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The effect of stud configuration on rotational traction using the Studded Boot Apparatus

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ABSTRACT (149 words)

Due its associated injury risk, rotational traction is a frequently measured natural turf surface property. The most commonly used equipment, the studded boot apparatus (SBA), consists of a circular stud configuration that does not replicate the stud pattern on a regular football boot and may under or over estimate the surface traction. The aim of this study was to establish potential differences in the rotational traction measured between the current stud configuration on the SBA and the stud configuration on the most commonly used Australian football boots. The Original studded boot had significantly higher rotational traction than the moulded stud sole or bladed sole. Location, quality and time tested all interacted significantly with the rotational traction measured. The current SBA may not accurately represent the rotational traction experienced by football players, and consequently may not be the most appropriate configuration to assess the relationship between rotational traction and injuries.

Keywords: natural turf, rotational traction, studded boot apparatus, stud configuration

1. INTRODUCTION

Rotational traction refers to the resistance of the shoe during pivoting movements [1] and has been implicated as a contributing factor to injury risk in many sports [2-5]. Consequently, the measurement of rotational traction is an important element of ground condition testing, particularly in sports where changing direction is a key performance component of the game. The validity of any measurement device for sports surfaces is critical for such factors as playability decision making, remediation processes and footwear selection by players. Due to commercial availability, the studded boot apparatus (SBA) [6] is one of the most widely adopted devices for measuring rotational traction. However, the shape of the stud configuration on the SBA does not replicate the stud configuration on the boots currently worn by football players and may in fact over or underestimate the rotational traction properties on football grounds.

The SBA has formed the basis for most devices used to measure rotational traction [7] and the original SBA, or slight variations, are currently used for both natural turf and synthetic turf surfaces across the football codes [8-10]. The SBA (46 ± 2 kg) consists of a base plate with six football studs in a circular configuration, a vertical shaft onto which weights are added, and a handle and torque wrench which is used to quantify the peak rotational traction. Six studs (approximately 14mm long) are located in a radial configuration at 60 degree intervals and 46mm out from the centre of the base plate. A moderate to high relationship has been reported between player perceptions of rotational traction and measurements recorded by the studded boot apparatus [11, 12]. One such study resulted in the recent categorisation of traction values for Australian football fields as unacceptably low (≤20 Newton metres (Nm)), low-normal (21-39 Nm), preferred range (40-54 Nm), high-normal (55-74 Nm) and unacceptably high (≥75 Nm) [12]. However, the relationship between the peak rotational traction experienced by players in conventional football boots and the SBA remains unknown.

Since the initial SBA device, several other rotational traction devices have been developed [1, 13-16] many with prosthetic pivot ankle joints fitted with a variety of footwear to further understand player-surface traction. Consequently, the differences in rotational traction between conventional and other stud configurations have been the focus of much research with the other devices [2, 5, 17]. Greater rotational traction has been associated with fewer and longer studs [18], a full foot stance compared to a toe-stance position [19], a moulded sole compared to the studded sole [13] and large cleats positioned around the edge of the outsole [4]. Lower rotational traction has also been established for boot design with fins (also known as blades or chevrons) compared to the edge design [20]. It has also been reported that wear on the studs or cleats will affect the traction results [20] and a recent study on synthetic turf found the number and placement of the studs on the SBA had an effect on rotational traction [21]. Much of this work has been carried out in the laboratory setting, questioning its ecological validity. In recent times, some work has been undertaken in the natural playing environment and provides a greater understanding of the factors that influence traction such as, orientation of the footwear, angle of penetration of the stud and velocity at impact [16].

Measuring a parameter such as traction is important but, to be useful, testing techniques must reflect the purpose of the test [22]. In Australian football, like many other sports, there are a number of different boot types worn, ranging from a moulded round stud to a screw-in stud. Currently however, the SBA stud configuration does not replicate any of the stud configurations on the boots worn and validity of the stud pattern is unknown. Therefore, the aim of this study was to establish if there was any difference in the peak rotational traction measured between the current six stud circular configuration on the studded boot apparatus and the stud configuration on the most commonly used Australian football boots. In doing so, it also considered the influence of location on the ground, quality of the ground and the period of testing (i.e. test date) on the peak rotational traction.

2. METHOD

At the beginning of the six week testing period, ground quality was subjectively assessed on community level Australian football grounds in Western Victoria and rated as excellent, average or poor based on the ground maintenance regime, percentage grass cover and evenness of the playing surface. Subsequently, six grounds (three in each category) were selected and each was assessed for rotational traction on three separate occasions over a six week period from August – September, 2008. As it took two weeks to assess all six grounds, a ‘period of testing’ refers to the two week testing cycle. The testing schedule was restricted to three grounds per week due to time and daylight limitations, however, each week, one ground from each quality category (excellent, average and poor) was tested.

Three stud configurations on the SBA were tested, including the traditional base plate and two variations. The SBA comprised a 45.4 kg circular weight with six football studs arranged in a circular pattern on the base plate. The device was lifted vertically by two testers and dropped from 60 mm onto the surface. A 60 mm marker was positioned in the ground to ensure consistency of drop height. A torque wrench, inserted into the handle at 90 degrees, was used to record the peak torque in Newton metres (Nm) required to rotate the studs in the ground. The traditional base plate consisted of six screw-in plastic tipped studs of 16mm ± 1 mm in length, to match the stud length for screw-in Australian football studs. The studs were attached in a circular configuration at 60 degree intervals and 46 mm out from the centre of the base plate (Fig 1a).

Variation 1 of the SBA was essentially the same piece of equipment with a different base plate. The studs and stud configuration for Variation 1 were from a commonly used Australian football boot, with traditional shaped moulded studs. There were eight 13 mm circular studs located around the edge of the boot at intervals of 30 mm and two additional studs 17 mm long and 10 mm high in the centre of the sole plate (Fig 1b). Only the forefoot of the Australian football boot was used as this part of the foot is most frequently used for turning and change of direction movements. The forefoot of the football boot was casted and attached to a metal base plate. As the weight of the base plate for Variation 1 differed to the original base plate, additional weight was added to ensure consistency across the variations.

The stud configuration for Variation 2 comprised irregular blade shaped studs which formed a concentric configuration on the base of the boot (Fig 1c). There were three small 5 mm blades at the front of the sole, four larger 12 mm blades and four smaller 10 mm blades in the middle of the forefoot region, and one 5 mm blade on the lateral edge of the end of the forefoot. The same procedure was used (as for Variation 1) to attach the sole of the boot to the base of the SBA.

(a) Original (b) Variation 1 (c) Variation 2

Fig 1: Images of the three stud configurations used.

Nine locations on each ground were selected for testing with the SBA, with the same one metre square locations assessed on every visit to each ground. The nine locations were selected as they represent the major positions and playing areas within Australian football (Fig 2), and also corresponded to the locations considered in previous studies of ground assessment [23]. Four peak rotational traction measures from each of the three stud variations were recorded at each of the nine locations on each ground, giving a total of 648 readings for each stud variation (4 repeated measures x 9 locations x 6 grounds x 3 occasions).

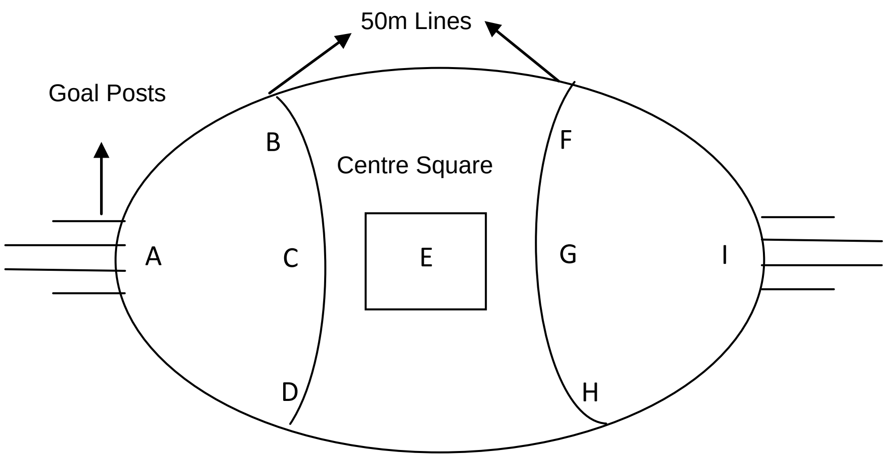


Fig 2: Distribution of sampling locations across the football oval.

All data were double entered and edited using Microsoft Excel and transferred to PASW (Version 18) for analyses. Descriptive and tabular frequencies were calculated across the three stud configurations and across the nine locations, three qualities of ground and three periods of testing. A General Linear Model was used to analyse differences in the three stud configuration mean measures across sub-groups of interest (sites, quality and period) and their interactions. Post-hoc pairwise comparisons were undertaken within the model to determine specific differences across levels of each significant factor. A p-value of less than 0.05 was considered significant.

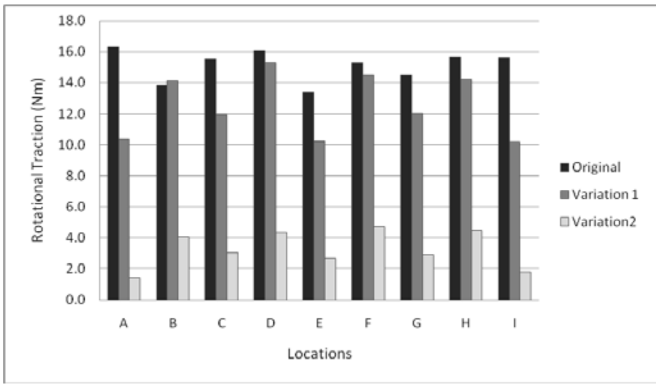
3. RESULTS

A comparison of the mean rotational traction measurement (i.e. all drops at all locations on all grounds) for each type of the studded boot configuration indicated significance, ($F_{2, 1944}$ = 1859.3, p<0.01). The Original studded boot had a significantly higher mean value (mean = 15.1 Nm), 95%CI 14.9 - 15.4) than both Variation 1 (mean = 12.6 Nm, 95%CI 12.3 - 12.8) and Variation 2 (mean = 3.3 Nm, 95%CI 3.0 - 3.6). The mean differences and 95%CIs between the three variations are provided in Table 1.

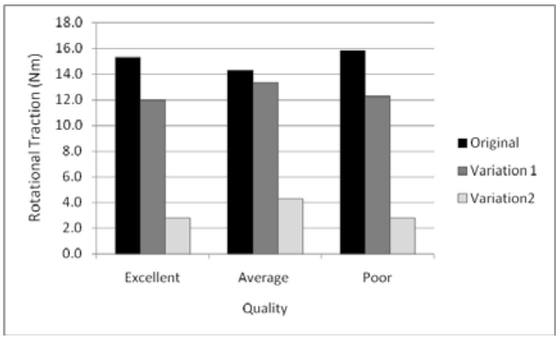
Table 1: Mean differences for the three stud configurations with 95% CI and significance level.

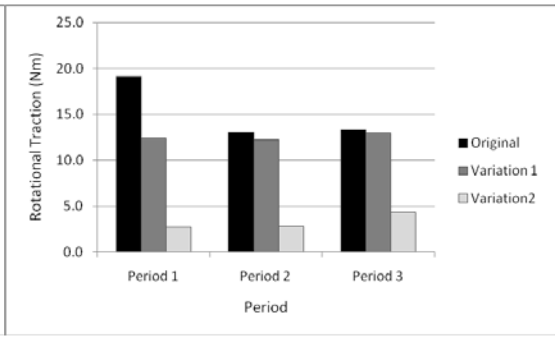
(A) Type	(B) Type	Mean Difference(Nm) (A-B)	95% CI for Difference(Nm) Lower Bound	Upper Bound	p value
Original	Variation 1	2.6	2.2	3.0	<0.001
	Variation 2	11.9	11.5	12.3	<0.001
Variation 1	Original	-2.6	-2.9	-2.2	<0.001
	Variation 2	9.3	8.9	9.7	<0.001
Variation 2	Original	-11.9	-12.3	-11.5	<0.001
	Variation 1	-9.3	-9.7	-8.9	<0.001

With respect to locations on the ground, the Original stud configuration produced the highest rotational traction followed by Variation 1, with the exception of location B where Variation 1 (mean = 14.1 Nm, 95%CI 13.3 – 15.0) was slightly higher than the Original (mean = 13.8 Nm, 95%CI 13.0 – 14.7) (Fig 3a). There was a significant difference between the three types ($F_{16, 1944}$ =7.2, p<0.01) across the nine locations. However when examined for each location, there was a significant difference between Variation 3 and the other two for all nine locations (p<0.01) and only for locations A, C, E, G, and I (i.e., all locations along the centre corridor) between the Original stud configuration and Variation 2.



(a)





(b) (c)

Fig 3: Mean rotational traction for the three stud configurations across (a) nine ground locations, (b) three qualities of grounds and (c) the three periods of testing.

On examining the quality of ground (excellent, average or poor), there was a significant difference between the mean rotational traction values across the three ground qualities ($F_{2, 1944} =$ 4.4, p = 0.01). A significant interaction was found between type of stud configuration and quality of ground ($F_{4, 1944}$ = 12.6, p<0.01) with the highest mean values for both Variation 1 (mean = 13.4 Nm, 95%CI 12.8 – 13.8) and Variation 2 (mean = 4.3 Nm, 95%CI 3.8 – 4.7) on the average grounds and the highest mean for the Original studded boot on the poor grounds (mean = 15.8 Nm, 95%CI 15.3 – 16.3) (Fig 3b).

A comparison of the means for each period, i.e. the set of tests for the two weeks, resulted in a significant difference between all periods ($F_{2, 1944}$ = 50.6, p<0.01). There was also a significant interaction between type of stud configuration and period of testing ($F_{4, 1944}$ = 76.4 p<0.01) and this significance remained after being adjusted for quality of ground ($F_{8, 1944}$ = 11.6 p<0.01). The mean for the Original studded boot for period 1 was 19.1 Nm (95% CI 18.6 – 19.6), and decreased considerably for the next two periods, with results of 13.0 Nm (95% CI 12.5 – 13.5) and 13.3 Nm (95% CI 12.8 – 13.6). The mean for Variation 1 was more consistent over all three periods, with results of 12.4 Nm (95% CI 11.94 – 12.93), 12.3 Nm

(95% CI 11.78 – 12.76) and 12.9 Nm (95% CI 12.46 – 11.44) respectively. The mean for Variation 2 was consistent for both periods 1 and 2 with mean results of 2.7 Nm (95% CI 2.21 – 3.19) and 2.8 Nm (95% CI 2.3 – 3.4), but increased for period 3 with a mean of 4.3 Nm (95% CI 3.8 – 4.8) (Fig 3c).

4. DISCUSSION

High rotational traction between football boots and playing surfaces is a frequently cited factor influencing injury to the lower extremity across all football codes [2, 4, 5, 17, 24].This study used the SBA to determine whether the rotational traction at the shoe-surface interface differed between the traditional SBA base plate and two currently available, popular studded Australian football boots. Overall, the results indicated that the rotational traction varied significantly between the three stud configurations and moreover that the Original SBA produced significantly higher rotational traction. These results have implications for the use of the original SBA in determining the playability of surfaces and using SBA data to establish injury risk.

Previous research has postulated that longer studs, that screw in, increase rotational traction [25]. Our study supports this suggestion, as compared to the Original SBA, Variations 1 and 2 had shorter studs and a significantly decreased level of rotational traction. The base plate for Variation 1 however, had similar shaped studs to the Original SBA which may in part explain the smaller difference in mean rotational traction between the Original SBA and Variation 1, compared to Variation 2. Not surprisingly, Variation 2 had the lowest average rotational traction which supports the intended design of the footwear, i.e., to facilitate ease on turning. The differences in rotational traction between each type of studded boot pattern tested indicates that the length of the stud, the pattern and the attachment technique all influence rotational traction achievable. Accordingly, when testing rotational traction in sporting contexts it is important that the stud pattern and configuration on the SBA replicates the boots that the players are wearing.

Although rotational traction results varied between the different locations on the ground, the significant difference in the magnitude of the rotational traction remained. Variation 3 (the bladed sole) was lower than the other two stud configurations across all nine locations but interestingly the Original SBA and the moulded studs were only significantly different along the centre corridor of the ground. As a hallmark of the increased level of play in that section of the grounds, the central corridor was worn and contained bare patches of ground and therefore may provide an explanation for the differences recorded. This finding is similar to other studies that have compared both grass and bare surfaces and found significant differences in rotational traction with increases in the amount of bare ground [1]. The botanical composition was not included in this study as the focus was on differences between the stud configurations and all testing was undertaken with the same botanical conditions at each site. However, further studies should investigate the botanical composition of the ground at specific test sites to enable a more accurate assessment of the relationship between field position and levels of rotational traction.

In this study, ground quality also impacted on levels of rotational traction. A significant difference was observed both when ground quality was considered independently of stud configuration and, when stud configuration was considered. Within this study however, no objective measure of establishing ground quality was used, and therefore assessment of ground quality may have been limited by subjective ratings. Whilst little research has been published on the accuracy of subjective ground ratings, studies that have used subjective assessment in other sporting contexts have highlighted that such a measure can only provide a broad impression of the state of the grounds [26]. In future studies it may be more meaningful to categorise grounds according to grass type and/or soil composition rather than the subjective quality.

The significant difference in the rotational traction at the shoe-surface interface over the three testing periods, suggests that rotational traction may be influenced by external weather conditions, such as rainfall and evaporation, grass growth and drainage. In this study, rainfall was measured the day prior to testing and was slightly higher before the first period of testing. It is therefore likely, that this increased rainfall influenced rotational traction between the Original SBA and the two variations. The lengths of the studs on the Original studded boot were longer, and screwed into the base plate in a circular pattern. In wet conditions stud length and attachment may result in the higher rotational traction readings, compared to the shorter and moulded studs (Variations 1 and 2) which in wet conditions had reduced rotational traction. Previous research supports this notion, indicating that stud length and position affects rotational traction [4, 18, 21]. In light of previous research, the angle of penetration or the contact between the base plate/sole surface may also have influenced the peak traction readings [16]. It is acknowledged that there were material and design differences between the base plates/soles of the three variations studied but these differences represent the footwear currently worn by players.

A limitation of the current study was that the period of testing was only six weeks in duration, and rainfall data was only considered for the day before testing. In future, it is recommended that the period of testing encompass the entire football season, and rainfall data be collected for the length of the season. In addition to rainfall data, soil moisture content and temperature readings, grass growth and botanic information should be obtained to determine the possible effects of these variables on measures of rotational traction. Furthermore, other limitations with the SBA, such as manual operation, application and angle of force and lack of time history data need to be addressed to improve the validity and reliability of this commonly used device.

5. Conclusion

Over the last decade, there has been increased attention around the link between ground conditions and injury risk, particularly with traction. This study however, is one of very few to measure rotational traction utilising a surface on the SBA that actually replicates popular football boot design. Overall, rotational traction varied between the stud configuration on the most commonly used Australian football boots and the Original six stud circular configuration on the SBA. This suggests that the current SBA may not give an accurate representation of the rotational traction experienced by football players, and consequently may not be the most appropriate configuration to assess the relationship between rotational traction and injuries. In this study, rotational traction measurements were also influenced by external factors including weather conditions, grass growth, ground quality and location on the ground. Further studies using a larger number of grounds with testing across the entire football season are required to confirm or refute the current findings. Future studies should also explore tractional characteristics of the shoe-surface interface across different sports that use dissimilar stud patterns, and continue to explore rotational traction in football as manufacturers continue to update and/or modify cleat designs.

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