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Effects of Different Sports Shoes and Bare Feet on Static and Dynamic Balance In Healthy Females: A Randomized Clinical Trial

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Abstract

Static and dynamic balance can be influenced by many factors. However, there is limited evidence regarding the effects that shoe sole hardness may have on balance. The aim of our study was to investigate effects of different sports shoes and bare feet on static and dynamic balance in healthy female individuals. Seventeen female participants were included in our study. All participants were assessed with bare feet, hard-support sports shoes and soft-foam sports shoes. The order of the assessment for each participant was randomly determined using an online random allocation software. The SportKAT 3000® device was used to assess dynamic double feet, static double feet, dominant foot and non-dominant foot balance. Static balance showed no significant difference between bare feet, hard-support and soft-foam sports shoes ($p_{double\ feet}$=0.390, $p_{dominant}$ side=0.465, $p_{non\text{-}dominant\ side}$=0.494). Difference for dynamic balance was statistically significant between bare foot, soft-foam and hard-support sports shoes (p=0.003). When investigating this difference in dynamic balance with dual comparisons, significant differences were confirmed between hard-support and bare foot (p=0.010) and between soft-foam and bare foot (p=0.001). No difference in static balance is present between the no-shoe and both shoe conditions. Different outcomes regarding dynamic balance were observed between bare feet and both shoe conditions. However, hard surface and soft surface shoes did not differ during the dynamic task condition. Therefore, the purchase of a running shoe may be decided according to the preferred footwear.

Keywords: *balance, shoe, static, dynamic*

Introduction

Sports shoes have considerably evolved during the last century in terms of features, materials and construction techniques and many different types of sport shoes are present nowadays (Nigg, Baltich, Hoerzer, & Enders, 2015). They differ based on insole material, support or sports type (Fong, Hong, & Li, 2007). Shoe characteristics are important for balance and stability, since these are able to influence the somatosensory feedback to the foot and ankle (Menant, Steele, Menz, Munro, & Lord, 2008b). An example can be seen when wearing elevated heels which can significantly alter static balance compared to standard low heel shoes (Menant, Steele, Menz, Munro, & Lord, 2008a). Conversely, the type and texture of insoles which has direct contact with the sole of the foot (S. H. Kim, Ahn, Jung, J. H. Kim, & Cho, 2016), can positively influence postural control, static and dynamic balance in either healthy or injured populations, young and old individuals (Menz, Auhl, & Munteanu, 2017; Steinberg, Tirosh, Adams, Karin, & Waddington, 2017). Therefore, depending on the type and structure of the shoe

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and its components, balance can be both positively or negatively influenced.

Among shoe characteristics also the type of support must be considered. Among these, hard-support and soft-foam soles are commonly employed. Hard-support soles regulate and support the foot structure thanks to their stiffer material (Robbins, Gouw, & McClaran, 1992). Soft-foam soles provide contact with the foot at all points and provide a softer support which harbors the structure of the foot (Nagano & Begg, 2018). However, excessively hard or excessively soft soles have been seen to negatively affect balance and gait, especially in older adults (Menant et al., 2008b).

Evidence also exists regarding the capacity of certain shoes have to absorb shocks and therefore may have the potential effect to prevent from injury occurrence (Peters, Zwerver, Diercks, Elferink-Gemser, & van den Akker-Scheek, 2015). Such shock absorption capacity is guaranteed by the inclusion of synthetic materials and air or gel cells within the sole or the insoles (Nigg, 2001).

Nowadays, there is also increasing interest towards walking and training barefoot or with minimal shoes in order to replicate more natural movements of the feet (Marchena-Rodriguez, Ortega-Avila, Cervera-Garvi, Cabello-Manrique, & Gijon-Nogueron, 2020). Intervention studies have observed that this type of training in runners may be beneficial to increase the strength of the feet or reduce the rate of injuries (Fuller et al., 2019; Rixe, Gallo, & Silvis, 2012), however no significant differences were seen regarding long term performance or running biomechanics improvements following long periods of bare feet running.

Despite the influence of shoe characteristics has been widely investigated concerning gait or performance in different populations, there is limited evidence regarding the influence of shoe typology on balance. Therefore, the aim of this study was to investigate the effects of different sport shoes or no-shoes on static and dynamic balance in healthy individuals. This question is especially important for athletes or sport professionals which require optimal balance during different motor tasks.

Methods

Participants

Seventeen female participants (mean age 27.0±9.55 years, BMI 23.10±4.15 kg/m2, shoe size 38-39) without lower extremity and low back problems were included. The exclusion criteria included: (a) Participants presenting with soft tissue or bone problems affecting the lower extremities, (b) neurologic pathologies or disfunctions, (c) scoliosis, (d) systematic rheumatic pathologies, (f) participants with history of orthopedic problems or surgery affecting lower extremities, and (g) being obese (BMI>30 kg/m2). A flow chart of participants inclusion and study assessment is presented in Figure 1.

FIGURE 1. Flow-chart of participants inclusion and assessment process

Research design

The study protocol was approved by the University Ethics Committee (n KA16/369; clinical trial n NCT04536948), and a written consent form was obtained from all participants. These were assessed with bare feet, with a hard-support sports shoe and with a soft-foam sports shoe. Nike Air-Max® sports shoes were used as hard-support shoes and Sketchers® sports shoes with memory-foam were used to provide soft-foam sole support. All participants were assessed by an experienced physiotherapist. The assessment order (bare feet, hard-support shoe and soft-foam shoe) for each participant was randomly assigned using an online random allocation software program (GraphPad Software QuickCalcs, GraphPad Software Inc., La Jolla, CA, USA).

Assessment Procedure

Anthropometric parameters of each participant were first collected. All participants were assessed for three conditions: bare feet, hard-support sports shoes and soft-foam sports shoes.

For each condition, four measures were collected: Dynamic double feet (DDF), static double feet (SDF), static dominant foot (DF) and static non-dominant foot (NF). Dominant foot was determined by asking the participants their preferred kicking leg (van Melick, Meddeler, Hoogeboom, Nijhuis-van der Sanden, & van Cingel, 2017). The Kinesthetic Ability Trainer (SportKAT 3000®) (LLC, Vista, California) device was used to assess balance. The SportKAT 3000® consists of a movable platform supported on a central point by a small pivot. A tilt sensor on the platform is connected to a computer, which registers the deviation of the platform from a reference position with a sampling frequency of 18.2 Hz. The distance from the central point to the reference position is measured at every platform variation. Each subject was allowed to familiarize on the platform for one-minute before the tests. After the familiarization, the subjects performed the different tasks for every condition. Each measurement was conducted over a 30 second timeframe.

During all the balance tests, the participants kept their eyes open and had to keep sight at a reference point (a red 'X') on a monitor in front of the SportKAT 3000® system at 1.5m distance. The target was constant for static measurements and active for dynamic measurements.

Each subject stood on the force platform in a natural position with arms placed at side. To ensure that the balance measurement was accurate, the SportKAT 3000® device was calibrated, as recommended in its manual, before the tests (Figure 2 and 3 show non-dominant static and static condition without and with shoes, respectively) (Surenkok, Kin-Isler, Aytar, & Gültekin, 2008; Yazicioglu, Taskaynatan, Guzelkucuk, & Tugcu, 2007).

After each condition the participants were asked to sit in a chair for 15 minutes without shoes.

FIGURE 2. Static Balance Assessment with Bare Feet in dominant Side

FIGURE 3. Static Double Feet Balance Assessment with Hard-Support Insole Sports Shoe

Statistical analysis

The power analysis indicated that 17 participants were needed with 80% power and a 5% type 1 error (G*Power 3.1.9.7). The power analysis of our study showed a power of 80% with balance as the primary outcome. The data were analyzed using statistical software (SPSS version 18, Inc., Chicago, IL, USA). All the statistical analyses were set a priori at an alpha level of $p<0.05$. The tests for homogeneity (Levene's test) and normality (Shapiro-Wilks) were used to determine the appropriate statistical methods to apply for comparison between groups. The differences between groups were analyzed by the Friedman Variance Analysis while paired comparisons between groups and multiple comparisons between the ranks of each groups with post-analysis Dunn's correction. The level of statistical significance was set at $p<0.05$.

Results

Dominant foot was calculated in 11.8% the left leg and in 88.2% the right leg. Static balance showed no significant difference between bare feet, hard-support sport shoes and soft-foam sport shoes (SDF p=0.390, DF p=0.465, NF p=0.494). Difference for dynamic balance was statistically significant between bare feet, soft-foam sport shoes and hard-support sport shoes (p=0.003).

Table 1. Comparison of balance outcomes between conditions

	Bare feet Mean±SD	Hard-support shoes Mean±SD	Soft-foam shoes Mean±SD	p
DDF (mm)	2946.88±666.29	2612.59±453.99[a]	2470.71±502.03[a]	0.003*
SDF (mm)	472.00±187.28	444.82±129.52	453.59±155.23	0.390
DF (mm)	3160.18±1116.06	3512.41±1308.96	3610.71±1480.41	0.465
NF (mm)	3121.53±1022.08	3212.88±1304.74	3382.24±1497.67	0.494

Legend: DDF-Dynamic double feet; SDF-Static double feet; DF-Static dominant foot; NF-Static non-dominant foot; *-p<0.05, Friedman Variance Analysis, a-p<0.05 compared to bare feet.

When investigating paired differences within the dynamic balance task, there was no significant difference between hard-support sport shoes and soft-foam sport shoes (p=0.259), while a significant difference was present between hard-support sport shoes and bare feet (p=0.010) and soft-foam sport shoes and bare feet (p=0.001) (Table 1).

Discussion

We investigated the effects of sport shoes with different midsole structure on static and dynamic balance and found that different midsoles such as soft-foam and hard-support are equally effective as bare feet in terms of static balance. When considering dynamic balance, sports shoes may be better than bare feet with no differences between the midsoles taken into exam.

There has been an evolutionary change in shoe supports and insoles over time. In addition to fashion, changes in sports shoe insoles have been affected by developing technology and sport needs (Nigg et al., 2015). Different shoe soles can have important implications in maintaining postural control and providing stabilization either in healthy (Corbin, Hart, McKeon, Ingersoll, & Hertel, 2007) and injured individuals (McKeon, Stein, Ingersoll, & Hertel, 2012). Corbin et al. (Corbin et al., 2007) reports that increased afferent information from textured insoles improves postural control in bilateral but not during unilateral stance. Results which seem in line with our findings for both dominant and non-dominant leg and bipodal stance. Regarding possible afferent information, an important consideration which needs to be addressed is that during our evaluations, the participants were for all conditions with their eyes open. As known, balance is the result of different sensory inputs as the visual, vestibular and proprioceptive systems, and the integration between these systems can influence the different balance outcomes (Peterka, 2002). Since dynamic balance was the only outcome which was influenced by the shoe or no-shoe condition, the inhibition of visual inputs could have emphasized the contribution of proprioceptive inputs during the balancing conditions.

Another aspect concerning shoe characteristics addressed by Waddington & Adams (Waddington & Adams, 2003) is that when specific textured insoles were compared to conventional smooth insoles it was possible to observe alterations of the biomechanics of the ankle. Therefore, also the insoles may provide appropriate sensory information needed for correct foot biomechanics. Considering the contribution of the soles and insoles to sensory input for dynamic balance, all shoe components become important factors for balance maintenance (Priplata, Niemi, Harry, Lipsitz, & Collins, 2003).

According to different studies, if there is a defect in the existing foot structure or its biomechanics, when soft-foam insoles are used, the foot will be supported in such direction and poor balance will be maintained (McKay, Goldie, Payne, & Oakes, 2001; Robbins, Waked, & McClaran, 1995). Hard-support sports shoes are expected to provide greater support for dynamic stability (Losa Iglesias, Becerro de Bengoa Vallejo, & Palacios Peña, 2012). Therefore, hard-support insoles are more frequently seen to concerning such aspects to effectively provide tactile sensation for quicker reactions of the foot in order to improve gait and balance (Menant et al., 2008a). However, according to the results of our study both sports shoe soles equally support dynamic equilibrium.

One of the major limitations of this study is that all participants were woman and that these were not using the same shoes used during the evaluation in their daily life.

Conclusions

Our investigation has shown that static balance is not influenced by the typology of shoe support compared to the no-shoe condition. No difference was also present between soft foam shoes and hard support shoes for dynamic balance. However, differences are present between both shoe and the no-shoe condition. These results suggest that wearing a shoe will help dynamic balance tasks. The purchase of a running shoe may be decided according to the preferred footwear.

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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