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Effects of Foot Deformities on Gait, Balance and Functional Mobility in Older Women

Yaşlı Kadınlardaki Ayak Deformitelerinin Yürüyüş, Denge ve Fonksiyonel Mobilite Üzerine Etkileri

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ABSTRACT Objective: Foot deformities occur in about 80% of the older women. Structural and physiological changes in the foot occur with aging. These changes can directly affect individual's mobility and quality of life. Therefore, the aim of this study was to investigate the effects of foot deformities regarding to severity on gait, balance and functional mobility in nursing home residing older women. **Material and Methods:** Eighty healthy women aged 65 years and older who resided nursing home were included in the study. Spatiotemporal characteristics of gait, balance and functional mobility and energy consumption among to all participants were evaluated. **Results:** The mean age of the participants was 67±3.24 years and body mass index (BMI) was 32.39±5.16 kg/m^2. Forty-five participants (56.2%) had mild deformity and 35 participants had moderate deformity. No participants had severe deformity. The most common foot deformity was pes planus (90%). Compared with the mild deformity group when BMI was as a covariate the moderate deformity group have higher energy consumption (p=0.037). There were no differences in right step length (p=0.627), left step length (p=0.925), cadence (p=0.508), step width (p=0.055), gait speed (p=0.708), Functional Reach Test (p=0.211), Four Square Step Test (p=0.542) and Time Up and Go Test (p=0.763) between deformity groups. **Conclusion:** Physiotherapists should include appropriate energy conservation techniques in the rehabilitation of older women who have foot deformities. They should offer orthotics and appropriate footwear to older women to prevent new deformities and decrease progression of existing foot deformities.

Keywords: Foot deformities; geriatrics; gait; postural balance; mobility limitation

ÖZET Amaç: Ayak deformiteleri yaşlı kadınların yaklaşık %80'inde görülmektedir. Yaşlanmayla birlikte ayakta yapısal ve fizyolojik değişiklikler meydana gelmektedir. Bu değişiklikler bireyin mobilitesini ve yaşam kalitesini doğrudan etkileyebilir. Bu yüzden çalışmanın amacı huzurevinde yaşayan yaşlı kadınlarda, ayak deformitelerinin şiddetine göre yürüyüş, denge ve fonksiyonel mobilite üzerine olan etkilerini araştırmaktır. **Gereç ve Yöntemler:** Huzurevinde ikamet eden, 65 yaş ve üzerindeki 80 sağlıklı kadın çalışmaya dahil edildi. Tüm katılımcılarda; yürüyüşün zaman mesafe özellikleri, denge, fonksiyonel mobilite ve enerji tüketimi değerlendirildi. **Bulgular:** Katılımcıların yaş ortalaması 67±3,24 yıl, vücut kitlesi indeksi (VKİ) ortalaması 32,39±5,16 kg/m2 idi. Kırk beş katılımcıda hafif şiddetli deformite (%56,2) ve 35 katılımcıda orta şiddetli deformite bulundu. Hiçbir katılımcıda şiddetli deformite yoktu. En çok görülen ayak deformitesi pes planus olarak tespit edildi (%90). VKİ homojenize edilerek hafif şiddetli deformite grubuyla karşılaştırıldığında, orta şiddetli deformite grubunda daha fazla enerji tüketildiği bulundu (p=0,037). Deformite grupları arasında sağ adım uzunluğu (p=0,627), sol adım uzunluğu (p=0,925), kadans (p=0,508), adım genişliği (p=0,055), yürüyüş hızı (p=0,708), Fonksiyonel Uzanma Testi (p=0,211), Dört Kare Adımlama Testi (p=0,542) ve Süreli Kalk ve Yürü Testi (p=0,763) açısından farklılık yoktu. **Sonuç:** Fizyoterapistler, ayak deformiteleri olan yaşlı kadınların rehabilitasyonuna uygun enerji koruma tekniklerini dahil etmelidir. Yeni deformiteleri önlemek ve mevcut ayak deformitelerinin ilerlemesini azaltmak için yaşlı kadınlara ortez ve uygun ayakkabı önerisinde bulunmalıdır.

Anahtar Kelimeler: Ayak deformiteleri; geriatri; yürüyüş; postural denge ; hareket kısıtlılığı

Structural and physiological changes in the foot occur with aging. There is a general belief for the aging foot to exhibit increased soft-tissue stiffness, a decreased range of motion, decreased strength and a more pronated posture, and to function in a more pronated position with a reduced range of motion and less efficient propulsion when walking.[1] These changes can directly affect individual's mobility and quality of life and may be caused by genetic predisposition, systemic illness, inadequate foot care, inappropriate footwear, long-term physical activity, trauma or abnormal gait pattern.[2-5] More severe pes planus and hallux valgus and lesser toe deformities have been observed with aging.[6,7] Studies in the literature have reported that foot deformities are seen in approximately half of elderly people.[8-10] Frey and colleagues (1993) found that foot deformities occur in about 80% of the older women. Use of inappropriate shoes is related to more deformities.[11] Women's shoes have been identified as being smaller and narrower and as having higher-heels.[12]

Community-dwelling people were recruited in the previous studies for population.[11-14] Similarly, the previous studies usually focused on hallux valgus and lesser toe deformities as foot deformities.[13-15] We contacted poor studies that investigated older women and effects of foot deformity regarding to severity.[15,17,18] Also, effects of foot deformities on gait, balance and functional mobility isn't clear according to literature.[13-16] Therefore, the aim of this study to investigate the effects of foot deformities (i.e., pes planus/cavus, hallux valgus, hallux limitus/rigidus, claw toe, hammer toe, overlapping toes, transverse arch drop, pes valgus/varus) regarding to severity on gait, balance and functional mobility in nursing home residing older women.

MATERIAL AND METHODS

In the present study, we contacted in nursing home residents in two different cities. The study inclusion criteria were as follows:

- Ability to understand the tests instructions,

- At least one deformity in both feet,

- Ability to walk 100 meters independently or with a cane,

- Age (65 years or older).[17, 19]

The study exclusion criteria were as follows:

- An injury or musculoskeletal system disorder that would hamper the ability to perform tests

- Diagnosis of central nervous system disease (such as Parkinson disease, dementia or stroke)

- Chronic disease with vital risks (such as cardiac dysfunction or risk of cerebrovascular accident)

- Foot pain (>3 points according to visual analogue scale)

- Recent surgery.[17,19]

Directorate General of Services for Person with Disabilities and Elderl y People of Republic of Turkey Ministry of Family and Social Policies and ethics committee gave approval for the current study and informed consent was obtained from each participant at the beginning of the study. Also, the study was performed in accordance with the ethical principles as described in the Declaration of Helsinki 2008.

Foot deformities, lower extremity muscle strength, spatiotemporal characteristics of gait (i.e., gait speed, cadence, step length, step width), balance, functional mobility and energy consumption were evaluated.

We evaluated severity of foot deformities (i.e., pes planus/cavus, hallux valgus, hallux limitus/rigidus, claw toe, hammer toe, overlapping toes, transverse arch drop, pes valgus/varus) in the normal standing posture and classified as mild, moderate and severe for which 1, 2 and 3 points were given, respectively. Deformity points for both feet were summed up and divided by 2 in order to obtain a total deformity score for each participant. The highest possible total deformity score was 24. We divided the total deformity score into 3 groups for comparison: 1-8 points (mild deformity), 9-16 points (moderate deformity) and 17-24 points (severe deformity).[17-20]

In the present study, we conducted practical demonstrations of all tests for the participants. Also at least one trial test is applied by participants before formal test.

The muscle strength of the hamstrings, quadriceps femoris, tibialis anterior, tibialis posterior, gastrocnemius, peroneus longus and brevis was measured manually in both lower extremities. We summed up bilateral muscle strength and divided by 2 in order to obtain total muscle strength.[19]

In our study we evaluated the spatiotemporal characteristics of gait using a device called LEGSys. The device is based upon work supported by the Scientific Research Projects Coordinatorship of university. It has two sensors that attach to both legs. These sensors provided objective data on the spatiotemporal characteristics of gait by transferring data via Bluetooth to a computer.[21] The gait test was performed over a distance of 10 m.

In the present study we used the Functional Reach Test (FRT) to assess static balance and the Four Square Step Test (FSST) to assess dynamic balance.

The FRT assesses limits of stability by measuring the maximum distance that an individual can reach forward while standing in a fixed position. A 122 cm ruler was fastened to the wall with tape at the height of the subject's acromion process. We instructed the subject to make a fist and raise the arm to 90 degrees of shoulder flexion. An initial measurement was recorded at the position of the subject's third metacarpal. We then instructed the subject to reach as far forward as possible while keeping the fist parallel and level with the ruler and without taking a step or touching the wall.[22]

The Four Square Step Test (FSST) is designed for elderly individuals at risk of falls with impaired balance. We asked the participants to stand in square number 1 facing square number 2 and to step clockwise forward, then right, backward and left, then anticlockwise right, forward and left and finally backward. The stopwatch started when the first foot contacted the floor in square 2 and finished when the last foot came back to touch the floor in square 1. We gave the following instructions to the subject, "Try to complete the sequence as fast as possible without touching the sticks. Both feet must make contact with the floor in each square".[23]

The Timed Up and Go test (TUG) is used to assess functional mobility. The TUG assesses many of the components of basic mobility, including balance, transferring, walking and turning. We held the time (in seconds) for an individual to stand from a sitting position, walk 3 metres, turn, walk back to the chair and sit down was recorded.[24]

In the present study we evaluated energy consumption using the Physiological Cost Index (PCI) which reflects the increased heart rate required for gait and is expressed as heartbeats per meter. It is calculated by dividing differences in gait speed.[25] The participants walked at a preferred speed for 100 m.

We divided the subjects into three groups: mild, moderate and severe foot deformity groups. Because severe foot deformities were not seen in any subjects, there was no severe foot deformity group in this study. We made comparisons between mild and moderate foot deformity groups and used univariate ANCOVA with BMI as covariate variable for comparisons between the groups. Statistical significance was defined as a value of $p<0.05$.

RESULTS

Ninety-six women agreed to participate in the current study. We excluded sixteen women from the study because they did not fulfil the inclusion criteria. The study was completed with 80 participants. Forty-five participants had mild foot deformities and 35 participants had moderate foot deformities. The mean age of the participants was 67±3.24 years, body mass index (BMI) was 32.39±5.16 kg/m² and total deformity score was 6.18±1.50 (Table 1).

In our study, we determined that 90% of the participants had pes planus, 88.8% had pes valgus, 72.5% had hallux limitus/rigidus, 66.2% had hallux valgus, 58.8% had claw toe, 47.5% had transverse arch drop, 30% had overlapping toes, 25% had hammer toe, 15% had pes cavus and 15% had pes varus deformity.

In the present study, when we compare the groups for demographic characteristics there were no statistical differences except for weight, body mass index and total deformity score (Table 1). Be-

TABLE 1: Demographic characteristic of participants.

Characteristics	Mild foot deformity group (n=45)	Moderate foot deformity group (n=35)	p
Age (year) mean [SD]	66.64±2.90	67.46±3.62	0.269
Height (cm) mean [SD]	154.42±6.85	156.04±6.54	0.285
Weight (kg) mean [SD]	75.00±13.50	82.94±9.98	0.003*
Body Mass Indeks (kg/cm2) mean [SD]	31.20±5.56	33.93±4.20	0.015*
Total deformity score mean [SD]	6.18±1.50	10.46±1.92	0.000*
Total muscle strength mean [SD]	28.02±1.83	28.11±2.09	0.834

*p<0.05

cause BMI may affect the differences between the groups, we evaluated the comparisons using by ANCOVA with BMI as covariate.

Moderate deformity group had larger step width but this difference wasn't significant (p=0.055) (Figure 1). Similarly there were no statistical differences in right step length (p=0.627), left step length (p=0.925) and cadence (p=0.508) (Figure 2).

Moderate deformity group showed that higher energy consumption (p=0,037) (Figure 3). There were no statistical differences FRT (p=0.211), FSST (p=0.542), TUG (p=0.763) scores (Figure 4).

DISCUSSION

The prevalence and effects of foot deformities regarding to severity on gait, balance and functional mobility in nursing home residing older women are reported in this study.

Percentage of prevalence was very high for pes planus and pes valgus. Similarly Kavlak and Demirtaş have previously reported that pes planus is most common deformity in elderly men residents of nursing home.[26] However they didn't examine pes valgus and pes varus among to the participants. Prevalence of other foot deformities in participants of this study is higher than Kavlak and Demirtaş's study. According to Menz and Morris (2005), women have the higher rate of foot deformities than men due to wearing narrow and smaller shoes of women. Wearing shoes substantially narrower is associated with corns on the toes, hallux valgus deformity and foot pain, whereas wearing shoes shorter than the foot is associated with lesser toe deformity.[12] This may have created the differences

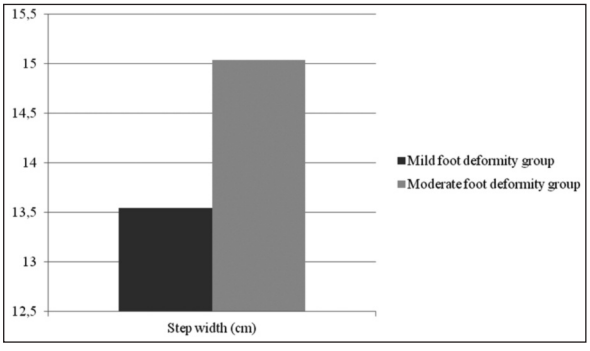

FIGURE 1: Comparison of groups in terms of step width using by ANCOVA (BMI as covariate).

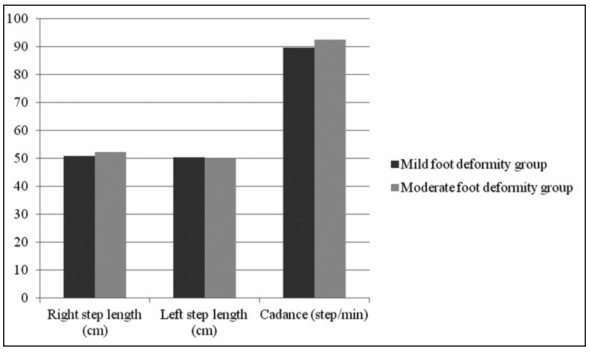

FIGURE 2: Comparison of groups in terms of step lengths and cadence using by ANCOVA (BMI as covariate).

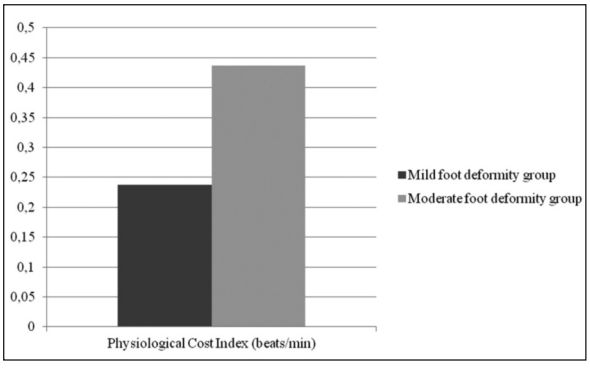

FIGURE 3: Comparison of groups in terms of energy consumption using by ANCOVA (BMI as covariate).

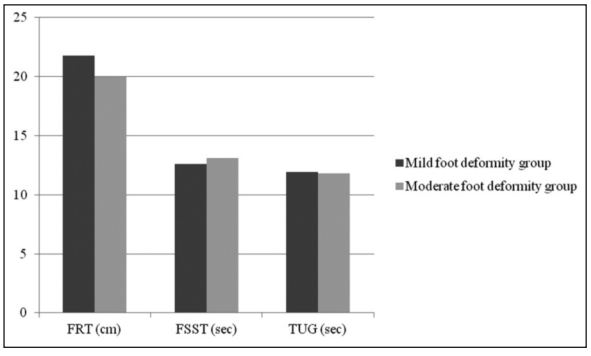

FIGURE 4: Comparison of groups in terms of FRT, FSST and TUG using by ANCOVA (BMI as covariate).
FRT: Functional Reach Test; FSST: Four Square Step Test; TUG: The Timed Up and Go test.

between studies. We found similarly results of the other foot deformities in the previous studies.[9,10,19,27]

In this study, moderate foot deformity group had wider step width but it wasn't statistically significant. Likewise, Mickle et al. (2011) reported that no difference in step width was between groups with and without hallux valgus and lesser toe deformities. Mickle and colleagues claimed that gait variability is not affected by toe deformities. The lacks of differences in gait speed and stride length between the groups in the present study is consistent with the results of Mickle and colleagues.[13] Comparative three studies between the groups with and without foot deformities support our results about gait speed.[13-15] There is one research evaluating gait performance regarding to severity of hallux valgus. Likely, according to the study there is no difference between mild, moderate and severe hallux valgus groups in terms of gait performance.[18]

According to our results, static and dynamic outcomes of balance tests weren't variable between the groups. Despite considerable differences in measurement techniques used in the literature, we found similar findings to previous studies about balance outcomes.[13,14] But these studies searched the differences between the groups with and without deformity. We could reach one study evaluating balance regarding to severity of hallux valgus. In the study, they obtained surprising results. While the differences in anteroposterior sway did not reach statistical significance in the study, individuals with mild hallux valgus displayed greater mediolateral sway compared to the moderate hallux valgus group.[18] Also outcomes of functional mobility tests didn't differ in the groups. Comparative one study between the groups with and without deformity was conducted by Spink and colleagues (2011) are consistent with our results.[14] However, according to Barr and colleagues' findings showed that foot and leg problems which was determined by self-report have a significant impact on the ability to perform functional task after adjusting for age, gender, common medical conditions and socio-demographic factors. Based on results of the Munro and Steele's research (1998) that compared the differences between self-report foot problems and had been consulted by medical personal, women consistently reported more foot problems as diagnosed medical conditions.[28] Therefore, self-report findings about foot problems among to women may be misleading.

In the present study demonstrates that the moderate deformity group had higher energy consumption. We found only one research about energy expenditure proved any associations between foot deformities and energy expenditure.[25] But there were no comparative studies in the literature.

In conclusion our findings proved older women with foot deformities consume more energy. Therefore physiotherapists should train older women with foot deformities about energy conservation techniques. Also, they should offer orthotics and appropriate footwear to older women to prevent new deformities and decrease progression of existing foot deformities.[29]

The fact that the subjects were residents of the nursing home is in itself a limitation of this study because there were no individuals with severe foot deformities in the population. In the future, we plan to include subjects with severe foot deformities and compare three groups. Unlike many studies, we evaluated participants according to the severity of foot deformity and make comparisons between the groups with BMI as covariate variable. This makes our study different from the other studies.

Conflict of Interest

Authors declared no conflict of interest or financial support.

Authorship Contributions

Idea/Concept: *Suat Erel, Emel Taşvuran Horata;* ***Design:*** *Emel Taşvuran Horata;* ***Control/Supervision:*** *Suat Erel;* ***Data Collection and/or Processing:*** *Emel Taşvuran Horata;* ***Analysis and/or Interpretation:*** *Emel Taşvuran Horata;* ***Literature Review:*** *Emel Taşvuran Horata;* ***Writing the Article:*** *Emel Taşvuran Horata;* ***Critical Review:*** *Suat Erel;* ***References and Fundings:*** *Suat Erel;* ***Materials:*** *Suat Erel.*

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