Türk Fizyoterapi ve Rehabilitasyon Dergisi

2015 26(2)93-99

Yasemin KAVLAK, Dr. Fzt.[1]

THE RELATION OF HALLUX VALGUS SEVERITY WITH FOOT FUNCTION AND BALANCE IN OLDER MEN

RESEARCH ARTICLE

ABSTRACT

Purpose: The aim of this study was to investigate the relationship between hallux valgus and foot function and balance in older men.

Methods: One hundred and six feet of 53 elderly men (mean age: 73.79±7.08 years) were evaluated in this research. Hallux valgus angle was measured using a goniometer. Foot function, dynamic balance and static balance were evaluated by the forefoot subscale of the American Orthopaedic Foot and Ankle Society Scale, Timed Up & Go Test and single leg stance, respectively, and their relations with hallux valgus were analysed.

Results: Hallux valgus angle values were 17.32±11.29 degree for right foot and 16.45±10.65° for left foot. No significant relationship was found between hallux valgus angle (right and left) and static and dynamic balance (p>0.05). However, hallux valgus angles of right and left foot were correlated with the scale scores of American Orthopaedic Foot and Ankle Society scale (r=-0. 34, p=0.01; r=-0. 38,p=0.005, respectively).

Discussion: According to these results, the severity of hallux valgus itself does not influence balance, although it partially affects the functional ability of the forefoot in older men.

Key words: Aging; hallux valgus; foot physiopathology; postural balance

YAŞLI ERKEKLERDE HALLUKS VALGUS ŞİDDETİNİN AYAK FONKSİYONU VE DENGE İLE İLİŞKİSİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Bu çalışmanın amacı, yaşlı erkeklerde görülen halluks valgus ile ayak fonksiyonu ve denge arasındaki ilişkiyi araştırmaktır.

Yöntemler: Bu araştırmada, yaş ortalaması73.79±7.08 olan 53 yaşlının 106 ayağı değerlendirildi. Halluks valgus açısı gonyometre ile ölçüldü. Ayak fonksiyonu, Amerikan Ortopedik Ayak ve Ayak Bileği Derneği skalasının ön ayak ölçeği ile, dinamik denge "Timed Up & Go" (kalk ve yürü testi) testi ile, statik denge tek ayak üzerinde durma süresi ile değerlendirildi ve halluks valgus ile ilişkileri araştırıldı.

Sonuçlar: Halluks valgus açısı sağ ayak için ortalama 17.32±11.29° ve sol ayak için ortalama 16.45±10.65° olarak ölçüldü. Sağ ve sol ayak halluks valgus açısı ile dinamik ve statik denge arasında anlamlı ilişki bulunmadı. Buna karşın sağ ve sol ayak halluks valgus açısı ile Amerikan Ortopedik Ayak ve Ayak Bileği Derneği skalasının puanı arasında anlamlı ilişkiler vardı (sırasıyla r=-0.34, p=0.01; r=-0.38, p=0.005).

Tartışma: Bu sonuçlara göre, halluks valgus şiddeti tek başına denge üzerinde etkili olmamıştır, buna karşın yaşlı erkeklerin ön ayak fonksiyonel yeteneklerini kısmen etkilediği görülmüştür.

Anahtar Kelimeler: Yaşlılık; halluks valgus; ayak fizyopatolojisi; postural denge

Geliş Tarihi: 30.05.2014 (Received)
Kabul Tarihi: 29.05.2015 (Accepted)

Bu çalışma 3-5 Eylül 2009 tarihinde 'Aging Male Congress'inde sözel bildiri olarak sunulmuştur.

İletişim (Correspondence):

Dr. Fzt. Yasemin Kavlak
Eskisehir Osmangazi Üniversitesi, Sağlık Hizmetleri Meslek Yüksekokulu, Yaşlı Bakımı Programı, 26480, Meşelik-Eskişehir
Tel: 02222393750
e-posta: ykavlak@hotmail.com

1 *Eskisehir Osmangazi Üniversitesi, Sağlık Hizmetleri Meslek Yüksekokulu, Yaşlı Bakımı Programı*

INTRODUCTION

Hallux valgus (HV) is a common deformity characterized by abnormal angulation, rotation and lateral deviation of the great toe at the first metatarsophalangeal (MTP) joint (1). It is characterized by lateral drift of the great toe (2,3). Factors contributing to the formation of hallux valgus can be sorted as wearing high heeled shoes which narrows toe box, excessively long first metatarsals, round metatarsal heads, large intermetatarsal angle, first ray hypermobility, and pronated foot posture (4,5).

Estimations of the community prevalence of HV vary widely (1), ranging from 21% to 65% of the general adult population (4). The etiology of hallux valgus is reported differently in literature (3,6). There is evidence that this condition is an autosomal dominant trait with partial penetrance, since ~90% of people with hallux valgus report a positive family history (7). Women are significantly more likely to have HV compared to men (2,8-10) and the prevalence of hallux valgus increases steadily with age (8,11). Women wear high heels and tight shoes causes this deformity has been shown in previous studies high. However, with aging, occurring in the foot structure, depending on the static and dynamic changes are also seen in both sexes. In this study, we would like to draw particular attention hallux valgus in men.

HV initially affects only the first MTP joint, but as the deformity progresses, the lateral displacement of the hallux interferes with the normal alignment and function of lesser toes, which results in hammer or claw toe deformation, altered weight-bearing patterns, and development of plantar keratotic lesions (5,12). Deformity of the great toe nail, splaying of the forefoot and problems with shoe fitting may also be observed. These problems can lead to considerable pain, gait abnormalities, functional limitations, balance disorders, and increase the risk of falling in the elderly (1,3,4,6,8,13-17). Furthermore, some studies have found that people with hallux valgus score poorly on evaluations of health-related quality of life (4).These findings suggest that hallux valgus does not simply cause isolated problems in the feet but can have a broader effect on the individual as a whole (5). For this reason, it is important to find out the risk factors of hallux valgus to prevent or minimise the progression of the disorder. As mentioned above, the literature often addresses the symptoms or functional hallux valgus reflections in women. In addition, it offers complex test results conducted in the laboratory. Whereas hallux valgus is a common foot problem seen in older men. This problem commonly encountered by physiotherapists working in the field can be determined by simple tests.

When examined anatomically, the foot is the most remote part of the lower extremity, playing a role mainly in the single-leg stance phase to protect posture. Biomechanical studies show that even small changes that occur in sequence between the foot structure or foot and ankle affect postural control mechanisms (18,19). The preservation of a stable upright position can be achieved through the interaction of sensorial organisation and motor coordination components (20,21). Neurological disorders are known to affect postural stability, but the biomechanical effect of foot structure may also affect balance (22).

Evaluation of physical impairments and functional limitations are an important aspect of studies on aging conducted by geriatric clinicians. Reduction in physical activity is common in older people. Enhanced mobility and even small improvements in balance and walking can have a major impact on the quality of life. Therefore, the measurement of balance and gait performance is critical for allied health care professionals and especially for researchers focusing on the real needs of the elderly (23).

In the literature, complex tests performed in the laboratory have been used to determine hallux valgus angles, functional impairment and balance disorders. In our study, we applied the more easily accessible and simple tests to determine the current problems of the elderly in their own environment. Furthermore, it was designed to attract attention to the functional impairment caused by foot problems in the elderly male.

METHODS

The study was planned with the purpose of evaluating the effects of hallux valgus severity on foot function and balance in older men who had resided

in a nursing home for at least one year. The study was carried out between June and August 2013. Our work included individuals aged 60 and over because 60 is the age limit for benefits in institutions in our country.

Approximately 150 elderly residents of two different nursing homes located in Eskisehir were interviewed. Elderly individuals were considered eligible if they met inclusion criteria, which were a hallux valgus angle of at least 15°, age 60 years or older, male, cooperative and able to understand the aim of study, independent for self-care and daily activity, and able to walk without assistance. Exclusion criteria were orthopaedic or postural problems that could confound the outcomes, previous foot surgery, systemic disease such as diabetes mellitus and rheumatoid arthritis which can foot deformity, and auditory, cognitive or mental problems. As a result, 53 elderly male volunteers aged between 61 and 93 years participated to the study.

The study was carried out by the Aging Care Department of University. Permission to conduct this study was obtained from the Turkish Social Services and Child Protection Agency. Additionally, the Human Ethics Committee of the Faculty of Health Sciences at University approved the study, and informed consent was obtained from all participants.

In selecting an evaluation strategy, it was important to use methods that were clear and easy to perform. To achieve the purpose of the study, we also selected the most accurate tests to measure the severity of the hallux valgus angle and the effect of the problem on function and balance.

The following assessments were carried out:

1- Demographic characteristics were recorded.

2- The hallux valgus angle was measured using a toe goniometer. The fixed arm of the toe goniometer was placed on the longitudinal line of the first metatarsal bone, and the movable arm was placed on the longitudinal line of the great toe. The value of the hallux angle between these 2 lines was recorded. Measurements were conducted while participants were bearing weight and hallux valgus angles of at least 15° were included in the study (17,24,25).

3- The hallux-metatarsophalangeal scale of the American Orthopaedic Foot and Ankle Society (AOFAS) was used to measure the effect of the hallux valgus deformity on function (26,27). This scale includes three main categories: pain (40 points), function (45 points) and alignment (15 points). The higher the AOFAS score is the better the patient's function.

4- Dynamic balance was evaluated using the Timed Up & Go (TUG) test. TUG is an objective measurement that asks each participant to arise from a chair, walk three meters, turn around, return to the chair and sit. The same armchair with hardwood arms, cushioned back and base was used for all participants. Walking distance was measured by tape measure and was marked with coloured tape. We asked participants to walk at maximum speed; this was timed using a digital stopwatch. Measurements were made both barefoot and in shoes (28).

5- Static balance was determined with one-leg standing balance time. Observations were made with patients' eyes open (barefoot and in footwear) and closed (barefoot and in footwear). Participants were asked to stand on one extremity with the other extremity flexed at 90°at knee level of the weight-bearing extremity. We asked them to hold this position. If knee flexion could not be maintained, the test was ended, and time was saved using a digital stopwatch.

6- The frequency of falls was recorded and correlated with pain resulting from hallux valgus. The AOFAS pain subscale was used to determine the intensity of pain.

7- The relationship between body composition and balance and function was assessed by comparing BMI with balance and function parameters.

The same physiotherapist conducted all assessments. The assessor was experienced in assessing and treating foot and ankle problems and underwent study-specific training. All measurements were carried out at least two hours later following breakfast and lunch and were finished within one session.

Statistical Analysis

Statistical evaluation was performed by using IBM SPSS (Statistical Package for Social Sciences) (PASW) 18.0 for Windows Shapiro Wilk's test

was used if data showed normal distribution. Descriptive statistics included frequency distributions of categorical variables and means and standard deviations for continuous variables. We utilised paired samples t test to compare the difference between the right and left sides for the same individual. Additionally, an individual t test was used for repeated measurements in the same individual comparing barefoot and shod conditions. To compare the data, we used the Pearson correlation coefficient so that the data could show normal distribution. Statistical significance was defined as a value of $p<0.05$.

RESULTS

We assessed 106 feet of 53 elderly men whose average age was 73.79±7.08 years. They resided in a retirement home for approximately 4-5 years. Participants' demographic characteristics are presented in Table 1.

When we analysed the distribution of HVA, it appeared that the problem is greater on the right foot than the left, but this trend was not statistically significant (Table 1). To determine the effect of the severity of hallux valgus on function, we examined the correlation between the AOFAS and HVA. We found that a statically significant relationship existed between right foot HVA and AOFAS. HVA severity in the left foot demonstrated a similar pattern (Table 2).

Results for participants wearing footwear were better than when barefoot. Among the various differences in outcomes obtained in barefoot and footwear conditions, we found that the only statistically significant difference was observed in dynamic balance (Table 3).

A total of 30.2% of the elderly in this study reported that they had fallen in the past year. The relationship between pain severity and frequency off

Table 1: Demographic characteristics

n=53	Minimum	Maximum	Mean	SD	t *(p)
Age (year)	61	93	73.79	7.08	
HVA (right) (degree)	15	78	17.32	11.29	0.91 (0.37)
HVA (left) (degree)	15	70	16.45	10.65	

HVA: Hallux Valgus Angle, SD: Standard deviation, *t: paired t test (HVA with left and right foot)

Table 2: Correlations between HVA of right and left foot and foot function and balance

		HVA (right)		HVA (left)	
		r*	p	r	p
AOFAS		-0.34	0.01	-0.38	0.005
TUG (barefoot)(second)		0.14	0.32	0.11	0.45
TUG (footwear))(second)		0.08	0.58	0.09	0.52
Barefoot	OLSB (opened eyes/ right)	-0.05	0.75	-0.14	0.35
	OLSB (closed eyes/ right)	-0.04	0.79	-0.11	0.49
Footwear	OLSB (opened eyes/ right)	-0.06	0.65	0.12	0.38
	OLSB (closed eyes/ right)	-0.14	0.32	0.14	0.32

OLSB: One leg standing balance, r*: Pearson correlation coefficient

Table 2: Correlations between HVA of right and left foot and foot function and balance

	Barefoot		Footwear		t*	p
	X	SD	X	SD		
AOFAS	64.17	16.80	-	-	-	-
TUG (second)	9.38	2.55	8.79	2.16	2.80	0.007
OLSB (opened eyes/ right)	12.35	23.54	15.43	26.37	-1.1	0.28
OLSB (closed eyes/ right)	2.74	3.09	2.77	3.40	0.21	0.84
OLSB (opened eyes/ left)	11.65	21.41	15.93	27.51	-1.44	0.16
OLSB (closed eyes/ left)	2.46	2.87	3.38	6.17	-0.71	0.48

OLSB: One leg standing balance, t*: paired t test

all was statistically significant (r=-0.342; p=0.12). The BMI of the participants was related to all balance parameters and AOFAS (p<0.05).

DISCUSSION

The aim of the study was to determine the effects of hallux valgus angle severity on foot function and balance in elderly men. The findings indicate that the degree of hallux valgus (HV) itself does not affect balance; however, the degree of HV does partially affect the functional ability of the forefoot in the elderly.

The hallux valgus deformity is generally observed in the fourth, fifth, and sixth decades of life. Although wearing narrow shoes seems to be an important external factor for its development, internal factors also play an important role. For example, relocation of the soft tissue around the first metatarsophalangeal joint, rotation in the long axis of the toe and re-positioning of the ligaments and tendons surrounding the joint increase the severity of the deformity. Medial deviation of the first metatarsal may be effective in the degradation of the anatomical balance, or the lateral deviation of the toe may apply retrograde force on the metatarsal head (29,30).

Bone sequences are known to play an important role in postural control and walking (22). The hallux and the first metatarsophalangeal joint play major roles in walking; in the presence of severe hallux valgus, the walking patterns of elderly people may change. When elderly with moderate or severe hallux valgus deformity walk on unsteady surfaces, an increase in instability is observed, and compared to their peers having no deformity or mild deformity; they have a greater risk of falling (15,31). In another study, this view is supported by the assertion that toe deformities affect foot function by causing mechanical instability. As a result, stability is required when corrective steps are necessary to protect weight-bearing and toe movement phases or balance of the gait (32). These results show that hallux valgus deformity reduces the effectiveness of the great toe when the body is pushed forward while walking and that hallux valgus can also cause significant detrimental effect on the gait pattern (15,31).

Age-related changes related to balance and walking biomechanics have been well documented. However, relatively few studies have examined the relationship between specific foot problems and foot function in the elderly population (33,34). In one of these studies, Menz et al. showed that the presence of deformities in little toes and the severity of hallux valgus in elderly individuals are related to balance and functional test scores (13). Additionally, Menz et al. reported in another study that toe deformities can reduce functional mobility (35).

We examined one-leg standing balance for each foot, both barefoot and in footwear, to assess static balance. The TUG test was used to assess dynamic balance and timed performance. As a result of the tests, we found no correlation between hallux valgus severity and static and dynamic balance. This result may have two reasons: first, because of the small sample size, and second, because of the few subjects with hallux valgus severity.

AOFAS was used for functional assessment in the present study. When the measurements were obtained, we observed that AOFAS was associated with the severity of hallux valgus in both the right and left foot. When the severity of hallux valgus increased, the AOFAS score deteriorated. This result is consistent with the results of Menz et al. and Gilheany et al. who stated that hallux valgus has a negative impact on health status and is associated with pain and function impairment (3,4).

Walking has not been assessed in recent studies. But, the TUG test includes rising from a chair, walking three meters, turning and returning to the chair and sitting. Although there is no statistical relation, the TUG test was positively correlated with hallux valgus severity. Specifically, when the severity of HV increases, the TUG test takes more time. This relatively suggests that hallux valgus affects walking ability and gait effectiveness.

Individuals with hallux valgus deformity have altered forefoot loading, as evidenced by increased plantar pressures (32). Higher plantar pressures generated during gait contribute to foot pain and discomfort as well as to risk of falls (36). In reviewing the literature, we found that the most common aspects of hallux valgus are foot pain and deficiency of foot function (4,13,14,29,35,36). We used the

AOFAS scale for assessment of foot function; this scale includes pain, function and alignment subscales. The AOFAS showed negative correlations with hallux valgus severity in each foot. Although there was no correlation between hallux valgus and the balance parameter, hallux valgus has been found to be associated with AOFAS. This result may be due to the AOFAS pain subscale. This result is consistent with recent studies.

Shoe selection has an effect on balance, slipping and falling because it changes the somatosensory feedback of the foot and ankle and due to frictional situations between the shoe and the ground. We know that elderly individuals' risk of falling increases while they are walking without shoes in their homes or while they are walking with high-heeled shoes inside or outside their homes. In addition, shoes with ankle support, a tough foot bed and tread as well as the heel's geometrical shape play roles in balance and gait. Many falls by the elderly in their homes could be prevented with appropriate footwear. Low-heeled shoes and non-slip soles can increase the safety of the elderly inside their homes (37, 38).

In our study, all measurements with footwear were superior to those while barefoot, but only the comparison of the TUG measurement results was significant. This was caused by the elderly residents wearing inappropriate footwear. If they wear optimal shoes, the foot will be controlled better, and likely all measurement parameters would be improved. Arnadottirand Mercer suggested after a study of 35 people that footwear intervention may improve the performance of balance and gait tasks of elderly people (23).

Hallux valgus poses a significant health problem and is associated with foot pain, poor balance, immobility, and risk of falling (8,14). Gait variability has been suggested as a marker for poor balance control and has also been found to predict falls in the elderly (39). We believe that hallux valgus affects foot function even when its severity is low. For this reason, improvement of foot function should be stressed for all levels of severity.

The pain associated with falls is an important factor for physiotherapists based on the results of this study. Some interventions including electrophysiological agents, manual methods and orthotic supports can reduce pain. Consequently, pain control can be achieved through improved balance function. An important result here is the relationship between body composition and balance function and effect of hallux valgus on that function. Physiotherapists, by increasing activity levels in the elderly, can help maintain an appropriate body composition. Thus, structural deformities and load distribution abnormalities of the foot due to excess body weight can be prevented.

Hallux valgus is common, and leads to important limitations of foot functional ability. However, elderly patients often believe that this deformity is a normal part of the aging process. As a result, the study included a small sample of volunteers. Another limitation is the lack of a control group. In addition, all measurements and assessments were conducted by the same physiotherapist; therefore, the study was not blinded. The participants used their own shoes, which were not fit well to their feet, causing insufficient support in terms of reflecting the relationship between shoes and feet.

The severity of hallux valgus was measured using a goniometer in this study. In the literature, participants were diagnosed using various methods including radiography, a self-report instrument and pedobarographic analysis (1,3,4,30). Surely, quantitative methods would provide more objective results. However, we prefer goniometric measurement because this method is easy, portable, and inexpensive. This method could allow participants to be assessed in retirement homes.

CONCLUSION

In this study, we found no difference between HVA of the right and left feet, and HVA was not correlated with any dynamic or static balance outcomes. We found that the degree of the hallux valgus severity itself does not reflect balance, although it does partially affect the functional ability of the forefoot of elderly men. Relationships between hallux valgus and balance and forefoot function will require further longitudinal investigations to confirm and clarify the clinical implications of these results.

REFERENCES

1. Roody E, Zhang W, Doherty M. Validation of self report instrument for assessment of hallux valgus. Osteoarthritis Cartilage. 2007;15(9):1008-12.
2. Mann R, Coughlin M. Hallux valgus; etiology, anatomy, treatment and surgical considerations. Clin Orthop Relat Res. 1981;157:31-41.
3. Gilheany MF, Landorf KB, Robinson P. Hallux valgus and hallux rigidus: A comparison of impact on health-related quality of life in patients presenting to foot surgeons in Australia. J Foot Ankle Res. 2008;1(1):14.
4. Menz HB, Roddy E, Thomas E, Croft PR. Impact of hallux valgus severity on general and foot-specific health-related quality of life. Arthritis Care Res. 2011;63(3):396-404.
5. Dawson J, Thorogood M, Marks SA, Juszczac E, Dodd C, Lavis G, et al. The prevalence of foot problems in older women: A cause for concern. J Public Health Med. 2002;24(2):77-84.
6. Pique-Vidal C, Sole MT, Antich J. Hallux valgus inheritance: pedigree research in 350 patients with bunion deformity. J Foot Ankle Surg. 2007;46(3):149-54.
7. D'Arcangelo PR, Landorf KB, Munteanu SE, Zammit GV, Menz HB. Radiographic correlates of hallux valgus severity in older people. J Foot Ankle Res. 2010;16(3):20.
8. Cho NH, Kim S, Kwon DJ, Kim HA. The prevalence of hallux valgus and its association with foot pain and function in a rural Korean community. J Bone Joint Surg Br. 2009;91(4):494-8.
9. Roddy E, Zhang W, Doherty M. Prevalence and associations of hallux valgus in primary care population. Arthritis Rheum. 2008;59(6):857-62.
10. Coughlin MJ, Jones CP. Hallux valgus; demographics, etiology and radiographic assessment. Foot Ankle Int. 2007;28(7):759-77.
11. Nguyen US, Hillstrom HJ, Li W, Dufour AB, Kiel DP, Procter-Gray E, et al. Factors associated with hallux valgus in a population-based study older women and men: the MOBILIZE Boston study. Osteoarthritis Cartilage. 2010;18(1):41-6.
12. Spink MJ, Menz HB, Lord SR. Distribution and correlates of plantar hyperkeratotic lesions in older people. J Foot Ankle Res. 2009;2:8.
13. Menz HB, Morris ME, Lord SR. Foot and ankle characteristics associated with impaired balance and functional ability in older people. J Gerontol A Biol Sci Med Sci. 2005;60(12):1546-52.
14. Menz HB, Lord SR. The contribution of foot problems to mobility impairment and falls in community-dwelling older people. J Am Geriatr Soc. 2001;49(12):1651-6.
15. Menz HB, Lord SR. Gait instability in older people with hallux valgus. Foot Ankle Int. 2005;26(6):483-9.
16. Torkki M, Malmiavaara A, Seitsalo S, Hoikka V, Laippala P, Paavolainen P. Surgery vs orthosis vs watchful waiting for hallux valgus. JAMA. 2001;285(19):2474-80.
17. Kilmartin TE, Barrington RL, Wallace WA. A controlled prospective trial of a foot orthosis for juvenile hallux valgus. J Bone Joint Surg Br. 1994;76(2):210-4.
18. Hertel J, Gay MR, Denegar CR. Differences in postural control during single-leg stance among healthy individuals with different foot types. J Athl Train. 2002;37(2):129–32.
19. Lebiedowska MK, Syczewska M. Invariant sway properties in children. Gait Posture. 2000;12(3):200–4.
20. Wrisley DM, Whitney SL. The effect of foot position on the modified clinical test of sensory interaction and balance. Arch Phys Med Rehabil. 2004;85(2):335–8.
21. Loovis EM, Butterfield SA. Influence of age, sex, and balance on mature skipping by children in grades K-8. Percept Mot Skills. 2000;90(3):974–8.
22. Lin CH, Lee HY, Chen JJJ, Lee HM, Kuo MD. Development of a quantitative assessment system for correlation analysis of footprint parameters to postural control in children. Physiol Meas. 2006;27(2):119-30.
23. Arnadottir SA, Mercer VS. Effects of footwear on measurements of balance and gait in women between the ages of 65 and 93 years. PhysTher. 2000;80(1):17–27.
24. Shereff MJ. Radiographic analysis of the foot and ankle, In: Jahss MH, editor. Foot and ankle, Philadelphia: WB Saunders Company, 1992;p. 95-108.
25. Lamur KS, Huson A, Snijders CJ, Stoeckart R. Geometric data of hallux valgus feet. Foot Ankle Int. 1996;17(9):548-54.
26. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Cinical rating system for the ankle-hindfoot, midfoot, hallux and lesser toes. Foot Ankle Int. 1994;15(7):349-53.
27. Baumher JF, Nawoczenski DA, DiGiovanni BF, Wilding GE. Reliability and validity of American orthopaedic foot and ankle society clinical rating scale: a pilot study for the hallux and lesser toes. Foot Ankle Int. 2006;27(12):1014-9.
28. Podsiallo D, Richardson S. The 'Timed Up & Go': A test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-8.
29. Nix S, Smith M, Vicenzino B.Prevalence of hallux valgus in the general population: a systematic review and meta analysis. J Foot Ankle Res. 2010;3:21.
30. Lazarides SP, Hildreth A, Prassanna A, Talkhani I. Association amongst angular deformities in hallux valgus and impact of deformity in health-related quality of life. Foot Ankle Surg. 2005;11(4):193-6.
31. Mickle KJ, Munro BJ, Lord SR, Menz HB, Steele JR. ISB Clinical biomechanics award 2009 toe weakness and deformity increase the risk of falls in older people. Clin Biomech. 2009;24(10):787-91.
32. Mickle KJ, Munro BJ, Lord SR, Menz HB, Steele JR. Gait, balance and plantar pressures in older people with toe deformities. Gait Posture. 2011; 34(3):347-51.
33. Kressig RW, Gregor RJ, Oliver A, Waddell D, Smith W, O'Grady M, et al. Temporal and spatial features of gait in older adults transitioning to frailty. Gait Posture. 2004;20(1): 30-5.
34. Winter DA, Patla AE, Frank JS, Walt SE. Biomechanical walking pattern changes in the fit and healthy elderly. PhysTher. 1990;70(6):340-7.
35. Menz HB, Morris ME, Lord SR. Foot and ankle risk factors for falls in older people: A prospective study. J Gerontology A Biol Sci Med Sci. 2006;61(8):866-70.
36. Mickle KJ, Munro BJ, Lord SR, Menz HB, Steele JR. Foot pain, plantar pressures, and falls in older people: a prospective study. J Am Geriatr Soc. 2010;58(10):1936-40.
37. Robbins S, Waked E, McClaran J. Proprioception and stability: Foot position awareness as a function of age and footwear. Age Ageing. 1995;24(1):67–72.
38. Menant JC, Steele JR, Menz HB, Munro BJ, Lord SR. Optimizing footwear for older people at risk of falls. J Rehabil Res Dev. 2008;45(8):1167-87.
39. Chaiwanichsiri D, Janchai S, Tantisiriwat N. Foot disorders and falls in older persons. Gerontology. 2009; 55(3):296-302.