Kinesiology tape mediates soccer simulated and local peroneal fatigue in soccer players

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Abstract

To investigate the efficacy of kinesiology taping in mediating the influence of fatigue on ankle sprain risk, twelve male soccer players completed single leg dynamic balance trials pre- and post-exercise (soccer-specific protocol, isokinetic ankle inversion/eversion protocol) in each of three counter-balanced taping conditions (no tape, zinc oxide tape ZO, kinesiology tape KT). Balance was quantified as the overall stability index (OSI) and directional stability indices of platform deflection. Soccer-specific fatigue only increased OSI in the no tape condition (P = 0.03), with ZO and KT trials negating a fatigue affect. Localised fatigue increased OSI in the no tape (P = 0.01) and ZO (P = 0.05) trials, with no increase in the KT trial. A similar pattern was observed in medio-lateral and anterio-posterior balance indices. Kinesiology tape mediates soccer simulated and local peroneal fatigue, with practical implications for epidemiological observations of increased injury risk during the latter stages of match-play.

INTRODUCTION

Ankle sprain injury is common in many sports, and exacerbated in those sports with a multi-directional and reactive activity profile. In an audit of soccer injuries, 54% of ankle sprain injuries were observed during tackle scenarios (Woods, Hawkins, Hulse & Hodson, 2003), but the 39% sustained during non-contact mechanisms offer the best scope for prevention. Hawkins et al. (1999) identified that an average of 14.6 days per season are lost due to injury in soccer, with a high re-injury rate and greater severity on reoccurrence. Twice as many ankle sprains were sustained in matches than training, and a disproportionately large proportion of match sprains were incurred during the latter stages of match-play (Woods et al., 2003), highlighting fatigue as a risk factor.

Fatigue is a complex phenomenon and has been categorised into central systemic (altered central nervous system transmission or recruitment) or local peripheral (impairment of functional transmission, muscle electrical activity and activation) fatigue (Kirkendall, Junge, & Dvorak, 2010). To investigate the influence of fatigue on the aetiology of injury, the exercise models must be valid as injury is commonly associated with mechanical load failure of tissue (Bahr & Holme, 2005). Soccer-specific exercise protocols based on the velocity profile of match-play can simulate the intermittent and irregular activity profile of soccer and have previously been used to quantify changes in functionally challenging movements such as balance and agility (Greig, 2009; Greig & Walker-Johnson, 2007; Lohkamp et al., 2009). Local, peripheral fatigue has typically been modelled using isokinetic dynamometry trials (Lin, Lin, Tsai, & Ling, 2008; South & George, 2007), targeting the contribution of peroneal latency to inversion control (Gribble, Hertal, Denegar, & Buckley, 2004).

The influence of fatigue on injury risk has been attributed to diminishing neuromuscular control and proprioception accuracy (Gurney, Milani, & Pederson, 2000), providing a focus for preventive strategies. The importance of preventative measures to potentially decrease ankle injury incidence and recurrence in sport have been well documented (Fong, Hong, Chan, Yung, & Chan, 2007). Ankle injury prevention has been given considerable attention with strategies often incorporating traditional taping methods (e.g. Raymond, Nicholson, Hiller, & Refshauge, 2012; Stryker, Di Trani, Swanik, Glutting & Kaminiski, 2016) to decrease biomechanical joint range of movement (ROM) or to stimulate kinaesthetically through cutaneous mechanoreceptors (Verhagen & Bay, 2010). More recently the potential of kinesiology tape has been explored in promoting proprioception and neuromuscular activation, both as a preventative measure (Briem, Eythorsdottir, Magnusdottir, Palmarsson, Runarsdottir, & Sveinsson, 2011) and as a treatment modality (Simon, Garcia & Docherty, 2014; Szymura, Maciejczk, Wiecek, Maciejczyk, Wiecha, & Ochalek, 2016). It is commonly proposed that cutaneous stimulation promotes joint stability and muscle activation, however the type of tape and the application influence the efficacy (Thedon, Mandrick, Foissac, Mottet & Perrey, 2011; Csapo & Alegre, 2015; Trecroci, Formenti, Rossi, Esposito & Alberti, 2015). The aim of the current study was to determine if taping offers the potential to mediate the negative effects of fatigue on balance performance, with practical implications for players and medical practitioners based on ankle sprain epidemiology.

MATERIALS AND METHOD

Participants

12 male semi-professional soccer players (age 21.6 ± 0.7 years; height 181.6 ± 9.3 cm; body mass 76.7 ± 5.2 kg; fat mass 10.8 ± 1.7 kg), participated in the present study. All players were contracted to play for clubs competing in tier 5 or 6 of the English Football Association. All testing was conducted following a 6 week pre-season period, and in the 3 weeks prior to the commencement of the competitive season. Inclusion criteria required that all players were currently completing a minimum of two club training sessions and one match per week to ensure standardisation of physical status. Additional criteria required that players were injury free in the previous 3 months, and specifically free from ankle and knee injury in the previous 6 months. Players who exhibited neurologic or balance disorders, or chronic ankle instability as determined by the Cumberland Ankle Instability Tool were excluded from the study. Players with skin allergies were also excluded from participation. This excluded an initial 8 participants recruited. Participants were fully informed of the demands and

possible risks associated with the investigation and were given the opportunity to withdraw from the study at any time. All tests were carried out at between 14:00 to 16:00 h to negate circadian influences, and in accord with regular competition time. Each participant provided written informed consent prior to the study. The study conformed to the standards set by the Declaration of Helsinki and was approved by the Institutional ethics committee (Harris & Atkinson, 2013).

Experimental Design

Participants completed a single legged balance task on the Biodex Stability System (BSS) at Level 2. The BSS has 8 levels, with Level 8 providing the most stable surface, and thus Level 2 was chosen as a functionally challenging level of stability for these participants. Testing was conducted on the dominant leg, defined as the preferred kicking leg (Hawkins et al., 1999) as epidemiological data suggests a higher incidence of injury to this side (Woods et al., 2003). Balance trials were completed pre- and post-exercise, with two exercise protocols being used. Three taping conditions were used in the current study, such that each player completed a total of six experimental conditions. The taping (3) and exercise protocol (2) conditions were order effect counter-balanced and randomised in delivery, and separated by a minimum of 72 hrs, with testing completed over a 3 week period. Single leg balance performance on the BSS task was quantified as overall stability index (OSI), and further sub-divided into the directional components of medial/lateral (ML) and Anterior/Posterior (AP) balance. Prior to experimental trials, participants attended the laboratory to complete familiarisation sessions on both exercise protocols and the BSS task. Baseline, pre-exercise scores for BSS task performance were also attained in each tape condition.

The three taping conditions used in the present study are categorised as a no-tape, control condition (NT), zinc oxide tape (ZO), or kinesiology tape (KT). In the ZO condition, a traditional taping anchor and 3 stirrups method was used, designed to provide lateral ligament support (Figure 1a). In the KT condition (RockTape, Essex, UK), designed for muscle facilitation application of the peroneals, I strip, after the initial resting position, 50% stretch was applied with the patient in dorsiflexion and eversion when taping post anchor application proximal to distal (Figure 1b), in accordance with KT® guidelines (Kase, Wallis, & Kase, 2003). With both taping techniques the area was shaved and prepared prior to application and the procedure for tape activation and removal was also adhered to (Kase et al., 2003). The same appropriate footwear was worn for each session, reducing the surface interaction effect.

** Insert Figure 1 near here **

The exercise protocols used in the present study were categorised as a 'soccer simulated,' soccer-specific treadmill protocol (Greig et al., 2006) and a 'local' isokinetic ankle inversion-eversion protocol (South & George, 2007). The 'soccer simulated' fatigue protocol is based on the notational analysis of soccer match-play, and has previously been utilised in conjunction with the BSS task (Greig & Walker-Johnson, 2007). A 45min period of irregular and intermittent running was completed, replicating the 1st half of a soccer match, on the basis that tape would be re-applied during the half-time period. The 'local' fatigue protocol comprised 3 sets of 30 repetitions of isokinetic ankle inversion/eversion at $60°\cdot s^{-1}$, with a 10 sec rest applied between sets. This protocol design has previously been used to induce fatigue within the peroneal muscle group, defined as when performance reached 50% of the subjects pre exercise peak torque (South & George, 2007).

Statistical Analysis

A two-factor (tape x exercise protocol) general linear model with repeated measures was used to compare between trials, supplemented with values of effect size (ES) to provide a measure of meaninglfulness. The assumptions associated with a repeated measures general linear model (GLM) were assessed to ensure model adequacy. To assess residual normality for each dependant variable, q-q plots were generated using stacked standardised residuals. Scatterplots of the stacked unstandardized and standardised residuals were also utilised to assess the error of variance associated with the residuals. Mauchly's test of sphericity was also completed for all dependent variables, with a Greenhouse Geisser correction applied if the test was significant. The aforementioned measures did not violate any of the assumptions, therefore inferential analyses were performed. Inferential analyses were performed using a repeated measure general linear model (GLM) to examine differences in the physical response between the speed, limb and contraction over time. Where significant main effects were observed, post hoc pairwise comparisons with a Bonferonni correction factor were applied. All statistical analysis was completed using PASW Statistics Editor 22.0 for windows (SPSS Inc, Chicago, USA). Statistical significance was set at P ≤ 0.05. Statistical significance was set at $P \leq 0.05$, and all data are presented as mean ± standard deviation.

RESULTS

Figure 2 summarises the influence of tape condition and exercise protocol on the overall stability index (OSI). Pre-exercise, and relative to the control condition (1.75 ± 0.35), both the ZO (1.39 ± 0.31, $P = 0.13$, ES = 1.06) and KT (1.30 ± 0.34, $P = 0.08$, ES = 1.32) interventions had a positive, but non-significant effect on OSI relative to the control condition. There was no statistically significant distinction between the taping interventions. The soccer-specific fatigue protocol had a significant detriment on OSI only in the control condition (2.14 ± 0.59, P = 0.03, ES = 0.98) relative to pre-exercise measures. The localised fatigue protocol produced a significant increase in OSI in both the control (2.93 ± 0.76, P = 0.01, ES = 1.55) and ZO (2.14 ± 0.69, P = 0.05, ES = 1.09) trials relative to baseline.

** Insert Figure 2 near here **

A similar temporal pattern was observed in both the anterio-posterior (Figure 3) and medio-lateral (Figure 4) directional indices of balance. In the anterio-posterior plane, the soccer-specific protocol only produced a significant increase in API in the control condition (P = 0.05, ES = 0.80), whilst the localised fatigue protocol significantly increased API in the control (P = 0.04, ES = 0.87) and ZO trials (P = 0.05, ES = 0.72). MLI was not significantly influenced by the soccer-specific trial, but the localised protocol induced a significant increase in the control (P = 0.02, ES = 1.42) and ZO (P = 0.05, ES = 1.31) trials.

** Insert Figure 3 & 4 near here **

DISCUSSION

Kinesiology tape demonstrated the potential to mediate a fatigue-effect observed in balance performance following both localised and soccer-specific exercise protocols. The KT application was also significantly better than the ZO application following localised fatigue, indicative that the ergogenic effect is greatest where needed the most. During the localised fatigue protocol an increased load is applied directly through the ankle complex, in comparison to the load distribution within the lower body during the soccer-specific running protocol. These findings have implications for injury prevention given the epidemiological observations of increased ankle sprain incidence during the latter stages of soccer match-play (Woods et al., 2003). However, the mediation of fatigue in the current study is contrary to that observed in some contemporary research, although direct comparisons should be treated with caution due to methodological differences, not least the target joint and taping application. For example, Zanca et al. (2015) reported that kinesiology tape application did not improve shoulder JPS acuity following repeated elevation in the scapular plane. Aarseth et al. (2015) also showed reduced JPS acuity at 90° of elevation, but showed no impairment at 50° or 110°, suggesting an angle-specific influence. In lumbar extensor muscular endurance tests, Alvarez-Alvarez et al. (2014) did observe improved time to failure with kinesiology tape application in healthy subjects, whilst Hagen et al. (2015) observed an improvement less than measurement error in patients with low back pain. The literature to date is thus equivocal, and efficacy is likely to be a function of a myriad of experimental design features including joint, exercise intervention, taping application, and outcome measure.

The mechanistic underpinning for the mediating benefits of KT may be due, in part, to the adhesive properties of the tape which create a positive thermal and tactile effect. Thedon et al. (2011) suggested that impaired postural performance might be compensated by increased skin stimulation via kinaesthetic stimulation of the cutaneous mechanoreceptors. Simoneau et al. (1997) associated this cutaneous receptors stimulation with enhanced motor activity, joint stability and muscle facilitation. The peroneal musculature has a primary role in ankle eversion, assisting plantar flexion, and thus the KT peroneal muscle facilitation application creates a multi-planar cutaneous benefit. This has been postulated to be attributable to altered speed and duration of peroneal activation (Wilkerson, 2002). Due to the anatomical position of the peroneals, the tape passes on to the sole of the foot, containing the subcutaneous receptors, and influencing the neuromuscular control of the whole kinetic chain due to the contribution to the control of stance and locomotion (Inglis et al., 2002). KT might assist in stimulation of these receptors to assist the kinetic chain generally, and ankle kinematics, as has previously been observed at the shoulder (Hsu et al., 2009).

Traditional taping has commonly been used as a preventative intervention, but in the present study ZO did not mediate local fatigue, with significant impairment in balance performance post-exercise. This finding is consistent with the majority of studies, suggesting a 50-90% decrease in support after application in a variety of sports due to moisture accumulation weakening the tape and the mobility of skin decreasing the taping efficacy over time (Delahunt, O'Driscoll, & Moran 2009; Tregouet, Merland, Horodyski, 2013). In contrast, ZO did mediate API and MLI after the soccer-specific protocol might be indicative that tape application assists joint restriction creating a reduction in inversion amplitudes and angular velocities whilst allowing joint protection through reflex responses under load (Delahunt et al., 2009; Hubbard & Cordova, 2010).

These results indicate that kinesiology taping in healthy participants can mediate fatigue, potentially as a preventative method to reduce the rate of peroneal latency and subsequent ankle inversion injury risk. However, it must be considered that the findings of the present study should not be generalised beyond the specific population, fatigue protocols, and taping interventions used. The participants were selected so as to be appropriate to the chosen soccer-specific fatigue protocol. This protocol has previously been shown to induce changes in dynamic balance (Greig & Walker-Johnson, 2007), but alternate free running protocols might be considered to pose a more functionally valid simulation given the multi-directional nature of soccer locomotion. Soccer-specific activities such as kicking, turning, and tackling are negated in such experimental protocols in order to attain greater experimental control, but their influence is worthy of consideration given their association with ankle sprain injury mechanism. Extending the exercise protocol to 90mins would also enable an investigation into the efficacy of kinesiology tape for the duration of a soccer match, and help inform strategy in terms of optimum application. Acknowledging limitations including confounding and extrinsic factors, future studies should consider the tape application influence on chronic and functional ankle instability, movement dynamics and altered loading. Study designs might also be developed to contrast the application of KT with other prevention programs and proprioception exercises. Limb dominance might be an additional variable worthy of analysis, given epidemiological observations of bi-lateral variation in incidence (Woods et al., 2003).

In conclusion, both traditional zinc oxide and kinesiology taping applications were observed to negate a fatigue-effect in dynamic stability following 45mins of soccer-specific activity. Kinesiology tape was also able to significantly reduce the influence of fatigue localised to ankle inversion-eversion. In terms of practical implications, if KT can act as a preventative strategy without joint restriction or biomechanical change the application needs to be considered as an alternative to current and widely used traditional taping methods in ankle inversion prevention. Equivocal findings across an expanding literature base have yet to fully determine the biomechanical and physiological mechanisms of the potential benefits to performance.

ACKNOWLEDGEMENTS

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LEGEND TO FIGURES

Figure 1. Application of the ZO and KT interventions.

Figure 2. The influence of tape condition on the fatigue response in Overall Stability.

Figure 3. The influence of tape and trial type on the Anterio-Posterior balance index.

Figure 4. The influence of tape and trial type on the Medio-Lateral balance index.

Figure 1. Application of the ZO and KT interventions.

338x190mm (96 x 96 DPI)

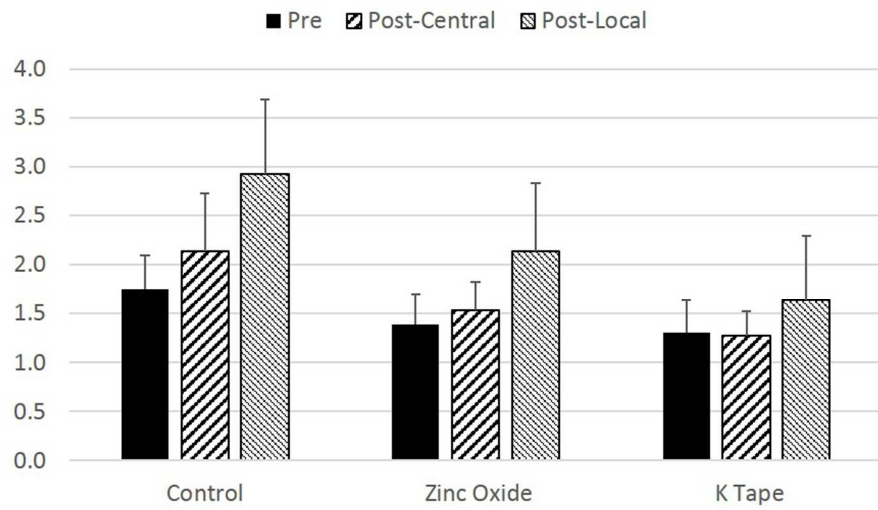

Figure 1. The influence of tape condition on the fatigue response in Overall Stability.

Figure 2. The influence of tape condition on the fatigue response in Overall Stability.

166x103mm (150 x 150 DPI)

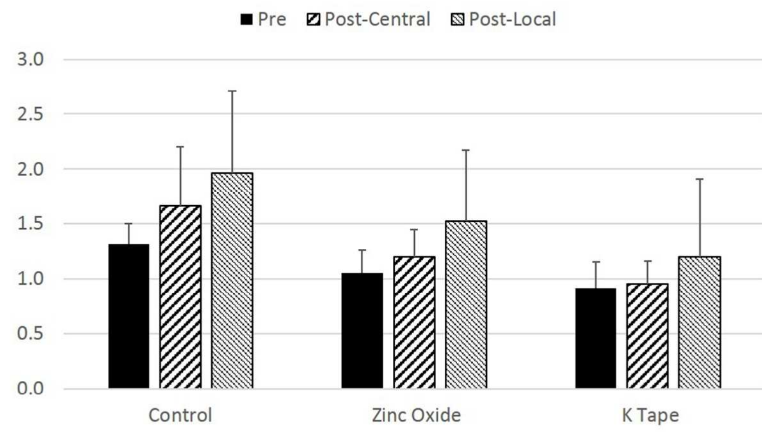

Figure 2. The influence of tape and trial type on the Anterio-Posterior balance index.

Figure 3. The influence of tape and trial type on the Anterio-Posterior balance index.

199x100mm (150 x 150 DPI)

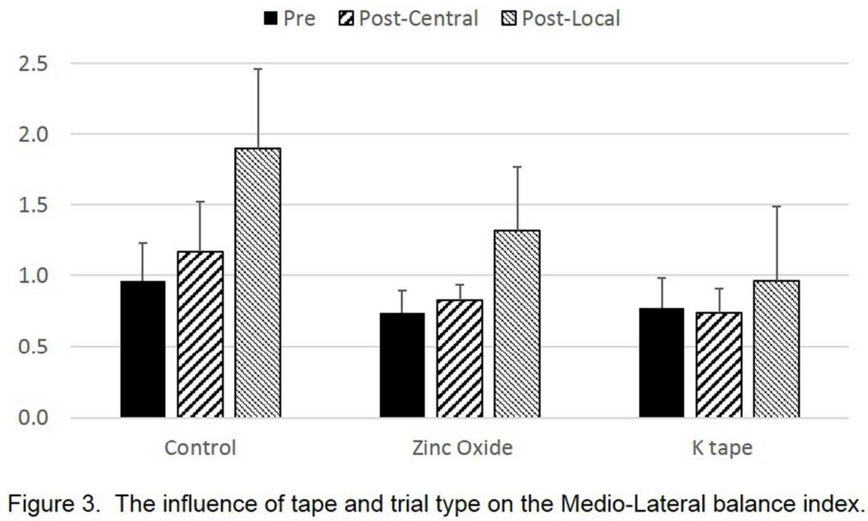

Figure 4. The influence of tape and trial type on the Medio-Lateral balance index.

176x96mm (150 x 150 DPI)

Response to Review 1:

Many thanks for the comments and feedback to the revised manuscript submission. We greatly appreciate the opportunity to improve the quality of our submission, and its usefulness to the readers. In particular the suggestion of additional citations we found particularly helpful.

There follows a summary of revisions made to the manuscript in response to Reviewer 1, and changes on the revised manuscript are highlighted in red font for clarity and ease of review. Of note the inclusion of new references has changed the numerical ordering, and this has been amended throughout the manuscript.

Suggested references have been reviewed and integrated within the revised manuscript (main body of text). We have also updated the reference list as stated above.

Acute effects of kinesio taping on a 6 s maximal cycling sprint performance, Athos Trecroci, et al., 25(1):48-57, 2017 | DOI: 10.1080/15438627.2016.1258644
In Text p3 L6
Reference 29

Effects of kinesio taping on anaerobic power recovery after eccentric exercise, Jadwiga Szymura, et al., 24(3):257-268, 2015 | DOI: 10.1080/15438627.2016.1202827
In Text p3 L3
Reference 26

Assessing performance, stability, and cleat comfort/support in collegiate club soccer players using prophylactic ankle taping and bracing, Sean M. Stryker, et al. , 24(1):39-53, 2016 | DOI: 10.1080/15438627.2015.1126274
In Text p2 L21
Reference 27

In addition, and upon reflection of previous comments, we have also slightly amended the manuscript in relation to the tape application, we hope to further increase clarity for the reader.
Amended p5 L3