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Comparing the effects of two distinct eccentric modalities to traditional resistance training in resistance trained, higher functioning older adults

Ashley Gluchowski[a], Deborah Dulson[b], Fabrice Merien[c], Lindsay Plank[d], Nigel Harris[a,*]

[a] Auckland University of Technology, Human Potential Centre, 17 Antares Place, Rosedale, Auckland 0632, New Zealand
[b] Auckland University of Technology, Sports Performance Research Institute New Zealand (SPRINZ), 17 Antares Place, Rosedale, Auckland 0632, New Zealand
[c] AUT-Roche Diagnostics Laboratory, School of Science, Faculty of Health and Environmental Sciences, Auckland University of Technology, Private Bag 92006, Auckland 1142, New Zealand
[d] Department of Surgery, Faculty of Medical and Health Sciences, University of Auckland, Auckland, New Zealand

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ABSTRACT

Background: The effects of eccentric resistance exercise are of interest in the older adult cohort, but to our knowledge, there is no research on the relative effects of different eccentric modalities on a range of outcomes in higher functioning, resistance trained older adults.

Methods: 33 resistance-trained older adults (aged 67 ± 4.5 years) were randomized into one of three supervised training groups: traditional (TRE), eccentric only (ERE) or eccentrically biased resistance exercise (EBRE) on a 45°, plate-loaded leg press machine. Participants trained twice per week with maximal strength, functional capacity, body composition and blood biomarkers measured before and after the eight-week intervention.

Results: Both eccentric and concentric strength, and important functional tasks for independent living significantly improved independent of group. Body composition and blood biomarkers were found to significantly improve in the EBRE group only however, no statistical differences were found between groups.

Conclusion: Compared to traditional resistance training, the two eccentric modalities investigated here were equally effective for improvements in maximum muscular strength, functional capacity, body composition and metabolic biomarkers. When training the resistance trained older adult, very heavy isoinertial external loads (at least 70% of one repetition maximum) are effective irrespective of contraction mode. With heavy strength training, resistance trained older adults can continue to expect improvements in health and function.

1. Introduction

Older adults with chronic disability or disease are of major social and economic concern (Salomon et al., 2012). However, even the smallest of early, preventative efforts are likely to translate into significant reductions in this overall burden (Viña et al., 2016). It is estimated that for every one dollar spent in encouraging physical activity, $3.20 is saved in medical costs (US Centers for Disease Control, 1999). Physical activity and structured exercise are regarded as our most effective interventions to prevent, delay or attenuate the devastating physical and physiological effects of aging (Viña et al., 2016). Thus, older adults and society as a whole would benefit from the meticulous investigation of theoretically and practically promising exercise interventions.

To this point, investigators have been particularly intrigued by eccentric muscle action and its characteristics (higher force production, relative preservation of eccentric strength, lower aerobic cost and even a lower rating of perceived exertion, RPE). The characteristics of eccentric exercise seem to allow even the lowest functioning older adult (those with limited strength or aerobic capacity, such as sedentary individuals or those affected by sarcopenia, obesity, cardiovascular or pulmonary disease) to participate in exercise by allowing them to utilize their remaining capacities (for instance, their preserved eccentric strength). As a consequence, eccentric exercise has been studied only on those particular older adults with no recent structured exercise history (Gluchowski et al., 2015). However, research has shown that the implementation of most exercise modalities will elicit significant benefits to an untrained or detrained population (Churchward-Venne et al., 2015; Conlon et al., 2016). Thus, the limitation with using an untrained population is that we are likely investigating the well-known

* Corresponding author.
E-mail addresses: agluchow@aut.ac.nz (A. Gluchowski), deborah.dulson@aut.ac.nz (D. Dulson), fabrice.merien@aut.ac.nz (F. Merien), l.plank@auckland.ac.nz (L. Plank), nharris@aut.ac.nz (N. Harris).

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neuromuscular adaptations that come with initiating any structured exercise program, rather than the adaptations that may or may not develop from the unique modality itself. In addition, we need to investigate whether each theoretically promising exercise modality provides physical or physiological benefit above and beyond the adaptations from a participant's current training.

As such, eccentric exercise may prove to be a powerful progressive tool for continued physical and physiological improvement for the resistance trained older adult. Yet, we are unaware of any studies that have used a trained, older adult population to investigate the effects of chronic eccentric exercise (Gluchowski et al., 2015). As a result, it is the aim of this research to investigate and if appropriate, expand our exercise programming options by exploring the relative efficacy of eccentric-only exercise (no concentric muscle action performed, from here on out termed eccentric resistance exercise or ERE) and the more practically applicable eccentrically-biased resistance exercise (an attempt to emphasize the eccentric muscle action but concentric muscle action is also performed by the participant, EBRE) when compared to the more conventionally prescribed traditional (both concentric and eccentric muscle action performed, TRE) resistance exercise in a population of resistance trained older adults. We hypothesized that due to the characteristics of eccentric muscle actions, the ERE group would inevitably train with greater absolute loads thus the additional mechanical tension would lead to significant improvements in maximal eccentric strength, lean muscle mass and bone mineral content compared to the EBRE and TRE groups. Furthermore, the increase in maximal strength would not likely lead to any further improvements of functional capacity or blood biomarkers for this healthy, high-functioning cohort.

2. Methods

2.1. Participants

Thirty-three resistance trained older adults (21 females and 12 males, mean ± SD age 67 ± 4.5 yr, weight 75 ± 15.3 kg, height 169 ± 8.6 cm) participated in this trial. Participants were excluded if they were not at least 60 years of age, were not participating in structured resistance exercise for at least the last three months, had any musculoskeletal issues that prevented the safe use of the required exercise loads, or were taking any performance or body composition enhancing supplements. The Institutional Ethics Committee approved this study and participants were made aware of both the risks and possible benefits before providing written informed consent.

2.2. Study design

This was a randomized, controlled, eight-week intervention comparing the effects of TRE, ERE and EBRE on lower body maximal muscular strength, functional capacity, body composition, and blood biomarkers.

Participants were matched for baseline strength on a 45° leg press machine and then randomly assigned to one of the three training groups: ERE (n = 11, 6 females), EBRE (n = 11, 8 females) or TRE (n = 11, 7 females, control group). Participants were asked to put their current resistance training on hold and replace it with that of the current study but encouraged to continue with their regular aerobic programming (which typically included recreational walking, jogging and hiking as well as both recreational and competitive sprinting, cycling and swimming). Participants were also asked not to alter their normal nutritional or habitual physical activity habits during the study.

2.3. Testing procedures

Baseline and post-intervention testing procedures included strength, function, body composition and blood biomarkers. Lower body maximal muscular strength (kg) was assessed with the same leg press machine used in training (Life Fitness, Rosemont, IL). Adjustable mechanical brakes were used to fix the stop-start position at 110° knee angle (using a goniometer centered at the lateral epicondyle of the knee and aligned to the lateral malleolus and greater trochanter). Foot position was self selected by participants but standardized to within 5 cm between all participants. The traditional 1RM (assessing concentric muscle strength in order to push the load from 110° of knee flexion) was performed first. Following a five-minute rest, an eccentric-only 1RM (1ERM) was performed (in which an assistant performed the concentric phase, the participant then took and lowered the load in a slow controlled manner back to the start-stop position from approximately 170° degrees knee flexion). A successful 1ERM attempt was one in which the participant was able to lower the load slowly (in approximately 2 s) while coming to a stop 'softly' on the blocks. No more than five attempts were needed to determine 1RM or 1ERM. Maximal strength was also assessed mid-way through the intervention (week four) to re-inform relative training load.

Functional capacity was assessed using sit to stand (Rikli and Jones, 1999), stair descent (Oh-Park et al., 2011), rise from ground (Alexander et al., 1997) and the 6 m fast walk (Rikli and Jones, 1999). All four were assessed through timed performance (s) in an attempt to avoid any ceiling effect that can occur with fixed maximum score based assessments (such as the Berg Balance Scale or the Fullerton Advanced Balance (FAB) scale) in a high functioning cohort. However, the FAB scale was used solely to ensure our participants were objectively classified as high functioning older adults. The five-repetition sit to stand (5STS) measured how quickly a participant (with their arms folded across their chest) could sit and stand from a box height of 40 cm, five times. The stair descent (SD) measured how quickly a participant could descend a 14-step staircase (height 17 cm, length 30 cm). Time began with participants' initiation of first step and stopped when both feet were on the landing. The rise from ground (RFG) assessment measured how quickly a participant could stand from a supine position. Time began with the word "go" and stopped when the participant was in an upright position. The 6 m fast walk (6FW) measured how quickly a participant could walk (without running) six metres. The 10 m track included two metres both preceding and following the timed six metres to allow for maximum acceleration and deceleration. Time began when the participant crossed the two-metre mark and stopped when they broke the eight-metre mark.

Body composition was assessed using whole-body Dual-energy X-ray Absorptiometry (DXA) scanning (GE-Lunar iDXA, GE Healthcare, Madison, WI). GE-Lunar enCORETM software (version 15) was used to determine lower limb (LL) lean mass (g), total bone mineral content (BMC) (g), total fat mass (g) and estimated visceral adipose tissue (VAT) (g). Height (wall stadiometer to nearest 0.1 cm, baseline only) and weight (to nearest 0.01 kg) were also taken.

Blood samples were collected through venipuncture of the anticubital vein on the morning (from 08:00 to 09:00 h) after a 12-hour fasting period. Serum was isolated by centrifugation at 1500g at 4 °C for 10 min and frozen at −80 °C until further analyses. Samples were subsequently thawed and analysed using specific commercial assays on a Roche Modular E170 at AUT-Roche Diagnostic Laboratory. Blood biomarkers assessed included metabolic biomarkers (HbA1c (mM/M), Glucose (mmol/L), Insulin (pmol/L)), cardiovascular biomarkers (low-density lipoprotein (LDL) (mmol/L), high-density lipoprotein (HDL) (mmol/L), Triglycerides (mmol/L)) and an inflammatory biomarker (high-sensitivity C reactive protein (hs-CRP) (mg/L)).

2.4. Familiarization sessions

Two familiarization sessions took place the week between baseline testing and the intervention. Familiarization allowed each participant to acquaint themselves with their respective leg press training modality (ERE, EBRE or TRE), as well as the remaining upper body and core