Muscular fitness program design: Get stronger to move well (falls prevention)!

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Introduction

"Get Stronger to Move Well" (GSTMW) is an eight-week (four two-week quarters) multifactorial (including two or more fall risk intervention components), muscular fitness falls prevention program targeting the older adult population (65+ years old, generally healthy, and cleared by physician for activity) (Vlaeyen et al., 2015). GSTMW is conducted in a group class setting with an open invitation to family, friends, and primary caretakers to participate (Kyrdalen, Moen, Røysland, & Helbostad, 2014).

GSTMW addresses whole-person wellness by incorporating education, occupational therapy, self-efficacy and community development in addition to the physical components (strength training, balance training, postural control, and neuromuscular coordination) (Granacher, Gollhofer, Hortobágyi, Kressig, & Muehlbauer, 2013; Granacher, Zahner, & Gollhofer, 2008; Karlsson, Magnusson, von Schewelov, & Rosengren, 2013).

The goals of GSTMW are: to improve overall confidence in mobility and adapting to perturbations; to potentially reduce the number of fallers (persons who fall) and recurrent falls attributed to compromised functional capacity; to prepare participants to continue to follow a home-care program (maintenance) upon GSTMW exit; and to serve as a community resource for individual falls risk assessment and education. GSTMW must be accessible, scaleable, easily implemented at a low cost, and adaptable/transferrable to an individual setting.

Rationale

Thirty to fifty percent of older adults experience falls every year (Cho & An, 2014). The risk of falling is at least ten times higher in the older adult demographic as compared to other age groups partly due to age-related physiological changes including sarcopenia, dynapenia (age-

related muscle strength and power decreases), decreased bone mass, loss of motor neurons, atrophy of type-II muscle fibers, increased reaction time, difficulties in balance/postural control, gait speed, frailty, sensory impairments (loss of sensory neurons, visual, vestibular, proprioceptive, tactile), medication side-effects, cognitive impairments, and co-morbidities (Cho & An, 2014; Granacher et al., 2013; Granacher, Muehlbauer, Gollhofer, Kressig, & Zahner, 2011; Karlsson et al., 2013; Kennis et al., 2013; Nicholson, McKean, & Burkett, 2014; Scanlon et al., 2013).

For example, on average, muscle strength decreases 1-1.5% per year for adults 50+ years old, and losses increase to 3% per year for adults 65+ years old (Kennis et al., 2013). Age-related muscle power ("explosive force production"; Granacher et al., 2008, p.326) declines are even greater than those of strength, particularly between the ages of 70-90 years (Kennis et al., 2013). Muscular power is needed in order to avoid obstacles and to recover balance.

Exercise is one of the most common, effective, accessible, and easily implemented interventions to decrease the risk of falls related to decreased functional capacity (Clemson et al., 2010; Peterson, Rhea, Sen, & Gordon, 2010). The well-studied Otago Exercise Program or OEP (strength, balance, and gait) was able to reduce both the number of falls and the number of fall-related injuries on average by 35% (Liston et al., 2014; *Otago exercise programme*, 2003). Similar programs based on the OTAGO study have also been successful.

Muscular Strength and Power

Compromised trunk ("core") and lower limb strength in addition to the lack of stabilization/support of the lumbo-pelvic hip complex (LPHC) is associated with mobility/task (activities of daily living, ADL) problems including gait, gait speed, transfers, stepping, stair climbing, and chair raise (Emilio, Hita-Contreras, Jiménez-Lara, Latorre-Román, & Martínez-

Amat, 2014; Granacher et al., 2013; Pizzigalli, Filippini, Ahmaidi, Jullien, & Rainoldi, 2011; Ribeiro, Teixeira, Brochado, & Oliveira, 2009). Muscular power Pizzigalli et al. (2011) defined the limits of stability (LOS) as "the maximum distance that a person can intentionally displace his/her center of gravity, and lean his/her body in a given direction without losing balance, grasping, or stepping" (p. 568). When LOS is exceeded (e.g. tripping, stumbling, picking something up, reaching for something, walking, etc.), someone will typically try to recover by generating muscle torque at the ankle (ankle strategy)/hip (hip strategy) or by taking additional steps to recover the center of mass (Ribeiro et al., 2009). Fallers have significantly reduced (50% less) ankle and knee strength as compared to non-fallers (Ribeiro et al., 2009). Resistance training should focus on the trunk; hip abductors and adductors; hip flexors and extensors; knee flexors and extensors; ankle plantar flexors (significant in gaining better balance) and dorsiflexors (Joshua et al., 2014; Granacher et al., 2013; *Otago exercise programme*, 2003; Ribeiro et al., 2009).

Balance and Postural Control

Improved static and dynamic balance decreases the risk of falling and increases self-efficacy (Emilio et al., 2014; Granacher et al., 2011). Balance programs that incorporate sensory-rich, proprioceptive exercises/training also aid in postural control. Shumway-Cook and Woollacott (as cited in Granacher et al., 2008, p. 328) defined postural control as "the control of the body's position in space for the purpose of balance and orientation". Postural control deterioration may be observed early in 30-39 year olds, gradually progressing among 40-49 year olds, and significantly progressing in 60+ year olds (Granacher et al., 2008).

Emilio's et al. (2014) 12-week (2 days/week) proprioception training increased lower-body flexibility, dynamic balance, and lumbar strength among older adults. Improved hip-joint

mobility, dynamic balance, and lumbar strength have also been associated with general balance exercise programs (Emilio et al., 2014). Granacher et al. (2011) noted that balance training improved mediolateral perturbation compensation in clinical functional reach tests and tandem walk tests; improved deceleration gait stability; power production in the leg extensors; and single/concurrent task performances.

Cognitive acuity is also a factor in situations involving loss of balance and postural control among older adults (Granacher et al., 2010). Higher risk of falls among older adults is associated with performing concurrent tasks (e.g. walking and carrying an object) or task-interference (e.g. reciting the alphabet backwards) (Granacher et al., 2010). Incorporating "brain games" and occupational therapy exercises to maintain/improve cognition/mentation (especially challenging multiple attentional demands) would create a well-rounded program addressing the whole-person model.

Pre-Screening and Orientation

All GSTMW participants will be pre-screened according to the American College of Sports Medicine's (ACSM) general guidelines by administering the Physical Activity Readiness Questionnaire (PAR-Q) and the American Heart Association (AHA)/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire (Pescatello, Arena, Riebe, & Thompson, 2014). The Physical Activity Stages of Change Questionnaire will also be administered, and GSTMW participants will be interviewed to ensure that all individuals are mentally, emotionally, and behaviorally ready to begin physical activity (PA) (Marcus & Forsyth, 2009; Skaal, 2013). Participants should be ending stage 2 (pre-contemplation) and/or be in stage 3 (contemplation) of Prochaska and DiClemente's Transtheoretical Model (Marcus & Forsyth, 2009). For long-term success (compliance and adherence), it is important to deliver physical activity programming and

health information that is suitable or relevant to a person's stage of change (Marcus & Forsyth, 2009). A copy of the GSTMW exercise program will be given to the participants requiring the signature and approval of both the participant and the participant's primary care physician. All participants must complete a medical conditions and medications list form (for exercise modifications due to potential side-effects) to be signed by both the participant and his/her physician. A mandatory orientation class will be held prior to the start of the program.

Acute Training Variables

Exercise Intensity

The American College of Sports Medicine (ACSM) recommends low (40-50% of 1 repetition maximum, RM, for beginners) to moderate-intensity (60-70% of 1-RM) muscle strengthening (resistance) exercise for older adults (Pescatello, Arena, Riebe, & Thompson, 2014). When exercise cannot safely be based on 1-RM, moderate (5 to 6) to vigorous (7 to 8) exercise on a scale from 1 to 10 is appropriate (Pescatello et al., 2014). The visual adult OMNI-RES resistance (rate of perceived exertion, RPE) scale has also been shown to safely and appropriately gauge intensities approximating 1-RM (Gearhart, Riechman, Lagally, & Andrews, 2011).

Frequency

Studies evaluating the effectiveness of falls prevention (FP) programs and the ACSM both recommend at least 2 days/week of resistance training/FP training (including balance exercises, proprioceptive training, and general non-resistance exercises) for older adults, but optimally 3 days/week (Gennuso, Zalewski, Cashin, & Strath, 2013; Pescatello et al., 2014; Power & Clifford, 2013). The OEP also encourages older adults to walk on their own 2days/per week (*Otago exercise programme*, 2003).

Duration

There are no specific recommendations for the duration of a resistance training bout by the ACSM for older adults. Power and Clifford (2013) noted that a FP training session ranged from 15 to 120 minutes with the longer bouts conducted in a group setting interspersed with demonstrations, explanations, and question/answers. The OEP structured 5 minutes of warm-up followed by 30-40 minutes of combined strengthening and balance exercises (*Otago exercise programme*, 2003). The OEP also recommended two 30-minute walks per week outside the training program (*Otago exercise programme*, 2003). The total duration of FP programs varied from 5 weeks, the 12-week OEP, to longer programs lasting 12-24 months (Cho & An, 2014; Power & Clifford, 2013). The FP follow-up period was important as well—the more support provided, the more successful (Vlaeyen et al., 2015; Power & Clifford, 2013).

Rest Interval

While the ACSM does not have specific recommendations for rest intervals (RI) for older adults, the OEP recommends 1-3 minute rest between sets (*Otago exercise programme*, 2003).

Repetition Tempo

The OEP recommends lifting at a slower pace—two to three seconds for the concentric phase, and four to five seconds for the eccentric phase (*Otago exercise programme*, 2003). Resistance and balance training should always be deliberate and under control.

Repetitions and Sets

The OEP recommends starting an individual (beginner) at one set of 8-10 repetitions for resistance training exercises (*Otago exercise programme*, 2003). Both the OEP and ACSM recommend progressing an individual to 1+ sets of 10-15 repetitions (or whatever may be best

tolerated per individual based on the OMNI RPE scale) (*Otago exercise programme*, 2003; Pescatello et al., 2014).

Exercise Modality

The ACSM recommends selecting exercise modality (e.g. dumbbells, Theraband, tubing) based on an individual's ability and comfort level (Pescatello et al., 2014). Safety is the top priority. The modality should be accessible, flexible enough to progress/regress difficulty easily, and transfer to individual training once the GSTMW has been completed.

GSTMW Program Design

First Quarter (weeks 1-2)

Instructor-led classes meet 3 days/week. Two 1-hour education classes will be held (preceding the exercise portion), each on the first GSTMW class of each week. The first seminar will present the etiology of falls and the concept of FP training. The second seminar will involve a group discussion on falls, fears, preventative measures, and self-efficacy. Participants are encouraged to discuss and enlist social support. Participants will make an appointment for a 1-hour occupational therapist-led walk-through session at their residence during the second quarter (weeks 3-4). The exercise portion of classes will run about 1 hour long. As a group class, acute training variables will vary per individual. See Table 1 for the exercise program.

Table 1

First Quarter (weeks 1-2) GSTMW Program

Warm-up	Neck flexion/extension, lateral flexion/extension, rotation. Standing/sitting trunk rotations. Standing/sitting arching and rounding back. Shoulder shrugs (elevation/depression) and rotation (without arms). Ankle rotations (sitting). Small stepping in-place (or sitting in chair).
Resistance exercises	Knee flexion and extension (standing/sitting/lying). Hip flexion and extension (standing/sitting/lying). Hip abduction and adduction (standing/sitting/lying). Calf raises (standing/sitting/lying). Tibialis anterior raises (standing/sitting/lying). Abdominal bracing (standing/sitting). Pilates hundred (lying/sitting).
Balance	All exercises done with or without support. Knee bends (quarter squats). Backwards walking. Lateral walking. Walking in figure eights. Heel-to-toe walking in a line. One-legged standing. Heel walking. Tippy toes walking. Sit-to-stand (get up from chair). Stairs walking (or walking up and over a series of aerobic steps set up in a course).
Note	All exercises may be progressed from more support to less support in addition to adding more resistance. All exercises may be regressed from less support to more support in addition to decreasing resistance.

Second Quarter (weeks 3-4)

Instructor-led classes meet 3 days/week. Two 1-hour education classes will be held (preceding the exercise portion), each on the first GSTMW class of each week. The first seminar presented by a licensed occupational therapist will cover residence hazard prevention. In lieu of the second education class, each participant will be visited at their residence by an occupational therapist for hazards assessment. The exercise portion of classes will run about 1 hour long. As a group class, acute training variables will vary per individual. See Table 2 for the exercise program.

Table 2

Second Quarter (weeks 3-4) GSTMW Program

Warm-up	Neck flexion/extension, lateral flexion/extension, rotation. Standing/sitting trunk rotations. Standing/sitting arching and rounding back. Shoulder shrugs (elevation/depression) and rotation (without arms). Ankle rotations (sitting). Small stepping in-place (or sitting in chair).
Resistance exercises	Knee flexion and extension (standing/sitting/lying). Hip flexion and extension (standing/sitting/lying). Hip abduction and adduction (standing/sitting/lying). Calf raises (standing/sitting/lying). Tibialis anterior raises (standing/sitting/lying). Abdominal bracing with hip-hinge (standing/sitting). Seated abdominal bracing with alternating knee lifts. Pilates twist and reach with Theraband.
Balance	All exercises done with or without support. Knee bends (quarter squats). Backwards walking. Lateral walking. Walking in figure eights. Heel-to-toe walking in a line. One-legged standing. Heel walking. Tippy toes walking. Sit-to-stand (get up from chair). Stairs walking (or walking up and over a series of aerobic steps set up in a course).
Note	All exercises may be progressed from more support to less support in addition to adding more resistance. All exercises may be regressed from less support to more support in addition to decreasing resistance.

Third Quarter (weeks 5-6)

Instructor-led classes meet 3 days/week. Additionally, two (once each week) 30-minute tai chi classes will be held on a non-exercise class day. The exercise portion of classes will run about 1 hour long. As a group class, acute training variables will vary per individual. See Table 3 for the exercise program.

Table 3

Third Quarter (weeks 5-6) GSTMW Program

Warm-up	Neck flexion/extension, lateral flexion/extension, rotation. Standing/sitting trunk rotations. Standing/sitting arching and rounding back. Shoulder shrugs (elevation/depression) and rotation (without arms). Ankle rotations (sitting). Small stepping in-place (or sitting in chair).
Resistance exercises	Knee flexion and extension (standing/sitting/lying). Hip flexion and extension (standing/sitting/lying). Hip abduction and adduction (standing/sitting/lying). Calf raises (standing/sitting/lying). Tibialis anterior raises (standing/sitting/lying). Seated abdominal bracing with alternating straight-legged lifts plus hip-hinge/spinal-twist. Pilates twist and reach with Theraband. Pilates seated skaters with arm reach.
Balance	All exercises done with or without support. Knee bends (quarter squats) with bicep curls (no resistance) or arms reaching to sky. Backwards walking. Lateral walking. Walking in figure eights holding a cup/mug. Heel-to-toe walking in a line holding cup/mug. One-legged standing holding cup/mu. Heel walking. Tippy toes walking. Sit-to-stand (get up from chair). Stairs walking (or walking up and over a series of aerobic steps set up in a course).
Note	All exercises may be progressed from more support to less support in addition to adding more resistance. All exercises may be regressed from less support to more support in addition to decreasing resistance.

Fourth Quarter (weeks 7-8)

Instructor-led classes meet 3 days/week. Additionally, two (once each week) 30-minute tai chi classes will be held on a non-exercise class day. The exercise portion of classes will run about 1 hour long. As a group class, acute training variables will vary per individual. See Table 4 for the exercise program. The program will close with an open questions and answers session on how to adapt and maintain the program for individual home/residence-use.

Table 4

Fourth Quarter (weeks 7-8) GSTMW Program

Warm-up	Neck flexion/extension, lateral flexion/extension, rotation. Standing/sitting trunk rotations. Standing/sitting arching and rounding back. Shoulder shrugs (elevation/depression) and rotation (without arms). Ankle rotations (sitting). Small stepping in-place (or sitting in chair).
Resistance exercises	Knee flexion and extension (standing/sitting/lying). Hip flexion and extension (standing/sitting/lying). Hip abduction and adduction (standing/sitting/lying). Calf raises (standing/sitting/lying). Tibialis anterior raises (standing/sitting/lying). Seated abdominal bracing with alternating leg ball/toe taps. Pilates twist and reach with Theraband. Pilates seated skaters with arm reach.
Balance	All exercises done with or without support. Knee bends (quarter squats) with bicep curls (no resistance) or arms reaching to sky. Backwards walking. Lateral walking. Walking in figure eights holding a cup/mug. Heel-to-toe walking in a line holding cup/mug. One-legged standing holding cup/mu. Heel walking. Tippy toes walking. Sit-to-stand (get up from chair). Stairs walking (or walking up and over a series of aerobic steps set up in a course).
Note	All exercises may be progressed from more support to less support in addition to adding more resistance. All exercises may be regressed from less support to more support in addition to decreasing resistance.

References

Cho, S. I., & An, D. H. (2014). Effects of a fall prevention exercise program on muscle strength and balance of the old-old elderly. *Journal Of Physical Therapy Science, 26*(11), 1771-1774.

Clemson, L., Singh, M., Bundy, A., Cumming, R., Weissel, E., Munro, J., & ... Black, D. (2010). LiFE pilot study: A randomised trial of balance and strength training embedded in daily life activity to reduce falls in older adults. *Australian Occupational Therapy Journal, 57*(1), 42-50.

Emilio, E. M., Hita-Contreras, F., Jiménez-Lara, P. M., Latorre-Román, P., & Martínez-Amat, A. (2014). The association of flexibility, balance, and lumbar strength with balance ability: Risk of falls in older adults. *Journal Of Sports Science & Medicine, 13*(2), 349-357.

Gearhart, R. J., Riechman, S. E., Lagally, K. M., & Andrews, R. D. (2011). Safety of using the adult omni resistance exercise scale to determine 1RM in older men and women. *Perceptual And Motor Skills, 113*(2), 671-676.

Gennuso, K. P., Zalewski, K., Cashin, S. E., & Strath, S. J. (2013). Resistance training congruent with minimal guidelines improves function in older adults: A pilot study. *Journal Of Physical Activity & Health, 10*(6), 769-776.

Granacher, U., Gollhofer, A., Hortobágyi, T., Kressig, R., & Muehlbauer, T. (2013). The importance of trunk muscle strength for balance, functional performance, and fall prevention in seniors: A systematic review. *Sports Medicine, 43*(7), 627-641.

Granacher, U., Muehlbauer, T., Gollhofer, A., Kressig, R. W., & Zahner, L. (2011). An intergenerational approach in the promotion of balance and strength for fall prevention—A mini-review. *Gerontology, 57*(4), 304-315.

Granacher, U., Zahner, L., & Gollhofer, A. (2008). Strength, power, and postural control in seniors: Considerations for functional adaptations and for fall prevention. *European Journal Of Sport Science, 8*(6), 325-340.

Joshua, A. M., D'Souza, V., Unnikrishnan, B., Mithra, P., Kamath, A., Acharya, V., & Venugopal, A. (2014). Effectiveness of progressive resistance strength training versus traditional balance exercise in improving balance among the elderly—A randomised controlled trial. *Journal Of Clinical & Diagnostic Research, 8*(3), 98-102.

Karlsson, M. K., Magnusson, H., von Schewelov, T., Rosengren, B. E. (2013). Prevention of falls in the elderly—a review. *Osteoporosis International, 24*, 747-762.

Kennis, E., Verschueren, S. M., Bogaerts, A., Van Roie, E., Boonen, S., & Delecluse, C. (2013). Long-term impact of strength training on muscle strength characteristics in older adults. *Archives Of Physical Medicine & Rehabilitation, 94*(11), 2054-2060.

Kyrdalen, I. L., Moen, K., Røysland, A. S., & Helbostad, J. L. (2014). The Otago exercise program performed as group training versus home training in fall-prone older people: A randomized controlled trial. *Physiotherapy Research International, 19*(2), 108-116.

Liston, M. B., Alushi, L., Bamiou, D., Martin, F. C., Hopper, A., & Pavlou, M. (2014). Feasibility and effect of supplementing a modified OTAGO intervention with multisensory balance exercises in older people who fall: A pilot randomized controlled trial. *Clinical Rehabilitation,* 28(8), 784-793.

Marcus, B. H., & Forsyth, L. H. (2009). *Motivating people to be physically active*. Champaign, IL: Human Kinetics.

Nicholson, V. P., McKean, M. R., & Burkett, B. J. (2014). Original research: Low-load high-repetition resistance training improves strength and gait speed in middle-aged and older adults. *Journal Of Science And Medicine In Sport*, doi:10.1016/j.jsams.2014.07.018

Otago exercise programme to prevent falls in older adults. (2003). Otago Medical School.

Pescatello, L. S., Arena, R., Riebe, D., & Thompson, P. D. (2014). *ACSM's guidelines for exercise testing and prescription*. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins.

Peterson, M. D., Rhea, M. R., Sen, A., & Gordon, P. M. (2010). Review: Resistance exercise for muscular strength in older adults: A meta-analysis. *Ageing Research Reviews, 9*, 226-237.

Pizzigalli, L., Filippini, A., Ahmaidi, S., Jullien, H., & Rainoldi, A. (2011). Prevention of falling risk in elderly people: the relevance of muscular strength and symmetry of lower limbs in postural stability. *Journal Of Strength & Conditioning Research, 25*(2), 567-574.

Power, V., & Clifford, A. (2013). Characteristics of optimum falls prevention exercise programmes for community-dwelling older adults using the FITT principle. *European Reviews Of Aging & Physical Activity, 10*(2), 95-106.

Ribeiro, F., Teixeira, F., Brochado, G., & Oliveira, J. (2009). Impact of low cost strength training of dorsi- and plantar flexors on balance and functional mobility in institutionalized elderly people. *Geriatrics & Gerontology International, 9*(1), 75-80.

Scanlon, T. C., Fragala, M. S., Stout, J. R., Emerson, N. S., Beyer, K. S., Oliveira, L. P., & Hoffman, J. R. (2014). Muscle architecture and strength: Adaptations to short-term resistance training in older adults. *Muscle & Nerve, 49*(4), 584-592.

Vlaeyen, E., Coussement, J., Leysens, G., Van der Elst, E., Delbaere, K., Cambier, D., & ... Milisen, K. (2015). Characteristics and effectiveness of fall prevention programs in nursing homes: A systematic review and meta-analysis of randomized controlled trials. *Journal Of The American Geriatrics Society, 63*(2), 211-221.