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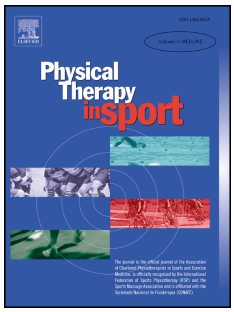

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The efficacy of elastic therapeutic tape variations on measures of ankle function and performance

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Abstract

Objectives: To investigate the effects of different variations of elastic therapeutic taping (ETT) on tests used to screen for ankle injury risk and function. **Design**: Randomised crossover. **Setting:** Laboratory. **Participants:** Twelve professional male soccer players completed three experimental trials: No tape (NT), RockTape™ (RT), and Kinesio™ Tape (KT) applied to the ankle complex. **Outcome Measures:** Clinical and functional ankle screening tests were used to assess the effects of ETT on measures of joint position sense, postural stability and ground reaction forces**. Results:** KT ($P = 0.04$) and RT ($P = 0.01$) demonstrated significant improvements in end range joint position sense. When compared to NT, RT significantly ($P = 0.02$) improved mid-range joint position sense at 15°, and time to complete a drop landing task. No significant differences were observed for measures of postural stability ($P \geq 0.12$) nor ground reaction force variables ($P \geq 0.33$). **Conclusions:** Results advocate the use of ETT for proprioceptive and functional tasks when applied to the ankles of healthy male soccer players. However, a greater number of practical and significant differences were observed when RT only was applied, indicating that practitioners may potentially advocate the use of RT for tasks requiring proprioception and functional performance.

Key Words: Kinesio™ Tape; Kinesiology; RockTape™; Screening

INTRODUCTION

The ankle is involved in approximately 30% of all sports related injuries, making it amongst the most frequently injured joints during athletic activity (16). Sprains are the most frequently occurring ankle injury, with up to 85% involving the lateral ligament complex (16). These injuries generally occur when the foot is placed into excessive plantarflexion and inversion (16). Additionally, ankle sprains are associated with particular chronic injuries including ankle instability and osteoarthritis (14). Literature has proposed several modifiable risk factors for initial ankle sprains, including; isokinetic strength (19), joint position sense (6, 20, 28), postural stability (32) and functional movement (20). Subsequently, the screening of risk factors has become common practice in the assessment of ankle joint function, with a variety of tests used to replicate the multifactorial nature of ankle injury occurrence (5).

Adhesive rigid tapes or ankle braces have often been used in an attempt to reduce ankle injury incidence (15, 29, 33, 36), via mechanical restriction of ankle range of motion (11). However, results surrounding the effectiveness of traditional taping do not support its use in reducing ankle injury incidence in healthy populations (29, 36) or when compared to other intervention such as low top shoes and ankle semi-rigid braces (29, 33, 36). Traditional white tapes have also been shown to negatively affect vertical jump performance and tasks which require plantarflexion (8, 36). When applied to the ankle complex, studies have demonstrated white tape to potentially enhance injury risk at anatomical locations more proximal in the kinetic chain, due to excessive unnatural talocrural joint movement restriction and altered knee joint kinematics during functional tasks (36). Furthermore, traditional white tapes have also been shown to lose their effectiveness after as little as 15 minutes of soccer-specific activity, thus questioning their use in a sporting context (17).

Elastic therapeutic tape (ETT) differs to that of adhesive rigid taping, as it purports to support and stabilize the ankle joint, without the restriction of joint motion (18). The most commonly researched ETT is Kinesio™ Tape (KT). Kinesiology tape is made from 100% cotton, latex free, elastic and heat-activated adhesive tape, designed to mimic the elasticity of a healthy muscle, allowing for a stretch of up to 140% of its original length. The ability for the KT to increase in stretch is purported to exert a pulling force to the skin (18), providing greater mechanical support and proprioceptive ability via stimulating mechanoreceptors and muscle activation patterns (34). Kinesiology tape has been reported to improve athletic performance via various methods including, enhanced proprioception, increased muscle activation, improved muscle strength, alteration of perception of exercise and pain alleviation (23). When compared to traditional white tapes, KT has demonstrated inconclusive findings, for example, in one study postural stability was shown to be improved following a of localized fatigue protocol (13), whereas another study identified limited tape application benefits in relation to fibularis longus activity during sudden inversion perturbation (9). Furthermore, equivocal findings have been reported regarding range of motion (2, 37), strength (2, 29) proprioception (6, 18, 21, 27) postural stability (15, 32) and functional performance (8, 32). Additionally, systematic reviews (7, 30 39) have identified no significant clinical effects when KT is applied, whilst highlighting a lack of high standard randomized clinical trials to support the proposed benefits of KT.

The popularity of ETT amongst practitioners has led to different variations such as RockTape™ (RT) being manufactured. RT alleges to have a greater degree of stretch (~180%) and a superior adhesiveness when compared to other ETTs (26). However, to date, limited studies have investigated the effectiveness of RT (28), with no studies comparing the efficacy of different variations of ETT. Due to the limited and equivocal nature of previous research, it is necessary to determine the efficacy of different variants of ETT on

multifactorial tests designed to replicate the diverse and complicated etiological mechanisms of ankle injury occurrence. It was hypothesized that ETT would significantly improve ankle joint performance during specific screening tasks when compared to the NT condition. A secondary hypothesis stipulated that the magnitude of performance improvement would vary dependent upon the variation of ETT used, with RT hypothesized to provide increased magnitudes of improvement due to the increase in stretch afforded and greater adhesive properties of the acrylic part of the tape, when compared to KT.

METHODS

Experimental Approach to the Problem

This current study consisted of a repeated measures design to investigate the effects of different variations of elastic therapeutic tape (KT and RT) and no tape (NT) on tests, designed to examine ankle function and performance. The battery of tests comprised of dynamic postural stability (Overall Stability Index), ankle joint position sense at 15 (Θ_{15}) and maximum inversion minus 5 degrees (Θ_M) and a reactive drop landing task including measures of time taken to complete the task (T) and kinetic parameters in the form of the magnitude ($\dot{F}xy$) and take-off vector (Θ). The dependent variables, were chosen from existing and contemporary literature, which has analyzed measures of performance shown to influence ankle injury risk factors.

Subjects

An *a priori* power calculation from pilot study data identified a maximum predicted sample size of n = 12 for dependent variables OSI, Θ and $\dot{F}xy$ to evaluate a condition main effect (statistical power > 0.8; $P < 0.05$), all other variables required a sample size of < 12. Consequently**,** twelve male professional soccer players (age = 25.5 ± 5.0 years, height =

1.75 ± 0.12m, body mass = 74 .50 ± 8.25 kg) were recruited to complete the study. Playing positions were defined as: defender (n=4), midfielder (n=5), forwards (n=3). Inclusion criteria required players to be contracted to the same professional soccer club, have no injury history in the lower limb for the previous six months, and no neurologic or balance disorder or chronic ankle instability as determined by the Cumberland Ankle Instability Tool (CAIT) (20). The study was approved by the appropriate University Research Ethic Committee in which it was performed and conformed to the Declaration of Helsinki. Written informed consent was provided by all participants before the start of data collection.

Procedures

Subjects attended the university laboratory on four occasions to complete a familiarization trial, followed by three experimental trials (NT, KT and RT), completed in a randomized order. A minimum of 48 h interspersed all trials. The familiarization and experimental trials consisted of the completion of all tasks according to their specific guidelines. All experimental tests were completed in a standardized order, interspersed by a minimum of 5 minutes to avoid the accumulation of fatigue. At the relevant testing session, either KT or RT was applied by a KT and RT qualified practitioner, according to guidelines (23). To remove participant bias, the same color of KT and RT was applied, with all branding removed from the ETT. All trials were completed at the same time of day, (12:00 h) to avoid any variation due to circadian rhythms. Subjects attended the ambient temperature controlled laboratory in a 3-hour post-absorptive state following 24 hours abstinence from alcohol, caffeine and vigorous exercise, wearing the same light weight athletic clothing and footwear. Prior to the completion of each testing sessions, subjects undertook a ten-minute standardized warm up protocol consisting of multi-directional running drills and dynamic flexibility stretches of the lower limb muscles.

ETT Application

All ETT application preparation conditions were followed according to kinesio taping guidelines (23). Subjects were taped using a corrective application technique (see Figure 1) in accordance with application guidelines (18), by a certified kinesio taping practitioner. The subject lay supine on a plinth, with the first strip of tape placed from the anterior mid foot stretched over the tibialis anterior at approximately 115-120% stretch of its maximal length, attaching distal to the anterior tibial tuberosity. The degree of stretch was determined according to the expertise of the practitioner using guidelines outlined by Kase et al (17) regarding maximal available stretch (100%) being 40% of the overall KT length. Subsequently, to achieve a 120% stretch of maximal ETT length, a 10cm strip would result in ETT length being 10.8cm for application. The 20% manual stretch was applied only to the middle third of the ETT strip, with no tension applied at the ends (23). The second strip began proximal to the medial malleolus, wrapping around the heel like a stirrup, attaching lateral to the first strip of tape. The third strip stretched across the anterior ankle, covering both the medial and lateral malleolus. Finally, the fourth strip originated at the arch and stretched slightly, measuring 5 inches above both the medial and lateral malleolus. At this point testing was delayed for a period of 25 minutes to allow the tape to gain its full adhesive strength (26).

Insert Figure 1 around here

Ankle Joint Position Sense (JPS)

Joint position sense is the most commonly used test to assess proprioception in most body regions (27). Ankle joint proprioception demonstrates clinical relevance as its decrease is

associated with an increased ankle sprain incidence, whilst also being crucial for rehabilitation treatments (24). JPS was assessed using an isokinetic dynamometer (IKD) (Biodex Medical System 2, Shirley, New York), with all subjects positioned in accordance with manufacturer guidelines. To reduce all feedback other than internal proprioception, subjects were blindfolded whilst the barefoot of the dominant limb was aligned with axis of the dynamometer and attached to the footplate by a small wrap (28). Subjects were permitted three familiarization trials for this test (28). Two target positions were tested, 15° of inversion (θ_{15}) and maximal active inversion minus 5 degrees (θ_M), with three repetitions interspersed with 30 seconds rest provided. Subjects were passively moved into the desired target position for a period of 5 seconds, before being passively returning to anatomical neutral. The participant then actively moved their dominant foot to what they perceived to be the desired testing position at which point they pressed a stop button. Absolute error scores were recorded as the difference between the actual position the subject is asked to achieve and the position they move their ankle to when asked to replicate the original position.

Biodex Stability System (BSS)

The Biodex Stability System (BSS) (Biodex Medical Systems, Shirley, NT, USA) is a popular method of assessment (3), evaluating measures of postural stability, moving in anteroposterior (AP), mediolateral (ML) and overall direction (OSI) (4). Subjects stood on their dominant barefoot whilst centering a visual stimulus on an electronic screen directly in front of them, upon which the subject's foot co-ordinates (vertical and horizontal) were recorded and inputted into the BSS. During the familiarization laboratory visit, participants were permitted five practice trials to familiarize themselves with the test (4) For the current study, the BSS was set to an unstable level 2 setting (34), with participants asked to maintain their balance on their dominant foot for a period of 10 seconds. During data collection, one

training test was provided to minimize a potential learning effect, followed by three consecutive trials with 10 s rest between each test provided. The mean of the three tests was calculated and considered the result (4). The BSS was utilized to objectively record and evaluate Overall Stability Index (OSI), which is a function of the variance of platform displacement in both the A/P and M/L planes of movement.

Drop Landing

Subjects were required to step off and land on the dominant barefoot from a 35cm high platform, positioned to ensure landing was centered on the force platform (Bertec, Columbus, USA) (10). Upon landing players were required to react to a light stimulus, triggered by subjects moving through an infra-red beam and accelerate through a set of timing gates (SmartSpeed, Fusion Sport, Australia) positioned at a 45° cutting angle from the mid-line of the force platform, at a distance of 4m. During the familiarization visit, subjects completed 5 trials of the previously discussed task. For right footed dominant subjects, the inversion trial was recorded when the stimulus required them to respond to a 45° cut to their left, as this placed them into a position of plantarflexion and inversion. Eversion trials required subject to respond to a 45° cut to their right. Inversion and eversion trials were counter-balanced, with 5 mins passive recovery between trials. A full description of the protocol has been previously reported (10).

Performance was quantified as the time taken to complete the task (T). Kinetic measures at a sampling frequency of 1000 Hz enabled the magnitude ($\dot{F}xy$) and angle of the takeoff vector (θ) to be determined. Resultant ground reactions forces were then normalized to individual body weights (BW).

Statistical Analyses

Statistical analysis was completed using PASW Statistics Editor 22.0 for windows (SPSS Inc., Chicago, IL USA). A 3x1 repeated measure ANOVA was used to investigate the effects of ETT for each variable. Assumptions associated with a repeated measures general linear model (GLM) were assessed and verified to ensure model adequacy. Q-Q plots were generated using stacked standardised residuals to assess residual normality for each dependent variable. Additionally, using standardised and unstandardised residuals, scatterplots were generated to assess the error of variance associated with residuals. Furthermore, Mauchly's test of Sphericity was also assessed for all dependent variables, with a Greenhouse Geisser correction applied if the test was deemed significant. Where significant main effects were observed, post hoc pairwise comparisons with a Bonferonni correction factor were applied. Between session reliability was assessed using Intraclass correlation coefficients (ICC), from which standard error of measurement (SEM) and the smallest change in participant scores that can be detected beyond random error known as minimal detectable difference (MDD) were calculated.

All data is reported as mean ± SD unless otherwise stated. For all significant interactions, 95% confidence intervals (CI) Cohen's *d* effect sizes (< 0.50 = small, 0.50 – 0.80 = small to moderate, > 0.8 = large) are reported.

RESULTS

Ankle Joint Position Sense

Θ_{15} demonstrated a significant main effect for taping condition (RT = 1.94 ± 0.73°; NT = 2.85 ± 0.65°; P = 0.02; 95% CI -1.59 to -0.15; *d* = 1.59; MDD = 0.75), with RT demonstrating significantly lower absolute error scores when compared to the NT condition. There was no significant difference (P = 0.47) between the two taping conditions (KT = 2.31

± 0.59°). Similar trends were observed for $\Theta_{M,}$ with significantly lower absolute error scores identified for both RT (1.57 ± 0.72°; P = 0.01; 95% CI = -1.92 to -0.32°; *d* = 1.68; MDD = 0.72) and KT (1.89 ± 0.55°; 95% CI = -1.55 to – 0.49; *d* = 1.60; MDD = 0.80) when compared to the NT condition (2.69 ± 0.86°). No significant differences were observed between the two taping conditions (P = 0.71). Intra Class Correlation (ICC) scores of 0.87 and 0.89 were recorded for θ_{15} and θ_M respectively, demonstrating excellent levels of reliability

Postural Stability

As highlighted in Table 1 OSI demonstrating no significant (P = 0.32) condition effect, indicating that ETT application neither hindered nor improved performance during this task (KT = 1.06 ± 0.30°; NT = 1.09 ±0.38°; RT = 1.10 ± 0.29°). Similar observations were noted for measures of AP (P = 0.37) and ML (P = 0.12), with both indices demonstrating no significant condition effects. Intra Class Correlation (ICC) scores of 0.89 were recorded for OSI, demonstrating excellent levels of reliability

Drop Landing

Functional drop landing task results are highlighted in Table 1. Time taken to complete the drop landing task (TTC), illustrated a significant (P = 0.02) main effect for condition, with RT (1.47 ± 0.16 s; 95% CI = -0.15 to -0.01; *d* = 0.58; MDD = 0.16) demonstrating significantly less time to complete the task when compared to the NT condition (1.66 ± 0.12 s). No significant difference (P = 0.10) was observed between the two taping conditions (KT = 1.58 ± 0.14 s). Other reported measures for the drop and drive landing task Θ (P = 0.33) and Ḟxy (P = 0.67) demonstrated no significant main effects for condition. Good to excellent

(ICC = 0.86 – 0.97) levels of reliability were recorded for the analysed measures during the drop and drive task

Insert Table 1 around here

DISCUSSION

The purpose of this study was to investigate the relative efficacy of different variations of ETT on multifactorial tests designed to examine ankle function. ETT in the form of RT and KT demonstrated significant and beneficial improvements in measures of proprioceptive performance, when compared to NT. JPS was used as the primary measure as it has been shown to be the most commonly used test to assess proprioception in most body regions (27). Previous research surrounding proprioceptive tasks has produced equivocal findings (6, 22, 35). This may be due to the variety of proprioceptive tasks available for researchers to select from, making it difficult to compare results across studies (7). The results are however similar to previous findings conducted using similar methods (22, 35), demonstrating proprioceptive performance to improve when ETT is applied. The authors hypothesize that the application of ETT stimulated skin cutaneous receptors and mechanoreceptors within tendons, ligaments and the joint capsule of the ankle (35). This increase in stimulation could help to provide elevated levels of afferent input to the central nervous system, subsequently improving the ability of the subjects to accurately replicate the desired joint position. Practically, an increase in afferent feedback would beneficial for athletes and practitioners. If athlete proprioceptive awareness is improved in a healthy population via the application of ETT it may allow the body to better determine joint position sense, potentially improving athletic performance and enabling improved detection before the body progresses to positions which predispose it to

greater aetiological risk of injury. Furthermore, ETT could also be potentially used with injured subjects, to help the body better determine its proprioceptive awareness.

During postural stability tasks, no significant improvements in performance were detected for postural stability variables measured during the BSS task. These findings disagree with previous literature (34) that has demonstrated improvements in OSI when KT was applied to semi-professional rugby union forwards when compared to backline positions. Backline players in rugby possess similar physical attributes as soccer players (31). Subsequently, soccer players may not achieve improved performance in functional skills such as postural stability through the application ETT, due to the superior attributes they already possess when compared to other sports (25) and the general population. Practical implications of these findings suggest that within this particular healthy population, it may be difficult to further improve postural stability levels, subsequently implying that strength and conditioning sessions could focus on areas which have greater scope for improvement

When compared to the NT condition, RT was the only variation of ETT to display improved performance during the proprioceptive (Θ_{15}), and time to complete task (T) drop landing test. ETT brands are developed from cotton, polyurethane synthetic fibres and hypoallergenic thermoactive acrylic adhesives. However, variations in ETT exist due to differences in the manufacturing process, with manufacturers claiming that their materials enhance both tension and the adherence to skin, to provide greater tissue stimulation. Improved performance during proprioception tasks may be a result of RT purporting to possess improved adhesive qualities when compared to KT. This increase in skin adhesion is alleged to produce enhanced proprioceptive capabilities via the stimulation of skin cutaneous mechanoreceptors (18). This greater degree of adhesion could allow RT to provide increased tactile contributions, creating a greater awareness of ankle joint position and improving subject proprioception, which is

believed to optimally align joints and improve range of motion (1, 8). If RT application helps to properly align the ankle joint, practitioners could expect improved coordination and movement (27), thus reducing the time taken to complete (T) the drop landing task, whilst also improving measures of proprioception and postural stability.

When examining the secondary hypothesis, data from the current study suggests that RT produced significantly improved performance when compared to KT during proprioceptive (Θ_{15}) and time taken to complete the drop landing task. Furthermore, during end range proprioceptive tasks (Θ_M), RT was the only ETT to exceed the MDD, suggesting that it exceeded the minimum amount of change required to exist between independently obtained scores for the change to be deemed significant. The authors hypothesise that this may be a result of the different adhesive properties used by RT when compared to KT. These findings suggest that in a healthy trained soccer population, medical and performance staff may potentially advocate the use of RT instead of KT during proprioceptive and functional performance as RT appears to facilitate greater and more practical improvements. It should also be noted that, neither variation of ETT demonstrated inhibitory effects when applied to a healthy ankle joint, suggesting that sport support staff can recommend the use of ETT with confidence that athletic performance will not be impaired.

Future research should investigate the effects of different brands of ETT in comparison to traditional white tapes when conducting tasks associated with aetiological risk factors. This would further provide practitioners with a greater depth of knowledge as to which if any form of taping intervention could be used to potentially reduce injury incidence and improve athletic performance.

PRACTICAL APPLICATIONS

ETT helped improve performance across a range of clinical and functional tests, highlighting potential implications for injury prevention and management in a healthy male soccer population. The current data identified that RT was the only brand of ETT to both significantly and practically improve performance during proprioceptive and functional performance tests, suggesting that medical practitioners and applied sports science staff may potentially advocate the use of RT for tasks requiring these measures.

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FIGURE LEGENDS

Figure 1: Application of ETT to the ankle joint

Table 1: Ankle Performance Results

Table 1: Ankle Performance Results

PREDICTOR OF PERFORMANCE	KT	RT	NT
Θ_{15} (ABSOLUTE ERROR°)	2.31 ± 0.59	1.94 ± .0.73* CI -1.68; -0.147 *d* = 1.59	2.85 ± 0.65
Θ_{M} (ABSOLUTE ERROR°)	1.89 ± 0.55* CI = -1.55, -0.49 *d* = 1.60	1.57 ± 0.72* CI = -1.92, -0.32 *d* = 1.68	2.69 ± 0.86
OSI (A.U.)	1.04 ± 0.30	1.16 ± 0.29	1.03 ± 0.32
TTC (S)	1.58 ± 0.14	1.47 ± 0.16* CI = -0.15 to -0.01 *d* = 0.58	1.66 ± 0.14
Θ (°)	57.86 ± 13.41	57.94 ± 18.28	52.86 ± 16.30
$\dot{F}_{XY}$ (BW)	2.35 ± 0.62	2.43 ± 0.69	2.19 ± 0.66

*****Denotes a significant difference with NT ($P < 0.05$)

NOTE. θ_{15} = Mid-Range Joint Position Sense; θ_M = End-Range Joint Position Sense; OSI = Overall Stability Index; TTC = Time to Complete Drop Landing Task; θ = Angle of Take-Off Vector; $\dot{F}_{xy}$ = Magnitude of Take-Off Vector

Figure 1: Application of ETT to the ankle joint

Highlights

- Elastic therapeutic tape improved proprioception and functional test performance
- RockTape provided an increased number of practical and significant findings
- RockTape could be advocated to improve proprioception and functional performance
- Neither RockTape nor Kinesio tape hindered clinical or functional performance

The efficacy of elastic therapeutic tape variations on measures of ankle function and performance

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We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all listed.

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We further confirm that any aspect of the work covered in this manuscript that has involved human patients has been conducted with the ethical approval of the relevant institution in which it was performed, with subjects providing informed consent to the work. Such approvals are acknowledged within the manuscript.

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