# The Influence of Soccer Boots Insole's Surface Roughness and Hardness on Short-Sprint and Change of Direction Performance

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https://doi.org/10.5109/7323240

出版情報：Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 10, pp.42-47, 2024-10-17. International Exchange and Innovation Conference on Engineering & Sciences
バージョン：

# The Influence of Soccer Boots Insole's Surface Roughness and Hardness on Short-Sprint and Change of Direction Performance

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**Abstract:** *The role of footwear is crucial in sports performance. So far, it remains unclear if the aspect of footwear's insoles could substantially influence sports performance. This study examined the effect of soccer boots with different insoles properties (insoles hardness and surface roughness) on soccer-specific change of direction and 6-meter short-sprint performance. A total of ten skilled-soccer players (age: 20.5 ± 1.9 years-old, height: 172.6 ± 4.7cm, weight: 65.8 ± 6.8kg, soccer experience: more than 5 years) maximally completed six-randomised crossover trials of a slalom course and a straight 6m sprint test using the two soccer boots with different insoles (PU and EVA). Timing-gate systems were utilized to record the time of the slalom and sprint test. Differences of resultant performance when running with different insoles were analysed by paired-sample T-test (p<0.05). We found that a relatively higher insoles surface roughness with lower material hardness could potentially contributed to greater change of direction performance.*

**Keywords:** Football; Footwear; Materials; Insert; Performance.

## 1. INTRODUCTION

Observation on the effect of footwear on athlete performance is one of the most essential components in athlete performance analysis as adequate force generated from footwear and the playing surface interaction helps athlete to execute the sport-specific movement successfully [1]. Several previous studies have reported significant influence of footwear under various settings on athlete's performance, in which strong focuses were made on the sprint and change of direction elements [1-3]. This is because analysis on the key performance indicators which could distinguished a winning and a losing outcome in sports such as soccer can be determined by rapid sprint and change of direction movements created by the players in competitive matches [4]. So far, most studies have focused on the role of the outsole elements of the footwear, namely the outsole materials and the design aspects when investigating the influence of footwear construction on performance [2, 3]. Meanwhile, the effectiveness of cushioning insoles, which correspond to the in-shoe aspect to provide comfort and to facilitate athletic performance improvement has been previously assessed with limited study so far being reported [5].

Despite various soccer-specific insoles that are currently available in the market, in modern soccer, the influence of such insoles on players performance is yet to be extensively investigated [6]. It was previously reported that while altering the cushioning of the in-shoe by increasing the material density up to 15% would regulate the loading during running and turning, no substantial changes of performance was reported [7]. Meanwhile, in another recent study, it was reported that higher interaction between the in-shoe foot and insoles was corresponded to an improvement of utilized traction with an average of 9% improvement in soccer-specific change of direction movement [8]. In another recent study, the role of in-shoe frictional properties on soccer-specific tasks were assessed, where it was reported that higher in-shoe friction condition using textured socks has contributed to an increase of overall traction, which has contributed to greater performance where soccer players have performed 180-degrees change of direction test faster (0.15 seconds faster on average) and have also dribbled significantly faster (0.11 seconds faster on average) under higher in-shoe friction condition [9]. In addition, previous study has also reported that experienced futsal players have completed a multiple change of direction test in faster time record (0.56 seconds faster on average) when running on futsal playing surface that possessed softer surface hardness as compared to surface with relatively higher surface hardness [10]. It is evident that the role of shoes and playing surface interaction in sports performance is crucial. However, it is still unclear if the shoe's insole would contribute to that performance outcome.

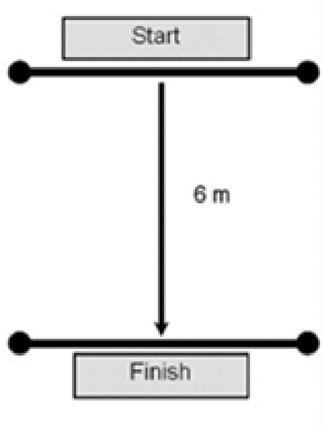
Therefore, the purpose of this study was to examine the effect of soccer boots with different insoles properties (insoles hardness and surface roughness) on soccer-specific change of direction and straight short-sprint (6 meter) performance among soccer players. It was hypothesised that there will be significant resultant performance outcome (time taken to complete the tasks) of the players when running using insoles with different hardness and surface roughness.

## 2. METHODS

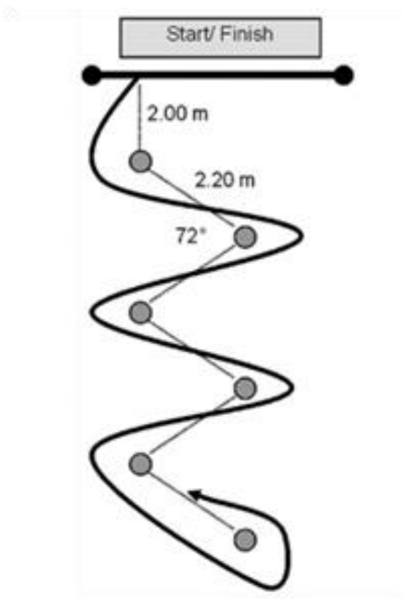
A total of ten male university level soccer players participated in this study (age: 20.5 ± 1.9 years-old, height: 172.6 ± 4.7cm, weight: 65.8 ± 6.8kg, soccer experience: more than 5 years). All participants are actively involved with the current university soccer team and free from any lower limb injury for the last 6 months. All participants provided written informed consent prior to participation in accordance with the research ethical approval obtained from the institutional research ethics committee (Ethical approval reference number: FERC/04/2023(UG/MR/0169)).

In this study, each participant was asked to maximally complete a slalom course (Figure 1) and a straight 6m sprint test (Figure 1) using the same soccer boots (Decathlon Kipsta Agility 100FG) but differencing in size (Figure 2). All tests were conducted on a 3G-Artifical Turf playing surface in dry condition.

(a)




(b)




(c)

Fig. 1. a: 6m-sprint, b: slalom course test and, c: Brower BMX TC Timing gate system used.

For both tests, participants were requested to complete six successful trials each (2 different insoles: 4mm-thick PU and EVA insoles x 3 trials) in randomized order of different insoles (Figure 2). Timing-gate system (Brower BMX TC, USA), as shown in Figure 1c, was utilized to record the time of the slalom and sprint test. All trials were conducted on the same day. Differences of resultant performance when running with different insoles were analysed by paired-sample T-test ($p<0.05$).

(a)

(b)

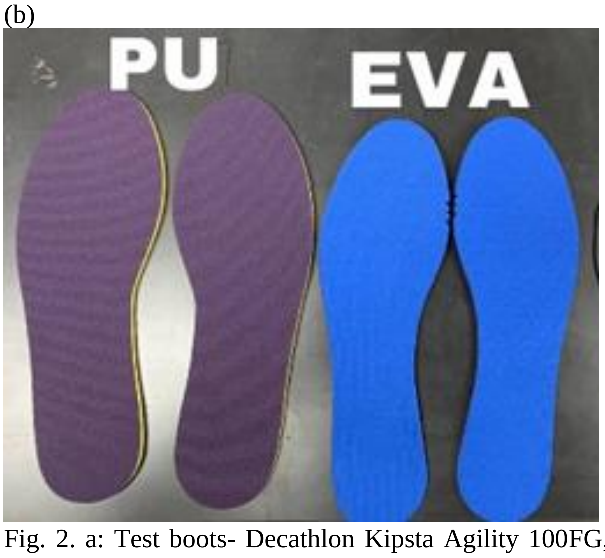



Fig. 2. a: Test boots- Decathlon Kipsta Agility 100FG, and b: PU and EVA insoles.

Meanwhile, the surface roughness (Ra: mean surface roughness and Rz: mean surface roughness depth, measured in µm) of each insole and the hardness (°) were measured using a profilometer (DR130, Sato Shoji, Japan) and a shore A durometer (PCE-DX-A, PCE Instruments UK) as shown in Figure 3. For both surface roughness and hardness measurement, the test specimens (insoles material) were placed on a table where the test specimens' positions were ensured to be in flat and fixed positions by using G clamps. For each test specimen, three measurements were made (three times each for roughness and hardness measurement) at three different positions of the specimens that were randomly selected. The mean of surface roughness components and hardness were calculated from average values the three-measurement done.

(a)


(b)


Fig. 3. a: profilometer (DR130, Sato Shoji, Japan), and b: shore A durometer (PCE-DX-A, PCE Instruments UK).

## 3. RESULTS

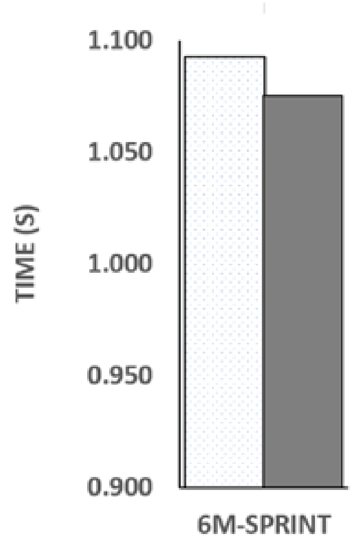
The insoles surface roughness and hardness are shown in Table 1.

Table 1. Insoles surface roughness and hardness (mean± SD).

| | PU | EVA |
|---|---|---|
| Ra (µm) | 4.14 ±0.12 | 2.83 ±0.18 |
| Rz (µm) | 24.33 ±0.74 | 22.56 ±0.57 |
| Hardness (°) | 31.2 ±1.2 | 43.8 ±0.4 |

PU insoles possessed relatively higher surface roughness as compared to EVA insoles (46% and 8% higher for Ra and Rz values respectively). In contrast, PU insoles possessed 29% relatively softer surface as compared to EVA insoles.

(a)




(b)

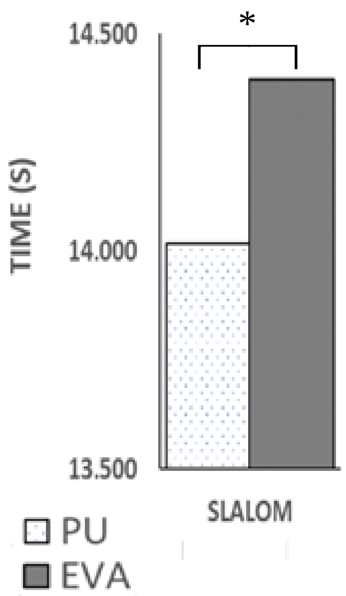



Fig. 4. a: 6m-sprint and, b: change of direction slalom course test results (*paired-sample T-test results: $p<0.05$, indicating a statistically significant difference in time recorded).

Meanwhile, the slalom course and 6m-sprint test results are shown in Figure 4. Participants performed significantly faster (0.38s faster, $p<0.05$) in the slalom-course test when ran using PU insoles (14.02 ±1.3s) as compared to EVA insoles (14.40 ±1.3s). No significant differences were observed in 6m-sprint test (0.01s difference).

## 4. DISCUSSION

The purpose of this study was to examine the effect of soccer boots with different insoles properties on soccer-specific change of direction (slalom course) and straight short-sprint (6 meter in distance) performance among soccer players. Two insoles (PU and EVA) were used by soccer players participated in this study to execute those tests in randomised order. It was hypothesised that insoles with different hardness and surface roughness would significantly influenced the resultant performance (time taken to complete the tasks) of the players in the two functional tests conducted. The study results demonstrated a mixed-outcome where, it was found that on average, all participants have performed significantly better in change of direction test when using PU insoles as compared to EVA insoles. However, it was also found that no significant difference was found in 6m straight-sprint performance among the players when running using those two insoles.

Differences with regards to the influence of insoles in both tests (6m sprint versus change of direction) likely were contributed by the differences in the human locomotor functions and the ground reaction forces associated in those two tests. In straight sprint, the movement is predominantly produced from shoe interaction with the floor surface on anteroposterior direction only, whereas in multiple change of direction slalom course test, the movement is the results of interaction of the shoe with the floor surface on both anteroposterior and mediolateral direction as participants performed multiple cutting maneuver motion. It could be interpreted that in the straight sprint, the differences in the shoe's element, for example the effect of insoles were not large enough to substantially affect the resultant performance because of no requirement to change direction. This notion was supported from the findings by Sterzing et al. (2009) [11], where it was found that changing the soccer boots stud's design could improve change of direction performance but no significant difference in running performance in straight sprint test was found. It was suggested that straight-sprint may not be the most appropriate test to discriminate between different shoe-running surface interface conditions with respect to running performances due to the absence of directional change element. The lack of directional change element means there are no braking-propulsion components in medio-lateral direction were tested in straight sprint. This has reduced the functionality aspects of the test, and therefore the role of shoes-running surface interaction was also reduced in straight sprint when compared with movements which includes directional change element. In this study, it was observed that PU insoles that possessed higher surface roughness and lower surface hardness as compared to EVA insoles managed to help improved slalom-course test performance up to 0.38 seconds faster in average. This result was in line with the findings reported in past studies [8, 9, 10] where changes of the in-shoe foot and insoles interaction have shown great improvement in soccer-specific change of direction performance where soccer players have performed significantly faster when using high-frictional socks or running on softer playing surface (0.15 to 0.56 seconds faster).

In addition, it has been demonstrated that the resultant ground reaction force in change of direction task was relatively larger when compared to straight-sprint task, where in change of direction task, the traction force requirement (grip force) is greater than straight-sprint task [12]. In a separate study, it was also found that increasing the footwear outsole traction force has improved change of direction performance (multiple v-cut run), however similar improvement was not observed in straight-sprint tasks (5m and 20m run) performed by futsal players [13]. Therefore, these findings also have supported the notion that suggest any discrepancy in terms of the of the footwear and running track surface interaction and its performance outcome may be greatly amplified more during change of direction, rather than in straight-sprint task.

Another factor which likely contributed to the outcome of this study was the insoles surface hardness property. It was found in this study that participants have performed change of direction test better when using insoles that possessed softer surface property (PU) as compared with a much harder material (EVA). Mohan et al. (2015) [14] investigated the influence of surface hardness on slip-resistance performance of visco-elastic materials with similar surface roughness but differences in hardness. It was reported that softer materials tend to create greater effective contact area and more pronounced microscopic deformations in the mechanical interlocking between two surface asperities during shoe–surface interaction. Similar findings were also reported by Derler et al. (2008) [15], where softer shoe sole materials tend to generate relatively higher friction coefficients and increased slip- resistance performance inside the shoe and reduced in-shoe movements. As found in this study, PU insoles which possessed 29% softer surface hardness when compared to EVA insoles was found to be much effective in promoting greater change of direction performance.

Meanwhile, the interaction of insole material with higher surface roughness with the foot likely has improved the in-shoe grip and friction property as well, as shown in the past study [16]. This has complimented the outcome found in this study where PU insole's mean surface roughness (Ra) and mean surface roughness depth (Rz) that were 48% and 8% relatively higher than EVA insole have significantly improved the change of direction performance among the participants. This outcome was supported by another study by Apps et al. (2020) [17]. In the study, researchers have tested the influence in-shoe frictional property and angle of cutting maneuver on change of direction performance. It was reported that as the in-shoe frictional property was increased (by increasing the socks surface roughness) the in-shoe foot movement was also reduced. It was also reported that the change of direction performance has increased greater at higher in-shoe friction condition. In addition, the role of in-shoe friction in reducing the in-shoe foot movement was observed to be much important at a much narrow cutting maneuver angle motion. Therefore, this finding also highlighted the role of cutting maneuver angle as another possible factor influencing the effectiveness of insoles, to determine if it is large enough to substantially affect the resultant performance in functional test such as change of direction test.

In this study, on average it was found that participants have executed the change of direction test faster when using the PU insole as compared to the EVA insoles. Those time difference would not just represent a statistically significant outcome. In terms of practical application, from a static position, on average, it only takes about 0.2 to 0.3 second to generate a 1-meter distance and gap between two soccer players [18], which would be sufficient enough for an attacking player to dribble-passed a defender in a soccer match. In addition, on average, a soccer player executes more than 300 times of change of direction movement in a soccer match [19]. Such high-frequency movement would likely benefited by having a footwear that would help them to move faster.

It is also important to address several limitations of this study. First, the results obtained from this study were based on one type and brand of soccer boots and two type of insoles that were commercially available. Therefore, generalizing the results from this study should be carefully considered as manufacturing quality among footwear makers may vary [20], and this could influence the study outcome. In this study, we have purposely chosen a soccer boots with a simple outsole cleat design. Therefore, the role of insoles in the test conducted may be amplified more, as compared to using a soccer boots design with a much complex cleat design that possessed more footwear features such as anti-slip and shockproof construction features. It is also worth-mentioning that in this study, the soccer boots cleat was a round-shape studs. Several studies have shown that different stud shape and cleat design could potentially have influence on lower limb kinematics and kinetics variables, resulting differences in running performance outcome [21, 22]. Therefore, the influence of altering the insoles material and mechanical properties may be less-significant if being used with a soccer boots with different cleat design and constructions. In addition, in this study, there were only two type of insoles that were tested. Therefore, further test using insoles with different specifications in terms of material properties and product dimensions (thickness, mass and density) are warranted. Furthermore, in this study, there were only two type of functional test that have been conducted: 6-meter sprint and slalom-course test. Therefore, different soccer-specific test protocols should also be considered for future study.

## 5. CONCLUSIONS

In this study, it was successfully demonstrated that insoles with different hardness and surface roughness may be able to improve change of direction performance among soccer players. Increasing the insoles surface roughness while reducing its hardness could potentially has contributed to soccer players change of direction performance in this study. The interaction of soft material with higher surface roughness insoles with the foot likely has improved the in-shoe grip and friction property. Possible higher ground reaction force during change of direction as compared to straight-sprint task could partially explained the differences with regards to the influence of insoles properties in both tests.

## ACKNOWLEDGEMENT

This study has been partly funded by Geran Penyelidikan MyRA (GPM), Universiti Teknologi MARA [600-RMC 5/3/GPM (017/2022)]. The authors would also like to thank all the soccer players that have volunteered to participate in this study.

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