Journal of Frailty, Sarcopenia and Falls JFSF

Mini Review Article

Obesity and its relationship with falls, fracture site and bone mineral density in postmenopausal women

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Abstract

Obesity in elder women is a difficult problem for public health, as it is related to increased incidence of fall-related injuries and fractures. The kind of fall-related fracture seems to relate to the distribution of body mass. A review of the literature was carried out based on systematic searches of electronic databases (PubMed/Medline). The results of this mini-review did not support that obesity increases the risk of falls during post-menopause compared to normal weight women. However, there was a relation between obesity and site of fractures.

Keywords: Obesity, Elderly, BMI, Postmenopausal woman, Fractures

Introduction

Obesity constitutes a disease that unfortunately presents a continuously increased tendency in the last decades. In the USA, for the period of 2007-2008, the tendency was nearly 35% for the elderly women[1]. Obesity is a serious problem for the health and functionality of old people, as there is some evidence that supports an increased risk for falling and fall related injury. Obese elderly women have a relatively higher risk for falling, in relation to women with a healthy weight[2]. This greater risk of falling is responsible for a number of fractures and fall-related injuries. On the other hand, there is an opinion that fat mass could be a protective factor during landing on the ground.

Method

A review of all current literature on the topic was carried out based on systematic searches of electronic databases (PubMed/Medline) using the key words of obesity, elderly, body mass index (BMI), postmenopausal woman, fractures. Only studies published after 2000 and in the English language were considered for inclusion. We identified 750 references in our literature search, were 10 excluded because of duplication and 43 considered to be potentially eligible (Figure 1). After the full-text screening, 17 studies met our inclusion criteria.

Differences of sex

The results of literature searching showed that elder women present a higher incidence of fall-related injuries when compared with elderly men[3-6]. This difference is not well understood, but it's related to the fact that women are frailer and have a longer expectation of life, and thus they present higher incidence of falls[5]. Besides this, elder men appear to have higher mortality rates because of fall incidence, and so, women's fall-related injury seems higher than men's[7].

Previous studies support that the female gender was a risk factor of falling in elder people. The other factors were the older age and the poor visual acuity that present in elderly women[8].

Obesity and falling incident

The old people suffer from a lot of diseases that contribute to the increased incidence of falling. The most important risk factors are the coexisting diseases, as Parkinson and cardiovascular disease, which could cause a loss of balance and walking difficulty. These factors increase the need for medical support and drug use, especially with the coexistence of obesity. Moreover, obesity is responsible for the appearance and deterioration of diseases like type-

The author has no conflict of interest.

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Edited by: *Yannis Dionyssiotis*

Accepted *24 April 2017*

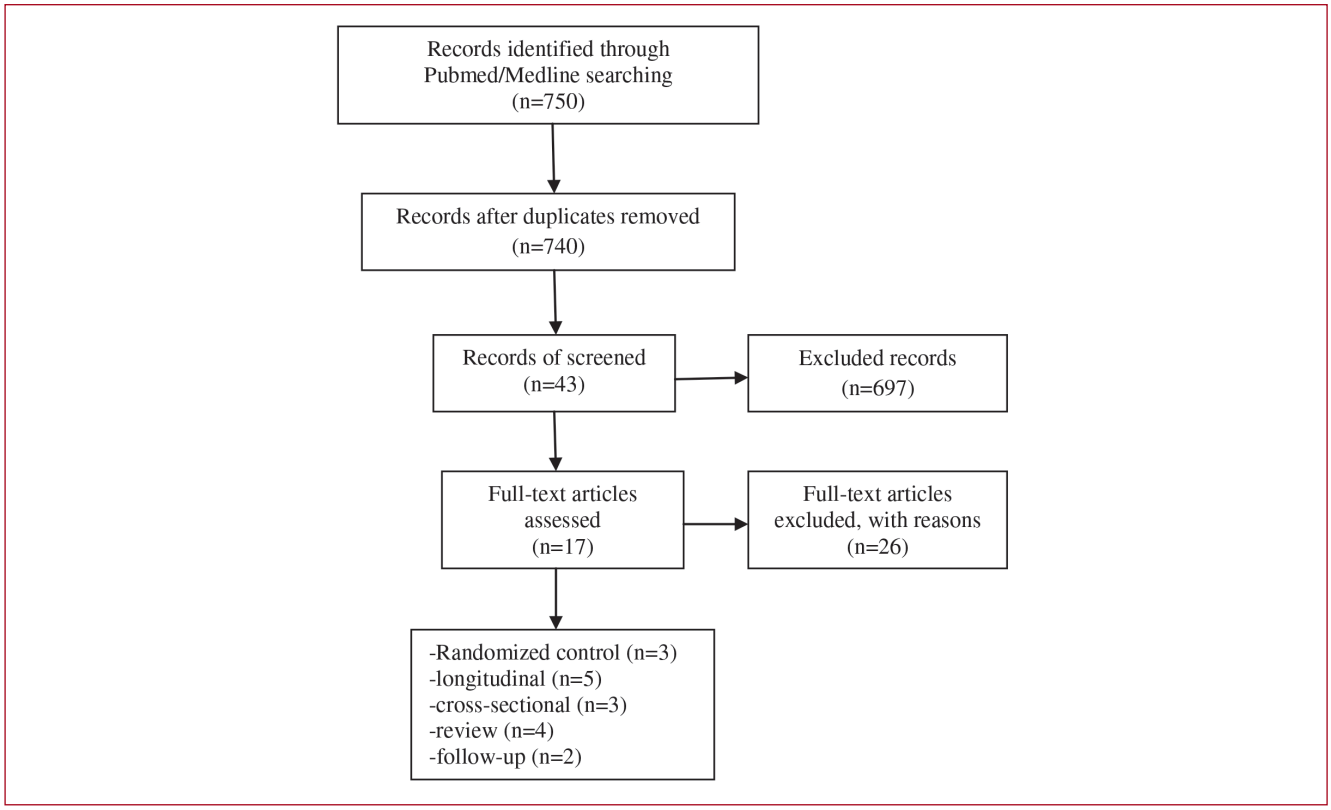

Figure 1. Flow diagram depicting the selection process of studies investigating the risk of fall in obese elderly women.

2 diabetes and peripheral neuropathies, which leads to increased incidence of falling. Approximately 30-40% of older adults will fall annually, but the exact influence of obesity on fall incidence still remains contributed[9].

Another study found that a novel associated factor that increased the incidence of fall in elder women, were the visual acuity and waist-to-hip ratio. In obesity, the circumference of waist reveals the existence of central obesity and has a major independent role as a fall-related indicator[8]. The existence of central obesity predisposes the development of metabolic syndrome, and at the same time affects the stability of body center and the incidence of fall-related injuries[10]. The measure of waist circumference is often used during a geriatric health examination for assessing the visceral fat[11], as it was found an association with the frailty in elder people[12].

In a review, it was found that there was no important difference of a fall incidence between an obese and a normal weight elderly woman[13]. Thus, perhaps the increased reported injuries of obese elderly women, is a result of the falling injuries itself. They also observed that there was only a small difference on the falling tendency for obese elderly women, but the reported injuries were mainly of soft tissues and less of bone fractures. These findings were also confirmed from other researchers[14].

The results from a laboratory experiment for falling revealed two possible mechanisms, responsible for the neuromuscular reaction of obese elder women during falling. They are called as *lower* and *elevating mechanisms*, and they explain the differences of the body correspond during a fall incidence[15,16]. It is speculated that the coexistence of obesity in elder women, decreases the ability of joints to react on time to support the body mass during falling. The researchers observed an average of 160-millisecond delay of corresponding for an obese body to react to a fall[16-18].

The increase of fall accidents among obese elderly women is a major health problem in high-income countries[19], as it is related to high socioeconomic status, and so the incidence of fall-related injuries appears to be more common[20]. In countries with insufficient intake of food and water, the numbers of obese people are too low in relation with the ones of developed countries[21]. As a result, the associated injuries of fall accidents in elder people are higher in developing countries.

Obesity and site of fracture

In most of the cases, obesity is associated with an incidence of fall-related fractures in elderly women. Obesity is responsible for a high incidence of fall mainly because

an obese subject is less well able to protect itself against a fall[22-24]. There are several studies that support that the site of fracture is depended on BMI (body mass index)[25-30]. In Global Longitudinal Study of Osteoporosis in Women (GLOW) was found that obesity, in contrast to widespread belief, is not protective against fracture, but also responsible for certain fractures, mainly in the ankle and upper leg. The study revealed a higher incidence of those two and a lower incidence of wrist fractures in contrast to non obese women. The possible explanation is that in obese people, abdominal fat tissue has a protective role for hip and pelvis, but ankle and legs have less fat, predisposing them to more fractures due to falling[25]. Overweight or obese individuals are possible to have a backward or sideward fall, and thus the wrist is less exposed in contrast to normal weight ones[31]. In another study, obesity was associated with a protective effect of abdominal fat tissue on hip, but without a relation on either wrist or ankle fracture[26].

There is a study for obese women that report a higher incidence of ankle fractures, but a reduced hip fracture, as the extra fat mass in pelvis and femur protects this area during a fall[32]. The higher incidence of exaggeration of introversion and extroversion of the ankle and lower leg in obese individuals could be the reason for the increased prevalence of fractures at these body parts. Also, the increased body mass is responsible for the increased pressure (stress) on some sites, predisposing to fracture[33]. Apart of hip fractures, there are types of injury and several other anatomical sites that are sensitive to a fall accident. The most frequent injury among obese older women is the sprains/strains[34]. These kinds of injuries are responsible for muscle pain and affected flexibility, with a high cost of treatment, and the probability of loss of the independent living[35-37].

Bone mass and obesity in elder women

There is some evidence that the additional fat mass of the obese elderly women has a protective role during a fall. The explain of this mechanism lands on the increased density of bone mass, that has a protective role against fractures, and the extra fat mass that creates a protective cushion during the landing on the ground. There is increasing evidence in recent studies that, the beneficial effects of fat mass on bone mass are various and depended on its distribution. Visceral fat has an adverse effect on bone mass, in contrast with subcutaneous fat that seems to have beneficial effects[38,39]. There is an association between fractures, bone mass and high BMI. Obese postmenopausal women appear to have higher serum levels of estrogens comparing to normal weight[40,41]. Estrogens are in part responsible for the higher bone mass found in women with high BMI. Apart from estrogens, there is an interaction between the adipose tissue and bone cell[42].

Adipocytes produce adiponectin, a molecule that is inversely related to BMI but seems to work as a marker of a disrupted adaptive response in overweight individuals[43-51]. A study found higher serum levels of adiponectin in obese women with fractures when compared with obese women without fractures[52]. Another factor that interferes with bone metabolism is leptin that acts in two contradicted mechanisms[52,53]. High serum levels of leptin are associated with increased bone mineral density. On the other hand, when leptin acts via central nervous system, it is responsible for decreased bone formation[52]. Another adipose tissue product is inflammatory cytokines that could affect the balance between bone absorption and formation[43-51].

Predicting the risk of fall

As the majority of fall incidences in the elder individuals are characterized as locomotive falls (80-90%)[53], there is an essential need for a good assessment to detect them. There is no agreement between researchers for which tests are more appropriate in a specific situation[54]. Most tools rely on assessments of balance and strength[55-60], so there are not applicable in the primary care settings.

A systematic review of the literature about fall prediction tools in rehabilitation hospitals showed that the most appropriate and applicable in elderly inpatients where the STRATIFY, PJC-FRAT, and the DOWNTON Fall Risk Index. The authors concluded that, even though they had good sensitivity and specificity, the implementation of them in clinical practice is expensive both in time and practice, and they could not yet replace the empirical judgment[61].

One of the tests used for assessment mobility and fall risk is the Timed Up and Go Test (TUG), which in accordance to some studies, has a limited predictive ability for community-dwelling elderly[47,62-63], but has better predictions in less healthy and lower functioning older people[64]. TUG with a Dual Task (TUG-DT) is a better predictor for measuring mobility among community-dwelling elderly, but it has a poor prognostic validity for the quality assessment[62,64-66]. Two others assessment tools are TUG man (Timed Up and Go Test with a manual dual task), and TUG cog (Timed Up and Go Test with a cognitive dual task), where the last one has a better predictive assessment of elderly community-dwelling persons[62].

Conclusion

As long as the societies continue to face aging, the prevention of fall incidence of elder people is a serious problem in public health. More than 30% of people over 65 years old face a fall per year, which leads them to injury, increased mortality and loss of functioning[67-70]. Moreover, in the last decades, there is also an increased rate of obesity in elder people, especially in female sex. It is urgent for early interventions in order to apply a convenient and systematic assessment of fall risk factors, exercise programs, and environmental adaptation, to decrease the rates of fall incidences and injuries. In conclusion, the prevention of fall-related injury in obese elder women needs a multifaceted approach to public health, by heightened awareness for the assessment, education, referrals, and recommendation.

References

1. Flegal KM, Carroll MF, Ogden CL, Curtin LR. Prevalence and trends in obesity among U.S. adults, 1999-2008. JAMA 2010;303:235-41.
2. Finklelstein EA, Chen H, Prabhu M, Trogdon J, Phaedra CS. The relationship between obesity and injuries among U.S. adults. Am J Health Promot 2007;21:460-8.
3. Cardona M, Joshi R, Ivers RQ, Iyengar S, Chow CK et al. The burden of fatal and non-fatal injury in rural India. Inj Prev 2008;14:232-237.
4. Li YH, Song GX, Yu Y, Zhou de D, Zhang HW. Study on age and education level and their relationship with fall-related injuries in Shanghai, China. Biomed Environ Sci 2013;26:79-86.
5. World Health Organization. Women's Health Fact Sheet 2012.
6. Yu PL, Qin ZH, Shi J, Zhang J, Xin MZ et al. Prevalence and related factors of falls among the elderly in an urban community of Beijing. Biomed Environ Sci 2009;22:179-187.
7. De Ramirez SS, Hyder AA, Herbert HK, Stevens K. Unintentional injuries: magnitude, prevention, and control. Ann Rev Public Health 2012;33:175-191.
8. Kuang TM, Tsai SY, Hsu WM, Cheng CY, Liu JH, et al. Visual impairment and falls in the elderly: the Shihpai Eye Study. J Chin Med Assoc 2008;71:467-472.
9. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1998;319:1701-7.
10. Leung WS, Chi HT, Hu MH, Liu MT. Fall mechanism and injury severity in community dwelling older people. Formosa J Phy Ther 2005;30:105-15.
11. Han SS, Kim KW, Kim KI, Na KY, Chae DW et al. Lean mass index: a better predictor of mortality than body mass index in elderly Asians. J Am Geriatr Soc 2010;58:312-317.
12. Hubbard RE, Lang IA, Llewellyn DJ, Rockwood K. Frailty, body mass index, and abdominal obesity in older people. J Gerontol A Biol Sci Med Sci 2010;65(4):377-81.
13. Rosenblatt NJ, Grabiner MD. Relationship Between Obesity and Falls by Middle-Aged and Older Women. Arch Phys Med Rehabil 2012;93:718-22.
14. Fjeldstad C, Fjeldstad A, Acree LS, Nickel KJ, Gardner AW. The influence of obesity on falls and quality of life. Dyn Med 2008;7:4.
15. Eng JJ, Winter DA, Patla AE. Intralimb dynamics simplify reactive control strategies during locomotion. J Biomech 1997;30:581-8.
16. Pavol MJ, Owings TM, Foley KT, Grabiner MD. Mechanisms leading to a fall from an induced trip in healthy older adults. J Gerentol 2001;56A:M428-37.
17. Pijnappels M, Maarten BF, vanDieën JH. How early reactions in the support limb contribute to balance recovery after tripping. J Biomech 2005;38:627-34.
18. Rogers MW, Hain TC, Hanke TA, Janssen I. Stimulus parameters and inertial load: effects on the incidence of protective stepping responses in healthy human subjects. Arch Phys Med Rehabil 1996;77:363-8.
19. Himes CL, Reynolds SL. Effect of obesity on falls, injury, and disability. J Am Geriatr Soc 2012;60:124-129.
20. Dinsa GD, Goryakin Y, Fumagalli E, Suhrcke M. Obesity and socioeconomic status in developing countries: a systematic review. Obesity Reviews 2012;13:1067-1079.
21. Norton R, Kobusingye O. Injuries. The New England Journal of Medicine 2013;368:1723-1730.
22. Chan BK, Marshall LM, Winters KM, Faulkner KA, Schwartz AV, Orwoll ES. Incident fall risk and physical activity and physical performance among older men: the Osteoporotic Fractures in Men Study. Am J Epidemiol 2007;165(6):696-703.
23. Corbeil P, Simoneau M, Rancourt D, Tremblay A, Teasdale N. Increased risk for falling associated with obesity: mathematical modeling of postural control. IEEE Trans Neural Syst Rehabil Eng 2001;9(2):126-36.
24. Ensrud KE, Ewing SK, Taylor BC, Fink HA, Cawthon PM, Stone KL et al. Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. Arch Intern Med 2008;168(4):382-9.
25. Compston JE, Watts NB, Chapurlat R, Cooper C, Boonen S, Greenspan S et al. Obesity is not protective against fracture in postmenopausal women: GLOW. Am J Med 2011;124(11):1043-50.
26. Gnudi S, Sitta E, Lisi L. Relationship of body mass index with main limb fragility fractures in postmenopausal women. J Bone Miner Metab 2009;27(4):479-84.
27. Nielson CM, Marshall LM, Adams AL, LeBlanc ES, Cawthon PM, Ensrud K et al. BMI and fracture risk in older men: the osteoporotic fractures in men study (MrOS). J Bone Miner Res 2011;26(3):496-502.
28. Premaor MO, Compston JE, Fina Aviles F, Pages-Castella A, Nogues X, Diez-Perez A et al. The association between fracture site and obesity in men: a population-based cohort study. J Bone Miner Res 2013;28(8):1771-7.
29. Prieto-Alhambra D, Premaor MO, Fina Aviles F, Hermosilla E, Martinez-Laguna D, Carbonell-Abella C et al. The association between fracture and obesity is site-dependent: a populationbased study in postmenopausal women. J Bone Miner Res. 2012;27(2):294-300.
30. Tanaka S, Kuroda T, Saito M, Shiraki M. Overweight/obesity and underweight are both risk factors for osteoporotic fractures at different sites in Japanese postmenopausal women. Osteoporos Int 2013;24(1):69-76.
31. Mignardot JB, Olivier I, Promayon E, Nougier V. Obesity impact on the attentional cost for controlling posture. PloS One 2010; 5(12):e14387.
32. Sukumar D, Schlussel Y, Riedt CS, Gordon C, Stahl T, Shapses SA. Obesity alters cortical and trabecular bone density and geometry in women. Osteoporos Int 2011;22(2):635-45.
33. Raina P, Dukeshire S, Wong M, Scanlan A, Chambers L, Lindsay J. Patterns of self-reported health care use in injured and uninjured older adults. Age Ageing 1999;28:316-318.
34. Luo X, Pietrobon R, Sun SX, Liu GG, Hey L. Estimates and patterns of direct health care expenditures among individuals with back pain in the United States. Spine 2004;29:79-86.
35. Mottram S, Peat G, Thomas E, Wilkie R, Croft P. Patterns of pain and mobility limitation in older people: cross-sectional findings from a population survey of 18,497 adults aged 50 years and over. Qual Life Res 2008;17:529-539.
36. Nevitt MC, Cummings SR, Hudes ES. Risk Factors for injurious falls: a prospective study. J Gerontol 1991;46:M164-170.
37. Gilsanz V, Chalfant J, Mo AO, et al. Reciprocal relations of subcutaneous and visceral fat to bone structure and strength. J Clin Endocrinol Metab 2009;94:3387-3393.
38. Russell M, Mendes N, Miller KK et al. Visceral fat is a negative predictor of bone density measures in obese adolescent girls. J Clin Endocrinol Metab 2010;95:1247-1255.
39. Reid IR. Fat and bone. Arch Biochem Biophys 2010;503(1):20-7.
40. Zhao LJ, Jiang H, Papasian CJ, Maulik D, Drees B, Hamilton J, et al. Correlation of obesity and osteoporosis: effect of fat mass on the determination of osteoporosis. J Bone Miner Res 2008;23(1):17-29.
41. Barbour KE, Zmuda JM, Boudreau R, Strotmeyer ES, Horwitz MJ, Evans RW et al. Adipokines and the risk of fracture in older adults. J Bone Miner Res 2011;26(7):1568-76.
42. Premaor MO, Comim FV, Compston JE. Obesity and fractures Arq Bras Endocrinol Metab 2014;58(5):470-7.
43. Karsenty G, Ferron M. The contribution of bone to whole-organism physiology. Nature 2012;481(7381):314-20.

44. Zeitler, HP, Gulich, M, Schmidt U.M. Stürze verhindern und therapieren [Preventing and treating falls]. Der Hausarzt 2004;41:50-53.
45. Hofheinz M Schusterschitz C. Dual task interference in estimating the risk of falls and measuring change: A comparative, psychometric study of four measurements. Clinical Rehabilitation 2010;24:831-842.
46. Podsiadlo D, Richardson S. The timed "Up & Go": A test of basic functional mobility for frail elderly persons. Journal of the American Geriatrics Society 1991;39:142-148.
47. Barry E, Galvin R, Keogh C, Horgan F, Fahey T. Is the Timed Up and Go Test a useful predictor of risk of falls in community dwelling older adults: A systematic review and meta-analysis. BMC Geriatrics 2014;14.
48. Beauchet O, Fantino B., Allali G., Muir SW, Montero-Odasso M, Annweiler C. Timed up and go test and risk of falls in older adults: A systematic review. The Journal of Nutrition Health and Aging 2011; 15:933-938.
49. Schoene D, Wu SM, Mikolaizak AS, Menant JC, Smith ST, Delbaere K, Lord SR. Discriminative ability and predictive validity of the Timed Up and Go Test in identifying older people who fall: Systematic review and meta-analysis. Journal of the American Geriatrics Society 2013; 61:202-208.
50. Gothe NP, Fanning J, Awick E, Chung D, Wójcicki TR, Olson EA, McAuley E. Executive function processes predict mobility outcomes in older adults. Journal of the American Geriatrics Society, 2014; 62:285-290.
51. Shumway-Cook A, Woollacott M. Attentional demands and postural control: The effect of sensory context. The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences 2000; 55:M10-M16.
52. Gates S, Fisher JD, Cooke MW, Carter YH, Lamb SE. Multifactorial assessment and targeted intervention for preventing falls and injuries among older people in community and emergency care settings: systematic review and meta-analysis. BMJ 2008;336:130-3.
53. Gillespie LD, Robertson MC, Gillespie WJ et al. Interventions for preventing falls in elderly people living in the community (Review). Cochrane Database Syst Rev 2009;(2):CD007146.
54. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing (Suppl 2) 2006;ii37-41.
55. Covinsky KE, Kahana E, Kahana B, Kercher K, Schumacher JG, Justice AC. History and mobility exam index to identify community-dwelling elderly persons at risk of falling. The Journals of Gerontology, Series A: Biological Sciences & Medical Sciences 2001;56:M253-M259.
56. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Wallace RB. A Short Physical Performance Battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. Journal of Gerontology 1994;49:M85-M94.
57. Lord SR, Menz HB, Tiedemann A. A physiological profile approach to falls risk assessment and prevention. Physical Therapy 2003; 83:237-252.
58. Pluijm SMF, Smit JH, Tromp EAM, Stel VS, Deeg DJH, Bouter LM, Lips P. A risk profile for identifying community-dwelling elderly with a high risk of recurrent falling: Results of a 3-year prospective study. Osteoporosis International: A Journal Established as Result of Cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 2006; 17:417-425.
59. Russell MA, Hill KD, Day LM, Blackberry I, Gurrin LC, Dharmage SC. Development of the Falls Risk for Older People in the Community (FROP-Com) screening tool. Age and Ageing 2009;38:40-46.
60. Stalenhoef PA, Diederiks JPM, Knottnerus JA, de Witte LP, Crebolder HF. The construction of a patient record-based risk model for recurrent falls among elderly people living in the community. Family Practice 2000;17:490-496.
61. da Costa BR, Rutjes AWS, Mendy A, Freund-Heritage R, Vieira ER. Can Falls Risk Prediction Tools Correctly Identify Fall-Prone Elderly Rehabilitation Inpatients? A Systematic Review and Meta-Analysis PLoS ONE 2012;7(7):e41061.
62. Podsiadlo D, Richardson S. The timed "Up & Go": A test of basic functional mobility for frail elderly persons. Journal of the American Geriatrics Society 1991;39:142-148.
63. Beauchet O, Fantino B, Allali G, Muir SW, Montero-Odasso M, Annweiler C. Timed up and go test and risk of falls in older adults: A systematic review. The Journal of Nutrition Health and Aging, 2011; 15:933-938.
64. Schoene D, Wu SM, Mikolaizak AS, Menant JC, Smith ST, Delbaere K, Lord SR. Discriminative ability and predictive validity of the Timed Up and Go Test in identifying older people who fall: Systematic review and meta-analysis. Journal of the American Geriatrics Society 2013; 61:202-208.
65. Gothe NP, Fanning J, Awick E, Chung D, Wójcicki TR, Olson EA, McAuley E. Executive function processes predict mobility outcomes in older adults. Journal of the American Geriatrics Society 2014; 62:285-290.
66. Shumway-Cook A, Woollacott M. Attentional demands and postural control: The effect of sensory context. The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences 2000; 55:M10-M16.
67. Gates S, Fisher JD, Cooke MW, Carter YH, Lamb SE. Multifactorial assessment and targeted intervention for preventing falls and injuries among older people in community and emergency care settings: systematic review and meta-analysis. BMJ 2008;336:130-3.
68. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in elderly people living in the community (Review). Cochrane Database Syst Rev 2009;(2):CD007146.
69. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing (Suppl 2) 2006;ii37-41.
70. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Physical Therapy 2000;80:896-903.