

The Influence of Ankle Taping on Changes in Postural Stability During Soccer-Specific Activity

Monika Lohkamp, Simon Craven, Colin Walker-Johnson, and Matt Greig

Context: Postural stability diminishes with longer activity, which may increase the risk of injury. Tape can increase stability, but this effect diminishes after exercise.

Objective: To investigate the influence of ankle taping on postural stability during soccer-specific activity. **Participants:** 10 male, injury-free, semiprofessional soccer players. **Intervention:** A 45-min treadmill protocol replicating the activity profile of soccer match play—with and without ankle tape. Postural stability was assessed every 7.5 min, requiring response to sudden ankle plantar flexion and inversion during single-leg stance. **Main Outcome Measure:** Reaction time to perturbation and center-of-gravity (CoG) displacement. **Results:** Reaction time was significantly longer ($P < .05$) with longer exercise for both movements and conditions. No significant effect was evident in CoG displacement. For both outcome measures a nonsignificant benefit of taping was observed during the first 22.5 min of activity. **Conclusion:** Prolonged exposure to soccer-specific activity negates any beneficial effect of taping in improving postural stability.

Keywords: fatigue, football, treadmill

Ankle injuries are a primary injury type in professional soccer, with 67% being sprains.¹ A disproportionate number of these injuries were sustained during the final 15 minutes of each half,¹ and fatigue was cited as a potential mechanism for this temporal pattern of injury incidence. Through fatigue—defined as a drop of muscle force below 50% of peak torque—deficits in postural control occur and therefore the risk of musculoskeletal injury may be increased.² This reduction in muscle force, leading to an increase in the threshold of muscle-spindle discharge that alters afferent input,² could explain why injuries occur toward the final 15 minutes of each half.¹ Prolonged exposure to soccer-specific activity has been shown to impair single-leg balance performance on an unstable platform, specifically toward the latter stages of each half.³

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Although there is not much evidence for an injury-prevention effect of ankle tape, and it has time and cost implications,⁴ many clinicians advocate the use of external ankle support such as braces or taping to help prevent acute ankle sprains.⁵ Ankle taping is commonly used in sport either as a preventive method⁶ or after injury,⁷ but the beneficial mechanisms of taping are not fully understood to date. The most commonly proposed mechanism is a mechanical effect whereby restricting the total range of motion of the ankle joint, especially in inversion and plantar flexion, increases its stability.⁸

A second proposed mechanism is a proprioceptive effect through stimulation of cutaneous mechanoreceptors near and around the ankle by the application of tape.⁴ Improvement in proprioceptive responses of an individual, especially in the ankle, has been linked with increased postural stability⁹ and therefore may help reduce injury incidence. Postural stability is determined not only by proprioception but also by other sensory input from the visual and vestibular systems.¹⁰ However, taping is only manipulating 1 source of sensory input—proprioceptive input—so a change in postural stability with taping may be caused by the change in sensory input. Some researchers have reported that ankle taping rapidly loses its initial level of resistance to motion during exercise, which reduces the mechanical effect.^{11–15} Some researchers^{16,17} have demonstrated that tape has a positive effect on postural stability in healthy subjects that was still present after 20 minutes of exercise. No study has yet investigated the effect of taping on postural stability in exercise for longer than 20 minutes.

The aim of the current study was to investigate the temporal pattern of the effect of ankle tape on postural stability during a functional task at regular intervals during soccer-specific activity. The hypothesis for this study was that with longer soccer-specific exercise postural stability would decrease and that tape would increase postural stability throughout 45 minutes of exercise.

Methods

Subjects

From 1 male, semiprofessional soccer squad, outfield players who were free from injury over the previous season were selected to participate in this study. No players from other teams were included because exposure to training would be difficult to standardize across teams. Ten players (mean \pm SD age 21.0 ± 2.0 years, body mass 74.0 ± 14.2 kg, height 184.9 ± 9.6 cm) fulfilled the criteria and agreed to take part in this study. All were regular first-team starters and completed, on average, 2 squad training sessions and 1 match per week. All participants provided written informed consent in accordance with departmental and university ethical procedures.

Experimental Design

Before the assessment, participants attended a minimum of 3 familiarization sessions for both the exercise protocol and balance tasks. Participants were tested between 3 and 5 PM or between 4 and 6 PM in accord with regular competition

and training times to account for the effects of circadian variation.¹⁸ Participants attended the laboratory in a 3-hour postabsorptive state, having performed no vigorous exercise or consumed any alcohol or caffeine in the 24 hours before testing, and with diet standardized for 48 hours preceding each test. Players consumed 500 mL of water 2 hours before testing to ensure euhydration. They came to the laboratory on 2 separate occasions with at least 3 days between sessions. Which condition was tested on the first day was determined randomly. Participants were instructed to wear the same footwear for both sessions. Testing was done once without tape as a control condition and once with nonelastic zinc oxide tape (Supa Sport, 5-cm width) applied at the ankle joint in a figure-8 taping technique.¹⁹ The foot was held in dorsiflexion and eversion, with further pulling into eversion during tape application.

Exercise Task

All familiarization and testing sessions were performed on a programmable motorized treadmill (LOKO S55, Woodway GmbH, Weil am Rhein, Germany). Before testing, each participant completed a standardized warm-up of 30 minutes replicating match-play preparation. The intermittent treadmill protocol described previously²⁰ was developed to replicate the activity profile of professional soccer match play. The 15-minute activity cycle comprises 195 discrete bouts of activity (Figure 1), based on work-rate profiles of professional soccer players, with a change in speed on average every 6 seconds.²¹ In the current study the 15-minute activity cycle was repeated 3 times to replicate the first half of a match. Because the temporal pattern of injury is repeated from the first half in the second half of soccer match play¹ and because tape would be reapplied during half-time, only one half was replicated for assessment here. Postural stability was assessed at rest and subsequently at 7.5-minute intervals throughout the 45-minute exercise protocol.

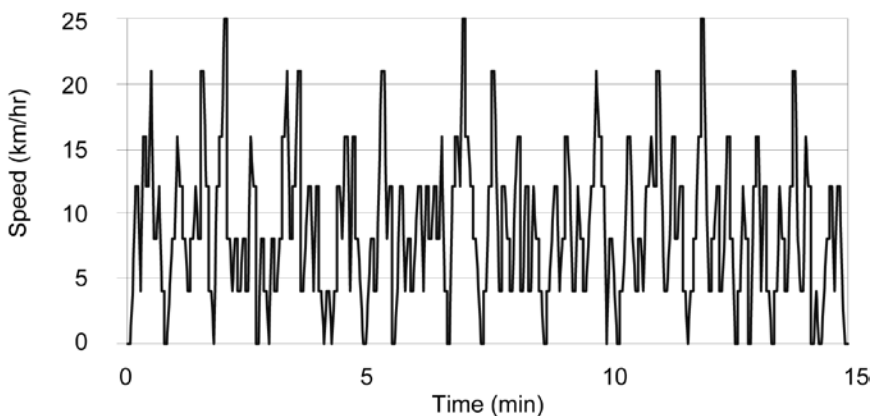


Figure 1 — The intermittent soccer-specific treadmill protocol.²⁰

Balance Task

Postural stability was measured using the NeuroCom Smart Equitest System (NeuroCom International Inc, Clackmas, OR, USA). Participants performed a single-leg stork stance on the center of the force plate of the NeuroCom system. They stood on their dominant leg, which was defined as the preferred leg with which to kick a ball. The participants were instructed to maintain their balance in response to a prescribed perturbation of the system. The force platform rotated by 8° over a period of 200 milliseconds to induce either ankle plantar flexion (forward rotation of the platform) or ankle inversion (lateral rotation of the platform). These movements are key components in the mechanism for ankle sprains, and with this method they are replicated in a controlled manner. The participants performed 1 trial for each direction of perturbation. Center-of-gravity (CoG) coordinate data were recorded at 100 Hz, with data collection initiated on first movement of the platform and recorded for 3 seconds.

Outcome Measures

The reaction time to perturbation was defined as the time between the start of the perturbation (movement of the CoG in 1 direction) and when the participant started to correct the CoG position (movement of the CoG in the opposite direction). This was calculated from the temporal pattern of the CoG coordinate data and measured accurately to 1 millisecond. The total displacement of the CoG from start of its movement to when the participant started to move back to a stable position was calculated, as well as the displacement in the lateral direction. The CoG path would initially follow the path and plane of the platform displacement and hence the reversal of this path was identifiable. The CoG displacement was measured accurately to 0.01 cm.

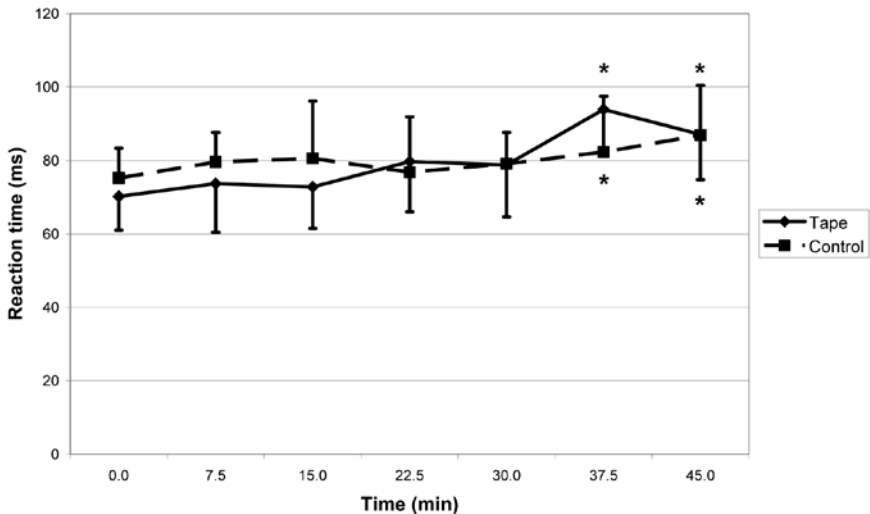


Figure 2 — Reaction time in response to plantar-flexion movement of the force plate. *Significant difference in exercise duration when compared with scores at time 0 ($P < .05$).

Statistical Analysis

Results are presented as mean \pm SD for each measure of postural stability and each condition (control and tape). A 2-way repeated-measures within-group analysis of variance (ANOVA) was conducted to explore a main effect for both taping condition and exercise duration on each measure of postural stability. The data comparisons were tested using SPSS version 14.0 (SPSS, Inc, Chicago, IL), with the significance level set at a $< .05$.

Results

Figure 2 shows the reaction time in response to the plantar-flexion movement of the force plate. There was a significant ($P < .05$) main effect for exercise duration in both the taped and control conditions. In the taped condition the reaction times at $t_{37.5}$ (93 ± 11 milliseconds) and t_{45} (87 ± 12 milliseconds) were significantly longer than at rest, t_{00} (70 ± 9 milliseconds). Similarly, in the control condition the reaction times at $t_{37.5}$ (82 ± 15 milliseconds) and t_{45} (86 ± 13 milliseconds) were significantly longer than at rest, t_{00} (75 ± 8 milliseconds).

There was no significant main effect for taping condition, although the fatigue effect was greatest in the taped condition.

Figure 3 shows the temporal pattern of changes in reaction time for the inversion trial. A similar fatigue effect was evident, with performance significantly ($P < .05$) impaired from midway through the exercise protocol to nearly the end ($t_{37.5}$) in both the taped and control conditions. In the taped condition the reaction times at $t_{22.5}$ (86 ± 24 milliseconds), t_{30} (90 ± 24 milliseconds), and $t_{37.5}$ (84 ± 13 milliseconds) were significantly different from baseline (63 ± 11 milliseconds). The control condition showed

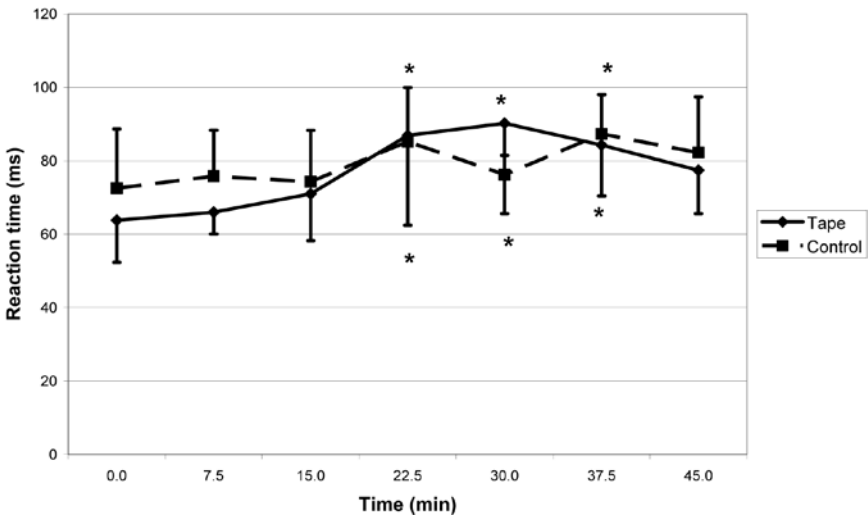


Figure 3 — Reaction time in response to inversion movement of the force plate. *Significant difference in exercise duration when compared with scores at time 0 ($P < .05$).

statistically significantly different reaction times at $t_{22.5}$ (85 ± 14 milliseconds), t_{30} (76 ± 5 milliseconds), and $t_{37.5}$ (87 ± 10 milliseconds) than at t_{00} (72 ± 16 milliseconds).

Figure 4 shows the total CoG displacement in response to plantar flexion. There was no significant main effect for either exercise duration or taping condition. Similarly, there was no main effect for exercise duration in the CoG response to inversion, as shown in Figure 5.

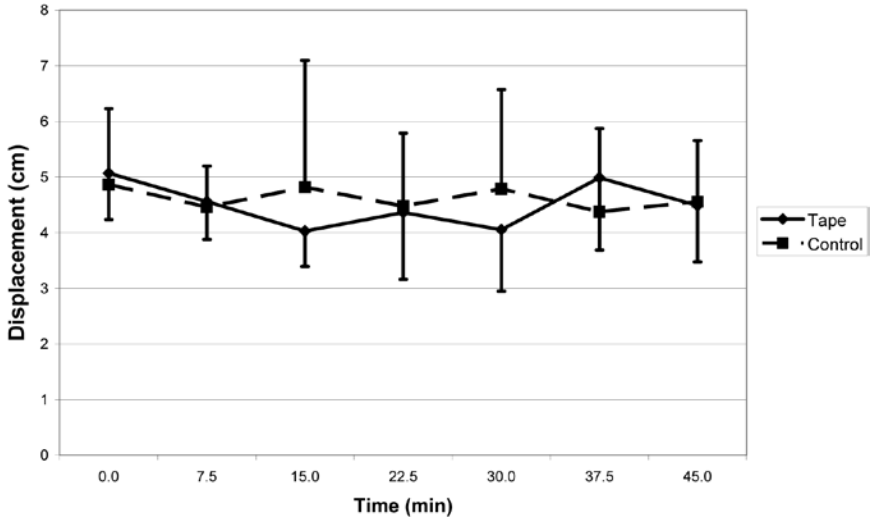


Figure 4 — Center-of-gravity total displacement in response to plantar-flexion movement of the force plate.

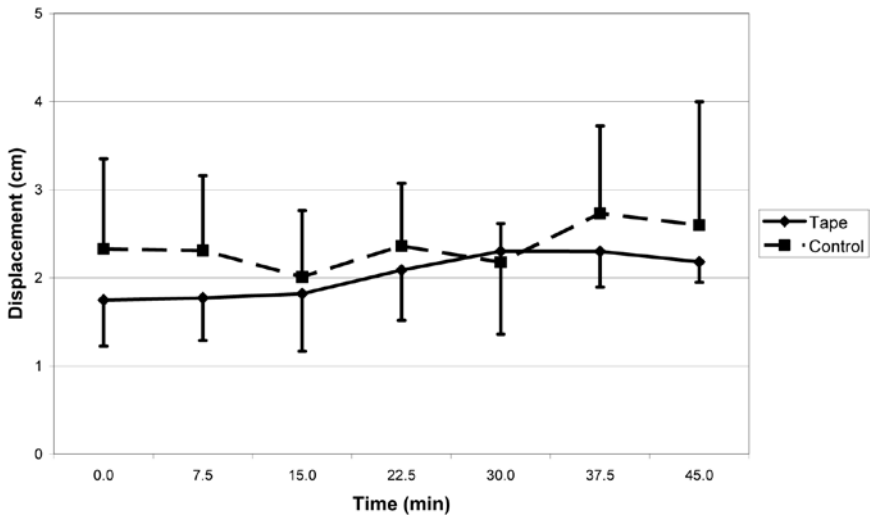


Figure 5 — Center-of-gravity total displacement in response to inversion movement of the force plate.

The lateral CoG displacement in response to plantar flexion is illustrated in Figure 6. It showed no significant main effect.

Figure 7 illustrates the lateral displacement of the CoG in response to inversion of the platform. There was no statistically significant main effect for exercise duration in either condition. Similarly, there was no significant main effect for taping condition.

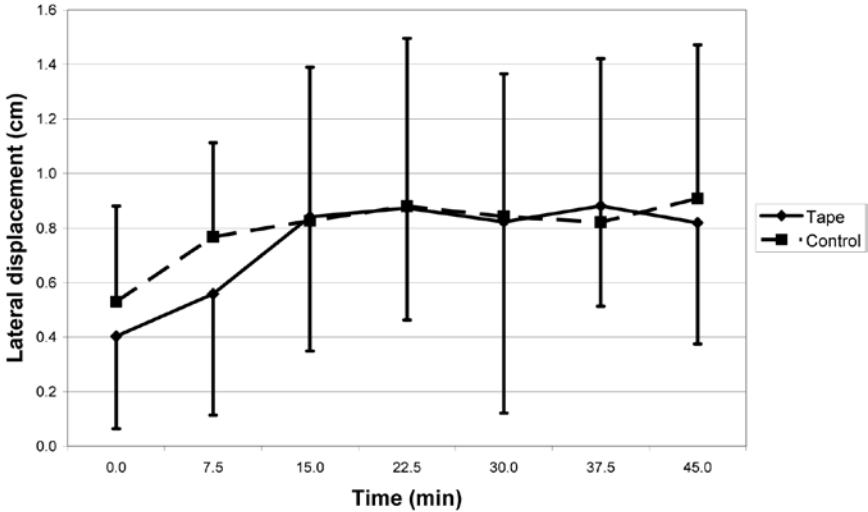


Figure 6 — Center-of-gravity lateral displacement in response to plantar-flexion movement of the force plate.

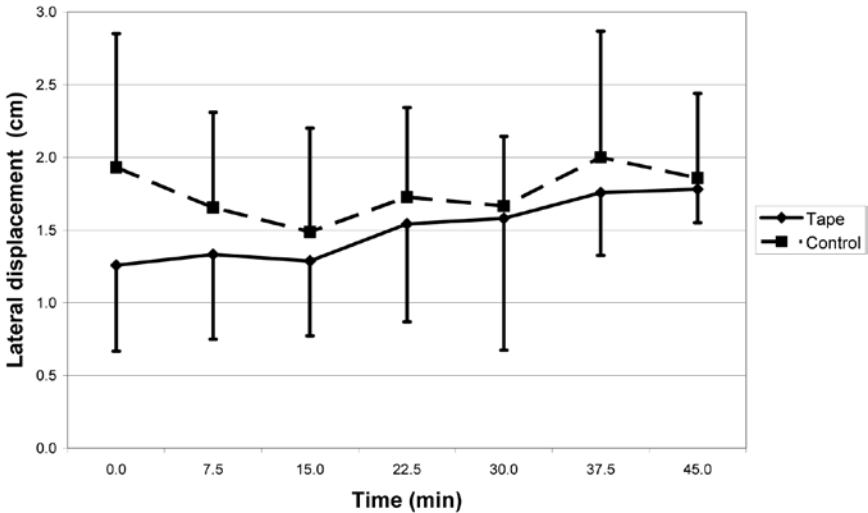


Figure 7 — Center-of-gravity lateral displacement in response to inversion movement of the force plate.

Discussion

The main findings of this study were a significantly longer reaction time after 22.5 minutes in the inversion trial and after 37.5 minutes in the plantar-flexion trial. This impaired performance might be attributed to localized muscle fatigue, which has previously been quantified during this exercise protocol.²⁰ Previous studies have found that fatigued muscles are characterized by extended latency in firing,²² electromechanical delay,²³ and slower muscle-reaction time.²⁴ The longer reaction time with prolonged exposure to intermittent exercise may contribute to the temporal pattern of injury incidence during match play.¹

No such fatigue effect was evident in the CoG displacement in response to system perturbation. In both the inversion and plantar-flexion trials there was no significant main effect for exercise duration. There was a marked and sustained increase in lateral displacement of the CoG in response to the plantar-flexion perturbation after 15 minutes of exercise. Although not statistically significant at the accepted level, this finding may be of clinical importance. The increased lateral displacement with the ankle in plantar flexion promotes inversion of the open packed ankle joint, this situation having been proposed as the most common mechanism of ankle sprain.⁵

We anticipated that the CoG displacement in response to perturbation of the system would increase with prolonged exercise time. When fatigued, in terms of impaired metabolism of contractile elements of muscles,²⁵ muscles may fail to react appropriately to a disturbance,²⁵ which is attributed to factors such as electromechanical delay.²³ The observation that the temporal pattern of changes in response time and CoG displacement was not parallel suggests that the 2 parameters are discrete. Future research should investigate the interrelationship of factors affecting balance and attempt to quantify their relative contribution to balance and their resistance to fatigue.

We quantified reaction time and CoG displacement as measures of stability to examine the influence of fatigue. We hypothesized that tape would increase the sensory input and hence increase postural stability and aimed to examine the temporal nature of this benefit. We found no statistically significant main effect for the taping condition in either balance parameter. In both the inversion and plantar-flexion trials the reaction time with tape application was shorter than with the control condition during the first 15 minutes of the soccer-specific protocol. Although this observation lacked statistical significance, possibly because of the small sample size, the shorter reaction time may be clinically meaningful in terms of influencing injury mechanism and maybe reducing the injury rate. However, more research is needed to determine the link between faster reaction time and preventing injuries and the “optimal” reaction time. Similarly, the application of tape reduced the lateral displacement of the CoG in response to the plantar-flexion perturbation. The temporal pattern of this enhanced performance was similar to the influence on reaction time, with the benefit of tape negated after 15 minutes of exercise. These observations are in accordance with previous research findings that ankle strapping can reduce postural sway²⁶ but that tape failed to restrict ankle joint range of motion after 20 minutes of exercise.^{12,27} In a separate study the effect of tape on postural sway was reduced after exercise despite a significant effect before exercise.²⁸

The beneficial influence of tape application on CoG displacement was more marked in response to the inversion perturbation than the plantar-flexion perturbation. This observation may be explained by the technique of tape application. The figure-8 application aims to keep the foot in a more everted position¹⁹ and therefore may provide more pull when moving in the inversion direction and hence provide a better effect than with plantar-flexion disturbance. In addition, the nature of treadmill locomotion might place greater relative stress on the plantar flexion/dorsiflexion, despite the high frequency of speed change. Therefore, with less movement in the inversion/eversion direction, tape may have not been stressed that much in this direction and hence able to provide a better effect over time. Future research might consider replicating the experimental design using a multi-directional running protocol.

The lack of a significant main effect for taping condition was in accordance with the results reported by Allison et al,²⁹ who did not find an alteration in neurophysiological response to sudden inversion when taping was applied in healthy subjects. In contrast, Alt et al¹⁷ reported a positive effect of taping on neuromuscular parameters such as muscle latency time in healthy subjects. Even though there was no statistically significant difference between the control and tape conditions in the current study, tape seemed to have a positive effect during the beginning of the exercises. In clinical practice tape is frequently applied as a preventive modality, but the results from the current study would suggest that this is not effective at the time when injury is most likely to occur and therefore would suggest not applying ankle taping as a preventive measure. This conclusion supports the earlier recommendation by Olmsted et al,⁴ who analyzed the cost effectiveness of taping as a preventive measure. Other, more effective preventive strategies should be developed that would still be effective toward the end of each half of soccer match play.

One of the limitations of the current study was that only the first half of a simulated soccer match was considered, and future research might consider extending the experimental design to analyze the second half also. Even though the injury pattern is the same in both halves, the tape application may have different effects if not reapplied during half-time. Another limitation of this study was the unidirectional nature of the simulated soccer match play; multidirectional simulation may have a different effect on the loosening of the tape, and therefore results might differ. Because the assessment of postural stability only took 3 seconds it was not seen to affect the effects of the intermittent exercise protocol. Future research might also consider experimental design features relating to the nature of the subjects used, the balance task, and the technique of tape application. Additional collection of electromyographic and kinematic data would enhance the understanding of the temporal pattern of changes in balance performance and stability.

Conclusion

Reaction time in response to system perturbation was observed to be more sensitive than CoG displacement to the duration of soccer-specific exercise. Both measures for postural stability indicated a decrease with longer exercise duration. The beneficial effect of tape in terms of increasing postural stability was observed only

during the initial stages of the exercise protocol. Any potential benefit of the tape was negated after 15 minutes of soccer-specific activity. The results from the current study demonstrate that ankle taping as a method to prevent ankle ligament sprains in healthy soccer players may only be effective during the first 15 minutes of a match.

Acknowledgment

No funding was received for the study.

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The *Journal of Sport Rehabilitation* (ISSN 1056-6716) is published four times a year (quarterly). Subscription fees are \$65 per year for individuals and \$325 per year for institutions.

The owner of the *Journal of Sport Rehabilitation* is Human Kinetics, Inc., whose office of publication is at 1607 N. Market St., Champaign, IL 61820-2200. The editor is Carl G. Mattacola, Division of Athletic Training, University of Kentucky, Lexington, KY 40536. There are no bondholders, mortgagees, or other security holders.

Average number of copies printed per issue (net press run) during the preceding 12 months is 840; number of copies nearest to filing date is 735. Average number of copies of each issue distributed after mass mailing to subscribers during the preceding 12 months is 12; number of copies nearest to filing date is 16. Average number of copies of each issue distributed in mass mailing to subscribers during the preceding 12 months is 566; number of copies nearest to filing date is 505. Average number of copies of each issue distributed free during the preceding 12 months is 46; number of copies nearest to filing date is 47.