Original article

Effect of different types of shoes on balance among soccer players

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Summary

Background: **in soccer, balance ability is important to reduce non-contact injuries. The effect of footwear on balance is poorly understood in this sport. Soccer boots and futsal trainers need to guarantee a good grip on compliant surfaces. Running shoes are designed to reduce friction on rigid su rfaces. The purpose of the present study was to investigate these types of shoes on balance ability.**
Methods: **twenty-four healthy male volunteers were recruited from amateur soccer teams. They were ask to perform the BESS (Balance Error Scoring System) test to measure the number of instability episodes in 6 conditions: double-leg, single-leg, and tandem stances on firm and foam surfaces. Anova with factor (several shoes) and Bonferroni were used to compare the means of two subtotal scores (firm and foam surface) and the final total score (BESS).**
Results: **the three shoe models led to greater stability than when the subject was barefoot (p=0.001). Only on the firm surface the soccer boots were statistically better than futsal trainers (p=0.009).**
Conclusions: **the lack of stability while barefoot could be explained by the fact that with shoes there is a greater surface area, which produces a sensory filter that leads to posture modifications to improve stability. The greater stability, that was found in the three types of footwear, could be guaranteed by the design to reduce friction (for running shoes) and by the presence of studs (for soccer boots and futsal trainers).**

KEY WORDS: barefoot, boots, futsal, runner, sport, stability.

Introduction

In recent years, an increase in sport participation has been observed at the recreational, semi-professional, and professional level[1].The maintenance of balance, both static and dynamic, is an essential requirement for reducing injuries and for excelling in sports. The balance is the ability to maintain an upright position. In human being it is more appropriately defined as postural stability. Postural stability can be described as the ability of an individual to maintain own center of gravity within the base of support[2, 3]. It is actively controlled by the central nervous system, which processes the afferent visual, otolithic, and somato-sensorial information. When standing up and moving, the foot is the first point of contact between the body and the external environment, providing sensory information to the central nervous system for stability and locomotion. Postural stability is dependent on the position of the centre mass of the body and its displacement within the base of support.
Footwear may influence the quality of sensory feedback from the feet and may act as a sensory filter between the feet and the external environment[4]. A wide selection of sport shoes for different types of surfaces and weather conditions is currently available[5]. Companies have made shoes specifically for each sport[6]. Different components of shoes have been studied in relation to their requested function[7]. The upper part of the shoe is the major surface of contact with the ball. The upper part can be natural or synthetic. Natural leather guarantees better sensitivity when touching the ball and is also breathable, whereas man-made

leather is stronger and more resistant but provides less comfort and sensitivity. The sole is the bottom part of the shoe and has direct contact with the ground. It consists of three layers: insole, mid-sole, and outsole. The insole lessens the impact with the ground, while the outsole influences stability.
Running shoes are built with a soft upper part which guarantees a lightness of step[8]. In the centre of the mid-sole there are specific plastic inserts to allow movement only in the longitudinal direction, to control and contain twisting during weight bearing immediately after a step. Rubber soles are able to soften the impact with the ground. This kind of shoe combines lightness, for easier stepping, allowing better stability in the longitudinal direction which are fundamental upon impact with the ground.
Soccer boots and futsal trainers are characterized by a more rigid upper part which must protect the dorsal part of the foot, guarantee a good grip on the ball and at the same time allow enough force when kicking the ball[6, 8, 9]. The sole (polyurethane or carbon fiber) has to be resistant and give stability. It is also made to cope with force of impact and lateral movement. The presence of studs may facilitate the foot sticking to the ground. These studs can be metal or rubber and come in different shapes (cylindrical or long). The number of studs also varies in relation to the motion of the player. In futsal trainers there are more studs, but they are smaller and only made of rubber. Both soccer boots and futsal trainers allow grip on the ball while kicking, and stability while changing direction. In studies on soccer boots more attention to detail was payed to the influence of the studs[10]. It was hypothesized that studs may aid the foot stick to the ground, increasing stress on the knee ligaments and moreover, the risk of abnormal motion and therefore the rupture of the anterior cruciate ligament[10].
Soccer combines a number of complex movements which include tackling, kicking and goal-keeping related movements[11]. These, and the running involved during the game, have been biomechanically assessed. At amateur level there could be the use of inappropriate shoes. The purpose of the study was to evaluate the influence of shoe type on balance among soccer players.

Methods

We set up a clinical observational study designed to recruit volunteer healthy male soccer players from amateur soccer teams, halfway through the season. The research was conducted according to international ethical standards[10]. All subjects or their parents (if they were underage) read and signed the informed consent form approved by the Bari University General Hospital Local Ethics Committee, which also approved the study procedures. Inclusion criteria required volunteers to be playing regular soccer and have a shoe size EUR 44. The subjects had been consistently participating in regular soccer training sessions for a total of 10 hours per week and strength and conditioning training for 3 hours per week. Subjects who had suffered a musculoskeletal injury to a lower extremity or a head injury were excluded from the study. We screened subjects for any pre-existing visual, vestibular, or balance disorders through self-report. The posture stability was valued by BESS (Balance Error Scoring System).

Shoes

Subjects were evaluated barefoot and with 3 different typed of shoes (Firm Soccer Boots, Futsal Soccer Trainers and Running Shoes).

1. **Firm soccer boots.** The upper part is made from kangaroo leather, the inner sole from EVA (ethylenvinylacetate), the outer sole from TPU (thermoplastic polyurethane) with 12 studs, cone-shaped (n. 8) and bladed (n. 4), used specifically for firm ground. Weight 270 g. These are classic soccer boots with studs (bladed and conical in shape) designed to provide traction and stability on natural grass, outdoor soccer fields.
2. **Futsal soccer trainers.** Upper part synthetic leather, inner sole in EVA (ethylenvinylacetate). Outer sole in Traxion™ TF for firm surfaces, beaten ground and synthetic grass (turf). Seventy small studs distributed equally for good grip in every direction. Weight 230 g. Futsal trainers are extremely lightweight. Futsal trainers have low profile rubber outsoles for traction on flat indoor courts and turf surfaces. They are designed for fast, five-a-side play.
3. **Running shoes.** Upper part synthetic fiber, intermediary sole made with EVA (ethylenvinylacetate) foam injected into the trainer, external sole rubber. Weight 230 g. They are made for running for up to 30 minutes in the streets and on firm ground.

All shoes were of the same size (EUR 44). The shoes were examined manually by palpation to ensure that they fitted the players. The three shoe types were provided for the players in random order. Players were required to finish the BESS in one shoe type before changing into another shoe type. Players wore the same type of thin soccer socks without being taped at the ankles. The players' feet did not present any visible valgus or varus, and none of the players reported any foot problem during the test procedures.

Balance Error Scoring System

Postural stability was measured using BESS (Balance Error Scoring System) error scores[11]. The BESS includes 6 conditions: double-leg, single-leg, and tandem stances on firm and foam surfaces. The firm surface was the floor of a gym. The foam surface consisted of a 46 x 46 x 13 cm block of medium-density foam on a 10 cm thick surface. A stopwatch was used to time each of the 20 second trials. One BESS error was scored if the subject engaged in any of the following: (1) lifting the hands off the iliac crests; (2) opening the eyes; (3) stepping, stumbling, or falling; (4) moving the hip into more than 30° of flexion or abduction; (5) lifting the forefoot or heel; or (6) remaining out of the test position for longer than 5 seconds. Error scores were calculated for each of the 6 conditions and summed up to obtain the total BESS score. A full description of BESS scoring and reliability has been previously published[12-14]. According to the inter-rater and intra-rater reliability for the total BESS scores of 0.57 and 0.74 respectively[15], each subject took the test twice and two independent investigators measured the error score separately. To improve the reliability, multiple errors committed simultaneously should be counted as 1 error[16, 17]. Single-leg stances and foam surface are associated with lower reliability[16, 17]. In previous research, BESS has been correlated with other measures of balance using testing devices, as stabilometric device, showing an acceptable reliability[14, 18]. To reduce any outside interference, we conducted the study in the closed environment of a gym, at ambient temperature of 19 °C and humidity of 50%[12, 19, 20]. Before the test, subjects were allowed to familiarize themselves with the different conditions. They were first allowed to try standing on the firm surface. Once they were comfortable standing on each surface, we then instructed them in the correct positioning for each of the 6 conditions. The double-leg stance conditions consisted of the subject standing with feet together. The single-leg stance was performed on the non-dominant leg, as determined by which limb the subject would not preferentially use to kick a ball. The dominant leg was positioned so that the hip was flexed to approximately 30° and the knee flexed to 90°, leaving the foot approximately 25 cm off the ground. We instructed the subject not to lean the dominant leg on the non-dominant leg. The non-dominant foot was positioned behind the dominant foot in the tandem stance, and the subject was instructed to maintain the stance with the big toe of the non-dominant foot touching the heel of the dominant foot. For all conditions, we instructed the subject to remain still with their eyes closed and hands on their hips. After instruction, each subject was given 2 familiarization trials on each condition before the actual data collection. During the familiarization and testing sessions, each condition lasted 20 seconds, and at no point was the clock stopped. We instructed the subject to remain as still as possible; if he moved from the test position, he was to return to it as soon as possible. During the testing, the examiner was positioned 3m away from the subject, so the subject's eyes, hands, and feet could all be observed.

Power analysis and statistical analysis

Given the previous data in literature related to mean and standard deviation of the number of BESS errors at recruitment and follows up[11, 12], we established alfa=0,05 and power =0,90 and yielded a minimum number of 24 subjects. For each subject a file was completed with demographic variables (age, weight, height, dominant limb, how many years playing this sport). Leg dominance was determined by methods used in previous studies[13]. The information was put into a database with FileMaker pro software which was analysed using STATA MP11 software. The continual variables were expressed as averages using standard deviations (SD). To compare the averages of each variable we used Anova with factor (several shoes) and Bonferroni. To evaluate any correlation of the BESS score using different type of trainers the linear regression was also calculated. We used a multiple regression model to evaluate any confusing factor linked to age, hight and weight. To investigate the role of the dominant leg as a possible confounding factor, multivariate regression models were performed. In this model, we considered the measure (firm surface total score, foam surface total score, BESS total score), as dependent variable and group (soccer boots, futsal trainers, running shoes and barefoot) as independent variables. F fisher and t-test for each independent variables were carried out. For each test a p value of <0.05 was considered to be significant.

Results

A total of 24 subjects participated in the study, who were of mean (±SD) age 18.7 (±3.3) years and mean (±SD) height 162 (±5.7) cm; mean (±SD) weight 54.3(±6.8) kg; self-reported experience of playing soccer 4 (±0,6) years. Their preferred leg according was identified; as recorded, 83,3% of them shoot dominantly with their left leg. The BESS results are expressed as number of errors. The higher the number, the greater the instability. The results of the different BESS tests performed with each shoe and barefoot are shown in Table 1. The BESS values for each shoe were not shown to be link to the BESS scores in barefeet nor were weight, height, years of sporting activity or age factor (p>0.05). The multivariate regression models did not show the dominant leg was a confounding factor (firm surface total F= 14.9, p<0.0001; group t=2.27, p=0.025; dominant leg t=1.14, p=0.257) (foam surface total F=14.9, p<0.0001; group t=5.43, p<0.0001; dominant leg t=0.6; p=0.55) (BESS total score F=15.1, p<0,0001; group t=5.4, p<0.0001; dominant leg t=0.77, p=0.442).

BESS: FIRM-SURFACE-total score

The ANOVA analysis showed that for BESS firm surface total score there was a difference due to footwear (F=8.6; p<0.0001). The soccer boots (0.1±0.3) were statistically better than futsal trainers (0.8±0.8) (p=0.009), soccer boots were statistically better than barefoot (1±0.9) (p<0.0001) and running shoes were statistically better than barefoot (p=0.002).

Table 1. BESS results.

	Barefoot	Soccer boots	Futsal trainers	Running shoes
Firm surface				
Double leg stance	0	0	0	0
Single leg stance	0.5±0.7	0.1±0.3	0.6±0.6	0.3±0.4
Tandem	0.4±0.6	0.0	0.2±0.4	0.1±0.3
Total	**1±0.9**	**0.1±0.3**	**0.8±0.8**	**0.3±0.4**
Foam surface				
Double leg stance	0.1±0.3	0	0	0.3±0.4
Single leg stance	6.8±2.4	4.8±2.2	4.8±2.1	3.5±1.2
Tandem	4.5±2.7	3.4±2.5	2.6±1.8	2.3±1.5
Total	**11.4±4.4**	**8.1±3.8**	**7.3±2.8**	**6±2.3**
BESS total	**12.3±5.0**	**8.3±3.7**	**8.1±3.1**	**6.2±2.4**

Footnote: The 24 soccer players performed the test in 6 conditions (double-leg, single-leg, and tandem stances on firm and foam surfaces) with three type of shoes (soccer boots, futsal trainers, running shoes) and barefoot. The data are expressed as an mean +/- standard deviation.

BESS: FOAM SURFACE-total score

The ANOVA analysis showed that for BESS foam surface total score there was a difference due to footwear ($F=10.91$; $p<0.0001$).
The futsal trainers (7.3± 2.8) were statistically better than barefoot (11.4±4.4) ($p=0.001$), soccer boots (8.1±3.8) were statistically better than barefoot ($p=0.008$) and running shoes (6±2.3) were statistically better than barefoot ($p<0.0001$).

BESS: total score

The ANOVA analysis showed that for BESS foam surface total score there was a difference due to footwear ($F=11.87$; $p<0.0001$). The futsal trainers (8.1±3.1) were statistically better than barefoot (12.3±5.0) ($p=0.001$), soccer boots (8.3±3.7) were statistically better than barefoot ($p=0.001$) and running shoes (6.2±2.4) were statistically better than barefoot ($p<0.001$).

Discussion

BESS is a standardized, rapid, inexpensive screening test of postural stability that can be helpful for documenting stability. It has been used in many studies with healthy athletes, and as an outcome, measuring lower limb instability or those completing neuromuscular training[13, 14].
The average number of BESS errors depends on the stance and surface. Very few errors are associated with the double-limb stance on either the firm or foam surfaces. The single-leg stance is the most responsible for adding errors to the total BESS score on the firm and on the foam surface. Less number of errors are added to the total BESS score during the tandem stance on the two surfaces[21, 22]. In bare feet, the errors of stability linked to position and surface were the same that we found in literature[21, 22].

The results of our study showed increased stability while wearing any of the three types of shoe compared to in bare feet. This data could be contradictory given that in bare feet there are more points of references on the sole of the foot[22]. Plantar proprioception activates reflexes and helps the central nervous system make decisions that help increase stability and avoid injury[23]. However, humans started walking with shoes 45,000 years ago[8]. Shoes were an important element in the development of human posture[24]. An increase in stability whilst wearing shoes rather than in bare feet could be explained by three hypotheses[25]. First, the greater shoe ground contact area compared to bare feet could result in the measurement of an increase in the support base. Second, the increased sole width of shoes, compared to when barefoot, could increase the base of support to avoid contact between feet. Third, shoes could act as a sensory filter by reducing proprioceptive feedback, and leading to posture modifications to improve stability[8].
Until now studies which have looked at shoe stability have only been conducted on the elderly population. The researchers' aim was to reduce the number of falls in this age range, who is most at risk. There were different results on the most stable shoes. Initially the Authors believed that a shoe with a soft thick sole could guarantee better stability[26]. A further clinical study put in doubt this previous hypothesis, and the Authors found a positive relationship between midsole hardness and stability, and a negative relationship between midsole thickness and stability[27]. There is some evidence to suggest that the use of thick, soft materials in midsole construction may cause instability by reducing afferent feedback from the sole of the foot. Logically, shoes with a low coefficient of friction could be considered a hazard in most environments; however, excessive slip resistance may also cause instability under certain conditions[28]. Footwear recommendations for older people advise the use of an outersole material with a medium coefficient of friction to provide stability over a range of surfaces encountered in normal daily activities.

This data must be compared with the sports shoe data. The latter are created in order to have a sole thick enough to cope with the impact on the ground, especially while running[8-10]. Our study verified that soccer boots guaranteed better stability than futsal trainers on the firm surfaces. The soccer boots allow better grip on more compliant (natural grass) surfaces and reduce the friction on hard (tarmac and concrete) surfaces[9]. We found that the futsal trainers gave the worst results, because they have much smaller studs than soccer boots. This data could be justified if we consider that the stability is reduced with the height of the studs[14]. On the foam surface, there was no difference between the shoes. The soccer boots sank into the foam giving less stability because of the studs. In the end we found that the running shoes were the most stable. At the final evaluation, all three shoes have been more stable than barefoot, with a trend to increased stability from running shoes to soccer boots. This result backs up the hypothesis that the stability of shoe could be inversely proportional to the grip and the amount of friction produced on the ground[9]. The soccer boots, which are designed to increase grip and higher friction for playing on grass surfaces show a tendency to lower stability, while the running shoes, which need to provide less grip and less friction on hard surfaces such as tarmac, present a tendency to greater stability[9].

Weak points need to be appointed. Commercially available shoes incorporate multiple components. Therefore, it is difficult to link the performance characteristics of different shoe models to single components, because these interact with one another. There is a lack of instrumental evaluation, such as baropodometry and stabilometry, that could provide us with more details on gait analysis. We measured the grip and the friction produced by each shoe linked to different playing surfaces. There have not been any other studies carried out on other types of shoe, for example analyzing the number or the shape of the studs. We used more expensive shoes at different price ranges. Some Authors suggest a positive correlation between the higher cost of the shoe and higher injury rates[7]. This correlation may exist because of an increased sense of security by purchasing a more expensive shoe.

The strong point of our study is that we were the first to study the stability of sport shoes. Until now the shoes that had been studied were to look at the overload on the knee and ankle joint and the injuries caused because of this. It will be necessary in the following studies to verify if the most stable shoes can also guarantee good performance specifically in soccer.

Competing interests

The Authors declare that they have no competing interests.

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