Identifying representative test parameters to assess skin laceration injury risk for individual studs

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Identifying representative test parameters to assess skin laceration injury risk for individual studs

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Introduction

Skin injuries account for ~6% of all injuries in rugby union. Skin lacerations resulting from stud-skin interactions in rugby union are frequently caused by stamping in the ruck (Oudshoorn et al. 2016). Stud design is regulated by World Rugby's Regulation 12, but no supporting evidence currently exists for the selected test parameters used in these standards. Ideally, mechanical tests that assess injury risk should replicate conditions observed during play (Ura and Carré, 2016). Relevant mechanical test parameters, such as foot inbound velocity, stud impact energy, inclination angle and effective mass, can be derived through biomechanical analysis of rugby stamping. However, due to human movement variability, the measured kinetics and kinematics of stamping impacts can have a large range and replicating all possible parameters within a mechanical test device is unfeasible. Identifying different stamp techniques by clustering provides an economical solution.

Purpose of the study

The purpose of this study was to identify representative impact values from rugby stamps for use in future mechanical tests.

Methods

Eight participants (mean ± standard deviation: age: 27.1 ± 4.4 years; stature: 174.1 ± 5.1 cm; mass: 76.2 ± 8.2 kg) were recruited; all procedures were approved by the Ethics committee of Sheffield Hallam University. During a rucking scenario, participants were asked to perform ten stamps on an anthropomorphic test device (Hybrid III 50th percentile male), used as a surrogate player. Two high-speed cameras (Phantom Miro Lab 320) recorded the three-dimensional position of three shoe markers, used to determine shoe kinematics. Stud inclination angle was calculated using a modified approach to that of Driscoll et al. (2015). Two pressure sensors (Tekscan, F-scan, 3000E 'Sport') recorded stamp pressure, from which force was derived. Effective mass (m_e, each stud) was calculated using equation (1), adapted from Neto et al. (2012);

$$m_e = \frac{\int_{t1}^{t2} F dt}{\Delta v} \qquad (1)$$

With Fdt being stud force over time, t_1 time at first impact, t_2 time at which foot velocity is ~0, and Δv the velocity difference between t_0 and t_1. The mean and standard deviation of stud energy, inbound velocity magnitude, inbound velocity angle, stud angle and stud mass of each participant were calculated. Inter-participant parameters were clustered using impact energy (respective means) and test parameters for each cluster were calculated.

Results

Four impact clusters were identified (Table 1): 6 J (cluster A), 9 J (cluster B), 11 J (cluster C) and 12 J (cluster D). Clusters C and D have similar stud energies; however, impact energy of cluster C was associated with a lower inbound velocity (3.7 m/s) and higher effective stud mass (1.7 kg). Cluster D exhibited high inbound velocity (5.4 m/s) combined with low stud effective mass (0.9 kg).

Table 1: Stud impact kinetics and kinematics during rugby stamps (mean ± standard deviation).

Participant Cluster	Stud Energy (J)	Stud Mass (kg)	Inbound velocity (m/s)	Inbound velocity angle (°)	Stud angle (°)
1	6.0 ± 1.9	1.4 ± 0.4	2.9 ± 0.6	33.6 ± 12.2	-4.3 ± 5.1
2	6.1 ± 3.0	1.5 ± 0.7	2.8 ± 0.4	25.2 ± 13.6	17.8 ± 4.7
cluster A	6.0	1.5	2.9	29.4	6.7
3	8.2 ± 1.5	0.7 ± 0.2	4.9 ± 0.6	59.9 ± 6.5	27.4 ± 5.5
4	9.1 ± 1.9	0.8 ± 0.2	4.8 ± 0.5	36.4 ± 4.3	8.3 ± 4.7
cluster B	8.7	0.8	4.8	48.2	17.9
5	11.0 ± 4.2	1.8 ± 0.5	3.5 ± 0.6	51.4 ± 12.3	-4.2 ± 3.9
6	11.0 ± 4.3	1.6 ± 0.6	3.9 ± 1.0	37.5 ± 9.2	25.5 ± 6.5
cluster C	11.0	1.7	3.7	44.5	10.6
7	12.0 ± 3.3	0.9 ± 0.4	5.3 ± 0.9	46.6 ± 7.6	1.5 ± 8.0
8	12.0 ± 2.4	0.9 ± 0.2	5.4 ± 0.6	61.7 ± 5.1	3.4 ± 8.5
cluster D	12.0	0.9	5.4	54.2	2.4

Discussion and conclusion

Large variations in impact parameters, such as stud mass and inbound velocity, were observed during rugby stamping impacts. Clustering participants based on stud energy showed four generic movement solutions were used during stamping, ranging from 6 - 12 J. The identified clusters provide a combination of test parameters that can be used in a mechanical test to assess laceration injury risk of studs. Using clusters of impact parameters provides an economical means to determine the laceration injury risk of a stud, whilst maintaining fidelity to the conditions observed during play.

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