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Abstract

Background and purpose: Postural impairments and functional limitations are linked to osteoarthritis knee adults. The purpose of this study was to identify the balance & postural impairments in osteoarthritis adults and compare the efficacy of two treatment strategies, Structured Neuromuscular Postural Training (SNPT) with conventional treatment (CT). *Methods:* In a prospective study design, Fifty-seven osteoarthritis knee subjects were evaluated and analyzed for balance variables such as viz. Timed up and go test (TUG), Berg balance test (BBT), Modified WOMAC (MW) and its subgroups pain (WP), stiffness (WS) and physical function (WPF) at the baseline and after 6-weeks of treatment. Data were analyzed to determine treatment efficacy. *Results:* The application of SNPT had statistical significance for the balance variable TUG, at baseline and 6 weeks follow up for both pre elderly and elderly subjects. Further, SNPT shows non- statistically significant higher scores for other qualitative balance variables in pre elderly osteoarthritis knee. However, conventional groups demonstrated better efficacy for the qualitative parameters MS, WS and WPF than SNPT in elderly group. *Conclusion:* SNPT treatment intervention has better efficacy for pre elderly and conventional for elderly in osteoarthritis knee subjects. Hence present study concludes that one should use treatment strategy depending upon the age i.e. SNPT intervention in pre elderly and conventional in elderly subjects. Further, blending strength training (CT) with balance training (SNPT) may have better functional outcome for individuals >40 years of age.

Introduction

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Fundamentally the 'Balance' is a skill often compromised with advancing age. The loss of confidence or fear of fall frequently results in reduced physical activity that in turn, may affect & further deteriorate the postural stability & quality of life. The standard clinical balance assessment can help to assess fall risk and determine the underlying reasons for balance disorders. *Mancini & Horak (2010)* narrated that the controlled balance involves maintaining posture, facilitating movement & recouping equilibrium. An assessment of the postural control performance reveals indirectly the character of the postural control capacity *(Hoffer et al, 1996; Raju, 2012),* and in the assessment of postural control capacity, the character of the environment and the task are highly relevant *(Shum way-Cook et al, 2000; Roger et al, 2003).* The environmental factors are influenced by the proprioceptive & somatosensory information, which is necessary for the neuromuscular control of the dynamic restraints *(Riemann et al, 2009). Braun (1998) and Shimada et al (2003)* found that the balance demands during the locomotive activities are different from the demands when standing still. Further, *Winter et al (1990)* noticed that the responses to postural perturbations are task- and perturbation specific. Currently, postural balance is studied using motion analysis and the techniques of biodynamic. *Sutherland (2002)* stated that neither kinematics nor electromyography is stand-alone components of clinical gait analysis. *Cordo and Nashner(1982) and Horak et al (1997)* researches on postural responses to surface translations has shown that balance is not based on a fixed set of equilibrium reflexes but on a flexible, automatic postural adjustments and functional motor skill, that can adapt with training and experience. A growing research indicates that the learning adaptation have an important influence on balance responses based on motor learning. It occurs due to the repetitions of the platform perturbation, prior experience; feed forward anticipatory control and accommodation of biomechanical constraints. *(Horak et al,1997; Tang et al, 1998; Park et al, 2004; Kisner & Colby, 2007).*

Brach & Van-Swearingen (2002) & *Shubert et al (2010)* research describe, participation in a multi-component exercise program or an intervention that primarily focus on strength and balance skills can have a positive impact on cognitive as well as physical outcomes. Much of the previous researches provide various forms of interventions. *Tinetti et al (1994)* described multifactorial interventions while *Campbell et al (2007)* narrated single factor component intervention. *Gillespie et al (2009) & Cameron et al (2010)* provoked multi-component exercise program, while *Sherrington et al (2008)* emphasized on moderate/high challenge balance exercise

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programs. The most effective fall risk research interventions Otago exercise program *(Campbell & Robertson, 2007)* and modular obstacle program *(Rogers et al, 2013)* provides safe challenges to fall risk.

The Structured Neuromuscular Postural Training (SNPT) is a specially designed strategy aimed to modify neurophysiology and biomechanical changes. The approach incorporates mass to individual moment technique of proprioceptive neuromuscular facilitation by changing graded functional tasks. According to *Hurley et al (1998),* both neurophysiologic and biomechanical techniques affect the musculoskeletal system in functional context. The goal of SNPT strategy is to optimize postural stability, performance enhancement and balance modulation. It uses sensorimotor training intervention to improve both static and dynamic mechanism of balance as well as the huge number of postural control balance strategies used by *Rogers and Page (2013). Hurley et al (1998)* specified the component of technique involved are sensorimotor experience (manual contact), selective stretch to augment dynamic motor response and concept of synergy to strengthen specific muscles.

The SNPT intervention strategy in context to knee osteoarthritis is known to consist oftwo phases viz: *Phase 1Adaptive phase:*In the primary phase; co-contraction of agonist and antagonist along with distraction and manual glide help to manage recurrent pain and swelling. Isometric and isotonic exercises without resistance is preceded. This incorporates basic neurophysiologic principles of Sherrington and Kabath of proprioceptive neuromuscular facilitation viz. joint traction, irradiation and co-contraction.

Further, resistive exercise regimen emphasis on, focused muscle training of Hip, knee and ankle joints viz. vastus medialis oblique, ankle dorsi flexors, peronias, gastrocnemius-soleus, gluteus medius, gluteus maximus, hip ext. rotators and lateral compartment knee. *(Vincent and Vincent, 2012)*The goal is to achieve joint stability, which in turn can improvise proprioceptive and kinesthetic sensation.Active stretch of hamstring muscle along with posterior capsule was performed in functional positions. Synergistic coupling movement along with proprioceptive re-education during mass moment of hip, knee and ankle is targeted to enhance neuromuscular control i.e. medicine ball / gym ball activity. *(Hurley et al, 1998).*

Subsequently, sensorimotor training adaptations improves rate of force development during voluntary isometric contraction performed to improve functional joint or postural stability. *(Bruhn et al, 2004).*

Phase 2: *Dynamic task phase:* In secondary phase; Get Up and Go test (3 metre walk) along with balance training is planned to restore neuromuscular control and coordination. This regimen

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emphasizes joint loading and unloading, planter weight distribution, weight shift, postural accommodation during various ADL task within functional context under dynamic conditions (viz. balance board, trampoline activities, Frankel's Exercise and Get-up-and-go test). This phase is aimed to modify neuromuscular control and coordination improvising functional joint stability, proprioception and kinesthetic awareness.

The purpose of this study was to identify the balance & postural impairments in osteoarthritis adults andcompare the efficacy of two treatment strategies viz. Structured Neuromuscular Postural Training (SNPT) with conventional treatment (CT).

Material and Method:

Symptomatic osteoarthritis knee patients visiting university hospital outpatient services of the Institute of Medical Sciences, BHU were recruited for the study. The individuals with radiographic confirmed knee osteoarthritis ranging between 41 to 80 years and having a risk/fear of fall gave their written consent and participated in full data collection. Exclusion criteria of study were sport injury/traumatic knee, inflammatory arthritis and metabolic disorders; along with specific vestibular, proprioceptive or visual impairment.

After checking inclusion/exclusion criteria's and ethical consent at entry level, sixty-two male subjects randomized from Sept' 2011 up to March' 2013, according to random number table in two groups i.e. Conventional and Structured Neuromuscular postural training (SNPT) groups by fiveyears age interval match. The subjects were divided into pre elderly (40-60 Years) & elderly (>61 years) groups age wise. However, 5 subjects in SNPT group did not complete follow-up hence were excluded from the analysis. Main reasons given for not completing the trial included health (n=2), family (n=2) and transport (n=1) problems. Thus, study is presented for 57 male subjects.

Subjects were evaluated for the balance variables such as viz. Timed up and go test (TUG), Berg balance test (BBT), Modified WOMAC (MW) and its subgroups pain (WP), stiffness(WS) and physical function(WPF) at entry level.

Control group subjects have undergone conventional approach (quadriceps strengthening & hamstring stretching) while, the study Group was subjected to Structured Neuromuscular Postural Training (SNPT) approach (strengthening focused muscle, knee joint distraction and dynamic balance training) for a week in OPD as per their allocation and training program to each group and latter for 5 weeks at home. Further, SNPT Patientswere instructed to carry out Frankel's exercise, proprioceptive reeducation & TUG at home, except

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balance board, trampoline training carried out as outpatient.

They were again measured for all the balance variables after 6 weeks.

Observations and results:

Basic characteristics of the subjects were assessed *at baseline* to see the correlation among the study groups. Pre elderly conventional subjects (n=19) mean demographics are as (age 49.79±5.73 yrs.; height 170.42±5.32 cm.; weight 71.11±8.84 kg. and BMI 24.61±2.02) while that of SNPT group (n=14) are as (age 52.57 ± 5.23 yrs; height 171.57 ± 4.80 cm.; weight 76.21 ± 8.61 kg. and BMI 26.04 ± 2.61). Similarly, elderly conventional subjects (n=12) mean demographics are as (age 67. 50 ± 4.58 yrs.; height 169.92 ± 5.05 cm; weight 71.67 ± 4.81 kg. and BMI 24.96 ± 2.02) while that of SNPT group (n=12) are as (age 67.92 ± 5.07 yrs.; height 166.50 ± 6.33 cm.; weight 70.17 ± 7.08 kg. and BMI 25.68 ± 3.32). There was no statistically significant difference at baseline in both pre elderly and elderly groups. It shows even distribution of age, height, weight and BMI of subjects within the treatment groups.

The difference of balance parameters in osteoarthritis knee subjects between groups is presented in Figure 1-1 in pre elderly and elderly subjects.

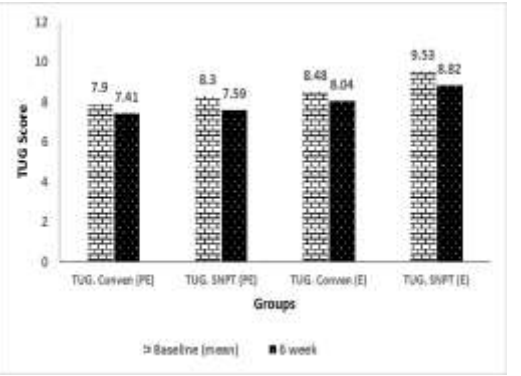

Fig. 1: Comparison of balance, &TUG variables in pre elderly & elderly subjects

Fig. 1 shows the intergroup comparison of difference of quantitative balance TUG variables between baselines to 6 weeks follow up among pre elderly (PE) and elderly (E) group subjects. The difference was found to be statistically significant (t=3.81, p=0.001) for TUG in pre elderly SNPT treatment groups. Mean difference from baseline to follow up for TUG in SNPT was 0.71 sec. and 0.49 sec. in the convention group. This difference of mean was observed to be statistically highly significant (t=3.81, p<0.001) for SNPT treatment group compared to the conventional group. Similarly, in elderly subjects, mean difference (post treatment – baseline) for TUG in SNPT group was found to be 0.72 sec. compared to 0.44 sec. in conventional group showing better efficacy of SNPT treatment. High statistically significant difference (t=5.54, p<0.001) was observed for SNPT treatment.

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The percent change of speed from initial to 6 weeks follow up was observed as 6.28±1.69 for the conventional group as compared to 8.63±2.60 in SNPT pre elderly subjects (t=3.14, p=0.004). Similarly % change of speed was observed as 5.21±0.60 for the conventional group as compared to 7.56±2.00 in SNPT elderly subjects (t=3.89, p=0.001). This shows greater rate of speed improvement in SNPT intervention group compared to the conventional treatment group in both pre elderly and elderly subjects.

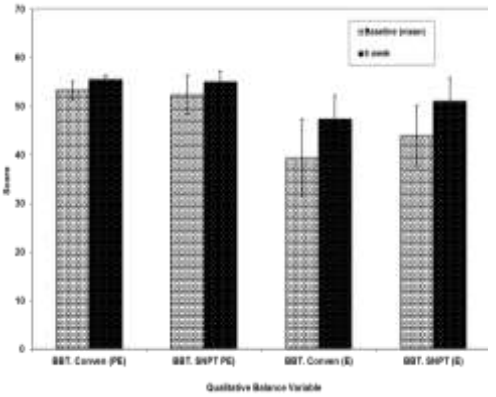

Fig. 2: Comparison of balance variable BBT in pre elderly & elderly subjects

Fig. 2 shows that the validity of BBT could not be seen in studied qualitative scale BBT (Berg balance test) as it was statistically insignificant in both pre elderly and elderly group subjects. Non-statistically significant high scores in SNPT treatment group (2.57) was seen compared to the conventional group (2.27) in pre elderly subjects. Similarly non-statistically significant high scores in conventional treatment (8.0) was seen compared to SNPT (7.17) in elderly subjects.

Fig. 3 shows that in the pre elderly subjects though statistical significance ($p<0.05$) was visible comparing initial and 6 weeks follow up for modified WOMAC subgroup pain (WP), other parameters were insignificant. Further, at pre elderly level SNPT maneuver shows higher scores for all the balance variables and its impact is reliable and encouraging in pre elderly osteoarthritis knee.

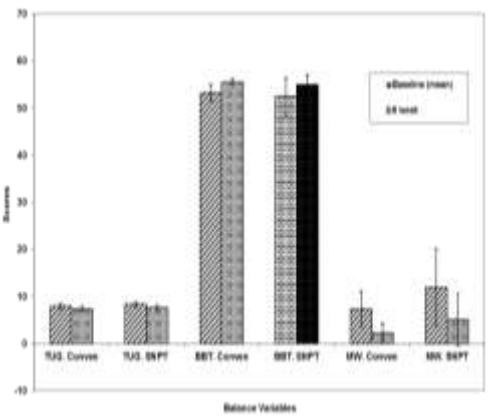

Fig. 3: Comparison of Balance and Functional variables at baseline and 6 weeks followup in pre elderly group

The intergroup comparison of difference of balance assessment variable between baselines to 6 weeks follow up among elderly group is depicted in Fig. 4. It shows statistically high significant difference for balance assessment variables *MW (modified WOMAC test)* and

it's subgroups WS (stiffness) and WPF (physical function) test.

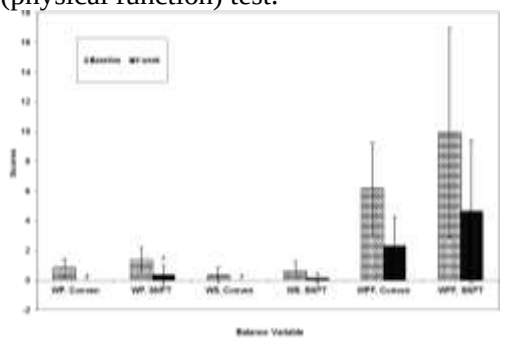

Fig 4: Comparison of subgroups of balance variable Mod. WOMAC (WP, WS and WPF) in elderly subjects

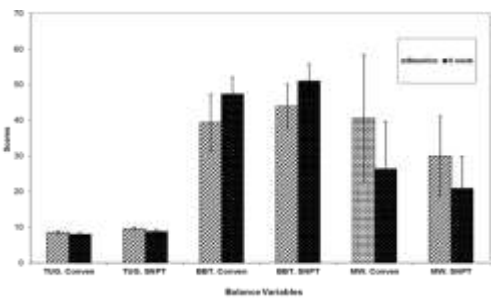

Figure 5: Comparison of balance variables among groups

The mean difference for balance parameters overall MW was statistically significant (t=2.55, p=0.018). However, mean difference of subgroups of MW for balance parameters WS and WPF was statistically significant (t=2.55, p=0.018, t=2.16, p=0.042 respectively) showing conventional group to be better in efficacy compared to the SNPT group in elderly subjects.

On the whole, quantitative balance parameter TUG has better efficacy in both the pre elderly and elderly subjects. At pre elderly level SNPT maneuver shows higher scores for all the balance variables and its impact is reliable and encouraging in pre elderly osteoarthritis knee. However, conventional groups shows better efficacy for the qualitative parameters MS, WS and WPF than SNPT in elderly group. Thus, SNPT was better in efficacy for pre elderly and conventional for elderly in osteoarthritis knee subjects.

Discussion:

The objective of the study was to assess the impact of balance variables in age related study groups. The intergroup comparison of difference of balance assessment showed that there was statistically high significant differences among elderly groups for variables TUG, MW, WS and WPF. Pre elderly group showed higher significance for TUG variable and significant for MW and WP.

In the present study, TUG average mean time score was 8.47 seconds at 58.02 years age and has been statistically significant in both pre elderly and elderly age groups. This finding is consistent with prior research that has shown the mean time score in TUG calculated as 9.4 seconds by *Bohannon, (2006);and Pondaland Del ser, (2008)*.

However, significance and validity of BBT could not be seen in any of the treatment groups in our study subjects i.e.

both were equally effective. This is in agreement with similar findings reported by *Bogle Thorbahn et al (1996)* study who also found no relationship between increasing age and decreasing performance. Decreased scores did not predict increased frequency of falls. Studies by *Thorp e al (2010) and Juhl et al (2012)* were also consistent with our results which have similar effect of WOMAC and its subscales. *Juhl et al (2012)* meta-analyses in knee osteoarthritis scaled WOMAC "pain" and "function" subscales were the most responsive composite scores. In our study WOMAC pain subscale was responsive in pre elderly and stiffness and physical function were responsive in elderly group subjects.

It could be argued that the kinematic differences in TUG may be indicative of characteristic gait adaptations due to knee OA rather than joint instability. Individuals with OA exhibit reduced walking speed/cadence *(Broströmet al, 2012)* likely due to alterations in the neuromuscular strategy of the lower extremity kinetic chain in response to joint pain or muscle weakness. *(Zeni and Higginson, 2011).* Further, *Gok et al (2002)* reported an increased dynamic varus malalignment during the loading response phase of gait in medial knee OA subjects. Thus, the exact contribution of either knee OA or joint instability to the reported alterations in knee joint kinematics cannot be readily elucidated.

Fall-prevention research interventions *(Shumway-Cook et al, 1997; Robitaille et al, 2005 and Shubert, 2011)* suggest that for best possible results, the exercise program needs to be structured, progressed, and must accomplish the minimum dose of exercise over a definite period of time *(Cameron et al, 2010).* The program designed has to be progressive and challenging as individual master's different strength, balance and coordination skills *(Thorp et al, 2010).*

The postural stability and balance has impact of feed-forward anticipatory control, in the form of SNPT approach based on motor learning. The strength training by way of high resistance improves the mechanical efficacy of the efferent drive on the motoneurons, while sensorimotor training alters the afferent input on the CNS. *(Bruhn et al, 2004).*

Summary & Conclusions: When focus is placed merely on the balance assessment in healthy and active elderly, it becomes difficult to find good suggestions for a valid test battery for fall risk assessment. Present study concludes that one should use treatment strategy depending upon the age i.e. SNPT in pre elderly and conventional in elderly subjects. The compared treatment strategies strength vs balance training were found to be equally effective and superior to each other at few balance parameters, indicates the need to blending of strength training with balance training for better outcome.

References:

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Bogle Thorbahn, L.D., Newton, R.A. 1996. Use of the Berg Balance Test to predict falls in elderly persons. Phys. Ther. **76(6):** 576-83

Bohannon, R.W. 2006. Reference values for the timed up and go test: a descriptive meta-analysis. *J. Geriatr. Phys. Ther*; **29:** 64-8.

Brach, J.S., VanSwearingen, J.M. 2002. Physical impairment and disability: relationship to performance of activities of daily living in community-dwelling older men. *Phys. Ther.*, **82(8):** 752-61

Braun, B.L.1998. Knowledge and perception of fall-related risk factors and fall-reduction techniques among community-dwelling elderly individuals.*Phys. Ther.*, **78(12):** 1262-76.

Broström, E.W., Esbjörnsson, A.C., von Heideken, J., Iversen, M.D. 2012. Gait deviations in individuals with inflammatory joint diseases and osteoarthritis and the usage of three-dimensional gait analysis. *Best Pract. Res. Clin. Rheumatol.;* **26(3):** 409-22.

Bruhn, S., Kullmann, N., Gollhofer, A. 2004. The effects of a sensorimotor training and a strength training on postural stabilisation, maximum isometric contraction and jump performance. *Int. J. Sports Med.*, **25(1):** 56-60.

Cameron, I.D., Murray, G.R., Gillespie, L.D., Robertson, M.C., Hill, K.D., Cumming, R.G., Kerse, N. 2010. Interventions for preventing falls in older people in nursing care facilities and hospitals. Cochrane Database Syst Rev.:CD005465doi: 10.1002/14651858.CD005465.pub2.

Campbell, A.J., Robertson, M.C. 2003. Otago Exercise Programme to prevent falls in older people: A home-based, individually tailored strength and balance retraining program. Otago.

Campbell, A.J., Robertson, M.C. 2007. Rethinking individual and community fall prevention strategies: a meta-regression comparing single and multifactorial interventions. *Age Ageing*,**36:**656-662

Cordo, P.J., Nashner, L.M. 1982. Properties of postural adjustments associated with rapid arm movements. *J. Neurophysiol*., **47(2):** 287-302.

Frank, J.S., Earl, M. 1990. Coordination of posture and movement. *Phys. Ther.*, **70:** 855-863.

Gahery, Y. 1987. Associated movements, postur al adjustments and synergies: some comments about the history and significance of three motor concepts. *Arch. Ital. Biol.*, **125: 345**–36

Gillespie, L. D., Gillespie, W. J., Robertson, M. C., Lamb, S. E., Cumming, R. G., & Rowe, B. H. 2001. "Interventions for preventing falls in elderly people", Cochrane.Database.*Syst.Rev*.No. 3, p. CD000340.

Gok, H., Ergin, S., Yavuzer, G. 2002. Kinetic and kinematic characteristics of gait in patients with medial knee arthrosis. *Acta Orthop. Scand.*,**73:**647–52.

Hoffer JA, Stein RB, Haugland MK, Sinkjaer T, Durfee WK, Schwartz AB, Loeb GE, Kantor C (1996). Neural signals for command control and feedback in functional neuromuscular stimulation : A review. Journal of Rehabilitation Research and Development **33(2):** 145-157

Horak, F.B., Henry, S.M., Shumway-Cook, A. 1997. Postural perturbations: new insights for treatment of balance disorders. Phys Ther.**77(5):**517-33

Hurley, M.V., Scott, D.L 1998. Quadriceps sensorimotor function and disability of patients with knee osteoarthritis following a clinical practicable exercise regime. The British Journal of Rheumatology, **37:** 1181-1187

Juhl, C., Lund, H, Roos, E.M., Zhang, W. and Christensen, R. 2012. A Hierarchy of patient-reported outcomes for meta-analysis of knee osteoarthritis trials: Empirical evidence from a survey of high impact journals. *Arthritis*, 17 pages. Available at http://dx.doi.org/10.1155/2012/136245

Kandel, E.R., Schwartz, J.H. & Jessell, T.M., 2000. Principles of Neural Science, 4th edit, Mc Graw-Hill, New York

Kisner, C. and Colby, L.A. 2007. Therapeutic Exercise: Foundations and Techniques, 5th edit, FA Davis company

Mancini, M., Horak, F.B. 2010. The relevance of clinical balance assessment tools to differentiate balance deficits. *Eur. J. Phys. Rehabil. Med*. **46(2):** 239–248.

Park, S., Horak F.B., Kuo, A.D. 2004. Postural feedback responses scale with biomechanical constraints in human standing.*Exp Brain Res*., **154(4):** 417-27.

Pondal, M., del Ser, T. 2008. Normative data and determinants for the timed "up and go" test in a population-based sample of elderly individuals without gait disturbances. *J. Geriatr. Phys. Ther.*, **31(2):** 57-63

Raju, Y.S. 2012. Maintenance of Balance and RehaBilitation in the elderly.Medicine Update, **22:** 725-29.

Riemann, B.L., Lephart, S.M. 2002. The Sensorimotor System, Part II: The Role of Proprioception in Motor Control and Functional Joint Stability. *J. Athl. Train*, **37(1):** 80-4.

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Robitaille, Y., Laforest, S., Fournier, M., Gauvin, L., Parisien, M., Corriveau, H., Trickey, F., and Damestoy, N. 2005. Moving forward in fall prevention: An intervention to improve balance among older adults in real-world settings. *Am. J. Public Health.,* **95(11):** 2049–2056.

Rogers, M.E., Page, P. 2013. Current concepts Review: Balance training for older athelete. *Int. Journal of Sport Physical Therapy*, **8(4):** 517-30.

Rogers, M.E., Rogers, N.L., Takeshima, N., Islam, M.M. 2003. Methods to assess and improve the physical parameters associated with fall risk in older adults. *Preventive Medicine*, **36:** 255-264.

Sherrington, C., Whitney, J.C., Lord, S.R., Herbert, R.D., Cumming, R.G., Close, J.C. 2008. Effective exercise for the prevention of falls: a systematic review and meta analysis. *J. Am. Geriatr. Soc.*, **56:** 2234-2243.

Shimada, S., Kobayashi, S., Wada, M., Uchida, K., Sasaki, S., Kawahara, H., Yayama, T., Kitade, I., Kamei, K., Kubota, M., Baba, H. 2006. Effects of disease severity on response to lateral wedged shoe insole for medial compartment knee osteoarthritis. *Arch. Phys. Med. Rehabil.,* **87(11):** 1436-41.

Shubert, T.E. 2011. Evidence based exercise prescription for balance and falls prevention: A current review of the literature. *J. Geriatric Physical Therapy*, **34(3):** 100-108.

Shubert, T.E., Mc Culloch, K., Hartman, M., Giuliani, C.A. 2010. The effect of an exercise-based balance intervention on physical and cognitive performance for older adults: A Pilot study. *J. Geriatric Physical Therapy*, **33(4):** 157-164.

Shumway-Cook, A. and Woollacott, M. 2000. "Attentional demands and postural control: The effect of sensory context," *J. Biological Sciences and Medical Sciences*, **55(1):** M10–M16.

Shumway-Cook, A., Baldwin, M., Polissar, N.L., Gruber, W. 1997. Predicting the probability for falls in community-dwelling older adults.*Phys. Ther.*,**77(8):** 812-9.

Sutherland, D.H. 2002. The evolution of clinical gait analysis. Part II kinematics. *Gait Posture*, **16(2):** 159-79.

Tang, P.F., Woollacott, M.H., Chong, R.K. 1998. Control of reactive balance adjustments in perturbed human walking: roles of proximal and distal postural muscle activity. *Exp. Brain. Res.*,**119(2):** 141-52.

Thorp, L.E., Wimmer, M.A., Foucher, K.C., Sumner, D.R., Shakoor, N., Block, J.A. 2010. The biomechanical effects of focused muscle training on medial knee loads in OA of the knee: a tpilot, proof of concept study. *J. Musculoskele. Neuronal. Interact.,* **10(2):** 166-173.

Tinetti, M.E., Baker, D.I., McAvay, G., Claus, E.B., Garrett, P., Gottschalk, M., Koch, M.L., Trainor, K., Horwitz, R.I. 1994. A multifactorial intervention to reduce the risk of falling among elderly people living in the community. *N. Engl. J. Med.*, **331(13):** 821-7.

Vincent, K.R., Vincent, H.K. 2012. Resistance exercise for knee osteoarthritis. P M & R: *The Journal of Injury, Function and Rehabilitation.* **4(5 Suppl):** 45-52.

Winter, D.A., Patla, A.E., Frank, J.S., Walt, S.E. 1990. Biomechanical walking pattern changes in the fit and healthy elderly. *Phys. Ther.,* **70(6):** 340-7.

Zeni, J.A., Higginson, J.S. 2011. Knee osteoarthritis affects the distribution of joint moments during gait. *Knee.* **18(3):** 156-9.

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