The Foot 24 (2014) 107–110

Contents lists available at ScienceDirect

The Foot

journal homepage: www.elsevier.com/locate/foot

# Rotational and peak torque stiffness of rugby shoes

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ARTICLE INFO

*Article history:*
Received 19 January 2014
Received in revised form 25 June 2014
Accepted 27 June 2014

*Keywords:*
Rugby
Shoes
Torque
Rotational
Stiffness

ABSTRACT

*Objective:* Sports people always strive to avoid injury. Sports shoe designs in many sports have been shown to affect traction and injury rates. The aim of this study is to demonstrate the differing stiffness and torque in rugby boots that are designed for the same effect.
*Methods:* Five different types of rugby shoes commonly worn by scrum forwards were laboratory tested for rotational stiffness and peak torque on a natural playing surface generating force patterns that would be consistent with a rugby scrum.
*Results:* The overall internal rotation peak torque was $57.75 \pm 6.26$ N m while that of external rotation was $56.55 \pm 4.36$ N m. The Peak internal and external rotational stiffness were $0.696 \pm 0.1$ and $0.708 \pm 0.06$ N m/deg respectively. Our results, when compared to rotational stiffness and peak torques of football shoes published in the literature, show that shoes worn by rugby players exert higher rotational and peak torque stiffness compared to football shoes when tested on the same natural surfaces. There was significant difference between the tested rugby shoes brands.
*Conclusion:* In our opinion, to maximize potential performance and lower the potential of non-contact injury, care should be taken in choosing boots with stiffness appropriate to the players main playing role.



## 1. Introduction

Rugby is a high impact sport but it is relatively unique due to the differing roles, and thereby different forces are encountered by players in different positions. Preatoni et al. [1] demonstrated that during scrimmaging these forces where mainly head on and lateral compression forces. However rucking and mauling are inherent parts of the forwards' game which will generate higher rotational forces. It has previously been demonstrated that there are significant differences in rotational stiffness in different football boot design [2–6]. The effect of this is that differing designs of football boots have been shown to be associated with higher rates of anterior cruciate ligament injury [7].

The aim of this study is to measure the peak torque and rotational stiffness of different designs of rugby boots as this may be significant in choosing the correct boot for players in different positions.

## 2. Materials and methods

This is a laboratory-based biomechanical study. Five different types of rugby shoes typically worn by scrum players were selected and used in the study. These shoes were all cleated with 8 screw-in metal studs designed for soft ground.

### 2.1. Shoes design

The five shoes were:

- Adidas AdiPure Regulate (A).
- Canterbury Stampade Club 8 stud (C).
- KooGa EVX II LCST Boot (K).
- Mizuno Fortuna SI Rugby (M).
- Puma Esito Finale H8 (P).

Each shoe had eight metal studs on the shoe with the layout of the studs being similar in all shoes with six studs on the forefoot and two on the heel part of the sole (Fig. 1). The characteristics of the shoes are summarized in Table 1.

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http://dx.doi.org/10.1016/j.foot.2014.06.006


**Fig. 1.** Rugby shoes models.

**Table 1**
Characteristics of the different rugby shoes.

| Shoe model | Upper | Outsole | Studs number and type | Studs dimensions |
|---|---|---|---|---|
| Adidas AdiPure Regulate (A) | Synthetic leather | Thermoplastic polyurethane | 8 screw-in metal | Length: 15 mm<br>Tip diameter: 10 mm |
| Canterbury Stampade Club 8 stud (C) | Soft synthetic | Nylon | 8 screw-in metal | Length: 18 mm<br>Tip diameter: 6 mm |
| KooGa EVX II LCST Boot (K) | Evapourex fabric | Venom/nylon | 8 screw-in metal | Length: 16 mm<br>Tip diameter: 6 mm |
| Mizuno Fortuna SI Rugby (M) | Soft synthetic | Thermoplastic polyurethane | 8 screw-in metal | Length: 16 mm<br>Tip diameter: 8 mm |
| Puma Esito Finale H8 (P) | Synthetic leather | Lightweight polyurethane | 8 screw-in metal | Length: 15 mm<br>Tip diameter: 6 mm. |

### *2.2. Surfaces description*

A natural grass (Paradello Vivai, Italy, Brescia) made of a mixture of *Lolium perenne* and *Poa pratensis* cultivated on a layer of sand and soil (4 cm thickness), was provided in form of turfs (60 cm × 40 cm; mass: 19.23 ± 0.89 kg). In order to investigate the possible variability of composition and water content of each turf, prior to testing, each turf was weighted verifying that the weights were comparable among the different turfs. The mean weight was 17.7 kg with a standard deviation of 1.6 kg, thus confirming that the surfaces were not a confounding variable.

The turf was housed within a wooden box. In order not to allow any rotation of the turf within the box during the tests, two wooden plates were pressed on the turf and constrained to the inferior part of the box using grips.

### *2.3. Artificial foot*

An artificial left foot (EU size 42–43) was prepared filling a silicon foot cosmetic cover (Road runner foot Engineering, Milano, Italy) with a silicone rubber in which an angled metallic core structure was immersed (Fig. 2). The internal structure is composed by an iron pin with rectangular section rigidly bound throughout screwed connections to two angled plates. The distal part of the iron pin (11 cm in length), which was only partially inserted into the foot, was used as the interface element for gripping to the loading machine.

### *2.4. Testing machine*

Tests were performed on a MTS 858 Bionix servohydraulic testing machine (S/N 1015457, MTS, Minneapolis, MN) installed in the Laboratory of Biological Structure Mechanics of the Politecnico di Milano. The MTS testing machine was equipped by an axial–torsional hydraulic actuator, with 25 kN axial capacity and 250 Nm torsional capacity, a ±100 mm range LVDT displacement transducer and a ±140° range ADT angular transducer mounted on the actuator. The loads applied were measured by means of a MTS axial/torsional load cell (model 662.20D-05, S/N 1007099, ±25 kN maximum axial load, ±250 Nm maximum torsional load). The tests were conducted in air at room temperature (24 ± 2 °C).

### *2.5. Test procedure*

Prior to testing the wooden base housing different turfs was secured to the inferior grip of the MTS through a T bar located at the inferior side of the panel. The shoe was dressed on the synthetic foot, then it was assured to the superior grip of the MTS through the pin (Fig. 3).

Tests were performed applying a quasi-static preload vertical force of 1000 N on the foot using the MTS testing machine, than the test was carried out under angular control at a rotation speed of 45°/s, until a maximum angular rotation of 140° was reached.

**Fig. 2.** Artificial foot used in rotational tests.