MAINTAINING A FIRM ANKLE: AN EFFECTIVE COACHING CUE FOR IMPROVING FOOTBALL KICKING?

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Kicking with high ball speed is important across football codes. Maintaining a firm ankle during impact has been used as a coaching cue to improve kick performance. However, biomechanical studies of human kickers have identified conflicting results, questioning its effectiveness. Recent mechanical modelling has identified reduced ankle plantarflexion was associated with increased impact efficiency, and the aim of this paper was to determine if reduced ankle plantarflexion was associated with increased impact efficiency in human kickers. An intra-individual analysis of human players was performed. Foot-ball impact characteristics were recorded at 4,000 Hz. Impact efficiency was highest when ankle plantarflexion during impact was minimised (<±3°) in eight of ten players. These results support the coaching cue of maintaining a firm ankle during impact.

KEYWORDS: coaching, feedback, Australian football, soccer, rugby.

INTRODUCTION: Kicking is used across the football codes to score goals, pass to team members and clear defensive pressure. It is desirable to impart a high ball speed as the opportunity for scoring and passing increases and the likelihood of interception decreases. Maintaining a firm ankle and foot during foot-ball impact has been used as a coaching cue to increase foot-ball speed ratio (a measure of impact efficiency) and, in-turn, ball speed (Nunome, Ball, & Shinkai, 2014). This coaching cue is biomechanically supported by studies suggesting reduced magnitude of ankle and/ or foot plantarflexion during impact increases impact efficiency and/ or ball speed (Asami & Nolte, 1983; Ball, Smith, & MacMahon, 2010; Lees & Nolan, 1998; Peacock, Ball, & Taylor, 2017; Sterzing, Kroiher, & Hennig, 2009).
Surprisingly, despite several studies suggesting the coaching cue as effective, no study has identified a significant association between reduced ankle and/ or foot plantarflexion during impact with improved impact efficiency. In fact, only one study reported a significant positive association with improved performance. Asami and Nolte (1983) identified a negative relationship between change in foot plantarflexion during impact with ball speed. However, this individual result should be taken with caution: foot speed, also known to influence ball speed (Andersen, Dörge, & Thomsen, 1999), varied between trials and the influence of change in foot plantarflexion alone was not identified. Each of the remaining studies, and others exploring the issue, have reported non-significant associations (Ball, et al., 2010; Nunome, Lake, Georgakis, & Stergioulas, 2006; Peacock, et al., 2017; Shinkai, Nunome, Suito, Inoue, & Ikegami, 2013; Sterzing, et al., 2009). Thus, the coaching cue of maintaining a firm ankle has no clear supporting evidence.
A common limitation of the previous analyses is the influence of confounding variables. Several impact characteristics are known to influence impact efficiency and ball speed, such as foot speed and physical mass (Andersen, et al., 1999). The previous analyses exploring the issue of reduced ankle and/ or foot motion during impact did not control these confounding variables. Recent studies using a kicking machine to eliminate the influence of confounding variables found impact efficiency was highest with the smallest magnitudes of change in ankle plantarflexion in both soccer and Australian football kicking (Ball & Peacock, 2017; Peacock & Ball, 2018, accepted). However, it is not known if this trend exists within human kickers. Therefore, the aim of this study was to determine if reduced ankle plantarflexion during impact was associated with increased impact efficiency in human kickers using a methodology that reduced the influence of confounding impact characteristics; an intra-individual analysis. It was hypothesised that reduced ankle plantarflexion during impact would be associated with increased impact efficiency when confounding variables are reduced.

METHODS: Ten players performed 30 x 30 m drop punt kicks toward a target using an Australian football ball (Sherrin Match Ball), enabling an intra-individual analysis to be performed. A constant task was chosen to eliminate the influence of player characteristics (mass, shoe structures) and reduce changes to task specific strategies (foot speed), issues influential to previous analyses (Peacock, et al., 2017; Shinkai, et al., 2013). Ankle motion is known to differ between tasks and players (Peacock, et al., 2017; Shinkai, Nunome, Isokawa, & Ikegami, 2009), but it is not known if ankle motion differs between trials of a constant task, making a statistical calculation for sample size unachievable. Therefore, 30 kicks of a submaximal task rather than a smaller number (~5) of kicks for a maximal effort task was chosen to increase statistical power.

Three-dimensional foot-ball impact data were recorded from three synchronised high-speed-video cameras sampling at 4,000 Hz (Photron SA3 & MC2, Photron Inc., USA). Video files were tracked in ProAnalyst software (Xcitex Inc., USA) to generate raw coordinate data. Raw coordinates were exported into Visual3d (C-Motion Inc., USA) and Matlab (The Mathworks, USA) software packages for smoothing and parameter calculation. A six degrees of freedom model of the shank, foot and ball was created from a static capture and applied to the kicking trials. Data were filtered with a low-pass Butterworth filter at 280 Hz (Nunome, et al., 2006; Peacock, et al., 2017).

Ankle angle was calculated using a six degrees of freedom model. Change in ankle angle was calculated from the difference in ankle angle at ball contact and ball release, and positive values represented plantarflexion and negative values represented dorsiflexion. The foot centre was defined using the ankle and metatarsal heads. Ball centre was calculated from its geometric shell. Foot and ball speeds were calculated as the average speed over five frames before ball contact and after ball release. Foot-ball speed ratio, the measurement of impact efficiency, was calculated from ball speed divided by foot speed.

A novel method was developed to calculate impact location on the foot in three-dimensional space. Impact location on the foot has been shown to influence ankle motion and impact efficiency with a kicking machine (Peacock & Ball, accepted). If ankle motion did differ between kicks in the present study, it was likely to be due to impact location because kick distance (associated with impact force; Peacock, et al., 2017) was held constant. Therefore, it was imperative that a method to calculate impact location was developed. Impact location on the foot was calculated by modelling the dorsal aspect of the foot as a semi-elliptical cylinder and the ball as an ellipsoid, and calculating their point of intersection at ball contact.

Second order bivariate regressions identified the relationship between ankle plantarflexion during impact and impact efficiency. Outliers were screened and removed (i.e. severe miskicks). The magnitude of ankle plantarflexion during impact producing the highest impact efficiency (± 95% confidence interval) was calculated from the coefficients of the regression. The relationship between proximal-distal impact location and change in ankle angle was identified. Effect classifications to describe the relationships were small (r = 0.1 – 0.3), medium (r = 0.3 – 0.5), large (r = 0.5 – 0.7), nearly perfect (r = 0.7 – 0.9) and perfect (r > 0.9) (Cohen, 1988).

RESULTS: Maximum foot-ball speed ratio was associated with a small magnitude of ankle plantarflexion during impact (<±3°) for eight players (Table 1). Of the remaining two players, Player 3 displayed little change in foot-ball speed ratio across the range of ankle plantarflexion and Player 7 did not display a turning point in the relationship. Near perfect – perfect linear relationships were identified between proximal-distal impact location and ankle plantarflexion during impact across players (r^2 = 0.64 – 0.93).

DISCUSSION: Impact efficiency was highest with small magnitudes ankle plantarflexion during impact (<±3°) for eight of ten players. Similarly for the kicking machine, foot-ball speed ratio increased as change in ankle plantarflexion decreased when maintaining a rigid ankle (in comparison to the rigid non-rigid ankle) (Peacock & Ball, 2018), impacting closer to the ankle joint and increasing ankle joint stiffness (Ball & Peacock, 2017; Peacock & Ball, accepted). These results positively support the coaching cue of maintaining a firm ankle during foot-ball impact to increase impact efficiency.

Table 1: The relationship between ankle plantarflexion and foot-ball speed ratio, and the change in ankle angle at maximum foot-ball speed ratio.

Player	R-squared	Classification	Δ ankle angle (°) (95%C.I.)
1	0.29	Large	2.1 (-4.7, 8.9)
2	0.05	Small	-2.9 (-6.4, 0.6)
3	0.10	Medium	5.9 (-3.9, 15.8)
4	0.45	Large	-2.2 (-6.7, 2.3)
5	0.05	Small	2.1 (-4.6, 8.7)
6	0.29	Large	2.8 (1.7, 3.9)
7	0.23	Medium	-7.3 (-35.8, 21.2)
8	0.44	Large	-2.3 (-3.3, -1.2)
9	0.45	Large	1.5 (-0.1, 3.2)
10	0.83	Perfect	2.7 (0.3, 5.1)

The results of the remaining two players do not oppose the coaching cue of maintaining a firm ankle during impact. The highest impact efficiency of the remaining two players was associated with greater magnitudes of ankle plantarflexion during impact (5.9° and -7.3°). However, due to the individual curves of their relationship between change in ankle angle and impact efficiency, a clear result for the magnitude of ankle motion associated with the highest level of impact efficiency was not identified. This is evidenced by the distance between the 95% confidence intervals; these two players yielded the widest distance between the upper and lower confidence intervals. Further, these confidence intervals overlapped the ± 3° ankle plantarflexion range, suggesting the highest impact efficiency might still be associated with a small magnitude of ankle motion during impact. Thus, while it was identified a greater magnitude of ankle motion was associated with the highest impact efficiency for these two players, there was uncertainty in their results, meaning they do not conclusively oppose the effectiveness of the coaching cue.

Previous analyses that identified non-significant associations between ankle plantarflexion during impact and increased impact efficiency (Peacock, et al., 2017; Shinkai, et al., 2013) or individual players conflicting group trends (Nunome, et al., 2006) were likely due to confounding variables. For example, the physical mass is influential to foot-ball speed ratio and ball speed (Andersen, et al., 1999), and differed between players in previous analyses (Nunome, et al., 2006; Shinkai, et al., 2013). Foot speed influences foot-ball speed ratio and ball speed (Peacock & Ball, 2017), and also differed between players and between tasks in previous analyses (Nunome, et al., 2006; Peacock, et al., 2017; Shinkai, et al., 2013). The results of the present study in comparison to previous literature can likely be explained by a reduced number of confounding variables.

Increased kick performance and reduced risk of player injury appear to be achieved using the same kicking technique. The results of this study identified highest kicking performance was associated with a small magnitude of ankle plantarflexion during impact. Similarly, decreased risk of injury (anterior ankle impingement syndrome) has been associated with decreased magnitudes of ankle plantarflexion (Tol, Slim, van Soest, & van Dijk, 2002). These similarities identify the importance of the coaching cue “maintaining a firm ankle during impact” toward overall player development and injury prevention. Players should be coached to impact the ball in a technique that produces small magnitudes of ankle plantarflexion.

Coaches of all levels can provide feedback to players on foot-ball impact. Due to the advancements in camera technology, such as mobile phones that can record video up to 1,000 Hz, knowledge of performance feedback and individual specific coaching cues can be provided to players by understanding the impact characteristics that influence the internal and external torques of the ankle joint. For example, if a player produces a large magnitude of ankle plantarflexion during impact, the coach should guide the player to impact closer toward the ankle joint, as supported by the perfect – near perfect relationships between proximal-distal impact location and ankle plantarflexion in the present study. Previous suggestions to reduce ankle plantarflexion include increasing joint stiffness, adopting a greater position of plantarflexion at ball contact, assessing footwear designs to determine their restriction of ankle motion and undertaking strength training of the ankle joint (Ball, et al., 2010; Peacock & Ball, 2018, accepted; Peacock, et al., 2017; Sterzing, et al., 2009).

CONCLUSION: This study identified small magnitudes of ankle plantarflexion during impact (<±3°) were associated with the highest impact efficiency. The hypothesis, that reduced ankle plantarflexion during impact would be associated with increased impact efficiency if confounding variables were reduced, is upheld by these results. This evidence supports the coaching cue of maintaining a firm ankle during foot-ball impact to improve kick performance and reduce injury risk.

REFERENCES

Andersen, T. B., Dörge, H. C., & Thomsen, F. I. (1999). Collisions in soccer kicking. *Sports Engineering, 2*, 121-125.

Asami, T., & Nolte, V. (1983). Analysis of powerful ball kicking. *Biomechanics VIII-B, 4*, 965-970.

Ball, K., & Peacock, J. (2017). Effect of Ankle Rigidity on Kick Speed. In G. Cabagno (Ed.), *World Congress in Science and Soccer* (pp. 187). University of Rennes.

Ball, K., Smith, J., & MacMahon, C. (2010). Kick impact characteristics of junior kickers. In R. Jensen, W. Ebben, E. Petushek, C. Richter & K. Roemer (Eds.), *28th International Conference on Biomechanics in Sports* (Vol. 28). Marquette: Michigan State University.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*: Lawrence Erlbaum.

Lees, A., & Nolan, L. (1998). The biomechanics of soccer: a review. *Journal of Sports Sciences, 16*, 211-234.

Nunome, H., Ball, K., & Shinkai, H. (2014). Myth and fact of ball impact dynamics in football codes. *Footwear Science, 6*, 105-118.

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

Peacock, J., & Ball, K. (2017). The relationship between foot-ball impact and flight characteristics in punt kicking. *Sports Engineering, 20*, 221-230.

Peacock, J., & Ball, K. (2018). The influence of joint rigidity on impact efficiency and ball velocity in football kicking. *Journal of Biomechanics*.

Peacock, J., & Ball, K. (accepted). Strategies to improve impact efficiency in football kicking. *Sports Biomechanics*.

Peacock, J., Ball, K., & Taylor, S. (2017). The impact phase of drop punt kicking for maximal distance and accuracy. *Journal of Sports Sciences, 35*, 2289-2296.

Shinkai, H., Nunome, H., Isokawa, M., & Ikegami, Y. (2009). Ball Impact Dynamics of Instep Soccer Kicking. *Medicine & Science in Sports & Exercise, 41*, 889-897.

Shinkai, H., Nunome, H., Suito, H., Inoue, K., & Ikegami, Y. (2013). Cross-sectional change of ball impact in instep kicks from junior to professional footballers. In H. Nunome, B. Drust & B. Dawson (Eds.), *Science and Football VII*. London: Taylor and Francis.

Sterzing, T., Kroiher, J., & Hennig, E. (2009). Kicking velocity: Barefoot kicking superior to shod kicking? In T. Reilly & F. Korkusuz (Eds.), *Science and Football VI*. London, United Kingdom: Routledge.

Tol, J. L., Slim, E., van Soest, A. J., & van Dijk, C. N. (2002). The relationship of the kicking action in soccer and anterior ankle impingement syndrome: a biomechanical analysis. *The American Journal of Sports Medicine, 30*, 45-50.