Effects of Using Insoles of Different Thicknesses in Older Adults

Which Thickness Has the Best Effect on Postural Stability and Risk of Falling?

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Background: Postural stability (PS) problems arise as individuals grow older, and as a result, risk of falling (RoF) increases in older adults. We sought to examine the effects of insoles of various thicknesses on PS and RoF in older adults.

Methods: Fifty-six study participants had PS and RoF evaluated statically and dynamically under five different conditions: barefoot, only-shoes, with 5-mm insoles, with 10-mm insoles, and with 15-mm insoles. Standard shoes with identical features were used. To avoid time-dependent problems, these assessments were performed under the same conditions in 3 consecutive weeks. The average of these three values was recorded.

Results: Insoles of different thicknesses significantly affected static PS (overall: $P = .003$; mediolateral [ML]: $P = .021$; anteroposterior [AP]: $P = .006$), static RoF (overall, ML, and AP: $P < .001$), dynamic RoF (overall: $P = .003$; ML: $P = .042$; AP: $P = .050$), and dynamic PS (overall: $P = .034$; AP: $P = .041$) but not dynamic PS ML ($P = .071$). For static PS overall, dynamic PS AP, static RoF overall and ML, and dynamic RoF overall and ML, the highest PS scores and the lowest RoF were recorded when using 10-mm insoles ($P < .05$).

Conclusions: The use of insoles of different thicknesses has been shown to be effective on all RoF and PS measurements except dynamic PS ML. The 10-mm-thick insole was a better option for elderly individuals to increase PS and reduce RoF compared. For older adults, 10-mm-thick insoles made of medium-density Plastozote may be recommended to help improve PS and reduce RoF. (J Am Podiatr Med Assoc 110(6): 1-7, 2020)

One of the most common causes of fatal injuries in older people is falls.[1] Although approximately 28% to 35% of people 65 years and older fall each year, this percentage increases to 32% to 42% in 70-year-olds.[2,3] Falls are also a common reason for hospitalization in older people because they can cause fractures (eg, in hips), soft-tissue injuries, and head traumas.[4,5] Not only falling itself but also fear of falling again adversely affect mobility and quality of life. Hence, as an important geriatric health problem, falls need to be prevented.[6]

Postural stability (PS) problems and consequent falls are related to a variety of intrinsic and extrinsic risk factors, one of which is footwear. It has long been thought to play a prominent role in some falls. The coefficient of friction on the walking surface can be influenced by an insole, which, in turn, may influence the risk of slipping. The shoe's tendency to accommodate and tip sideways while walking on an uneven surface can be influenced by insole properties and heel height and width. This may affect gait and posture as well.[6-9]

According to some researchers, somatosensory

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data received by plantar cutaneous receptors can be altered by insole interventions.[10] These interventions, on the other hand, provide a mechanical support and, hence, can influence postural control and falls.[11] In a study by Priplata et al,[12] static and dynamic PS were evaluated in 27 uninjured young and old adults both with and without vibrating gel-based insoles. With the theory of proprioception and biofeedback strategy[13,14] in mind, the researchers reported a more significant improvement in PS in older adults using the vibrating insoles compared with the younger participants. To compare the effects of different insoles on falls, Liu et al[2] conducted a study in which 15 older adults who had already experienced falls were placed in one group and 18 older adults with no history of falls were placed in the second group. According to the results of the study, in both groups the best balance performance was achieved by using proactive insoles.[2] The effect of spiked insoles on PS and plantar surface cutaneous sensitivity in volunteer older adults was investigated by Palluel et al,[15] who concluded that these insoles could enhance PS.

Deficits in PS, which are significant predictors of falls in older adults, are tightly linked to foot orthoses or different types of insoles.[9] This link is well described in the literature. It is, therefore, imperative to identify and implement practical clinical interventions to protect older adults from falls. Most previous studies in this field have focused on the physical properties of shoes, external shoes modifications, and different types of insoles. However, the effects of insole thickness on PS and risk of falling (RoF) in older adults are not known. The aim of this study was to evaluate the immediate effects of different insole thicknesses on PS and RoF in older adults with a history of falls and to determine which insoles are the most suitable. We hypothesized that the use of insoles would be associated with greater PS and less RoF compared with the barefoot condition.

Materials and Methods

Participants

Fifty-six individuals (30 women) 65 years and older who had fallen and, hence, had applied to the Department of Physiotherapy and Rehabilitation, Hacettepe University, Faculty of Health Science (Ankara, Turkey), were included in the study. Medical history, sociodemographic data, and health profiles of the participants were recorded through face-to-face interviews. The inclusion criteria were living independently in the community, agreeing to participate in the study voluntarily, having fallen at least once during the year before study enrollment, ensuring independent mobilization, and no neurologic or musculoskeletal diagnosis that could account for possible imbalance and falls, such as a history of cerebrovascular accident, Parkinson's disease, cardiac problems, transient ischemic attacks, or lower-extremity joint replacements. Individuals were excluded due to the presence of peripheral sensory neuropathy, inner ear problems, visual disorders, sole deformities that limited standing, and dementia (Mini-Mental State Examination score $\leq$23).[16,17]

The protocol of this study was approved by the ethics committee of Hacettepe University, Faculty of Medicine and was conducted in accordance with the rules of the Declaration of Helsinki. Written and oral information were given to all of the participants before the evaluations, and they gave their written consent to participate in the study.

Insoles and Shoe Conditions

Three different types of insoles made of medium-density Plastozote (Zotefoam, Inc, Hackettstown, New York) were used in the present study. These insoles were 5, 10, and 15 mm in thickness. Except for the thickness, all of the other properties of the insoles were identical. Both PS and RoF were measured after these insoles were placed into the participants' shoes. Different sizes of insoles were available to properly fit different foot sizes. Participants underwent PS and RoF assessments in five conditions: 1) barefoot, 2) only shoes (without placing anything in the shoes), 3) with a 5-mm insole, 4) with a 10-mm insole, and 5) with a 15-mm insole. Standard shoes with the same features were used according to the foot size of the individuals.[18] The participants did not use any insoles independently of this study.

PS and RoF Assessment

The Biodex Balance System (Version 3.1; Biodex Inc, Shirley, New York) was used to determine PS and RoF scores. This system has a mobile balance platform with 360° of joint movement range and a surface that can form an inclination of 20°."1" is the least stable and "12" is the most stable level in this moving platform. Higher values indicate deteriorated PS and increased RoF.[19,20] All of the measurements were performed by an experienced physiotherapist in the morning in a quiet, well-lit room. Individuals were verbally informed about the device, and a testing measurement was made before the actual ones to help the participants get used to the device. Participants were asked to stand on the platform, approximately 50 cm from the screen, with their arms open at the sides and without touching the handrails, and to keep their balance in this position. For static measurements, the platform was adjusted to "static" level. For dynamic measurements, the same standing position was used, and the platform movability ranged from the sixth level as the starting point to the second level as the final point.[21] All of the tests consisted of three measurements, each of which lasted for 20 seconds. A 30-second relaxation period was given between the measurements. At the end of the tests, an additional 3 min was given to the older adults to avoid unexpected tiredness. Of the obtained scores, the overall, anteroposterior (AP), and mediolateral (ML) index scores were used for PS and RoF.[22] The PS and RoF are composed of several components.[23,24] It is known that determining PS and RoF values by a single measurement, especially in elderly individuals, would not be appropriate because time-dependent problems cannot be avoided in only one assessment.[25] Owing to the long duration of measurements performed in this study, it was thought that there might be fatigue in the elderly, and this fatigue would affect the accuracy of the measurements. Therefore, to avoid time-dependent problems, these assessments were retaken under the same conditions in 3 consecutive weeks. The averages of these three values were recorded as the individual's PS and RoF scores. It is important to mention that all of the measurements in the present study were performed while the participants' eyes were open. The reason lies in the fact that most of the activities of daily living are performed with eyes open.

Power Analysis

Regarding the study by Iglesias et al,[14] sample size was based on PS values for older adults with eyes open. Their study was designed to identify the differences between soft and hard insoles, and we used their data to determine the effect size. An effect size of 20% was calculated for this study. A sample size of 56 provided 95% power at $P = .05$ for repeated measurements of one sample including five different insole conditions.

Statistical Analyses

Statistical analyses were performed using SPSS software (Version 22.0; SPSS Inc, Chicago, Illinois). Visual (histograms, probability plots) and analytical (Kolmogorov-Smirnov test) methods were used to determine whether the variables were normally distributed. For normally distributed variables, descriptive analyses were presented using mean ± SD. A one-way repeated-measures analysis of variance with a Bonferroni-adjusted post hoc test was used to compare means between each assessment (data were normally distributed). A $P < .05$ was considered to show a statistically significant result.[26]

Results

Participant Characteristics

The participant group included 30 women and 26 men with a mean ± SD age of 72.04 ± 6.37, body mass index of 31.72 ± 3.45, number of falls in previous year of 1.72 ±0.24, and Mini-Mental State Examination score of 27.04 ± 1.77 (Table 1).

Comparison of Insoles in PS Measurements

The mean ± SD values obtained from the participants using five different insoles (barefoot, only shoes, and 5-, 10-, and 15-mm insoles) are given in Table 2. The comparison of static PS (SPS) measurements evaluated for each insole shows that different insoles have significant effects on SPS (overall: $F = 4.596$, $P = .003$; ML: $F = 3.258$, $P = .021$; and AP: $F = 4.125$, $P = .006$). Similarly the comparison of dynamic PS (DPS) measurements revealed that different insoles have significant effects on DPS overall ($F = 2.845$, $P = .034$) and AP ($F = 1.685$; $P = .041$) scores. However, according to the DPS ML measurements, the use of insoles was not found to have a significant effect on DPS ($F = 0.789$; $P = .071$).

Table 1. Sociodemographic Data for the 56 Study Participants

Characteristic	Value
Age (mean ± SD [years])	72.04 ± 6.37
Total body weight (mean ± SD [kg])	82.85 ± 4.21
Height (mean ± SD [m])	1.61 ± 8.13
Body mass index (mean ± SD [kg/m^2])	31.72 ± 3.45
Mini-Mental State Examination score (mean ± SD)	27.04 ± 1.77
No. of falls in the past year (mean ± SD)	1.72 ± 0.24
Sex (No. [%])	
Female	30 (53.5)
Male	26 (46.5)

Table 2. Analysis of Variance Results Comparing the Effect of Each Insole Condition on PS

Type of PS	Barefoot Mean ± SD	Barefoot 95% CI	Only Shoes Mean ± SD	Only Shoes 95% CI	5-mm Insoles Mean ± SD	5-mm Insoles 95% CI	10-mm Insoles Mean ± SD	10-mm Insoles 95% CI	15-mm Insoles Mean ± SD	15-mm Insoles 95% CI	F	P Value
Static												
Overall	3.944 ± 1.362	3.619–4.270	2.751 ± 1.117	2.566–2.936	2.504 ± 0.772	2.279–2.730	2.152 ± 0.774	1.957–2.346	3.548 ± 1.136	3.073–4.023	4.596	.003
ML	2.822 ± 0.684	2.572–3.073	1.921 ± 0.652	1.756–2.086	1.752 ± 0.354	1.576–1.927	1.552 ± 0.334	1.378–1.727	2.574 ± 0.781	2.289–2.859	3.258	.021
AP	1.981 ± 1.122	1.662–2.280	1.545 ± 0.840	1.355–1.735	1.123 ± 0.552	0.938–1.309	0.923 ± 0.446	0.769–1.078	1.844 ± 0.657	1.629–2.059	4.125	.006
Dynamic												
Overall	5.084 ± 2.024	4.666–5.483	3.435 ± 1.121	3.020–3.850	2.991 ± 1.089	2.726–3.256	2.781 ± 1.039	2.486–3.078	4.175 ± 1.195	3.710–4.640	2.845	.034
ML	3.525 ± 1.575	3.180–3.870	2.480 ± 0.842	2.285–2.675	2.154 ± 0.742	1.859–2.449	1.987 ± 0.556	1.722–2.253	2.988 ± 0.982	2.693–3.283	0.789	.071
AP	2.897 ± 1.212	2.712–3.083	1.475 ± 0.455	1.310–1.640	1.886 ± 0.430	1.691–2.081	1.127 ± 0.485	0.962–1.293	2.224 ± 0.726	1.939–2.509	1.685	.041

Abbreviations: AP, anteroposterior; CI, confidence interval; ML, mediolateral; PS, postural stability.

In older adults, the use of 10-mm insoles was found to provide better SPS overall and DPS AP measurements compared with measurements made with barefoot, only shoes, and 5- and 15-mm insoles ($P < .05$). Moreover, according to the results of SPS ML and DPS overall, significantly better PS was found with 10-mm insoles compared with barefoot, only shoes, and 15-mm insoles ($P < .05$). However, there was no significant difference between 5- and 10-mm insoles ($P > .05$) (Table 3).

Comparison of Insoles in RoF Measurements

The mean ± SD RoF values obtained from the participants using five different insoles (barefoot, only shoes, and 5-, 10-, and 15-mm insoles) are given in Table 4. Different insoles were found to have significant effects on static RoF (SRoF) in elderly individuals (overall: $F = 7.895$, $P < .001$; ML: $F = 8.215$, $P < .001$; and AP: $F = 7.921$, $P < .001$). Dynamic RoF (DRoF) was also found to be influenced by using different insoles (overall: $F = 4.852$, $P = .003$; ML: $F = 2.015$, $P = .042$; and AP: $F = 1.985$, $P = .050$).

The SRoF overall, SRoF ML, DRoF overall, and DRoF ML measurements made with the 10-mm insole were significantly better compared with those made with barefoot, only shoes, and 5- and 15-mm insoles ($P < .05$). In addition, comparing SRoF AP and DRoF AP measurements in 5- and 10-mm insoles showed no significant differences ($P > .05$) (Table 5).

Discussion

The aim of this study was to examine the effects of insoles of different thicknesses on statically and dynamically measured PS and RoF in elderly individuals and to determine which insole could improve PS and decrease RoF in an early period. According to the results of the present study, in measurements of SPS overall, DPS AP, SRoF overall, SRoF ML, DRoF overall, and DRoF ML, the best PS scores and the least RoF were recorded with the 10-mm insole. In addition, although 10-mm insoles had the best outcomes on the participants' SPS ML, DPS overall, SRoF AP, and DRoF AP

Table 3. Pairwise Comparison of Insole Conditions for Postural Stability

Pairwise Comparison of Insole Conditions	Difference (Mean ± SE)	P Value	95% CI
SPS overall			
Barefoot-10 mm	1.792 ± 0.841	.026	1.325–2.259
Only shoes-10 mm	0.599 ± 0.147	.05	0.514–0.684
5 mm-10 mm	0.352 ± 0.201	.05	0.265–0.439
15 mm-10 mm	1.369 ± 0.654	.038	1.145–1.593
SPS ML			
Barefoot-10 mm	1.270 ± 0.478	.012	0.924–1.616
Only shoes-10 mm	0.369 ± 0.102	.05	0.287–0.451
15 mm-5 mm	0.822 ± 0.265	.04	0.754–0.890
15 mm-10 mm	1.022 ± 0.231	.028	0.912–1.132
SPS AP			
Barefoot-10 mm	1.058 ± 0.146	.018	0.914–1.202
Only shoes-10 mm	0.622 ± 0.324	.039	0.314–0.930
15 mm-5 mm	0.721 ± 0.189	.05	0.647–0.795
15 mm-10 mm	0.921 ± 0.238	.05	0.814–1.028
DPS overall			
Barefoot-10 mm	2.303 ± 0.547	<.001	1.845–2.761
Barefoot-5 mm	2.093 ± 0.749	.001	1.587–2.599
Only shoes-10 mm	0.654 ± 0.328	.041	0.421–0.896
15 mm-5 mm	1.184 ± 0.454	.017	0.946–1.422
15 mm-10 mm	1.394 ± 0.395	.01	1.167–1.621
DPS AP			
Barefoot-only shoes	1.422 ± 0.964	.023	1.147–1.697
Barefoot-10 mm	1.770 ± 0.872	.006	1.236–2.304
15 mm-only shoes	0.749 ± 0.165	.045	1.247–2.293
5 mm-10 mm	0.759 ± 0.612	.045	0.368–1.150
15 mm-10 mm	1.097 ± 0.168	.038	0.914–1.280

Abbreviations: AP, anteroposterior; CI, confidence interval; DPS, dynamic postural stability; ML, mediolateral; SE, standard error; SPS, static postural stability.

Table 4. Analysis of Variance Results Comparing the Effect of Each Insole Condition on RoF

Type of RoF	Insole Condition: Barefoot, Mean ± SD	Barefoot, 95% CI	Only Shoes, Mean ± SD	Only Shoes, 95% CI	5-mm Insoles, Mean ± SD	5-mm Insoles, 95% CI	10-mm Insoles, Mean ± SD	10-mm Insoles, 95% CI	15-mm Insoles, Mean ± SD	15-mm Insoles, 95% CI	*F*	*P* Value
Static												
Overall	4.282 ± 2.031	3.977–4.587	3.597 ± 1.543	3.302–3.892	2.597 ± 0.831	2.272–2.922	1.612 ± 0.832	1.437–1.787	2.850 ± 1.412	2.545–3.155	7.895	<.001
ML	2.552 ± 1.411	2.237–2.867	2.152 ± 1.026	1.962–2.342	1.714 ± 0.620	1.544–1.884	0.878 ± 0.427	0.783–0.973	1.955 ± 0.887	1.750–2.160	8.215	<.001
AP	2.343 ± 1.782	2.158–2.528	1.682 ± 0.847	1.507–1.857	1.241 ± 0.415	1.051–1.431	0.956 ± 0.494	0.851–1.061	1.448 ± 0.742	1.283–1.613	7.921	<.001
Dynamic												
Overall	4.989 ± 2.254	4.644–5.334	3.078 ± 0.891	2.763–3.393	2.302 ± 1.082	2.037–2.567	1.741 ± 1.054	1536–1946	3.941 ± 0.902	3.586–4.296	4.852	.003
ML	3.474 ± 1.872	3.179–3.769	2.145 ± 0.452	1.890–2.330	1.644 ± 0.654	1.474–1.814	1.087 ± 0.472	932–1242	2.981 ± 0.613	2.686–3.276	2.015	.042
AP	2.121 ± 1.123	1.876–2.366	1.955 ± 0.512	1.790–2.120	1.177 ± 0.472	1.032–1.322	0.961 ± 0.249	846–1076	2.219 ± 0.461	2.024–2.414	1.985	.050

Abbreviations: AP, anteroposterior; CI, confidence interval; ML, mediolateral; RoF, risk of falling.

measurements, no statistically significant difference was noted between 5- and 10-mm insoles. Furthermore, in DPS ML measurements, insoles of different thicknesses were found to have no effect on PS. According to the results of the study, it can be generally stated that compared with the other insoles, 10-mm insoles improve PS in an early period and reduce RoF. Both PS and RoF are adversely affected in the barefoot condition compared with the use of insoles because insoles of different thicknesses may have an effect on PS and RoF by causing artificial somatosensorial changes.[26]

The present study shows that in elderly individuals, PS and RoF can be influenced by using different insoles. However, in DPS ML measurements, different insoles did not seem to have any effect on PS. The DPS ML measurement is not only one of the important components of dynamic balance but also one of the factors that can increase the potential RoF. It has been shown in a previous study that depending on the hardness of the insole and the heel height of the shoe, DPS ML measurement results could change.[27] It has also been shown that using shoes or orthoses has no effect on postural oscillations in the ML direction.[28] Although the findings of this study are in accordance with the literature, no study was found to examine the effects of insoles of different thicknesses on DPS ML.

Iglesias et al[14] conducted a study of 20 healthy elderly individuals and showed that the use of insoles could be an inexpensive way to reduce RoF and increase SPS. According to a study that included 13 elderly individuals who had fallen at least once during the past year, it was found that insoles improved static balance in an early period.[29] This study found, in accordance with the literature, that SPS and SRoF scores could be significantly altered by using different insoles.

According to the results of the present study, except for DPS ML, all of the RoF and DPS measurements are affected by using different insoles. In their study of 15 fall-experienced and 18 nonfaller older adults, Liu et al[2] found that using insoles decreased the dynamic oscillations of the participants. In a study investigating the effects of four biomechanically different insoles on the DPS of 13 healthy elderly individuals, it was reported that DPS ML and DPS AP did not change with the use of insoles.[30] Twenty-four asymptomatic young adults were included in a study to investigate the effects of textured insoles on postural oscillations. According to the results, textured insoles had no effect on DPS AP and DPS ML.[31] There are some inconsistencies in terms of DPS in studies that used insoles with different characteristics. Although different materials and measurement methods used in each study could be one possible reason for this inconsistency, another reason might be the fact that some of the evaluations in the previously mentioned studies were performed with open eyes and others with closed eyes. It is known that visual input affects somatosensory feedback and is important for PS.[30] Because most of the activities of daily living are performed while eyes are open, the evaluations of the present study were performed while the participants' eyes were open.

The use of high-heeled shoes in elderly individuals is not recommended because it adversely affects the lower-extremity functions and alignment.[9] There is no consensus on optimal heel height for the elderly population.[9,18,32] However, the increase in heel height has been found to increase the angle of supination during the heel strike phase and, thus, cause inversion injuries, balance problems, and falling. It has been reported that RoF is particularly increased in heel height greater than 25 mm.[9,32] The results of another study showed that a shoe heel of 45 mm increased the RoF.[18] Based on the results of the present study, it was found that a 10-mm-thick

Table 5. Pairwise Comparison of Insole Conditions for Risk of Falling

Pairwise Comparison of Insole Conditions	Difference (Mean ± SE)	*P* Value	95% CI
SRoF overall			
Barefoot-5 mm	1.685 ± 0.687	.034	1.425–1.945
Barefoot-10 mm	2.670 ± 0.324	.002	1.478–3.862
Only shoes-5 mm	1.000 ± 0.458	.021	0.968–1.032
Only shoes-10 mm	1.985 ± 0.698	.048	1.472–2.498
5 mm-10 mm	0.985 ± 0.147	.026	0.867–1.103
15 mm-10 mm	1.238 ± 0.856	.038	0.915–1.561
SRoF ML			
Barefoot-5 mm	0.838 ± 0.269	.05	0.712–0.964
Barefoot-10 mm	1.674 ± 0.679	.024	1.247–2.101
Only shoes-10 mm	1.274 ± 0.367	.032	1.104–1.444
5 mm-10 mm	0.836 ± 0.168	.05	0.713–0.959
15 mm-10 mm	1.077 ± 0.329	.041	0.823–1.331
SRoF AP			
Barefoot-5 mm	1.102 ± 0.697	.012	0.935–1.870
Barefoot-10 mm	1.387 ± 0.356	.001	1.167–1.607
Only shoes-10 mm	0.726 ± 0.329	.032	0.514–0.938
Only shoes-15 mm	0.434 ± 0.369	.041	0.127–0.741
15 mm-10 mm	0.492 ± 0.314	.04	0.269–0.715
DRoF overall			
Barefoot-5 mm	2.687 ± 1.003	.001	1.965–3.409
Barefoot-10 mm	3.248 ± 0.968	<.001	2.514–3.982
Only shoes-10 mm	1.337 ± 1.017	.008	0.521–2.153
5 mm-10 mm	0.561 ± 0.214	.05	0.415–0.707
15 mm-5 mm	1.639 ± 0.682	.043	1.498–1.780
15 mm-10 mm	2.200 ± 1.068	.006	1.369–3.031
DRoF ML			
Barefoot-5 mm	1.830 ± 0.364	.002	1.698–1962
Barefoot-10 mm	2.387 ± 0.985	<.001	2.145–2.629
Only shoes-10 mm	1.328 ± 0.684	.0048	0.745–1.911
5 mm-10 mm	0.557 ± 0.351	.05	0.368–0.746
15 mm-10 mm	1.894 ± 0.861	.002	1.261–2.527
DRoF AP			
Barefoot-5 mm	0.944 ± 0.631	.014	0.537–1.351
Barefoot-10 mm	1.160 ± 0.943	.001	0.561–1.759
Only shoes-10 mm	0.994 ± 0.219	.018	0.842–1.146
15 mm-5 mm	1.042 ± 0.659	.001	0.612–1.472
15 mm-10 mm	1.258 ± 0.861	.001	0.813–1.703

Abbreviations: AP, anteroposterior; CI, confidence interval; DRoF, dynamic risk of falling; ML, mediolateral; SRoF, static risk of falling.

insole generally results in a better PS and a lower rate of RoF compared with insoles of other thicknesses. The possible reason is thought to be that the thickness of the medium-density Plastozote used for the insoles may have affected the contact surface formed on the sole of the feet. That is, this surface might be smaller in the 5-mm insole than in the 10-mm insole. Note that the same assumption works for the 15-mm insole. As the insole gets thicker, it pushes the foot out of the shoe and causes more instability in the ML direction.

A limitation of this study was that only short-term effects of the selected insoles on PS and RoF were investigated. Because people may adapt to these insoles over time, a longitudinal study should be conducted to investigate how the insoles affect PS and RoF statically and dynamically over a longer period. According to Perry et al,[11] adaptation did not have any significant effects on PS when wearing a passive balance-enhancing insole for 12 weeks. Qu et al[30] also reported similar findings when evaluating DPS and RoF. Therefore, we may expect that long-term effects would be similar to the short-term effects found in the present study. Another limitation of this study is that dynamic assessments were evaluated on only the unstable surfaces. Nearly 70% of falls in older adults occur during walking,[30,33] and walking balance in real-life conditions should be evaluated.

Conclusions

In summary, except for DPS ML, the use of insoles of different thicknesses has been shown to be effective on RoF and PS. Therefore, the initial hypothesis was generally supported by this study. In addition, it can be said that the best insole for elderly individuals to increase PS statically and dynamically and reduce RoF is the 10-mm-thick insole. The data obtained with the present study may help us better understand the relationship between insole thickness and PS and RoF. For older populations, 10-mm-thick insoles made of medium-density Plastozote can be recommended to help improve PS and reduce RoF. Deteriorated PS increases RoF and may cause falling[34]; hence, the use of insoles could be a practical solution to prevent falls in elderly individuals. There is a need for further studies in this field, especially to evaluate changes in PS and RoF during walking.

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