KICK IMPACT CHARACTERISTICS OF JUNIOR KICKERS

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Impact is important to kicking performance and while differences have been found between kick distances and between preferred and non-preferred leg kicks, no work has examined junior kickers. This study examined impact characteristics of the Australian football (AF) drop punt kick for juniors and compared these data with seniors from Smith et al. (2009). Twenty one junior AF players performed a maximum distance kick. The foot, ball and shank were digitised from 6000 Hz video to calculate seven foot/ball parameters. Junior players produced significantly smaller foot and ball speeds but not foot to ball speed ratios compared to senior players. Work was also significantly different due to lesser force being applied to the ball. Junior players should focus on increasing foot speed and force on the ball to increase kick distance.

KEYWORDS: Australian football, junior skill development, punt kick

INTRODUCTION: The nature of impact between the foot and the ball is an important technical factor in the kicking skill. Ball velocity in soccer kicking has been proposed to be developed by a combination of foot speed and the nature of impact between foot and ball. Similarly, in Australian Football (AF), it has been suggested that kick distance is influenced by the nature of impact between the foot and ball (Baker and Ball, 1996). Further, the importance of impact has been highlighted by recent recommendations made by the Australian Football League (AFL) kicking committee that coaches should prioritise evaluating impact before other technical aspects.

An important influence on the characteristics of impact is footedness. Impact factors have been shown to differ between preferred and non-preferred foot kicks in AF and soccer. Smith et al. (2009) compared maximal distance kicking for the preferred and non-preferred foot kicking for elite AFL players from 6000 Hz video. Smith et al. (2009) found that foot speed, ball speed, change in shank angle and work differed significantly between feet (see table 1 in results). However, no significant difference existed for time in contact with the ball or for the ratio between foot speed and ball speed. Similarly, foot and ball speed did but foot to ball speed ratio did not differ significantly by foot in soccer (Nunome et al., 2006a, preferred = 1.35, non-preferred = 1.32).

Impact factors have also been shown to differ for kicks of different distances. Ball (2008a) examined impact in 1000Hz video of 30 m and 50 m kicks, performed by eight elite Australian Football League (AFL) players. Significant differences existed between 30 m and 50 m kicks for change in ball velocity (50 m kick = 25.0 m/s, 30 m kick = 22.1m/s), change in shank angle during ball contact (50 m kick = 18 degrees, 30 m kick = 14 degrees) and work done on the ball (50 m kick = 271 J, 30 m kick = 198 J). The combination of significant change in ball velocity but not time in contact (50 m kick = 10 ms, 30 m kick = 9.8 ms) led Ball to conclude that the amount of force, rather than how long the force was applied to the ball was the key performance determinant for kick distance. This was supported by Smith et al. (2009) who found the preferred leg kick produced significantly larger change in velocity but with no difference in time in contact compared to the non-preferred foot (the preferred foot produced greater ball speed which is associated with kick distance, Ball 2008b).

An important extension of these previous examinations of the nature of impact is to determine what characteristics junior players exhibit and how these compare to senior performers. This information can potentially identify key parameters that differ between these age groups and more precisely guide programmes aimed at junior kicking development. As yet, few studies in any kicking sport have examined junior players and how they differ from senior players. The aim of this study was to measure impact characteristics for junior AF players and to compare them with senior players.

METHOD: Twenty-one junior AF (Age 16.9 ± 1.1 years; height = 1.78 ± 0.20 m; mass = 71.3 ± 8.1 kg) players participated in this study. To allow for direct comparison with senior data, the test protocols and analysis methods used by Smith et al. (2009) were used for this study. All players kicked a Sherrin Australian Rules football (used in AFL competition, pressure range of 67-75 kPa) for maximal distance with the preferred and non-preferred leg. Players were allowed to kick up to five kicks on each leg until they had achieved what they felt was a good kick. This kick was confirmed by their kicking coach who was in attendance. A Photron Fastcam APX-RS high speed camera (Photron Ltd, San Diego) operating at 6000Hz was placed perpendicular to the line of kick and 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. Seven body/boot landmarks (head of fibula, lateral malleolus, heel of boot, head of the 5th metatarsal, toe of boot, top point of ball, bottom point of ball) were digitised for these ten frames before and after ball contact using Silicon Coach Analysis tools (Silicon Coach Ltd, NZ). Data was 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 the top and bottom of the ball), 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), 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) and work [calculated as m.a.d, where m (of ball) = 0.45 kg, a (of ball) = change in ball velocity from before contact to after separation divided by the time in contact between ball and foot, d = ball displacement while ball in contact with the foot, Ball 2008a). The force component of the work equation (m.a) was also used in evaluation of findings.
To compare with senior players, preferred leg kicking data from Smith et al. (2009) were used (N=18 senior AFL players, Age: 22.8 ± 4.2 years).
Paired t-tests were conducted to compare junior and senior players for each kicking parameter. Statistical significance was set at $p < 0.007$ (using a Bonferroni adjustment of $p < 0.05$ for seven parameters). Effect sizes (large: $d > 1.2$, medium: $d > 0.6$, small: $d > 0.2$) as defined by Cohen (1988) were also calculated for each comparison.

RESULTS: Table 1 reports mean values for the junior kickers along with comparison data from Smith et al. (2009). Statistical analyses are also included.

Table 1. Impact characteristics for preferred foot kicking for junior AF players. Comparison data from Smith et al. (2009, preferred leg kicking data only) and statistical analyses also included.

	Junior (N=21)	Senior (N=18) (Smith et al., 2009)	t-test (*p*-value)	Effect size (*d*)
Foot speed (m/s)	21.3 ± 1.3	26.5 ± 2.5	<0.001*	2.6
Ball speed (m/s)	24.7 ± 2.1	32.6 ± 4.4	<0.001*	2.3
Ball:foot speed ratio	1.16 ± 0.08	1.23 ± 0.11	0.02	0.7
Time in contact (ms)	11.06 ± 0.93	11.53 ± 1.25	0.19	0.4
Ball displacement (m)	0.20 ± 0.02	0.22 ± 0.02	<0.001*	1.0
Change in shank angle (°)	14 ± 2	13 ± 1	0.01	0.6
Work done on the ball (J)	135.7 ± 22.5	225.0 ± 45.0	<0.001*	2.5

* Significant difference (p<0.007) after Bonferroni adjustment.

Junior AF players produced significantly lower foot speed, ball speed, ball displacement and work values. These were large effects. Ball to foot speed ratio, change in shank angle and time in contact produced non-significant, medium effects.

DISCUSSION: The aim of this study was to measure impact characteristics in kicking for junior AF players and to compare with senior players. There is no comparison data for junior AF players and very limited data for comparison with junior kickers from other sports. Ball speeds for juniors in this study (16.9 years, 24.7 m/s) lay between previously reported values reported for maximal soccer kicking for juniors (10-17 years, 14.9-22.2m/s, Luhtanen, 1988; 17.6 years, 22.3-30.0 m/s, Rodano and Tavana, 1993; 16.8 years, 32.1m/s, Nunome et al., 2006a). Foot speeds in this study (21.3 m/s) were similar to the values reported by Nunome (2006a, 16.8 years, 22.7 m/s).

Junior kickers produced lower foot and ball speeds compared to senior players. These differences were substantial, with foot speed differing by 5.4 m/s (24% smaller) and ball speed by 7.9 m/s (32% smaller), and reflected by the effect size. Given Ball (2008b) reported foot speed was the most strongly correlated technical factor associated with distance ($r = 0.68$, $p < 0.01$), the difference in foot speed found in this study is likely to relate to a substantial difference in kick distance between juniors and seniors.

While foot and ball speeds were significantly different between junior and senior players, ball:foot ratio was not. This suggests that attempting to increase foot speed rather than focussing on the nature of impact is the more appropriate method of improving junior players. However, from a practical perspective, the difference in ratios represents a 6% difference in ball speed for the same foot speed. In terms of kick distance in the elite level, this is likely to represent a meaningful difference. Further, while junior and senior players produced significant correlations between foot and ball speed, these values were different for each group (senior $r = 0.79$ $r^2 = 62\%$, $p < 0.001$, junior $r = 0.57$, $r^2 = 32\%$, $p < 0.001$) and a substantial amount of variance was not accounted for in both groups. This can only be explained by impact factors such as ball orientation, position of ball on foot, behaviour of the foot due to impact with the ball and/or work done on the ball. As such, while foot speed should be a priority for development, impact factors should not be ignored.

Junior players performed less work on the ball than senior players. This was due to a combination of less average force applied to the ball (junior = 679 N; senior = 1023 N) and a smaller displacement over which force was applied to the ball (junior = 0.20 m; senior = 0.22 m). Work and foot speed were positively correlated (senior; $r = 0.84$, $r^2 = 71\%$, junior; $r = 0.55$, $r^2 = 30\%$) indicating that foot speed is an influencing factor in this generation of work. However, as for the relationship between foot and ball speed, there are clear differences between seniors and juniors.

Of interest from table 1 was that ball displacement was significantly smaller for the junior group while the change in shank angle was slightly larger (medium effect although not significant). This could be explained by one of three things: differences in knee linear velocity, differences in ankle plantar flexion, or differences in ball deformation at release. *Post-hoc* analysis of the kicks in this study showed that knee linear velocity did not differ and visual inspection of video indicated no difference in deformation of the ball at release. However, ankle plantar flexion was greater for junior players (Senior = 4°, Junior = 6°, $p < 0.003$). This might explain some of the variance unaccounted for in work on the ball by foot speed. Asami and Nolte (1983) and Sterzing and Hennig (2008) both reported that ankle plantar flexion occurred during ball impact in soccer and suggested a firmer foot (less flexion) is better for performance. This was questioned by Nunome et al (2006b) who reported observing a player that produced one of the highest ball velocities also produced one of the highest ranges of plantar flexion. However, given senior AF players plantar flexed less than juniors, a reduced plantar flexion would seem to be the better option in AF, supporting Asami and Nolte (1983) and Sterzing and Hennig (2008). This finding suggests that training to reduce plantar flexion during impact through kicking drills and conditioning of the ankle musculature might be beneficial to improving kick distance.

The underlying mechanisms for these impact differences between senior and junior players need exploration in future research. Attempting to link kinetic and kinematic factors with important impact factors is essential in developing useable coaching cues. Strength is another likely source of impact differences. This is another useful future direction, which should be explored through kinetic analysis of the kick itself, as recommended by Nunome et al. (2006a), as a more task specific measure of strength compared to isokinetic measures.

CONCLUSION: This study provides descriptive data for impact characteristics for junior AF players performing the drop punt. Junior kickers produced smaller foot and ball speeds as well as displacement of the ball while in contact with the foot and work on the ball compared to senior AF players. No statistical difference existed for ball to foot speed ratio although the differences are suggested to be practically significant. Juniors need to develop the ability to produce greater foot speeds and to apply greater force to the ball to develop their kicking to a senior level.

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