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MEDIO-LATERAL AND LATERAL EDGE FRICTION IN INDOOR SPORTS SHOES

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INTRODUCTION

It has previously been speculated that the occurrence and severity of lateral ankle sprain injuries is linked to excessive shoe-surface friction [1], [2]. Especially the lateral parts of the shoe outsole are suggested to play an important external role in this scenario, but have never been quantified in a systematic manner. Therefore, the purpose of this study was to investigate the variation of friction of indoor sport shoes with foot orientation and compare it to the traditional forefoot traction test.

METHODS

Twelve of the most popular indoor shoe models of the season 2017-18 were used for the mechanical friction tests. The test setup consisted of a steel frame that was bolted to the floor above a force plate-equipped mechanical hydraulic platform. All tests were conducted against a standard vinyl indoor sports floor (7.5 mm Taraflex – Evolution, Gerflor, FRA). Vertical and horizontal ground reaction forces were recorded using an AMTI force plate (Watertown MA, USA) which movements were captured via a single retro-reflective marker using eight infrared cameras (Qualisys AB, Gothenburg, Sweden). We conducted and modified ISO:13287:2019 [3] test for footwear slip resistance by positioning the shoe on its forefoot (7° pitch), lateral forefoot (7° pitch, 90° rotation) and lateral edge (15° pitch, 30° roll, 90° rotation) (Fig. 1). The latter two were supposed to replicate medio-lateral movements similar to previously reported ankle sprain incidents [4].

Tests were conducted with a constant normal force of 500N, translation distance of 120 mm and a sliding velocity of 0.3 m/s. Shoes were mounted to a last and fixed with their shoes laces. The friction coefficient for each shoe and test condition was then calculated for the time of horizontal plate movement via the horizontal and vertical reaction forces. The available dynamic friction coefficient (ACOF) was ultimately calculated as an average over the plateau following the peak in static friction, as per ISO: 13287:2019. A total of five repetitions was performed for each shoe and testing condition. For statistics, a two-way ANOVA was performed to analyze the effect of test type and shoe model on ACOF. Tukey's HSD post-hoc test was used to investigate differences between test setups and between shoe models. Additionally, a linear regression analysis was performed to test for correlations between testing conditions.

Fig. 1 Test setups, from left to right: anterior-posterior, medio-lateral, lateral edge. The arrow indicates the movement direction of the surface (hydraulic force plate).

RESULTS AND DISCUSSION

Simple main effects analysis showed that test type ($p<0.001$) and shoe model ($p<0.001$) both did have a statistically significant effect on ACOF. In general, we found that medio-lateral ACOF on average was 14% lower, and lateral edge friction 22% lower than anterior-posterior ACOF (Table 1). The test results demonstrate a large variability in ACOF between shoes and tests.

The linear regression analysis revealed that the ACOF of anterior-posterior significantly predicted medio-lateral and lateral edge ACOF ($y=0.55x+0.35$, $p=0.0008$ and $y=0.59x+0.21$, $p=0.002$). Here anterior-posterior accounted for 70% of the variation in medio-lateral ($R^2 = 0.7$, $p=0.0008$), and 63% of the variation in lateral edge ($R2 = 0.63$, $p=0.002$). However, these correlation coefficients are not strong, hence existing recommendations for anterior-posterior friction values can hardly be transferred to lateral movements.

In summary, this implies that if one wishes to accurately assess traction for other directions or areas, one should perform such specific tests accordingly.

Table 1 Mean ACOF by test setups. Significant difference compared to anterior-posterior (*) and to medio-lateral (~).

	Anterior-Posterior	Medio-Lateral	Lateral Edge
ACOF	1.18	1.00*	0.91*/~
	± 0.21	± 0.14	± 0.16

CONCLUSIONS

This study showed that there is a significant difference in friction coefficient between a traditional forefoot test, the medio-lateral forefoot test and the modified lateral edge test. We suggest that if specific footwear friction properties need to be assessed accurately, then motion specific tests should be conducted. Future research needs to investigate if friction properties of different shoe outsole areas have clinical implications for injury prevention.

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