Functional-Strengthening: A Pilot Study on Balance Control Improvement in Community-Dwelling Older Adults

Micah D. Josephson[1], John G. Williams[2]

Affiliations: [1]University of Delaware, Department of Kinesiology and Applied Physiology, Newark, DE, USA, [2]West Chester University of Pennsylvania, Department of Kinesiology, West Chester, PA, USA

Correspondence: Micah Josephson, University of Delaware, Department of Kinesiology and Applied Physiology, 541 S. College Ave, 156 Human Performance Lab, Newark, DE, USA 19716. E-mail: micahj@udel.edu

ABSTRACT Adults over the age of 65 have a 1 in 3 chance of falling; in 2012, more than $30 billion was spent on medical costs due to these falls. The division of resistance training and neuromotor training balance improvement interventions has shown to yield low to moderate results. Athletes combine both resistance training and skill development (function) training to improve skilled performance. Older adults may not be performing high-level sports activities, but still require strength, power, and functional fitness levels to perform relatively high-level skills. The purpose of this study was to determine the effects of combining resistance and functional training into functional-strength training on dynamic balance control in moderately active older adults. Eighteen healthy older adults were divided into three groups; functional resistance, standard resistance, and control. All groups met for their intervention twice a week for six weeks. Dynamic balance was assessed using the Fullerton Advanced Balance Scale (0-40). Results of individual paired T-tests showed a significant improvement in balance control in the functional resistance group ($t(5) = -3.492$, $p = .017$) and a very large effect size ($d = 1.33$) whereas neither the standard resistance nor control group had a significant reduction in the risk of falls. Manipulating multidimensional, neuromotor function during resistance training exercises is an effective method of applying the overload principle in order to reduce falls risk in moderately active seniors.

KEY WORDS Neuromotor, ADL, Falls risk, Overload progression, Functional training.

@MJSSMontenegro
FUNCTIONAL-STRENGTHENING
http://mjssm.me/?sekcija=article&artid=136

Introduction

Older Adults have a one in three chance of falling during daily activities (Stevens et al., 2012). Balance control is a critical factor in fall risk, and various authoritative bodies have addressed the issue. Research using exercise to enhance balance has taken many forms, applying various low to moderate intensity interventions. These interventions resulted in low to modest outcomes (Buchner et al., 1997; Means, Rodell, O'Sullivan, & Cranford, 1996; Topp, Mikesky, Wigglesworth, Holt, & Edwards, 1993). In contrast, balance-specific interventions particularly those including strength training have produced positive results (Islam et al., 2004).

Contrary to the latest balance recommendations from the Panel on Prevention (PoP) (Kenny et al., 2011), research shows that standard resistance training has a functional ceiling (Hazell, Kenno, & Jakobi, 2007; Sayers, 2007). If the reported research concludes that the balance:function relationship is not improved through standard resistance training, then it seems that critical dimensions of what is clearly an important motor skill have not been considered.

Combining the multidimensional nature of the balance:skill with standard resistance training can address both the PoP's recommendations and the need for motor skill development. Using progressive overload methods, the exercises can be intensified through normal methodology or a change in stability or complexity. Such techniques have been shown to be an effective means of improving performance in a variety of sports. (Henry, 2011; Myer, Ford, Palumbo, & Hewett, 2005).

Accepted after revision: September 22 2016 | First published online: September 01 2017

Conflict of interest: This research was supported in part by the Student-Faculty Research Grant from West Chester University.

This study was a comparative analysis of a conventional strength training regimen with a "functional" strength training program designed to emphasize balance as a dynamic skill. We predicted that a "functional" training group would show a greater improvement in balance than both the conventional strength training and the control groups.

Methods

Participants

Participants were recruited from a local health club. For participation, responders had to be over 65 years old and not have had any lower body injuries in the previous 12 months or a hip or knee replacement. Eighteen (n=15 women/n=3 men) community-dwelling subjects met the criteria, provided informed consent, and participated in this study. All participants attended senior fitness classes at least three days per week and performed other strengthening and cardiovascular exercise to maintain a moderate level of physical activity as defined by the American College of Sports Medicine (ACSM). The project was approved by the West Chester University of Pennsylvania Institutional Research Board. The mean age was 75.9 (+5.1) years.

Design

This study was a three-group pre- to post- training design. Participants were randomly assigned to intervention groups. Each group attended two exercise classes per week for six weeks for thirty to forty-five minutes at approximately the same time of the day. All three groups met simultaneously and performed their intervention in separate areas of the facility to keep them blind to the other exercises. The exercise programs were delivered by appropriately qualified exercise science certified instructors. The focus was the lower limb function. Groups had a single program progression after three weeks. Participants were assessed pre- and post-training with the Long-Form Fullerton Advanced Balance (FABS) scale. This is a ten-item assessment system developed and validated previously to assess multiple components of balance. It is scored 0-40 with a higher score indicating greater balance control. (Rose, Lucchese, & Wiersma, 2006).

Functional Group (FG)

The FG program was an exercise circuit consisting of seven exercises. Subjects completed the circuit twice and completed eight repetitions of each exercise prior to moving to the next station. The circuit consisted of: (1) Sit-to-stands with feet on a VersaBalance™ pad with a 3.64 kg (8 lb) weight; (2) Step-ups with 5-2 inch risers and a 2.73 kg (6 lb) weight in each hand; (3) Split squats holding onto a support bar; (4) Forty steps of foot heel-to-toe farmer's walks with a 5.54 kg (12 lb) weight in one hand; (5) Standing hip abduction; (6) Standing heel-raises.

In week four, the exercises were progressed to (1) Squats while standing on a VersaBalance™ pad with a 4.55 kg (10 lb) weight; (2) Crossover step-ups with 3.64 kg (8 lb) weights in each hand; (3) Single-leg heel-raises; (4) Split-squats front leg on an Airex mat; (5) Standing long jumps; (6) Forty-foot heel-to-toe farmer's walks with a 6.82 kg (15 lb) weight in one hand; a 187.42 cm (73 in) VersaBalance™ beam was laid out at the twenty-foot mark; (7) One leg-to-one leg lateral jumps. Exercises were modified to allow for individual differences among participants.

Strength group (SG)

The SG exercised in a sets and repetitions program working around a "pin-selectorized", weight-rack apparatus. Two sets of eight repetitions of each exercise were performed at a subject-selected weight, with a 90-second rest interval between each set. The exercises consisted of (1) Seated leg press; (2) Standing hip extension; (3) Seated leg-curl; (4) Seated hip-abduction; (5) Seated hip-adduction; (6) Straight leg heel-raises on seated leg press; (7) Seated knee extension. The leg press, knee extension, leg curl, and heel raise all became unilateral movements. Resistance was increased when the participant could complete both sets comfortably.

Control group (CG)

The CG carried out a seven flexibility/range-of-motion exercise course. For six weeks, the participants performed the same exercises: (1) Figure-four hip-stretch; (2) Seated hamstring stretch; (3) Chair lunge-stretch; (4) Standing chair calf stretch; (5) Standing quadriceps stretch; (6) V-sit inner thigh stretch; (7) Angry cat dynamic stretch. Exercises 1 to 5 were performed either seated in a chair or holding onto a chair for support. Exercises 6 and 7 were performed on the floor.

Statistical analysis

The scores for the FAB were totaled, and data were analysed in SPSS 21. Descriptive statistics were calculated for the pre- and post-training values. As the sample size was that of a pilot study, paired t-tests were performed on each group individually to determine the significance of each intervention group.

Results

Pre-training there were no statistically significant differences in FABS score between the three groups ($F=3.008$, $p>.05$). The overall adherence level was 76 % (± 21%) of exercise sessions, and no statistically significant differences were found between the groups.

TABLE 1 Risk of fall in moderately active older adults pre- and post-exercise intervention

Exercise Condition	Pre- to Post-score change	Adherence	Effect-size
Functional	3.33 (±2.3)*	81% (±20%)	1.33 (very large)**
Conventional	1.0 (±3.4)	73% (±21%)	0.07 (negligible)
Control	.83(±1.7)	75% (±27%)	

Legend: Descriptive statistics (FABS values) under the exercise intervention conditions pre- to post–training. **Cohen's d, (5)= -1.185, p=.289, *significant: t(5) =-3.492, p=.017**.

Of the 18 participants, 10 changed in a positive direction, 4 showed no change, 3 changed in a negative direction, and 1 did not complete the protocol. All groups improved FABS performance at program completion. The FG had a statistically significant 3.33-point improvement in balance control (t(5)-3.492, p=.017); the SG had a 1.0 improvement in balance, and the control group had a 0.83 improvement in balance. Cohen's D was used to compare the effect size of each intervention. Effect size was found to be very large in the functional training group and negligible in the conventional strength group when compared to the control (d=1.33, .07 respectively). These can be observed in Table 1. Figure 1 shows pre- and post-FABS score for each group.

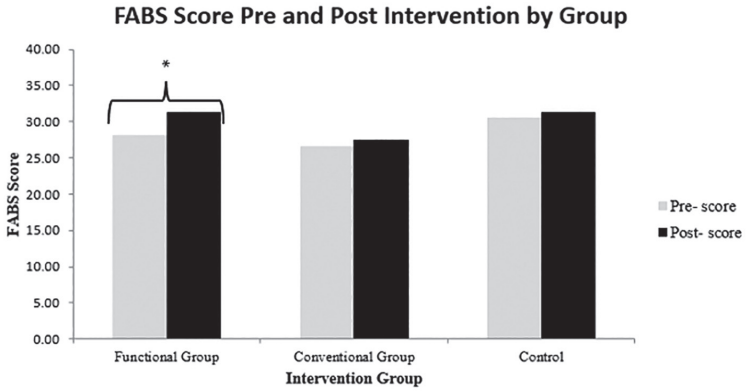

FIGURE 1 Neither the conventional strengthening group (FABS scores: 26.6 to 27.4) or the control group (FABS scores: 30.5 to 31.3) had significant improvements in dynamic balance control pre- to post-intervention. The functional strengthening group showed significant improvements in dynamic balance control pre- to post-intervention (FABS scores: 28 to 31.1; *t(5) =-3.492, p=.017)

Discussion

Functional strength training (FT) was an effective balance intervention, as observed through the "large" effect size. Conventional strength training (CT), as described earlier, alone does not produce significant improvement in balance. Here, neither the CT group nor controls showed statistically significant or clinical changes (effect size) whereas the FT group had a mean change in score of 3.33 (+1.33). In line with the findings of Buchner et al. (1996), functional strength training combining both interventions types yielded a large clinical effect. Therefore, it can be stated that functional strength training is an effective method of applying the overload principle to increase balance control.

This study was limited by its small sample size and current activity level of the participants. These subjects may not necessarily represent the average older adult population. Future studies targeting a sedentary population may show greater improvement with FT.

This type of functional training, unexplored in academic research, has been common practice in the fitness industry for decades. In research, functional training is typically discussed with the interest of sports performance enhancement. In this study, the "sport" is activities of daily living with particular focus on the skill of balance control.

Acknowledgements

Ellis Athletic Center of Newtown Square, PA for the use of the facility.

REFERENCES

Buchner, D. M., Cress, M. E., de Lateur, B. J., Esselman, P. C., Margherita, J., Price, R., & Wagner, E. H. (1997). The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *52*(4), M218–M224.

Hazell, T., Kenno, K., & Jakobi, J. (2007). Functional benefit of power training for older adults. *Journal of Aging and Physical Activity*, *15*(3), 349–359.

Henry, T. (2011). Resistance Training for Judo: Functional Strength Training Concepts and Principles. *Strength and Conditioning Journal*, *33*(6), 40–49. http://doi.org/10.1519/ SSC.0b013e31823a6675

Islam, M. M., Nasu, E., Rogers, M. E., Koizumi, D., Rogers, N. L., & Takeshima, N. (2004). Effects of combined sensory and muscular training on balance in Japanese older adults. *Preventive Medicine*, *39*(6), 1148–1155. http://doi.org/10. 1016/j.ypmed.2004.04.048

Kenny, R. A., Rubenstein, L. Z., Tinetti, M. E., Brewer, K., Cameron, K. A., Capezuti, L., … Peterson, E. W. (2011). Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. *Journal of the American Geriatrics Society*, *59*(1), 148–157. http://doi.org/10. 1111/j.1532-5415.2010.03234.x

Means, K. M., Rodell, D. E., O'Sullivan, P. S., & Cranford, L. a. (1996). Rehabilitation of elderly fallers: pilot study of a low to moderate intensity exercise program. *Archives of Physical Medicine and Rehabilitation*, *77*(10), 1030–1036.

Myer, G., Ford, K., Palumbo, J., & Hewett, T. (2005). Neuromuscular training improves performance and lower-extremity biomechanics in female athletes. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association*, *19*(1), 51–60.

Rose, D. J., Lucchese, N., & Wiersma, L. D. (2006). Development of a multidimensional balance scale for use with functionally independent older adults. *Archives of Physical Medicine and Rehabilitation*, *87*(11), 1478–1485. http://doi. org/10.1016/j.apmr.2006.07.263

Sayers, S. P. (2007). High-speed power training: A novel approach to resistance training older men and women. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association*, *21*(2), 518–526.

Stevens, J. A., Ballesteros, M. F., Mack, K. A., Rudd, R. A., DeCaro, E., & Adler, G. (2012). Gender differences in seeking care for falls in the aged Medicare population. *American Journal of Preventive Medicine*, *43*(1), 59–62. http:// doi.org/10.1016/j.amepre.2012.03.008

Topp, R., Mikesky, A., Wigglesworth, J., Holt, W., & Edwards, J. E. (1993). The Effect of a 12-week Dynamic Resistance Strength Training Program on Gait Velocity and Balance of Older Adults. *The Gerontologist*, *33*(4), 501–506. http://doi. org/10.1093/geront/33.4.501