Upper and Lower Body Tackles in Rugby Union: the Effect on Head Kinematics

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I. INTRODUCTION

Tackling is an integral part of Rugby Union, but can sometimes lead to concussion injuries. Concussion has been defined as "a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces" [1] and the incidence in Rugby Union is high (8.9/1,000 player hours) [2]. It is well known that the tackle phase of play is the most regular cause of concussion within the game [3-4 (in review)]. A recent kinematic analysis [4] shows that the tackle can be split into two main types: Upper Body Tackle and Lower Body Tackle. An Upper Body Tackle (UBT) is defined by the Tackler's intended primary contact being above the Ball Carrier's hip. A Lower Body Tackle (LBT) is defined by the Tackler's intended primary contact being at or below the Ball Carrier's hip [4]. With some players making over 30 tackles per game [5], there is still little knowledge of the specific motion patterns of the head during a tackle. In particular, repeated significant head motion in the absence of a direct head impact may, over time, be associated with symptoms of concussion [6]. Therefore, the aim of this study is to examine the differences in head kinematics between typical Upper and Lower Body Tackles in Rugby Union using multibody simulations.

II. METHODS

Video analysis, using freely available video, was conducted on 40 tackles (20 UBT and 20 LBT) from two Rugby World Cup 2015 games where no direct impact to the head occurred. The Ball Carrier and Tackler stances and orientations were estimated two-dimensionally by creating multibody model representations of the players at the time of impact (Fig. 1). This allowed the Ball Carrier and Tackler torso angles with the horizontal and the players' overall orientations and stances to be examined at the time of impact.

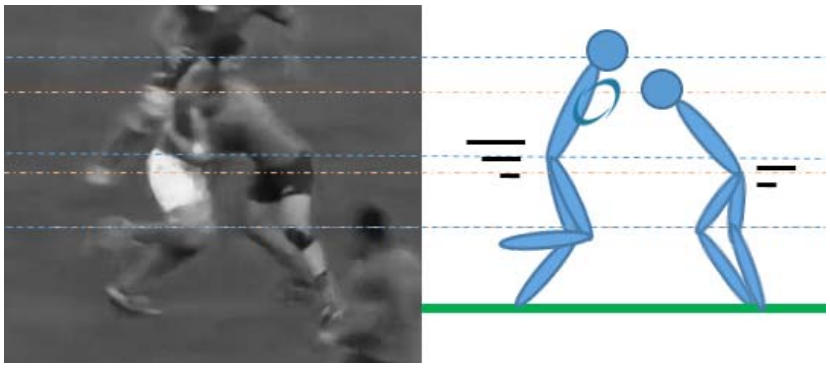

Fig. 1. Two-dimensional tackle configuration for an Upper Body Tackle.

Using the average Ball Carrier and Tackler torso angles at the time of impact, as well as recommended tackling techniques to prevent a direct head impact [4] (i.e. head placed to the side of and not in the trajectory of the Ball Carrier, and Tackler on the balls of his feet), representative multibody simulations of an Upper and Lower Body front-on Tackle, where no direct impact to the head occurred, were developed using the MADYMO pedestrian model (Fig. 2). The player mass and height were scaled based on average elite player height and mass [7], and the initial velocities were based on the average elite player speeds recorded at 0.1 s prior to the time of impact [8]. Both the UBT and LBT multibody simulations were run with two scenarios – once with all joints locked (except for head and neck joint), and once with all joints unlocked – to provide estimated upper and lower bound head kinematics in actual tackles. The simulations were run for 30 ms, to include the upper bound of impact duration for a rugby impact in which the head experiences >10 g of resultant linear acceleration [9]. Head angular velocity and linear and angular acceleration were assessed for the different conditions.

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(a) (b)

Fig. 2. The multibody player-to-player configuration for an (a) Upper Body Tackle and (b) Lower Body Tackle.

III. INITIAL FINDINGS

The average torso angles of the Ball Carrier and the Tackler for UBT and LBT are shown in Table I. The peak resultant linear and angular head kinematics are shown in Table II.

TABLE I
THE AVERAGE TORSO ANGLE OF THE BALL CARRIER AND TACKLER FOR UBT AND LBT

	Average Torso Angle	
	Ball Carrier	**Tackler**
UBT	60	50
LBT	50	20

TABLE II
PEAK HEAD ANGULAR KINEMATICS FOR BALL CARRIER AND TACKLER IN UBT AND LBT.
LOCKED CONDITION RESULTS ARE PRESENTED WITH UNLOCKED CONDITION RESULTS IN BRACKETS

	Ball Carrier		Tackler	
	UBT	**LBT**	**UBT**	**LBT**
Peak Angular Velocity (rad/s)	22 (17)	10 (5)	19 (15)	17 (17)
Peak Linear Acceleration (g)	94 (67)	21 (8)	96 (77)	37 (33)
Peak Angular Acceleration (rad/s²)	2783 (1898)	848 (580)	2417 (1759)	1929 (1776)

IV. DISCUSSION

Table II shows that the resultant kinematics of the Tackler's and the Ball Carrier's heads are substantially greater as a result of UBT for both locked and unlocked conditions, even though there is no direct head contact. For example, the resultant kinematics of the head for the Ball Carrier increased by a factor of 2.2, 4.5 and 3.3 for peak angular velocity, linear acceleration and angular acceleration, respectively, for the locked condition. Similar results are shown for the unlocked case. The values reported are broadly within the reported range of non-concussive impacts in rugby [10]. These preliminary results indicate that UBT should be the focus of further assessment in relation to possible repeated sub-concussive loading of the head.

V. REFERENCES

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