Original Research

TRX Suspension Training: A New Functional Training Approach for Older Adults – Development, Training Control and Feasibility

ANGUS GAEDTKE†, and TOBIAS MORAT‡

Institute of Movement and Sport Gerontology, German Sport University Cologne, Cologne, GERMANY

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 8(3): 224-233, 2015. Because of its proximity to daily activities functional training becomes more important for older adults. Sling training, a form of functional training, was primarily developed for therapy and rehabilitation. Due to its effects (core muscle activation, strength and balance improvements), sling training may be relevant for older adults. However, to our knowledge no recent sling training program for healthy older adults included a detailed training control which is indeed an essential component in designing and implementing this type of training to reach positive effects. The purpose of this study was to develop a TRX Suspension Training for healthy older adults (TRX-OldAge) and to evaluate its feasibility. Eleven participants finished the 12 week intervention study. All participants trained in the TRX-OldAge whole-body workout which consists of seven exercises including 3-4 progressively advancing stages of difficulty for every exercise. At each stage, intensity could be increased through changes in position. Feasibility data was evaluated in terms of training compliance and a self-developed questionnaire for rating TRX-OldAge. The training compliance was 85 %. After study period, 91 % of the participants were motivated to continue with the program. The training intensity, duration and frequency were rated as optimal. All participants noted positive effects whereas strength gains were the most. On the basis of the detailed information about training control, TRX-OldAge can be individually adapted for each older adult appropriate to its precondition, demands and preference.

KEY WORDS: Sling exercise training, healthy older adults, program development, training protocol

INTRODUCTION

The aging process of skeletal muscles is characterized by a reduced number of motor units, muscle fibers and size of type 2 fibers that lead to a loss of muscular strength and power (32). Furthermore, deteriorated proprioception (14, 1) and reaction time (6) were observed with increasing age. These age-related changes result in strength, balance, and mobility declines (13, 7, 8, 3, 2), which could induce falls or a loss of independence (28, 18). It is recommended for older adults to perform regular physical activity to avoid functional limitations (22). Beyond that, exercise intervention studies have demonstrated positive effects on strength, balance, and functional performance for older adults (10, 17, 29). Traditional strength training with weight machines for older adults has been shown to increase muscular strength (29), balance performance if lower limb muscles were trained (17), and functional tasks (10).

In past years, sport science has tended to focus on functional strength training for older adults, because it is geared to daily life movements (performing complex movements with own body weight). Compared to traditional resistance training, previous studies showed a similar one repetition maximum (1RM) increase (29, 19) and a significant improvement in the sit-to-stand test (19) through functional resistance training, whereas the weight machine group did not change significantly. For maximal walking speed, a significant enhancement was observed within the functional strength training but not within the traditional resistance training group (29). During a reaction task, older adults participating in functional resistance training significantly enhanced their movement time whereas training with weight machines could not achieve this result (33). Strength improvements from traditional resistance training alone and with additional functional (strengthening) exercises are similar (11). However, compared to traditional strength training alone, timed performance of functional abilities like chair rising or stair climbing (20) and balance (5) only changed with additional functional exercises during strength training.

Core stability training is a sort of training that combines both functional and strength components. By strengthening core muscles an optimal load transmission from upper to lower body can be realized (34). This can result in better core stability and balance. Because of these effects, functional core stability training programs were conducted in previous intervention studies for older adults (12, 9). One possible core stability program is called sling training. Previous studies focusing on patients with low back pain indicated an increased trunk muscle activation of transversus abdominis, internal oblique, rectus abdominis, multifidi and erector spinae during exercises with a sling trainer (15, 25). In studies with younger adults, both improvements in muscular strength (4, 24) and balance (16, 23) were observed. In regard to older adults, however, there is less evidence from intervention studies implementing sling training. The existent studies with older participants examined osteoporosis and knee osteoarthritis patients (26, 27, 31).

Based on the positive effects of sling training on balance and strength parameters in younger adults and patients, this kind of training may be suitable for healthy older adults. However, to our knowledge no sling training program for this target group exists. Therefore the purpose of this study was to develop a detailed exercise prescription for a whole-body sling training program for healthy older adults and to analyze its feasibility. This pilot study provides information about feasibility and practicability of the TRX Suspension Training program developed for older adults (TRX-OldAge).

METHODS

Participants

The target population of the study was community-dwelling older adults aged 60 years and older. Participants were recruited by advertisements placed on web pages, in local newspapers, posters, and flyers in Cologne and the surrounding area. Eleven healthy older adults, nine males and two females (mean ± standard deviation height, 176 ± 8 cm, *M* ± *SD* body mass, 88 ± 16 kg) and age ranged from 60 to 73 years (*M* ± *SD*, 66 ± 4 years) participated in the feasibility study. Good health had to be ensured by a medical certificate from the participants' physician. Despite that, the following diseases were recorded: hypertension adjusted by a physician (n = 4), type 2 diabetes (n = 3), rheumatoid arthritis (n = 1), scoliosis (n = 1), herniated disk more than 10 years ago (n = 1), elevated blood cholesterol level (n = 1).

Protocol

The exercise regimen presented here was developed using the TRX Suspension Trainer (TRX; Fitness Anywhere LLC, San Francisco, California, USA). The TRX is characterized by two straps hanging down from the anchor point. The Suspension Anchor™ allows the TRX to be adjusted to each strap length necessary to execute different exercises. To ensure safety throughout training, it is of the greatest importance to have an anchor point that will support body weight. According to the features of the various exercises, either the foot cradles or the handles at the end of each strap are used. With TRX-OldAge, participants train with their own body weight. During all exercises the body must be engaged as one coordinated system. In particular, the core muscles are activated to maintain the required positions during dynamic movements in the exercises. To coordinate these three-dimensional exercises, neuromuscular coordination is one key aspect of TRX training.

In TRX-OldAge, seven exercises were developed (see figure 1). Previously existing exercises were modified to be suitable for older adults. Two exercises target upper body, two lower body, two exercises focus on the abdominal muscles while the seventh exercise includes the whole ventral muscle chain. In respect of functional limitations in some older adults, for almost every exercise an alternative was developed (see appendix II).

Figure 1. TRX-OldAge - seven exercises targeting the whole body.

Through training regulation and controlling the load progression, different exercise versions and settings have been designed and characterized by specific parameters and principles. According to common training principles, the progression of intensity and difficulty is realized through 3-4 progressively advancing stages of difficulty (version A: easiest version; version C or D: most difficult version) for each exercise. In respect of the different versions, increasing difficulty is achieved through various bases of support conditions (Principle of base of support, PBS). By modifying the standing position between 'step position stance', 'shoulder width stance', 'hip width stance', 'closed-leg stance', 'narrow stance', 'single-leg stance' or 'single-leg stance on a balance pad', the base of support is varied. As a consequence, instability increases and movement execution becomes more difficult. Exercises in a lying position are different in respect of the body parts' contact with the mat. The different versions of each exercise are displayed in appendix II.

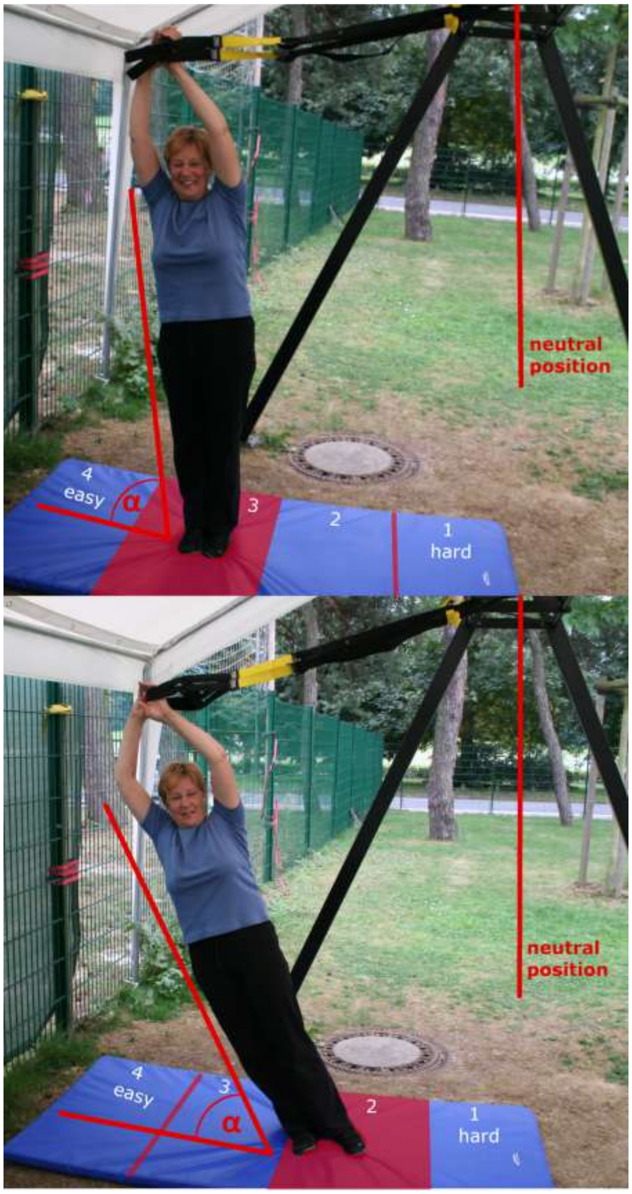

Figure 2. Principle of body angle (PBA).

In order to progressively increase intensity within each version, different settings are defined and adjusted in compliance with some TRX-specific principles (see table 1).

In practice, the supervisor should initially utilize the different settings throughout the various stages of difficulties. Only if this is done, will the participant start the next version at the easiest setting. The settings described cannot be used for every exercise. In appendix II the suitable and adjustable settings and the order in which they should be carried out for each exercise is presented.

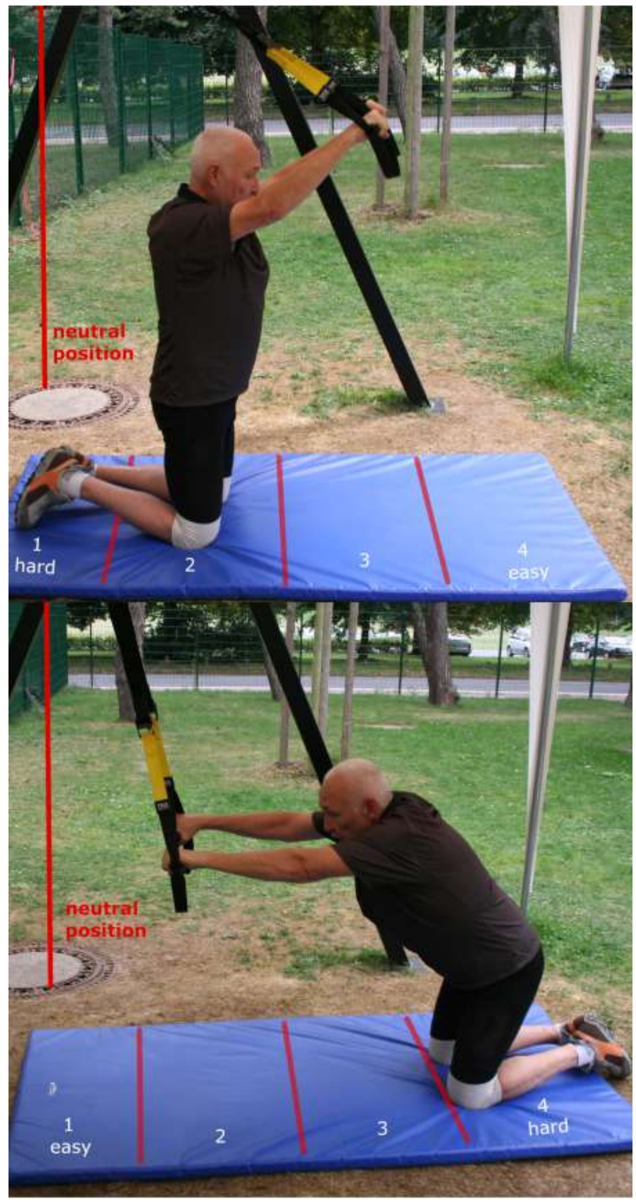

Figure 3. Principle of facing (PF).

After developing the training program TRX-OldAge, it was conducted outdoors with healthy older adults for 12 weeks (three times per week for 30 minutes) from

Table 1. Settings developed to increase intensity within the different exercise versions

Principle	Description
body angle (PBA)	By reducing the angle alpha between body and surface, the center of gravity (COG) moves outside the base of support, more load is transferred on the TRX and the person has to generate more force (see figure 2).
facing (PF)	Ropes deflected from neutral position implicate a restoring force that increases with greater angular position. While conducting a frontal exercise... ...facing away from the anchor point, the restoring force helps to recover starting position (see figure 3a). ...towards the anchor point, the restoring force does not support the recovery of starting position (see figure 3b). For exercise 7 (version B and C), facing away from anchor point is more difficult than facing towards it.
grip position (PGP)	By grasping the handles with the whole hand, movement execution is facilitated. Grasping with 4, 2, or only 1 finger, the instability increases and complicates the exercise execution.
sling length (PSL)	A greater sling length in the same standing/lying position gives a decreased body angle and greater sling vibration (instability). These aspects result in an increased intensity.
body part contact (PBP) (specific for exercise 7 version B and C)	Version B: By placing the heels in the loops, exercise execution becomes easier. If the hands grab the loops and the feet have to be kept in an angled position with a 90 degree flexion in hip and knee, the execution is complicated. Version C: Because of a lower center of gravity distance to the floor, exercise execution with forearm support is easier than supporting the body with the hands.

June to August. The participants were kept dry and protected from sunlight by an awning. Two TRX Suspension Trainers (TRX; Fitness Anywhere LLC, San Francisco, California, USA) were attached to a TRX Suspension Frame (TRX; Fitness Anywhere LLC, San Francisco, California, USA). The participants trained in pairs. The exercises were performed in the order as described in appendix II.

The practical implementation of TRX-OldAge was evaluated with a self-developed questionnaire. It consisted of eight questions that assessed the subjective rating of training, its effects, problems and experiences with TRX Suspension Training (see appendix III). Participants completed the questionnaire after the training period of 12 weeks. Items were generated in the form of a Likert scale or as open-ended and dichotomous yes-no questions. A five-point Likert scale (1 = too low; 5 = too high) was used to assess the subjective rating of training control, whereas a six-point version of a Likert scale (1 = not at all; 6 = extremely) analyzed satisfaction and effects of training.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics for Windows (version 22, IBM, Armonk, New York, USA). Descriptive statistics were calculated for every questionnaire item. Feasibility of the self-developed questionnaire was analyzed with an item analysis and a Rasch model using jMetrik for Windows (version 4.0.0, jMetrik, Charlottesville, Virginia, USA). Because it was a pilot study with only one measurement point, a sample size calculation was not executed.

RESULTS

All participants (N = 11) completed the assessment and no data were missing. No participant indicated any former theoretical or practical experience with the TRX Suspension Trainer. The mean training compliance was 85 ± 10 %. In the questionnaire, training intensity was rated as optimal by 91 % of the participants, and training frequency (three times per week) by all 100 % of participants (see figure 4). The duration (30 minutes per session) of a single training session was perceived as slightly too short for 9 % and slightly too long for 18 %, whereas 73 % rated it as optimal (see figure 4).

All participants (100 %) subjectively reported that TRX-OldAge training induced positive effects. The answer distribution for strength, gait and balance improvements are shown in figure 5. For flexibility 27 % reported only negligible or small improvements (2 or 3 on a six-point Likert scale), whereas 73 % recognized strong improvements (4 or 5 on a six-point Likert scale). Almost 82 % of participants refer to small (46 %) or strong (36 %) improvements (4 or 5 on a six-point Likert scale) of overall well-being.

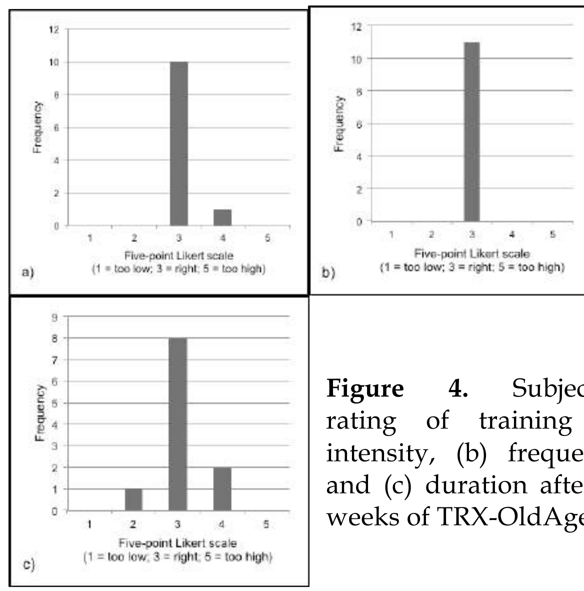

Figure 4. Subjective rating of training (a) intensity, (b) frequency, and (c) duration after 12 weeks of TRX-OldAge.

For three participants (27 %) TRX-OldAge led to knee, hip or thoracic spine pain. No problems were reported by 64 % of the participants and one participant abstained from answering. Existing pain prior to TRX-OldAge was reduced by the intervention for 36 % of the participants (4 or 5 on a six-point Likert scale). No change (1 on a six-point Likert scale) was observed for 27 % of the participants.

Almost 91 % of the participants wanted to continue TRX-OldAge (4 to 6 on a six-point Likert scale). The answer distribution is presented in figure 6. Satisfaction about training in small groups of two participants per group was high. Whereas 82 % of the participants reported a 5 or 6 on a six-point

Likert scale, only 2 participants (18 %) rated a 4 on the same scale.

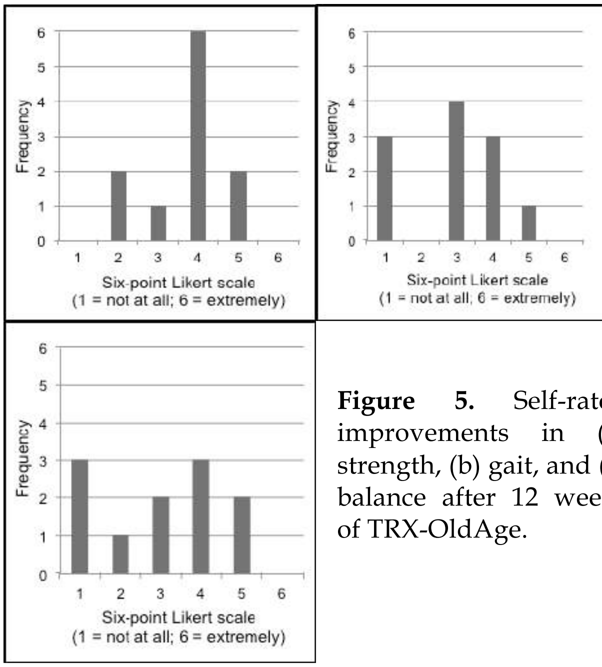

Figure 5. Self-rated improvements in (a) strength, (b) gait, and (c) balance after 12 weeks of TRX-OldAge.

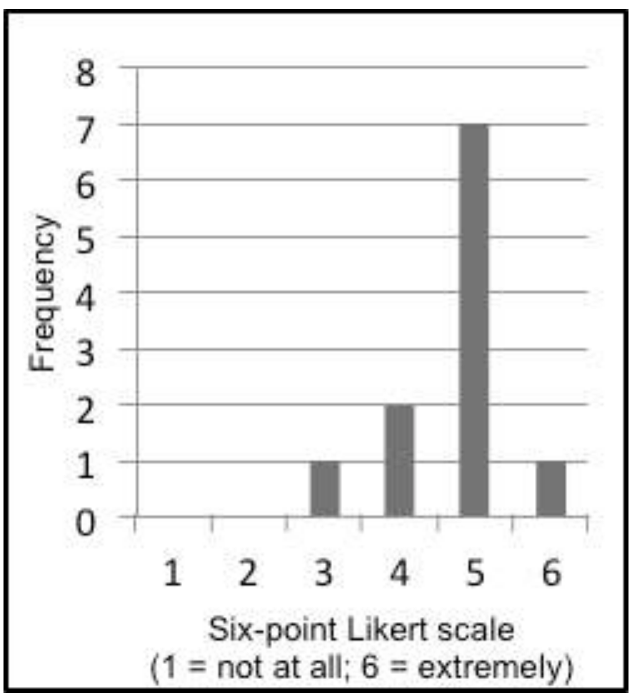

Figure 6. Answer distribution for interest in continuing TRX-OldAge.

The item analysis revealed a mean discrimination of 0.46 (range: -0.05 to 1.18). Item difficulty, measured by Rasch model analysis, ranged from -3.11 to 4.32 with a mean of -0.14. For polytomous items rating, the improvements of flexibility (-0.6) and overall well-being (-0.6) were the easiest items, whereas rating the group size for future interventions (Would you consider practicing TRX-OldAge in a group of 15 participants?) was the most difficult item (0.66). Beyond that, item reliability and person reliability were 0.48 and 0.70, respectively.

DISCUSSION

The results of the questionnaire showed that the mean item discrimination was acceptable (21). However, a negative discrimination value appeared for one item (Are you interested in continuing TRX-OldAge?). These results indicate a serious problem with the item, which should be deleted or revised (21). Both item reliability and person reliability were lower than the recommended value of 0.8 (21). The item reliability of 0.48 indicates that the sample size for the questionnaire was too small (21). A more comprehensive test is needed to increase the person reliability.

However, compliance was high, and training intensity and frequency were predominantly positively rated. This indicates that TRX-OldAge is suitable for and accepted by the target group of healthy older adults. The defined training duration of about 30 minutes was also rated as optimal and seems to be adequate to ensure high concentration and a sufficient recovery period for the participants during the TRX Suspension Training.

All participants noted positive effects. In comparison to gait and balance improvements, strength gains were mostly reported. This might be due to the program that primarily focuses on strength. Slight balance improvements can be explained by increased core muscle activation and advanced balance abilities during sling exercises. However, TRX-OldAge should be modified for persons with risk of falling. For this target group, additional balance exercises can be developed and added to the program.

At the end of the training, three participants reported pain. Knee pain occurred during the squat exercise and might be caused by a joint damage prior to the training. Thoracic spine pain was observed during the crunches version B, whereas hip pain was reported while performing squat version C and hip abduction version D. Many of these pain problems were solved by choosing the alternative exercise. However, in regard to the likelihood of pre-existing injuries and discomfort in the target group TRX-OldAge should be expanded with further exercise alternatives. In addition to pre-existing problems, a weak core activation and incorrect spine position during the exercises may have caused the pain. Thus, careful supervision and ongoing correction of the proper muscle activation and spine position during the execution is essential. In this context, it has to be mentioned that the group size should be kept low for beginners without sling training experience (1:2 ratio between instructor and participants is recommended). Only in this way, can appropriate supervision through individual feedback and correction be given. In the case of improved exercise execution during training progression, larger group sizes (e.g. 1:5) or independent training sessions are possible. This fact may be relevant for large scale implementations of TRX-OldAge. In contrast to the negative effect on pain, four participants noted decreased pain after TRX-OldAge. This confirms the results of other sling exercise intervention studies focusing on pain (27, 30).

Subsequent to the development of the TRX Suspension Training for older adults of 60 years and older (TRX-OldAge), the next step will be to analyze the program's effects on strength, balance and functional mobility in a systematic intervention study with objective measurements. For this study, a larger sample size with a balanced gender ratio is needed. The results of the intervention study can be used to confirm the self-rated positive effects of TRX-OldAge on strength, balance and functional ability and to compare the effects with other functional strength training programs.

However, due to the detailed description of all relevant information about the TRX-OldAge program presented here, this new training program can be adapted individually to older adults in practice. The first subjective trends showed that a TRX Suspension training (TRX-OldAge) was feasible for healthy older adults.

REFERENCES

1. Adamo DE, Martin BJ, Brown SH. Age-related differences in upper limb proprioceptive acuity. Percept Mot Skills 104(3 Pt 2): 1297-1309, 2007.

2. Akbari M, Mousavikhatir R. Changes in the muscle strength and functional performance of healthy women with aging. Med J Islam Repub Iran 26(3): 125-131, 2012.

3. Baloh RW, Ying SH, Jacobson KM. A longitudinal study of gait and balance dysfunction in normal older people. Arch Neurol 60(6): 835-839, 2003.

4. Danelly BD, Otey SC, Croy T, Harrison B, Rynders C.A., Hertel JN, Weltman A. The effectiveness of

traditional and sling exercise strength training in women. J Strength Cond Res 25(2): 464-471, 2011.

5. de Bruin ED, Murer K. Effect of additional functional exercises on balance in elderly people. Clin Rehabil 21(2): 112-121, 2007.

6. Der G, Deary IJ. Age and sex differences in reaction time in adulthood: results from the United Kingdom Health and Lifestyle Survey. Psychol Aging 21(1): 62-73, 2006.

7. Forrest KY, Zmuda JM, Cauley JA. Patterns and correlates of muscle strength loss in older women. Gerontology 53(3): 140-147, 2007.

8. Fujita T, Nakamura S, Ohue M, Fujii Y, Miyauchi A, Takagi Y, Tsugeno H. Effect of age on body sway assessed by computerized posturography. J Bone Miner Metab 23(2): 152-156, 2005.

9. Granacher U, Lacroix A, Muehlbauer T, Roettger K, Gollhofer A. Effects of core instability strength training on trunk muscle strength, spinal mobility, dynamic balance and functional mobility in older adults. Gerontology 59(2): 105-113, 2013.

10. Hanson ED, Srivatsan SR, Agrawal S, Menon KS, Delmonico MJ, Wang MQ, Hurley BF. Effects of strength training on physical function: influence of power, strength, and body composition. J Strength Cond Res 23(9): 2627-2637, 2009.

11. Henwood TR, Taaffe DR. Short-term resistance training and the older adult: the effect of varied programmes for the enhancement of muscle strength and functional performance. Clin Physiol Funct Imaging 26(5): 305-313, 2006.

12. Hosseini SS, Asl AK, Rostamkhany H. The effect of strength and core stabilization training on physical fitness factors among elderly people. World Appl Sci J 16(4): 479-484, 2012.

13. Hughes VA, Frontera WR, Wood M, Evans WJ, Dallal GE, Roubenoff R, Fiatrone Singh MA. Longitudinal muscle strength changes in older adults: influence of muscle mass, physical activity, and health. J Gerontol A Biol Sci Med Sci 56(5): B209-217, 2001.

14. Hurley MV, Rees J, Newham DJ. Quadriceps function, proprioceptive acuity and functional performance in healthy young, middle-aged and elderly subjects. Age Ageing 27(1): 55-62, 1998.

15. Kang H, Jung J, Yu J. Comparison of trunk muscle activity during bridging exercises using a sling in patients with low back pain. J Sports Sci Med 11(3): 510-515, 2012.

16. Kim JH, Kim YE, Bae SH, Kim KY. The effect of the Neurac sling exercise on postural balance adjustment and muscular response patterns in chronic low back pain patients. J Phys Ther Sci 25(8): 1015-1019, 2013.

17. Lee IH, Park SY. Balance improvement by strength training for the elderly. J Phys Ther Sci 25(12): 1591-1593, 2013.

18. Lin MR, Hwang HF, Hu MH, Wu HD, Wang YW, Huang FC. Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and Tinetti balance measures in community-dwelling older people. J Am Geriatr Soc 52(8): 1343-1348, 2004.

19. Lohne-Seiler H, Torstveit MK, Anderssen SA. Traditional versus functional strength training: effects on muscle strength and power in the elderly. J Aging Phys Act 21(1): 51-70, 2013.

20. Manini T, Marko M, VanArnam T, Cook S, Fernhall B, Burke J, Ploutz-Snyder L. Efficacy of resistance and task-specific exercise in older adults who modify tasks of everyday life. J Gerontol A Biol Sci Med Sci 62(6): 616-623, 2007.

21. Meyer JP. Applied measurement with jMetrik. Meyer, New York, 2014

22. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, Macera CA, Castaneda-Sceppa C. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 39(8): 1435-1445, 2007.

23. Pedersen JLS, Kirkesola G, Magnussen R, Seiler S. Sling exercise training improves balance, kicking velocity and torso stabilization strength in elite soccer players. Med Sci Sports Exerc 38: 243, 2006.

24. Prokopy MP, Ingersoll CD, Nordenschild E, Katch FI, Gaesser GA, Weltman A. Closed-kinetic chain upper-body trainings improves throwing performance of NCAA division I softball players. J Srength Cond Res 22(6): 1790-1798, 2008.

25. Saliba SA, Croy T, Guthrie R, Grooms D, Weltman A, Grindstaff TL. Differences in transverse abdominis activation with stable and unstable bridging exercises in individuals with low back pain. N Am J Sports Phys Ther 5(2): 63-73, 2010.

26. Schröder G, Knauerhase A, Kundt G, Schober HC. Effects of physical therapy on quality of life in osteoporosis patients - a randomized clinical trial. Health Qual Life Outcomes 10: 1-8, 2012.

27. Schröder G, Knauerhase A, Kundt G, Schober HC. Trunk stabilization with sling training in osteoporosis patients - a randomized clinical trial. Eur Rev Aging Phys Act 11(1): 61-68, 2014.

28. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther 80(9): 896-903, 2000.

29. Solberg PA, Kvamme NH, Raastad T, Ommundsen Y, Tomten SE, Halvari H, Loland NW, Hallén J. Effects of different types of exercise on muscle mass, strength, function and well-being in elderly. Eur J Sport Sci 13(1): 112-125, 2013.

30. Stuge B, Laerum E, Kirkesola G, Vøllestad N. The efficacy of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy. A randomized controlled trial. Spine 29(4): 351-359, 2004.

31. Tsauo JY, Cheng PF, Yang RS. The effects of sensorimotor training on knee proprioception and function for patients with knee osteoarthritis: a preliminary report. Clin Rehabil 22(5): 448-457, 2008.

32. Vandervoort AA. Aging of the human neuromuscular system. Muscle Nerve 25(1): 17-25, 2002.

33. Webber SC, Porter MM. Effects of ankle power training on movement time in mobility-impaired older women. Med Sci Sports Exerc 42(7): 1233-1240, 2010.

34. Willardson JM. Core stability training: applications to sports conditioning programs. J Strength Cond Res 21(3): 979-985, 2007.