KICK IMPACT CHARACTERISTICS FOR DIFFERENT RUGBY LEAGUE KICKS

Kevin Ball

School of Sport and Exercise Science, Victoria University, Melbourne, Australia

Kicking is becoming increasingly important in rugby league and one of the most important aspects of kicking is the nature of impact. This study examined impact characteristics for five rugby league kicks – the goalshot, the punt kick, the dropkick, the grubber and the 'bomb'. Seven elite players performed these kicks while being videoed (6000Hz). Digitised data of nine points (five on the kick leg, four on the ball) were used to quantify parameters near and during impact. Rugby league kicks produced a smaller time in contact and a larger amount of work compared to kicks in other sports. Differences also existed between the five types of rugby league kick tested in terms of ball to foot ratio and foot and ball positioning at impact. These differences between kicks within the same sport highlight the need to evaluate different kick types separately within a sport.

KEYWORDS: Ball to foot**,** Drop kick, Goalshot,

INTRODUCTION: Kicking has become increasingly important in rugby league. Where once the kick was used to get out of defense and attacking kicks were predominantly 'bombs' (a high trajectory into the attacking scoring zone that gave attacking players time to get under it) recent years has seen the emergence of more precise kicks to wide receivers across the ground. The kicking game of National Rugby League team the Melbourne Storm is considered to be a key reason for their success in gaining four grand finals in a row and in 2007, more than a third of their tries were scored from kicks (Ball, 2007). The advent of the golden point rule, where the first team to score in extra time (played when scores are tied at the end of regular time) has seen field goal kicking once again becoming important.

An important part of any kick is impact between the foot and the ball. This is the only point at which the performer can propel the ball during the kick and so factors at impact must be influential to ball trajectory. Ball to foot factors have been found to be important in soccer kicking (e.g. Nunome et al., 2006) and in Australian football for kick distance (Ball, 2008a) and between the preferred and non-preferred foot (Smith et al., 2009). Further, in Australian Football (AF) where kicking is the main skill in the game, impact has been deemed the most important aspect of kicking in coaching resources (AFL kicking committee, 2009).

To date, no study has examined impact characteristics for rugby league kicks. Given the different balls used for rugby league compared to soccer and AF, these characteristics might be expected to differ. There are obvious differences in shape between the soccer ball (spherical) and the league ball (ovoid). The league and AF balls are more similar in shape, but the league ball is synthetic rather than leather, is slightly lighter (approximately 400g compared to the 450g of an AF ball) and has a slightly rounder overall shape. As such, ball to foot characteristics might be different and need to be evaluated specific to rugby league.

A limitation of previous impact studies is the small number of kick types that have been examined (AF: drop punt only; soccer: instep and toe kicks). In AF for example, kicks include spirals (where the ball rotates about its long axis in flight) and snaps (where the ball spins about its short axis) in addition to the drop punt examined in impact studies. Similarly, many variations of the instep or toe kick are evident in soccer. Useful information on the nature of foot to ball impact can be gained from examining these different kicks within each game.

The aim of this study was to examine impact characteristics of rugby league kicks and to determine if these characteristics differ for different kicks.

METHOD: Seven elite rugby league players contracted to an Australian National Rugby League performed kicks using a Steeden rugby league football (used in NRL competition). All players performed a drop punt over 45 m, a 15 m grubber kick (kick that rolls along the ground), a 'bomb' (an attacking kick that requires maximum or near maximum height), a drop

kick at goal from 40 m from the goal and goalshots from a placekick. These were chosen as they are found to be the most frequently used kicks in the National Rugby League competition (Ball, 2007). Players only performed kicks in testing if they were currently performing them in games (hence N varied for different kicks, see table 1). This was also the reason for not including the kick off, line dropout and kick for touch from a penalty which are all prevalent in the game but only one player had performed them in games during the current season (note: this is typical of most clubs). With the exception of the goalshot for which a minimum of four kicks was performed, players were allowed to kick up to five of each kick until they had achieved what they, and their kicking coach who attended testing, felt was a good kick. A Photron Fastcam APX-RS high speed camera (Photron Ltd, San Diego) operating at 6000Hz was placed perpendicular to the line of kick. The field of view was maximised for digitising accuracy so was zoomed in to capture the ball, foot and kick leg knee for a minimum of ten frames before until ten frames after ball contact.
Eleven body and boot landmarks were digitised using Silicon Coach Analysis tools (Silicon Coach Ltd, NZ) for the ten frames before and after ball contact. Data were then transferred to Microsoft Excel to calculate foot speed (ten frames prior to impact, average of the ankle and three foot markers), ball speed (ten frames after ball and foot parted, average of four points on the ball, the top point, bottom point, two mid points), ball:foot speed ratio, time in contact (from initial contact to the point of separation of the ball and foot), ball displacement (displacement from initial contact to separation point) and work (W) = mad [where m (of ball) = 0.401 kg, a (of ball) = change in ball velocity from before contact to after separation divided by contact time between foot and ball, d = ball displacement while ball in contact with the foot, Ball 2008b]. The change in shank angle (difference between the angle of the shank, defined by the head of the fibula and lateral malleolus, from impact to separation) was also quantified but due to the lateral body lean with which the goalshot and drop kick are performed, this parameter was not quantified for these kicks.

RESULTS: Table 1 reports mean values for the five kicks assessed.

Table 1. Mean values for five rugby league kicks

		45m (N=7)		Bomb (N=4)		Field Goal (N=5)		Grubber (N=6)		Goalshot (N=4)	
		m	sd	m	sd	m	sd	m	sd	m	sd
Foot Speed (m/s)	Before BC	20.0	2.5	21.0	1.5	21.8	1.6	11.0	2.3	21.2	1.7
Ball Speed (m/s)	After BC	25.8	1.8	26.9	4.2	26.5	2.4	13.7	2.4	25.2	4.0
Ball:Foot Ratio		1.30	0.13	1.28	0.12	1.22	0.11	1.27	0.25	1.20	0.20
Time in Contact (ms)	During BC	7.2	0.6	6.8	0.2	7.1	0.5	8.8	0.7	7.4	0.3
Ball Displacement (m)	During BC	0.20	0.02	0.20	0.01	0.23	0.04	0.12	0.03	0.22	0.02
Work (J)	During BC	290	49	342	50	316	48	68	17	306	71
Ball Angle (°)	Before BC	66	10	75	5	70	4	12	9	36	4
	After BC	70	8	77	9	65	17	20	25	53	8
	Change	4	8	2	10	5	17	-8	19	17	4
Foot Trajectory (°)	Before BC	7	5	24	13	8	7	0	8	2	5
Ball Trajectory (°)	After BC	32	11	53	12	39	9	1	2	36	3
Support Foot to	Horizontal	0.39	0.15	0.58	0.07	0.23	0.15	0.60	0.18	0.15	0.14
Ball distance(m)	Vertical	0.40	0.07	0.63	0.05	0.30	0.10	0.23	0.04	0.28	0.01

DISCUSSION: The aims of this study were to provide data for impact characteristic data for rugby league kicks and to compare different kicks. There is no comparison data in the scientific literature for rugby league kicking. Ball speeds and angle of trajectories were similar to values reported by Holmes et al (2006) for rugby union kickers (goal kick = 26.44 m/s, 30.22°; drop kick = 25.60 m/s, 35.76°). Ball displacements during foot contact of 0.20-0.23m

for the four long kicks in this study lay between values reported for AF (0.19m and 0.24 m for 30m and 50m kicks, Ball, 2008b; 0.19 m and 0.23 m for preferred and non-preferred kicks, Smith et al., 2009) and soccer (0.15 m, Asai et al., 2002; 0.26 m Tsaousidis and Zatsiorsky, 1996). Ball speed to foot speed ratios also lay between values reported for soccer (1.1, Asai et al., 2002; 1.37 Nunome et al., 2002) although the 50 m kick, bomb and grubber were all slightly higher than the 1.23 reported for preferred foot kicks for AF (Smith et al., 2009).

Differences in impact characteristics existed between rugby league kicks and those of other sports. Time in contact values for all kicks (6.8 ms for the bomb up to 8.8 ms for the grubber) were lower than any other values reported (AF: 9.8-10 ms, Ball, 2008b; 11.5ms, Smith et al., 2009; soccer: 9ms, Asai et al., 2002; 16ms, Tsaousidis and Zatsiorsky 1996; 11.1 ms, Nunome et al., 2006). The smaller mass of the rugby league ball is likely to have contributed to this difference (rugby league ball = 0.400kg, soccer ball = 0.435 kg, AF ball = 0.450 kg). For the same force, the rugby league ball will experience greater acceleration compared with the soccer and AF balls. Certainly, the difference in contact time cannot be explained by kick intensity. While for most studies, kicks were maximal (compared to 45-50m kicks in this study, or 80-95% maximum), Ball (2008b) performed kicks over a shorter distance and contact time remained larger than for rugby league kicks (30 m kick, 9.8 ms contact time). Further, the shortest kick for this testing (grubber) also exhibited the largest contact time.

Work on the ball for all kicks excluding the grubber was larger than values reported for AF kicks (225-271 J, Ball, 2008, Smith et al., 2009). It was also larger for the 45m kick and bomb compared to soccer kicks (290-310 J, Tsauosidis and Zatsiorski, 1996) and values were similar for the 45 m kick (290J) and goalkick (306J). Of note here is that the kicks in this study were sub-maximal while the soccer kicks were maximal. Given Ball (2008) reported work increased with increased kick distance, it is possible that maximal goalkicks and drop kicks might exceed soccer kicks for work done on the ball. Coefficient of restitution (COR) is a likely contributor to this finding although no data exists for the rugby league ball for comparison. Where COR has been evaluated under kicking conditions, rugby balls (0.77-0.81, Gallagher and Cooke, 1998) had much higher values than soccer balls (0.45-0.65, Dorge et al., 2002). Given the similarities between league and union balls, a similar COR might be expected. The differences in mass might also contribute. Once again, the sub-maximal kick performed in this study cannot explain this finding. Ball (2008) reported larger work values for longer (or more maximal) kicks so the submaximal kicks in this study would be expected to produce smaller and not larger work values. Further, had the field goal and goalshot been maximal, it is likely they would have also produced more work than soccer kicks.

Differences existed between the rugby league kicks examined in this study. Not surprisingly, the grubber was significantly different to other rugby league kicks for most parameters due to its trajectory being along the ground and its aim to stop within 15 m. Further, it was noted from video footage than a large range of techniques and ball angles were used for this kick. While foot speeds and trajectories (foot and ball) were similar, players angled the ball differently to obtain different spin and run along the ground. This variance was evident in large standard deviation values for ball angles before and after contact in table 1.

Differences also existed between the longer rugby league kicks examined in this study. Ball to foot speed ratios ranged from 1.2 to 1.3 (8% difference) and work ranged from 290 J to 342 J (18% difference). Other differences related to ball and foot position/trajectory also existed with ball angle, ball and foot trajectory and support foot position differing between a number of the kicks. These ‘position’ factors were related to the kick task. For example, during the bomb, for which maximum height is desirable, the ball was higher from the ground and foot trajectory was more vertical at ball contact compared to the other kicks for which horizontal distance was the more dominant aspect of the task.

With the small N, statistical analysis was not appropriate so future testing with larger numbers is needed to determine if the differences between parameters is significant. However given the large relative differences that existed between kicks in this study it is clear they need to be evaluated separately for impact characteristics. These differences probably also exist between kicks in other sports. Currently soccer kick impact analysis has largely

been limited to instep and toe kicks and only one kick (the drop punt) has been examined in AF. As such there would seem to be a need to evaluate more kick types in these sports.
Ball orientation and change in ball angle during contact produced interesting results. For the goalshot the ball moved through 17 degrees from the instant of foot contact until the instant of foot-ball separation. This was less evident in the other kicks with the field goal, bomb and 50m kick only moving through 5 degrees. The point of contact on the ball and the orientation of the ball at contact would have influenced this. However it was also noted that among the goalkickers that the most junior goalkicker was far more variable (range of values 8 – 19 degrees) compared to the more senior kickers (range of values less than 2 degrees for all three kickers). The consistency of ball strike and how it relates to performance is an important future direction for this work, as is the evaluation of how this large change in angle influenced performance compared to field kicks.

CONCLUSION: This study has provided impact data for a range of different rugby league kicks. In comparison to AF and soccer kicks, rugby league kicks exhibited smaller time in contact. A larger amount of work done on the ball compared to AF kicks while showing similarities for foot and ball speeds, ball to foot ratio and displacement of the ball while in contact with the foot. Further, differences existed between the different types of rugby league kicks tested, indicating these kicks need to be evaluated separately. This is also likely to generalise to different kicks within other sports such as AF and soccer so evaluation of different types of kick is necessary in these sports.

REFERENCES:

Asai, T., Carre, M. J., Akatsuka, T. and Haake, S.J. (2002). The curve kick of a football 1: impact with the foot. *Sports Engineering*, 5, 183-192.

Ball, K. (2007). Performance analysis of kicking in Rugby League. Technical report for the Melbourne Storm Rugby League club, Melbourne, Australia.

Ball, K. (2008a). Biomechanical considerations of distance kicking in Australian Rules football. *Sports Biomechanics*, 7, 10-23.

Ball, K. (2008b). Foot interaction during kicking in Australian Rules Football. In: T. Reilly, F. Korkusuz (Eds.), *Science and football VI* (pp. 36-40). London: Routledge.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioural Sciences* (2nd Ed.). Hillsdale: Lawrence Erlbaum Associates.

Nunome, H., Lake, M., Georgakis, A., and Stergioulas, L. (2006). Impact phase kinematics of instep kicking in soccer. *Journal of Sports Sciences*, *24*, 11-22.

Tsaousidis, N., and Zatsiorsky, V. (1996). Two types of ball-effector interaction and their relative contribution to soccer kicking. *Human Movement Science*, *15*, 861-876.

Bull Andersen, T., Dorge, H.C. and Thomsen, F.I., 1999, Collisions in soccer kicking. *Sports Engineering*, 2, 121-125.

Holmes, C., Jones R., Harland A., and Petzing J., Ball launch characteristics for elite rugby union players, in The Engineering of Sport, Springer, 2006.

Smith, J., Ball, K. and MacMahon, C (2009). Foot to ball interaction in preferred and non-preferred leg Australian Rules kicking. In proceedings of the 27th International conference on biomechanics in sports (edited by Anderson, R., Harrison, D. and Kenny, I) pp 650-653. University of Limerick.

Acknowledgements

Thanks to the Melbourne Storm players for participation and assistant coach Michael Maguire for coaching support and input into the findings. Thanks also to the research assistants Dale Talbert, Lucy Parrington, Jamie Falloon and Jason Smith.