



Measurement of Interaction between Futsal Footwear and Futsal Pitch Surface under Different Outsole Condition [†]

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Abstract: The interaction between footwear and the pitch surface is an important aspect for successful performance and injury prevention in futsal. We aimed to investigate shoe-surface interaction of non-marking and multi-studded outsole designs. Five university players were recruited to perform two futsal specific movements (front translational traction-FTT and side translational traction-STT). A motion capture system including an embedded force plate covered by a synthetic material for futsal pitch, were utilized to collect the ground reaction force components. During FTT and STT, the multi-studded outsole was characterized by significantly higher mean peak traction forces. Moreover, although there were no significant differences in peak coefficient of traction between the two types of futsal shoes during STT, the multi-studded outsole tended to produce marginally higher peak coefficient of traction during FTT. It can be concluded that the multi-studded outsole design is prone to generate higher traction force and coefficient of traction.

Keywords: traction; futsal; shoes; outsoles

1. Introduction

In a report back in 2007 [1], it was recorded that there were 270 million people who were actively involved in the game known as football (soccer). That represents 4% of the world's population at that time. From those population, 0.5% (more than 1 million people) were related to 5-a-side indoor soccer known as 'futsal' [1]. Futsal has been considered as a social sport that is played on hard-surface and much smaller pitch size compared to soccer. Futsal is becoming popular all over the world. From the latest estimation (reported in 2015), around 30 million people participate this sport on a competitive basis or as a leisure activity [2]. Futsal's prominence in the sports arena is even more highlighted when FIFA launched its first futsal development program in 2015 [2].

On a different note, futsal does present a higher risk of injury to its players, resulting to six times more injuries compared to soccer [3] where ankle sprain is one of the most common ones [4]. The type of surface played in futsal has been speculated to be as one of the factors related to these alleged injuries [5]. A previous study revealed that the aspects of traction between the shoe outsole and the playing surface are important factors that are related to player's safety and performance, where appropriate traction helps athletes to successfully perform the intended movements without the risk of slipping [6]. However, there has been limited focus on indoor footwear study in the

past [7]. A recent systematic review on futsal literature [8] reported that most futsal related studies focused on coaching, physiological, psychological, tactical and technical aspects, thereby highlighting a lack of biomechanical studies to date.

Despite the very little information in previous reports relating to futsal shoe traction aspect [9], there have been several previous studies which quantified the traction coefficient between the shoe outsole-playing surface in soccer and other sports [10–12]. They reported critical traction coefficient for maximum athletic performance was around 0.82 [12]. One previous study, which compared the shoe-surface traction on few different futsal playing surfaces during cutting task, reported that the translational traction coefficient ranges between 0.17 and 0.22 [9]. A more recent study on indoor dry shoe-floor condition suggested that minimum traction coefficient value around 0.70 is required to create a good grip perception among subjects in a forward and backward ‘sports-like movement’ cutting tasks [13].

We aimed to identify the kinetic properties relating to futsal shoe outsole and the playing surface under different shoe-surface interaction conditions, including the movement’s plane of motion. In the present study, the traction components between non-marking and multi-studded outsole design of futsal shoes when interacting with the futsal pitch during forward and side movement were investigated.

2. Method

2.1. Participants

In this study, five male university level futsal players were recruited (Age 23.5 ± 2 years old, body mass 58.5 ± 6.5 kg, height 165 ± 6 cm). All of these participants are active players in competitive futsal competitions with more than 3 years of experience. The exclusion criteria are: (1) history of fracture in any parts within the lower limb area and (2) lower limb ligament injury. All participants provided their written informed consent prior to the study, in accordance to the research ethical approval obtained from the research ethics committee of the Faculty of Sports Science and Recreation, Universiti Teknologi MARA.

2.2. Instrumentation

AMTI Force Plate system (sampling rate 1000 Hz) embedded within a synthetic futsal pitch and Vicon Nexus Motion System (sampling rate 250 fps) were utilized to collect the kinetic and kinematics data of the specific futsal movements. The experiment set-up is shown in Figure 1. Reflective markers (14 mm in diameter) were attached onto 15 bony anatomical landmarks of the participants’ lower limbs which includes anterior superior iliac spine, sacral, thigh, knee, tibia, calcaneus, ankle and toe.

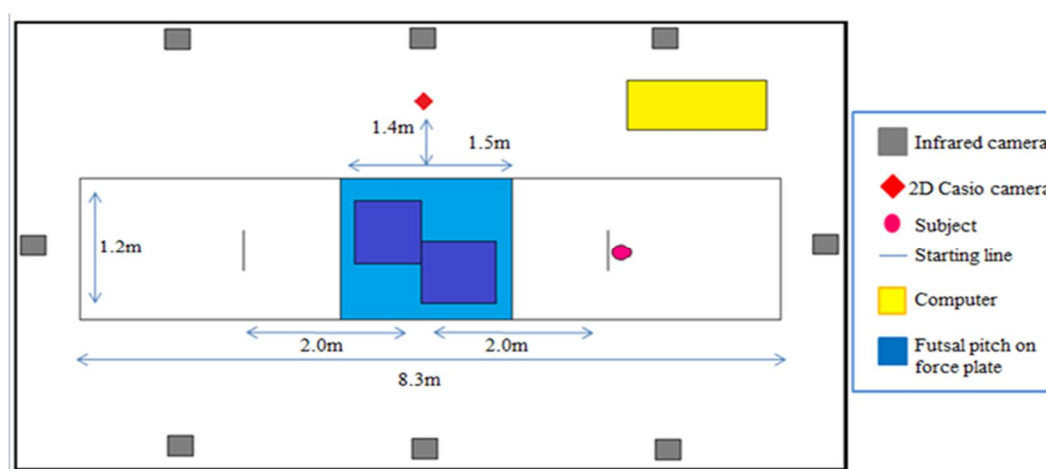


Figure 1. The experiment set-up.

2.3. Procedure

The participants wore two types of futsal shoes with an identical upper design but different outsole designs (multi-studded and non-marking outsole—Figure 2). The multi-studded outsoles have small rubber stud configuration while the non-marking outsoles have low-profile rubber outsole design. All participants were requested to perform two different types of futsal movements (Front Translational Traction (FTT): sagittal plane-translation and Side Translational Traction (STT): anteroposterior plane-translation) while controlling the ball on the platform. These are shown in Figure 3. Approach velocity for all movements were 3.25 ± 1.15 m/s. Only the force data of the participants' support leg were recorded. Each type of shoe was worn in four trials for each movement.



Figure 2. (a) Multi studded outsole-CTL-5TF (Admiral); (b) Non-marking outsole-CTL-5IC (Admiral).

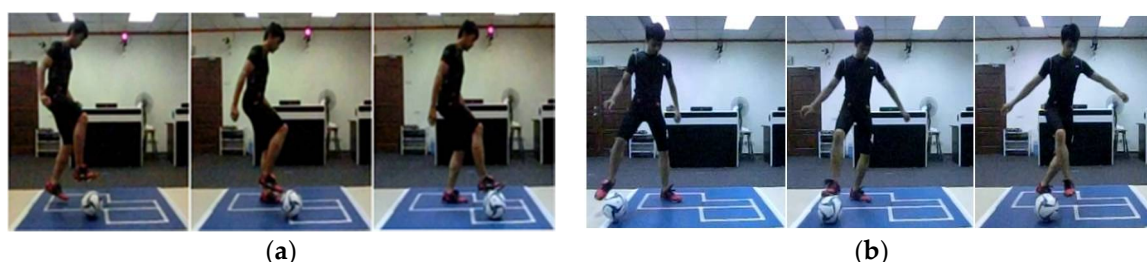


Figure 3. (a) Front Traction Movement (FTT); (b) Side Traction Movement (STT).

2.4. Data Analysis

The amount of force generated in three components (F_x , F_y and F_z) were normalized to the body weight of each participant (BW). The time series force data were analysed from the beginning of the foot strike of the stance leg until prior to the foot off, then the analysed times were normalized to 100%. Coefficient of Traction (COT) was determined from the ratio of vertical to shear forces using the following equation [14]:

$$\text{Coefficient of Traction, } COT = (|F_x| + |F_y|)/F_z \quad (1)$$

Statistical Package for the Social Sciences (SPSS) version 19 was used to statistically analyze the data collected. Data were analyzed using paired-sample t -test at 0.05 significance level to observe the differences between two types of outsole-surface traction conditions.

3. Results

The results obtained from this study are presented in Tables 1 and 2.

Based on the paired t -test analysis shown in Tables, it was found that there are significant differences in peak horizontal forces ($F_{y_{\max}}$) between the two types of futsal shoes in all movements ($p < 0.05$). Also, although there were no significant differences in peak coefficient of traction (COT_{\max}) between the two types of futsal shoes during FTT and STT, the multi-studded outsole tended to produce marginally higher peak coefficient of traction during FTT ($p = 0.82$).

Table 1. Comparison of maximal horizontal force ($F_{y_{max}}$) between multi studded outsole design and non-marking outsole design during front translational traction (FTT) and side translational traction (STT) movement.

	Type of Shoe Outsole	N (Trial)	Mean (SD)	<i>t</i>	<i>df</i>	<i>p</i> Value
FTT	Multi studded	20	0.19 (0.04)	2.79	38.00	0.016 *
	Non-marking	20	0.16 (0.04)			
STT	Multi studded	20	0.23 (0.17)	2.31	38.00	0.032 *
	Non-marking	20	0.17 (0.05)			

* $p < 0.05$.

Table 2. Comparison of maximal coefficients of traction (COT_{max}) between multi studded outsole design and non-marking outsole design during front translational traction (FTT) and side translational traction (STT) movement.

	Type of Shoe Outsole	N (Trial)	Mean (SD)	<i>t</i>	<i>df</i>	<i>p</i> Value
FTT	Multi studded	20	1.26 (1.18)	1.82	23.07	0.082
	Non-marking	20	0.75 (0.39)			
STT	Multi studded	20	2.10 (2.67)	1.61	20.49	0.124
	Non-marking	20	1.12 (0.53)			

4. Discussion

There are two main findings in this study. The first one is the effect of the shoe outsole design on the traction components. The multi-studded outsole design was characterized by significantly higher peak horizontal force ($F_{y_{max}}$) during FTT and STT movements (see Table 1). Also, peak coefficients of traction (COT_{max}) of the multi-studded outsole design during FTT was marginally higher than that of the non-marking outsole design (see Table 2). These results highlighted that outsole design of futsal shoes has a substantial impact on its traction properties. In particular, critical traction coefficients of the multi-studded outsole design (1.26 for FTT; 2.10 for STT) were distinctively higher compared to the values previously reported for athletic performances (around 0.82) [12]. This finding might partially explain a higher risk of injury of futsal compared to soccer [3]. It can be suggested that type of outsole generally used for artificial turf surfaces is inadequate to use on a synthetic futsal pitch. Therefore, the selection of the outsole design, in terms of the matching with the surface property could be more important for futsal players to reduce the risk of injuries.

The second is the effect of the direction of futsal specific movement on the traction components. In both types of outsole design, traction force and coefficient of traction of STT were rather higher than those of FTT. The difference of the traction force was in the range of 6–20% when compared these two types of movements. The coefficient of traction increased in a greater range (49–66%) when these two types of movements were compared. Therefore, the outsole design of the shoes should take into account the direction of movement performed by futsal players because the coefficient of traction may substantially differ when the players steps towards different directions. It was also found that there was no significant difference in COT_{max} values between the two types of futsal shoes ($p > 0.05$) during STT while the multi-studded outsole tended to produce marginally higher peak coefficient of traction during FTT. It can be suggested that the participants somehow maintained similar COT_{max} values by manipulating other ground reaction force components (F_x and F_z) during STT. This result confirmed that some adjustment was performed by futsal players when dealing with higher or lower traction force during different shoe-surface interaction to obtain the desired traction condition. Similar findings were also reported in other previous studies regarding this adjustment behavior [10].

The present study is unique because it dealt with player's movements while controlling a futsal ball. It is still unknown how much the movements with ball and without ball influence the traction components of the support leg (the leg that was not in contact with the ball during movement).

Therefore, all the results in the current study need to be interpreted with caution, especially when comparing player's other off-ball movements.

5. Conclusions

This study concludes that the multi-studded outsole design tends to generate a higher peak traction force (F_y) and higher peak coefficient of traction (COT_{max}) than the non-marking outsole on a synthetic surface, whereby being more prone to injuries cause by foot fixation or non-contact situation. Changes of movement direction also demonstrated an influence on the coefficient of traction component in futsal. Future studies should consider observing the interaction between shoes with outsole that are manufactured with the same material but different patterns of outsole thread design. It should also be paired or rather tested on different types of surfaces that are commonly used for futsal pitch including wood, polypropylene and polyurethane-based flooring.

Additionally, it was also found that similar COT_{max} values maintained while $F_{y_{max}}$ increased significantly during side way motion. Human adaptations to these different shoe–surface interactions may account for it.

Conflicts of Interest: The authors declare no conflict of interest.

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