USING BIOMECHANICS AND ENGINEERING TOOLS IN THE DESIGN OF FOOTBALL SHOE OUTSOLES

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INTRODUCTION

Atheletes require adequate traction between their shoe and surface to perform their desired movements. Traction force and moments during certain movements must also be limited to control the risk of injury [1]. Traction requirements can be defined to a certain extent from kinetic measurements for example, [2]. However, determining the appropriate materials and configurations of shoe outsoles which provide the desired traction is complex and requires holistic knowledge of biomechanical factors, such as movement patterns and loading scenarios, together with an understanding of the outsole-ground interactions which give rise to tractive forces and moments. This paper outlines biomechanical and engineering techniques which can be used to better understand traction and thus implement meaningful modifications to shoe outsole configurations with a focus on football (soccer).

METHODS

This paper highlights 3 subject areas relevant to the holistic understanding of football shoe-surface traction: a) loading conditions during football movements; b) influence of stud (cleat) shape; and c) influence of stud configuration using soil mechanics theory.

a) Loading conditions. Kinetic (ground reaction force data) and kinematic parameters (shoe-ground orientation and stud velocity vectors) were established for youth-team players of a Premiership football club. Drills of football specific movements were incorporated into regular training sessions with the aim of capturing movements close to those performed during a game.

b) Influence of stud shape and configuration. Eighty studs of systematically varying geometry were manufactured and mechanically traction tested. Artificial Neural Networks (ANNs) were used to model the experimental data and provide functions of traction based on the stud geometrical parameters.

c) Soil mechanics theory and models applied in civil engineering [3] were adopted and modified to better understand how the outsole-surface interaction gives rise to traction forces. The influence of stud spacing on traction force could be predicted by the models and analysing the predicted stress field around the studs.

RESULTS AND DISCUSSION

a) Analysis of ground reaction force data from the subjects together with mechanical traction test data showed the timings within movements when the players were most at risk of slipping. The kinetic and kinematic parameters at these phases were useful for the following applications: to define the alignment of the stud to enhance penetration into the surface, hence greater traction (Figure 1); and to better recreate the loading conditions used in traction test devices and analytical models.

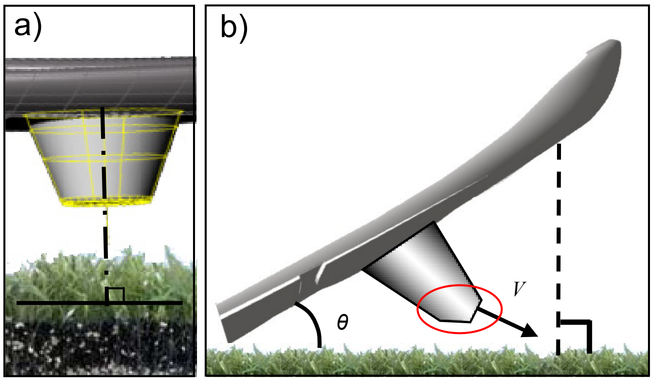

Figure 1: Alignment of studs in order to achieve efficient penetration into the surface. a) Studs aligned assuming sole is normal to surface. b) Modified alignment for oblique impact experienced in reality.

b) Experimental traction forces for studs of differing geometry showed that the traction force varied in a non-linear manner with some geometrical parameters. ANNs were able to account for this non-linearity and were used to develop traction functions based on stud geometry. The trained ANNs were used as empirical models capable of predicting the traction force on prototype geometries.

c) The analytical models modified for football shoe traction showed that the traction force was dependent on stud spacing due to the interaction of stress fields for spacings below a critical separation. Experimental traction results supported these predictions. The analytical models were highly sensitive to the applied loading conditions including the normal force which dictated the mode of soil failure. This supports previous observations [4] that experimental traction tests must closely represent the loading scenario of the movement. Therefore, traction test devices used to assess the traction prototype outsoles should adhere to the loading conditions determined from the biomechanical observations.

CONCLUSIONS

Achieving desired traction properties of sports shoes requires biomechanical and engineering insight. Interdependence of several factors in the sub-studies presented illustrates the need for the holistic use of these disciplines in the design of novel outsoles.

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