CARRYING A BALL CAN INFLUENCE SIDESTEPPING MECHANICS IN RUGBY

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Sidestepping mechanics have been implicated as a risk factor for knee injury in rugby. Carrying a ball is proposed to alter movement patterns. Therefore the purpose of the study was to examine the effects of sidestepping with a ball compared to sidestepping without a ball on lower-extremity biomechanics in male rugby athletes. Three-dimensional kinematics of 18 male rugby athletes were recorded during a maximal effort 45° sidestepping task without and with a ball. Sidestepping with a ball resulted in 15% greater knee adduction angle during weight acceptance and 18% greater hip adduction angle during peak push-off than without a ball. Future biomechanical evaluations of athletes require the inclusion of the ball specific to the sport to ensure accurate interpretation of movement patterns.

KEYWORDS: knee injury, anterior cruciate ligament, ACL, planned, cut, manoeuvre.

INTRODUCTION: Rugby union is the most played contact sport in the world with over seven million participants spanning 120 countries ("Year in Review 2014," 2014). Rugby includes an assortment of physically demanding activities including running, sprinting, kicking, passing, colliding, tackling and scoring; all are required during the course of an 80-minute match (Brown, Brughelli, Griffiths, & Cronin, 2014). Rugby athletes are often plagued with lower-extremity musculoskeletal injuries, specifically hamstring and anterior cruciate ligament (ACL) injury (Brown, Brughelli, & Hume, 2014). The majority of ACL injury rehabilitation claims are classified as non-contact and are seen frequently during sidestepping (Brown, Brughelli, & Hume, 2014). Previous research examining sidestepping has primarily focused on females, footballers or a combination of the two (Brown, Brughelli, & Hume, 2014). With 78% (4.5 million) of all rugby athletes being male ("Year in Review 2014," 2014), there is limited research that has examined male rugby athletes and accurately replicated the tasks seen in match play. While sidestepping has been examined in Australian Rules footballers, the velocities at which the task was performed may potentially be lower than match velocities (Brown, Brughelli, & Hume, 2014), calling into question the applicability of findings. Several authors have examined the influence of ball-handling (Chaudhari, Hearn, & Andriacchi, 2005), passing (Fedie, Carlstedt, Willson, & Kernozek, 2010) and dribbling (Chan, Huang, Chang, & Kernozek, 2009) during sidestepping and have discovered substantial alterations in lower-extremity mechanics. There is no published study that has examined the effects of carrying a ball during sidestepping in rugby; ball retention being a major component of success in rugby ("Year in Review 2014," 2014).
The purpose of this research was to examine the effects of carrying a ball on lower-extremity biomechanics during sidestepping compared to sidestepping without a ball in male rugby athletes. It was proposed that sidestepping with a ball would alter knee kinematics relevant to ACL injury risk such as decreased knee flexion angle at initial contact and increased knee adduction angle during weight acceptance.

METHODS: Eighteen male academy (high performance development) rugby athletes (age 20 ± 3 y, body-height 1.9 ± 0.1m, body-mass 100 ± 14 kg) performed maximal effort 45° sidestepping tasks without and with a rugby ball.
Data collection: The planned sidestepping task (Brown, Wang, Dickin, & Weiss, 2014) consisted of athletes accelerating with maximum effort for 10-m before performing an offensively-initiated evasive manoeuvre, using their preferred kicking leg, at a 45° angle and then reaccelerating out to complete the task. Following a warm-up, static calibration and range of motion trials were captured at 200 Hz with a nine-camera three-dimensional motion capture system (T10S, Vicon Motion System Ltd., Oxford, UK) and a synchronised embedded force platform (Type 9287C, Kistler Instrumente AG, Winterthur, CH) collected at 1000 Hz. Athletes completed a minimum of eight trials without and with a ball given in a random order. A

successful trial consisted of athletes reaching a velocity of ≥ 6 m/s, striking the force platform completely with the sidestepping leg and executing the task as quickly as possible to closely simulate the requirements of a match situation.

Data processing: Athlete-specific joint-centre locations were calculated from the range-of-motion trials using a custom-made MATLAB programme (R2014b, The MathWork, Inc., Natick, MA, US). Three-dimensional motion and ground reaction force data were filtered with a fourth-order Butterworth low-pass filter using a cutoff frequency of 16 Hz in Visual 3D (4.91.0, C-Motion, Inc., Germantown, MD, US). Knee power data were normalised by body-mass (W/kg) and time data were normalised to stance phase (%; from initial contact to final contact) to facilitate comparison between all athletes. Knee angle and hip data were examined during initial contact, weight acceptance, peak push-off and final push-off phases while knee power and knee velocity were examined at peak braking and peak propulsive phases using another custom-made MATLAB programme (Brown, Wang, et al., 2014).

Data analysis: To describe the results in detail, two-tailed, paired Student's *t*-tests were established and magnitude-based inferences were used to assess the standardised effects (the difference between the means was divided by the standard deviation of the leg sidestepping without a ball; effect size [ES]) of sidestepping with a ball using previously established methods (Hopkins, Marshall, Batterham, & Hanin, 2009). If the confidence limits were within the levels of the negative, trivial or positive mechanistic scale, the outcome was noted as clear and the likelihood of the true effect observed was described. If the confidence limits spanned all three levels, the outcome was noted as unclear.

RESULTS: Performance variable effects of sidestepping with a ball compared to without a ball were: approach velocity (6.6 ± 0.7 m/s and 6.6 ± 0.4 m/s; ES = 0.13) was unclear, stance time (0.19 ± 0.02 ms and 0.19 ± 0.03 ms; ES = 0.013) was likely trivial, depart velocity (6.1 ± 0.4 m/s and 6.2 ± 0.5 m/s; ES = -0.20) was possibly trivial and the angle (16 ± 2° and 16 ± 3°; ES = 0.092) was likely trivial. Knee flexion angle showed a possibly trivial decrease (ES = -0.16) at initial contact, knee adduction angle showed a possibly trivial increase at initial contact, a likely small increase at weight acceptance, a possibly trivial increase at peak push-off (ES = 0.19, 0.38 and 0.17 respectively) and hip adduction angle showed a possibly small increase at peak push-off (ES = 0.27) when sidestepping with a ball compared to without a ball; all other variables showed unclear or trivial inferences (Table 1). Sidestepping with a ball showed peak knee power as unclear and peak knee velocity with a possibly trivial decrease (ES = 0.032 and ES = -0.14 respectively) during the braking phase and possibly trivial decreases (ES = -0.20 and -0.16 respectively) during the propulsive phase compared to without a ball (Figure 1).

DISCUSSION: Studies (Chan, et al., 2009; Chaudhari, et al., 2005; Fedie, et al., 2010) including a ball during sidestepping have noted kinematic increases in knee flexion, knee abduction and hip adduction angles; the current study can only partially support these findings. Knee flexion angle for example, while carrying a ball, was slightly smaller at initial contact and then remained consistent throughout the remaining phases of sidestepping. Knee adduction angle was slightly larger while carrying a ball at all phases of sidestepping; with an unclear inference at final push-off. Unlike Chan et al. (Chan, et al., 2009) who found that dribbling a ball increased knee abduction angle at weight acceptance in female basketball athletes, we found an increased knee adduction angle at initial contact, weight acceptance and peak push-off when sidestepping with a ball which is more in line with findings (Fedie, et al., 2010) while attending to a ball in male and female basketball athletes. Hip adduction angle was larger at all phases while carrying a ball in this study and showed a clear and possibly small increase during peak push-off, which is comparable to findings of larger hip adduction angles (Chan, et al., 2009; Fedie, et al., 2010). Our findings of larger knee and hip adduction angles may be the result of substantially faster velocities while entering (~6.6 m/s) and exiting (~6.2 m/s) the manoeuvre. In addition, male rugby athletes may present different (unique) sidestepping mechanics as the requirements of the sport differ considerably from those found in male and female basketball athletes.

Table 1. Mean ± standard deviation of knee and hip joint kinematics during sidestepping without and with a ball and inferences for change of the means.

Joint angles: Sidestepping phase:	Without ball (°)	With ball (°)	With–without ball sidestepping *p*-value	Mean change; 90% CL	ES: Qualitative inference
Knee flexion (+) / extension (–)					
Initial contact	27 ± 8	26 ± 7	0.091	-1.4; ±1.3	-0.16: Trivial* -ive
Weight acceptance	39 ± 7	39 ± 6	0.732	0.29; ±1.41	0.041: Trivial**
Peak push-off	52 ± 5	52 ± 6	0.919	-0.086; ±1.457	-0.016: Unclear
Final contact	22 ± 7	22 ± 6	0.877	-0.15; ±1.69	-0.023: Unclear
Knee adduction (+) / abduction (–)					
Initial contact	9 ± 5	10 ± 4	0.199	1.1; ±1.5	0.19: Trivial* +ive
Weight acceptance	13 ± 5	15 ± 4	0.023	2.2; ±1.5	0.38: Small** +ive
Peak push-off	18 ± 7	19 ± 6	0.207	1.3; ±1.7	0.17: Trivial* +ive
Final contact	11 ± 5	11 ± 4	0.821	0.16; ±1.24	0.039: Unclear
Hip adduction (+) / abduction (–)					
Initial contact	5 ± 8	6 ± 6	0.179	1.04; ±1.28	0.13: Trivial**
Weight acceptance	6 ± 8	7 ± 7	0.191	0.94; ±1.20	0.12: Trivial**
Peak push-off	10 ± 8	12 ± 7	0.031	2.2; ±1.6	0.27: Small* +ive
Final contact	11 ± 7	11 ± 5	0.561	0.33; ±0.97	0.055: Trivial***

Values are means ± standard deviation; mean change; ±confidence limits (CL) (90%); ES, effect size; (+) and (–) , positive and negative values associated with the corresponding angle; +ive and -ive, substantial positive and negative change with ball relative to without ball sidestepping; trivial and small inference: 25-74%, possibly (*); 75-94%, likely (**).

The results for knee power and knee flexion velocities were unclear or trivial mechanistically and are most likely due to large confidence limits. While further work is needed in this area to clarify our findings, it is interesting that smaller peaks were observed in knee joint power while the knee velocity peaks were similar when sidestepping with a ball during the braking and propulsive phases when compared without a ball. During these phases, the ACL and other soft tissue structures in the lower-extremity have the potential to experience a greater amount of loading over a longer period as a result of increased tension development (Brown, Wang, et al., 2014). If sidestepping without a ball elicits greater energy absorption and production peaks, the ACL may experience greater tensile loading; results of which may present incorrect or misleading information that are unrepresentative of those found during match play. Furthermore, when compared to female footballers performing sidestepping on the preferred leg without a ball, the male rugby athletes in this study elicited substantially larger power absorption (-34 vs -23 W/kg; 33%), power production (20 vs 12 W/kg; 42%), knee flexion velocity (-708 vs -499 deg/s; 30%) and knee extension velocity (587 vs 530 deg/s; 10%) (Brown, Wang, et al., 2014). Based on this simple observation, it would seem essential that male and female athletes should not be placed into the same data pool for lower-extremity analyses.

While purely speculative at this time, the altered mechanics of sidestepping with a ball compared to without a ball as observed in this study may be the due, in part, to the athletes' ingrained protection of the ball to maintain possession. In order to acquire a similar centre-of-mass position without the use of the arms (e.g. while carrying a ball) and obtain the same performance objective, an athlete may be required to reorient the trunk and/or the lower-extremities. As this topic was not the focus of the current study, further investigation is required to accept or reject this contention.

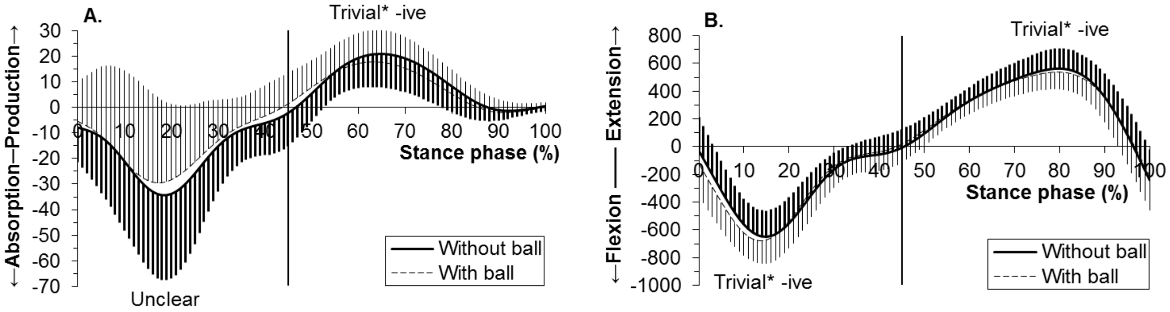

Figure 1: Graphical representations of (A.) knee power (W/kg) and (B.) knee velocity (deg/s) without and with a ball during the stance phase of sidestepping; error bars, equivalent to one standard deviation; vertical line, indicates the division of the braking and propulsive phases; -ive, substantial negative change with ball relative to without ball sidestepping; trivial inference: 25-74%, possibly (*).

CONCLUSION: Sidestepping with a ball resulted in 15% greater knee adduction angle during weight acceptance and 18% greater hip adduction angle during peak push-off than without a ball; implicating that sidestepping with a ball alters lower-extremity mechanics relevant to ACL injury risk. It is suggested that future biomechanical evaluations of athletes require the inclusion of the implement/ball specific to the sport in order to ensure accurate interpretation of movement patterns.

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