometric strength. These physiological adaptations may translate to improved gait mechanics, but further study is required to identify this potential crossover effect.

Use of Eccentron: eccentric strength assessment using peak force across 3 repetitions to calculate a 1RM which served as exercise prescription. Participants in this study were apparently healthy males and females with iSCI

“Eccentric resistance training in adults with and without spinal cord injuries.”

Stone WJ, Stevens SL, Fuller DK, et al. Eccentric resistance training in adults with and without spinal cord injuries. *Int J Exerc Sci*. 2017;10:154-165.

ABSTRACT:
The purpose of this study was to examine the effects of active lower body eccentric resistance training (ERT) in individuals with incomplete spinal cord injury (iSCI) and controls (CON). Specifically, the study was designed to determine if those with iSCI adapt similarly to ERT as CON participants as well as the overall safety and efficacy of ERT in this population. This pilot investigation involved the recruitment of persons with iSCI ($n = 3$) and age- and sex-matched able-bodied CON ($n = 3$). The 8-week intervention focused on building lower extremity eccentric strength by progressively increasing the duration and intensity of training sessions. Control participants completed the same training intervention. Main outcome measures were eccentric strength (eccentric ergometer), isometric strength (hand-held dynamometer), and leg muscle mass (DEXA). All participants completed the ERT. At posttest, eccentric strength improved from pretest ($p = .044$, □p2 = .68) with similar changes between groups ($p > .05$). The percent improvement in isometric strength for those with iSCI (41.5%) was different than CON (-2.8%) after training ($p = .044$). Neither group demonstrated muscle mass gains at posttest ($p > .05$). Active lower body ERT is well tolerated and effective at increasing lower extremity strength in those with iSCI. These adaptations are likely attributable to neuromuscular development rather than a hypertrophic response.

Use of Eccentron: eccentric strength training to improve lower extremity strength of individuals with and without incomplete spinal cord injury

“Eccentric loading rehabilitation of patient with severe post-operative muscle atrophy.”
Donatelli R, Colthart ZQ, Bascharon R. Eccentric loading rehabilitation of patient with severe post-operative muscle atrophy. *J Sports Injr Med*. 2017;2:107.

ABSTRACT:
This case is a demonstration of the benefits of utilizing eccentric exercises early in the rehabilitation of post-op left knee arthroscopy for partial lateral meniscectomy, excision of the plica and chondroplasty with micro fracture. Secondary to the injury and then post-op the patient demonstrated severe muscle atrophy and post-op pain. Trauma to a joint causing joint effusion followed by disuse, resulted in loss of strength, stabilization and function. It is important to facilitate and promote muscle strengthening early in the rehabilitation. There are various exercises that utilize three different types of muscle actions concentric, eccentric or isometric contractions. Eccentric loading, especially in rehabilitation, is the most efficacious method of increasing strength gains while minimizing the unfavorable effects caused by compression forces into the joint, especially post-op surgeries that involve intra-articular repair. The purpose of this patient case is to demonstrate the effectiveness of eccentric loading in the recovery of muscle strength in the lower limb, improvement in function and to suggest its implementation as an important part of rehabilitation programs.

Use of Eccentron: treatment intervention to increase lower extremity muscle strength and hypertrophy post knee injury of male power lifter

“Eccentric versus traditional resistance exercise for older adult fallers in the community: a randomized trial within a multi-component fall reduction program.”
LaStayo P, Marcus R, Dibble L Wong B, Pepper G: Eccentric versus traditional resistance exercise for older adult fallers in the community: a randomized trial within a multi-component fall reduction program. *BMC Geriatrics.* 2017;17:149 DOI 10.1186/s12877-017-0539-8

ABSTRACT:
Background: Addressing muscle deficits within a multi-component exercise fall reduction program is a priority, especially for the highest risk older adults, i.e. those who have fallen previously. Eccentric resistance exercise with its high-force producing potential, at a low energetic cost, may be ideally suited to address muscle impairments in this population. The purpose of this study was to compare the effects of resistance exercise via negative, eccentrically-induced, work (RENEW) versus traditional (TRAD) resistance exercise on mobility, balance confidence, muscle power, and cross-sectional area, as well as the number of days high fall risk older adults survived without a fall event over a 1 year period.
Methods: Randomized, two group, four time point (over 1 year) clinical trial testing RENEW versus TRAD as part of a 3-month multi-component exercise fall reduction program (MCEFRP). Primary outcomes of mobility, balance confidence, muscle power output, and cross-sectional area were analyzed using mixed effects modeling. The secondary outcomes of days to fall and days to near-fall were analyzed using survival analysis.
Results: The MCEFRP did have an effect on fall risk factors considered reversible with exercise interventions though there was no differential effect of RENEW versus TRAD (p = 0.896) on mobility, balance confidence, muscle power, and cross-sectional area. There were also no group differences in the number of days survived without a fall (p = 0.565) or near-fall (p = 0.678). Despite 100% of participants having at least one fall in the year prior to the MCEFRP, however, after 3 months of exercise and 9 months of follow-up <50% had experienced a fall or near fall.
Conclusions: There were no differential effects of RENEW or TRAD as components of a MCEFRP on the primary or secondary outcomes. The two modes of resistance exercise had identical effects on fall risk and fall -free survival.

Use of Eccentron: neuromuscular strength eccentric training with visual feedback to improve lower extremity strength, mobility, and balance in adults 65 years and older who experienced at least one fall in the previous 12 months

"A pilot study examining the impact of exercise training on skeletal muscle genes related to the TLR signaling pathway in older adults following hip fracture recovery."
McKenzie AI, Briggs RA, Barrows KM, et al. A pilot study examining the impact of exercise training on skeletal muscle genes related to the TLR signaling pathway in older adults following hip fracture recovery. *J Appl Physiol*. 2017;122:68-75.

ABSTRACT:
Older adults after hip fracture surgery experience progressive muscle atrophy and weakness, limiting full recovery. Further understanding of the molecular mechanisms in muscle with adaptation to exercise training in this vulnerable population is necessary. Therefore, we conducted a pilot study to investigate the skeletal muscle inflammatory and ceramide biosynthesis gene expression levels associated with the toll-like receptor (TLR) pathway before (Pre) and following a 3-mo multicomponent exercise training program in older adults (3M, 4F; 78.4 ± 13.3 yr; 25.5 ± 2.3 kg/m2) ~4 months after repair from hip fracture (HipFx). Vastus lateralis biopsies from the surgical limb were obtained before (Pre) and after training. Molecular end points and muscle function data were also compared with matched non-exercise healthy controls (CON). As a follow-up analysis, we evaluated specific sphingolipid pools in HipFx and CON muscle. Following training, quadriceps cross-sectional area, strength, and 6-min walk (6MW) increased in the surgical limb ($P < 0.05$). Additionally, MYD88, TAK1, NFKB1, IL6, SPT2, and CERS1 gene expression decreased after training ($P \leq 0.05$), but some remained elevated above CON levels. Interestingly, MYD88 mRNA was inversely correlated to quadriceps CSA, strength, and 6MW. Finally, muscle dihydroceramides and phosphoceramides in HipFx were lower than CON at Pre ($P \leq 0.05$), but after training differences from CON were removed. Together, our pilot data support that exercise training alters skeletal muscle inflammation and ceramide metabolism associated with TLR signaling in older adults recovering from hip fracture surgery and may be related to improvements in muscle function recovery.

Use of Eccentron: eccentric strength training to improve lower extremity strength of community-dwelling older adults post-hip fracture. The program is described as "high-intensity, task-oriented, resistance training.

"Effects of early combined eccentric-concentric versus concentric resistance training following total knee arthroplasty."
Suh MJ, Kim BR, Kim SR, et al. "Effects of early combined eccentric-concentric versus concentric resistance training following total knee arthroplasty." *Ann Rehabil Med.* 2017;41:816-827. https://doi.org/10.5535/arm.2017.41.5.816

ABSTRACT:
Objective: To investigate the effects of early combined eccentric-concentric (ECC-CON) or concentric (CON) resistance training following total knee arthroplasty (TKA).
Methods: Patients who underwent a primary TKA were randomly assigned to an ECC-CON group (n=16) or a CON group (n=18). All patients received early, progressive resistance training with five sessions per week for 2 weeks starting 2 weeks after TKA. Isometric knee flexor and extensor strength of the surgical and non-surgical knees, instrumental gait analysis for spatiotemporal parameters, 6-Minute Walk Test (6MWT), Timed Up and Go Test (TUG), Timed Stair Climbing Test (SCT) were used to evaluate performance-based physical function. The Western Ontario McMaster Universities Osteoarthritis Index (WOMAC) and EuroQOL five dimensions (EQ-5D) questionnaire were used to evaluate self-reported

physical function and self-reported quality of life. All patients underwent these evaluations before and 1 month after TKA.
Results: The ECC-CON group showed clinically meaningful improvements in extensor peak torque (PT) of the non-surgical knee, gait speed, and 6MWT from preoperative values. The CON group had an increase in H/Q ratio of the surgical knee and improvement in SCT-ascent postoperatively. Both groups showed significant improvements in WOMAC-Pain, function, and EQ-5D scores. Although extensor PT of the surgical knee did not reach the preoperative level in either group, the postoperative change was significantly less in the ECC-CON group than the CON group.
Conclusion: Early combined ECC-CON resistance training minimizes the loss in quadriceps strength of the surgical knee and improves endurance and gait speed after TKA.

Use of Eccentron: progressive eccentric-concentric strength training to improve strength, endurance, and gait speed in older adult patients post-total knee arthroplasty

"The effect of virtual reality-based eccentric training on lower extremity muscle activation and balance in stroke patients."

Park SK, Yang DJ, UHM YH, Heo JW, Kim JH: The effect of virtual reality-based eccentric training on lower extremity muscle activation and balance in stroke patients. *J Phys Ther Sci*. 2016;28:2055-2058.
ABSTRACT:
Purpose: The purpose of this study was to examine the effect of virtual reality-based eccentric training on lower extremity muscle activity and balance in stroke patients.
Subjects and Methods: Thirty stroke patients participated, with 15 patients allotted to each of two eccentric training groups: one using a slow velocity (group I) and one using a fast velocity (group II). The virtual reality-based eccentric training was performed by the patients for 30 minutes once a day, 5 days a week, for 8 weeks using an Eccentron system. Surface electromyography was used to measure the lower extremity muscle activity, while a BioRescue was used to measure balancing ability.
Results: A significant difference in lower extremity muscle activation and balance ability was observed in group I compared with group II.
Conclusion: This study showed that virtual reality-based eccentric training using a slow velocity is effective for improving lower extremity muscle activity and balance in stroke patients.

Use of Eccentron: neuromuscular strength eccentric training with visual feedback to improve lower extremity strength and balance in patients post-stroke

"Exercise and medication effects on persons with Parkinson disease across domains of disability: a randomized clinical trial."

Dibble LE, Foreman KB, Addison O, Marcus RL, LaStayo PC: Exercise and medication effects on persons with Parkinson disease across domains of disability: a randomized clinical trial. *J Neurol Phys Ther*. 2015; 39:85-92.

ABSTRACT:
Background and Purpose: Hypokinesia and bradykinesia as movement deficits of Parkinson disease are thought to be mediated by both basal ganglia dysfunction and a loss of muscle mass and strength commensurate with aging and decreased levels of physical activity. For these reasons, we sought to utilize resistance training as a means to increase muscle force and minimize hypokinesia and bradykinesia in persons with Parkinson disease and examine the effects of exercise and medication on Body Structure and Function (muscle force production and muscle cross-sectional area), Activity (mobility), and Participation (Health Status) outcomes.

Methods: Forty-two participants were enrolled in a 12-week randomized clinical trial that compared 2 active exercise interventions: a standard care control group (Active Control) and an experimental group that underwent Resistance Exercise via Negative Eccentric Work (RENEW).
Results: Participants in both groups improved in muscle force production and mobility as a result of exercise and medication ($P < 0.02$). There were no significant interaction or between-group differences and no significant changes in muscle cross-sectional area or health status were observed. Effect sizes for exercise and medication combined exceeded the effect sizes of either intervention in isolation.
Discussion and Conclusions: Taken together, these results point to the complementary effects of exercise and medication on the Body Structure and Function and Activity outcomes but little effect on Participation outcomes.

Use of Eccentron: neuromuscular strength training targeted at bilateral lower extremity extensor musculature. A high-intensity eccentric resistance exercise program (Resistance Exercise using Negative Eccentric Work [RENEW] was used.

"Effects of age and acute muscle fatigue on reactive postural control in healthy adults."
Papa EV, Foreman KB, Dibble LE: Effects of age and acute muscle fatigue on reactive postural control in healthy adults. *Clin Biomech*. 2015;6 pgs. http://dx.doi.org/10.1016/j.clinbiomech.2015.

ABSTRACT:
Background: Falls can cause moderate to severe injuries such as hip fractures and head trauma in older adults. While declines in muscle strength and sensory function contribute to increased falls in older adults, skeletal muscle fatigue is often overlooked as an additional contributor to fall risk. The purpose of this investigation was to examine the effects of acute lower extremity muscle fatigue and age on reactive postural control in healthy adults.
Methods: A sample of 16 individuals participated in this study (8 healthy older adults and 8 healthy young per-sons). Whole body kinematic and kinetic data were collected during anterior and posterior reproducible fall tests before (T0) and immediately after (T1) eccentric muscle fatiguing exercise, as well as after 15-min (T15) and 30-min (T30) of rest.
Findings: Lower extremity joint kinematics of the stepping limb during the support (landing) phase of the anterior fall were significantly altered by the presence of acute muscle fatigue. Step velocity was significantly de-creased during the anterior falls. Statistically significant main effects of age were found for step length in both fall directions. Effect sizes for all outcomes were small. No statistically significant interaction effects were found.
Interpretation: Muscle fatigue has a measurable effect on lower extremity joint kinematics during simulated falls. These alterations appear to resolve within 15 min of recovery. The above deficits, coupled with a reduced step length, may help explain the increased fall risk in older adults.

Use of Eccentron: in the context of the study, the Eccentron was utilized to induce quadriceps and hip extensor fatigue

"Age-related differences in lean mass, protein synthesis and skeletal muscle markers of proteolysis after bed rest and exercise rehabilitation."
Tanner RE, Brunker LB, Agergaard J, et al. Age-related differences in lean mass, protein synthesis and skeletal muscle markers of proteolysis after bed rest and exercise rehabilitation. *J Physiol.* 2015;593:4259-4273.

ABSTRACT:
Bed rest-induced muscle loss and impaired muscle recovery may contribute to age-related sarcopenia. It is unknown if there are age-related differences in muscle mass and muscle anabolic and catabolic responses to bed rest. A secondary objective was to determine if rehabilitation could reverse bed rest

responses. Nine older and fourteen young adults participated in a 5-day bed rest challenge (BED REST). This was followed by 8 weeks of high intensity resistance exercise (REHAB). Leg lean mass (via dual-energy X-ray absorptiometry; DXA) and strength were determined. Muscle biopsies were collected during a constant stable isotope infusion in the post-absorptive state and after essential amino acid (EAA) ingestion on three occasions: before (PRE), after bed rest and after rehabilitation. Samples were assessed for protein synthesis, mTORC1 signaling, REDD1/2 expression and molecular markers related to muscle proteolysis (MURF1, MAFBX, AMPKα, LC3II/I, Beclin1). We found that leg lean mass and strength decreased in older but not younger adults after bedrest ($P < 0.05$) and was restored after rehabilitation. EAA-induced mTORC1 signaling and protein synthesis increased before bed rest in both age groups ($P < 0.05$). Although both groups had blunted mTORC1 signaling, increased REDD2 and MURF1 mRNA after bedrest, only older adults had reduced EAA-induced protein synthesis rates and increased MAFBX mRNA, p-AMPKα and the LC3II/I ratio ($P < 0.05$). We conclude that older adults are more susceptible than young persons to muscle loss after short-term bed rest. This may be partially explained by a combined suppression of protein synthesis and a marginal increase in proteolytic markers. Finally, rehabilitation restored bed rest-induced deficits in lean mass and strength in older adults.

Use of Eccentron: eccentric strength training to improve lower extremity strength and hypertrophy of healthy community dwelling individuals aged 18–35 and 60-75 years of age post 5 days of continuous bed rest. A 3 x per week exercise rehabilitation protocol was incrementally increased over 8 weeks was used to maintain intensity.

"Resistance exercise with older fallers: its impact on intermuscular adipose tissue."

Jacobs JL, Marcus RL, Morrell G, LaStayo PC: Resistance training with older fallers: its impact on intermuscular adipose tissue. *Biomed Res Intl*. 2014;7pgs. http://dx.doi.org/10.1155/2014/398960.

ABSTRACT:
Objective: Greater skeletal muscle fat infiltration occurs with age and contributes to numerous negative health outcomes. The primary purpose was to determine whether intermuscular adipose tissue (IMAT) can be influenced by an exercise intervention and if a greater reduction in IMAT occurs with eccentric versus traditional resistance training.
Methods: Seventy-seven older adults (age 75.5 ± 6.8) with multiple comorbidities and a history of falling completed a three-month exercise intervention paired with either eccentric or traditional resistance training. MRI of the mid-thigh was examined at three time points to determine changes in muscle composition after intervention.
Results: No differences in IMAT were observed over time, and there were no differences in IMAT response between intervention groups. Participants in the traditional group lost a significant amount of lean tissue ($P = 0.007$) in the nine months after intervention, while participants in the eccentric group did not ($P = 0.32$). When IMAT levels were partitioned into high and low IMAT groups, there were differential IMAT responses to intervention with the high group lowering thigh IMAT.
Conclusions: There is no decrease in thigh IMAT after a three-month exercise intervention in older adults at risk for falling and no benefit to eccentric training over traditional resistance training for reducing IMAT in these individuals.

Use of Eccentron: neuromuscular progressive eccentric-negative work strength training targeted at bilateral lower extremity extensor musculature

"Eccentric exercise in rehabilitation: safety, feasibility, and application."

LaStayo PC, Marcus RL, Dibble LE, Frajacomo F, Lindstedt S: Eccentric exercise in rehabilitation: safety, feasibility, and application. *J Appl Physiol*. 2014; 1426-1434.

ABSTRACT:

This non-exhaustive mini-review reports on the application of eccentric exercise in various rehabilitation populations. The two defining properties of eccentric muscle contractions - a potential for high muscle-force production at an energy cost that is uniquely low - are revisited and formatted as exercise countermeasures to muscle atrophy, weakness, and deficits in physical function. Following a dual-phase implementation, eccentric exercise that induces rehabilitation benefits without muscle damage, thereby making it both safe and feasible in rehabilitation, is described. Clinical considerations, algorithms of exercise progression, and suggested modes of eccentric exercise are presented.

Use of Eccentron: neuromuscular progressive eccentric-negative work strength training targeted at bilateral lower extremity extensor musculature