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ORIGINAL ARTICLE

Effects of gluteal kinesio-taping on performance with respect to fatigue in rugby players

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Abstract
Kinesio-tape® has been suggested to increase blood circulation and lymph flow and might influence the muscle's ability to maintain strength during fatigue. Therefore, the aim of this study was to investigate the influence of gluteal Kinesio-tape® on lower limb muscle strength in non-fatigued and fatigued conditions. A total of 10 male rugby union players performed 20-m sprint and vertical jump tests before and after a rugby-specific fatigue protocol. The 20-m sprint time was collected using light gates (SMARTSPEED). A 9-camera motion analysis system (VICON, 100 Hz) and a force plate (Kistler, 1000 Hz) measured the kinematics and kinetics during a counter movement jump and drop-jump. The effect of tape and fatigue on jump height, maximal vertical ground reaction force, reactivity strength index as well as lower limb joint work were analysed via a two-way analysis of variance. The fatigue protocol resulted in significantly decreased performance of sprint time, jump heights and alterations in joint work. No statistical differences were found between the taped and un-taped conditions in non-fatigued and fatigued situation as well as in the interaction with fatigue. Therefore, taping the gluteal muscle does not influence the leg explosive strength after fatiguing in healthy rugby players.

Keywords: *Biomechanics, fatigue, performance, strength, team sport*

Introduction

Kinesio-tape® is an elastic tape with the ability to stretch up to 140% of its original length (Chang, Chou, Lin, Lin, & Wang, 2010). Its traditional purpose has been that of injury treatment, pain reduction and joint stabilisation (Kase, Wallis, & Kase, 2003). One theorised mechanism by which kinesio-taping affects biological function includes, that the taped area forms convolutions, which lift the skin from the muscle, providing more space between muscle and skin (Kase et al., 2003). This further promotes an increase in blood flow and lymphatic fluid as well as an increased mechanoreceptor stimulation (Kase et al., 2003; Kataoka & Ichimaru, 2005). As such, these factors would impact on muscle strength, explosive muscular power, movement control and could have a beneficial effect on performance in sports, such as rugby. In a clinical setting, it is suggested that applying tension to the tape is of more importance than the effect of convulsions though (Parreira et al., 2014), and despite the widespread popularity of Kinesio-tape®, controversial scientific evidence exists on its effect on the muscle performance of healthy athletes. Studies report an increase in explosive power of the gluteus muscle (Mostert-Wentzel et al., 2012; in absence of a control group), eccentric isokinetic quadriceps force (Vithoulka et al., 2010), isokinetic quadriceps peak torque (Slupik, Dwornik, Bialoszewski, & Zych, 2007), m. gastrocnemius medialis activity (Huang, Hsieh, Lu, & Su, 2011) and hand grip strength (Lee, Yoo, & Lee, 2010) as well as increase the functional movement for a hurdle step task (An, Miller, McElveen, & Lynch, 2012). These findings are opposed by studies reporting no effect on muscle strength (Chang et al., 2010; Fu et al., 2008; de Hoyo, Alvarez-Mesa, Sanudo, Carrasco, & Dominguez, 2013; Lins, Neto, Amorim, Macedo Lde, & Brasileiro, 2013; Vercelli et al., 2012; Wong, Cheung, & Li, 2012) and functional movement scores for deep

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squats and in-line lunges (An et al., 2012) due to kinesio-taping in a healthy population. However, these reported results were achieved in a non-fatigued situation and a healthy rested muscle might not refer to the stimuli of the Kinesio-tape®.

Multiple factors are linked to the development of muscular fatigue, such as psychological, central nervous, peripheral or cellular factors, with the muscle cell itself most likely being the driving limitation (Fitts, 1994). An increase in blood circulation and lymph flow might aid the cellular metabolism and support the transport of exudates (Kase et al., 2003) as well as the oxygen allotment to the muscle might be facilitated, which could lead to an improved muscle function (Okamoto, Masuhara, & Ikuta, 2006). The combination of these mechanisms could lead to a decelerated fatigue. However, only three study reports composed in English, investigating effects of Kinesio-tape® on fatigue supporting this theory were found by the authors. Kataoka and Ichimaru (2005) reported an increase in peripheral blood circulation after 20 min of cycling due to Kinesio-tape®. In addition, Schneider, Rhea, and Bay (2010) demonstrated that participants allocated to a Kinesio-tape® group showed a tendency to maintain isometric forearm extensor strength after a tennis fatiguing protocol better than the athletes in the untaped condition. Alvarez-Alvarez, Jose, Rodriguez-Fernandez, Gueita-Rodriguez, and Waller (2014) reported an increase in time to failure of the lumbar extensor muscle after the kinesio-tape was applied to this musculature. In contrast, Lins et al. (2013) suggested that the tension produced from the tape is not sufficient to increase interstitial space in a rested situation to enhance blood flow. Stedge, Kroskie, and Docherty (2012) did not find an effect on blood circulation or on the endurance ratio over 30 isokinetic maximal plantar and dorsiflexions when kinesio-taping the gastrocnemius muscle of healthy participants. These findings highlight the conflicting results on the Kinesio-tape's® ability to restrict fatigue. Therefore, the aim of this study was to investigate the effect of Kinesio-tape® on sprint and vertical jump performance in healthy participants in non-fatigued and fatigued conditions. Due to the increasing popularity of gluteal Kinesio-tape® in rugby, this research is set within the sports-specific setting of rugby union players. It is hypothesised that kinesio-taping gluteal muscles has no effect on the performance of a non-fatigued muscle, but leads to a diminished decrease in sprint and jump performance in a fatigued condition compared to an untaped muscle.

Methods

Participants

A total of 10 male rugby union players of university level (8 players) and regional level (2 players) (mean age: 21, SD = 1.1 years, mean height: 181, SD = 6 cm, mean mass: 88, SD = 10 kg) participated in this study. All participants were free of injury within six months prior to testing and engaged in regular rugby training sessions (two per week). Participants were recruited through university squads. Twelve players originally volunteered, with two players dropping out due to injury during rugby practice. The institutional ethics board approved the study and all participants signed informed consent. Additionally, this study was performed in accordance with the ethical standards proposed by Harriss and Atkinson (2013).

Taping conditions

For the Kinesio-tape scenario, a black Levotape Kinesiology Tape (Vivomed Limited, Downpatrick, UK) was used. The application was in alignment with other published studies and the Kinesio-taping association guidelines (e.g. Mostert-Wentzel et al., 2012). To assist the muscle and provide facilitation and increase muscle tone, the Kinesio-tape was anchored at the origin and ends at the insertion, thus applied to support the contractile direction of the muscle. A Y-cut was used to surround the muscle along the fascial margins, increasing the percentage of fascia and muscle support. The tape was applied in a flexed hip position of 90°; thus the recoil effect provides sensory stimulation to fascia and skin receptors during movement. The Kinesio-tape was individually tailored to each subject before application. Two Y-shaped pieces of taping of approximately 25 cm long and 5 cm wide were used. The tails of the Y were approximately 25 cm long and 2.5 cm wide, a base of 5 cm (the estimated distance between the subject's greater trochanter and fifth lumber (L5) spinous process). The base of the Kinesio-tape was stabilised and the anterior tail nearest to the clinician was taped to the iliac crest with tape tension of 50%. Subjects were then asked to flex, adduct and internally rotate the hip and flex the knee to ensure the tape remained *in situ*. The Kinesio-tape was stabilised and the posterior tail was attached to the sacral base, enclosing the gluteus maximus muscle, with the tape tension between 75% and 100%. In some cases, the two ends of the Y were connected by a 10 cm piece to ensure enclosure and that the tape remained *in situ* (Figure 1). For the placebo-taped (PT) scenario, the same type of Kinesio-tape® was applied from the greater trochanter to the posterior super iliac spine without tension (Figure 1). All taping was completed by the same physiotherapist, who was trained and experienced in working with Kinesio-tape® in a rugby union environment.

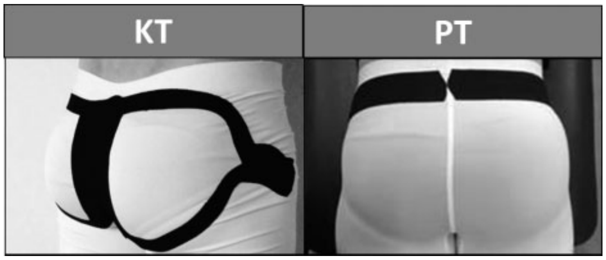

Figure 1. Location of the Kinesio- and Placebo-tape. For the study the tape was applied directly on the skin.

Testing protocol

Participants underwent the testing protocol in untaped (NT), kinesio-taped (KT) and PT condition (Figure 1). Time between each session was either 7 days or 14 days to ensure standardised 48 hours prior to testing (48 hours prior: no lower body resistance training; 24 hours prior: no exercise) and adequate recovery from previous testing or game play. The conditions were tested in a randomised order, as such that a participant started with KT followed by PT in the next session and NT in the last session (KT–PT–NT). The combination NT–KT–PT was applied to the next participant while the other four possible combinations (KT–NT–PT, NT–PT–KT, PT–NT–KT and PT–KT–NT) were each carried out by two participants. The three testing sessions followed the same protocol: participant preparation, warm-up, pre-test, fatigue protocol and post-test. Participant preparation consisted of applying the tape (if necessary) and reflective markers followed by a 20-min rugby-specific warm up (5 min jog, 5 min sprints and squat jumps, 5 min active stretching and 5 min jog). The test protocol consisted of two 20-m sprints, three counter-movement jumps (CMJ) and three drop-jumps (DJ) from 0.40 m, ranging from strength tests with high gluteal muscle contribution (sprint) to low gluteal muscle contribution (DJ). The same protocol was executed in the non-fatigued and in the fatigued situation. The fatigue protocol adopted exercises from the Bath University Rugby Shuttle Test (BURST; Roberts, Stokes, Weston, & Trewartha, 2010) and compromised 5 × 290 s cycles of one 20-m sprint and 30 s of each sled push (80% BW), shuttle runs, vertical jumps on a crush mat, lunges (15% BW), max cycling and isometric squat followed by a 1-min rest (Figure 2).

Data collection

The 20-m sprint time was collected for the sprints using an automated light gate system (SMARTSPEED™, Fusion Sport Inc., Australia; 1000 Hz). This system is able to identify the timing of the trunk segment interruption as reference. Kinematic and kinetic data for all jumps were collected simultaneously by a 9-camera 3D motion analysis system (VICON, MX camera system, Oxford Metrics Ltd, UK; 100 Hz) and a force plate (Kistler, 5233A, Winterthur Switzerland; 1000 Hz) embedded in the floor. Participants contacted the force plate with the right foot only and reflective markers were placed according to the Cleveland Clinic lower body marker set (Motion Analysis Corp, Santa Rosa, USA), in order to calculate the centre of mass (COM), as well as the sagittal ankle, knee and hip joint power of the right leg.

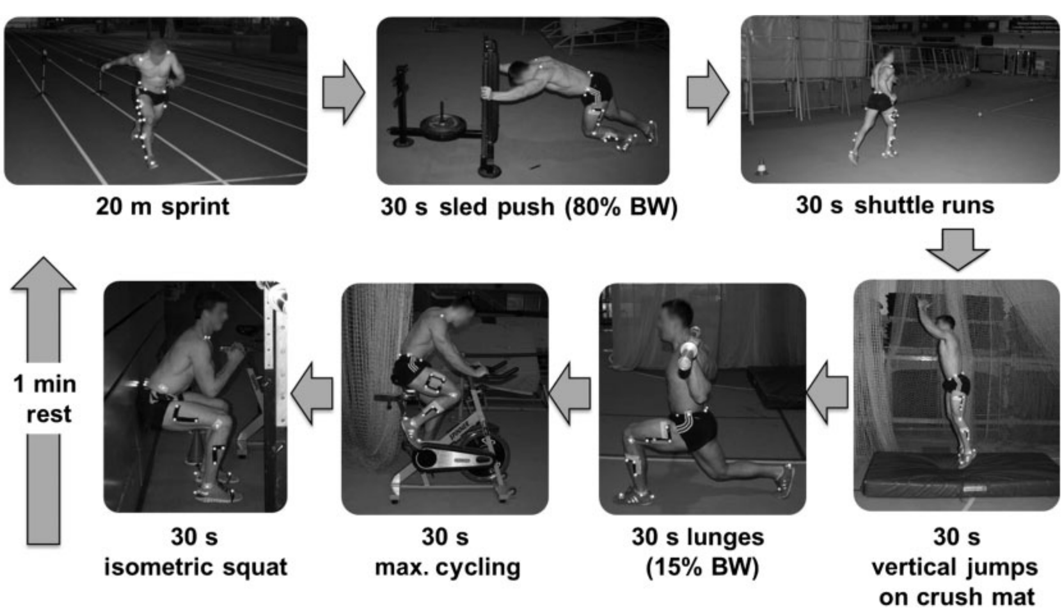

Figure 2. Rugby specific fatigue protocol.

Data analysis

Data analysis was conducted in Visual 3D (V3D; C-motion, Rockville, MD, USA). The key variables analysed included for the 20-m sprint the sprint time (t_{sprint}) (s) and for both CMJ and DJ the jump height, maximal vertical ground reaction force (Fz_{max}) (N/kg) and hip, knee and ankle joint work (W_{Hip}, W_{Knee}, W_{Ankle}) [J/kg] of the take-off motion. Maximum jump height was calculated via the maximal COM displacement during the flight time of the jump in reference to the average COM height in standing position (detected via three static standing trials). The COM as well as the lower limb joint power was calculated via the six degree of freedom model inserted in V3D (Selbie, Hamill, & Kepple, 2013). Further, the ankle, knee and hip joint work (J/kg) was calculated by integrating the respective sagittal joint power over time for the take-off motion of the jump. As participants stood with one leg only on the force plate, the start of the take-off motion for the CMJ was defined as the time point when the vertical force undercut half of the body weight by one standard deviation, identified over the 200 ms period of standing quietly with the right leg on the force plate (Focke et al., 2013). For the DJ, the take-off motion was defined when the vertical force overcut 20 N at first force plate contact. The sum of the ankle, knee and hip joint work was characterised as total lower limb work (W_{total}) (J/kg). Additionally, the reactivity strength index (RSI = jump height/ground contact time) (m/s) was calculated for the DJ. All kinetic data were normalised to body mass. The mean values of the trials performed for each movement (two for sprint and three for CMJ and DJ) were computed and used for further analysis.

Statistical analysis

Statistics were calculated with SPSS 20.0 (SPSS Inc., Chicago, Illinois). Test for normality and sphericity were found to meet the requirements for parametric statistics. Differences between the conditions were calculated using a two-way repeated-measure analysis of variance (ANOVA; taping × fatigue) including Bonferroni adjustments. The level of significance was set at $p \leq 0.05$. Effect size was calculated using partial η^2 (borders: $\eta_p^2 = 0.01$: small, $\eta_p^2 = 0.06$: medium, $\eta_p^2 = 0.14$: high effect sizes; Cohen, 1973) for main and interaction effects of taping and fatigue. The 95% CI of mean difference with respective Cohen's d effect sizes (borders: d = 0.1, 0.3 and 0.5 for small, moderate and large; Cohen, 1988) was calculated for more detailed comparisons.

Results

Significant changes occurred only for the main effect of fatigue for sprint time and jump height for both CMJ and DJ and the RSI for the DJ respectively. For all conditions (NT, KT, PT) the 20-m sprint time significantly increased by 2.9%, while the jump height significantly decreased by 14% for both jumps due to fatigue. The reduction of CMJ jump height of approximately 5 cm is in accordance with a significant reduction in total lower limb joint work (0.19 J/kg), with each joint showing a significant fatigue effect. The hip joint work showed a reduction by 16.9%, the knee joint work by 12% and the ankle joint work by 6.5%. Similarly, the DJs total lower limb work is significantly reduced by 0.23 J/kg, but only the knee joint work reveals a significant reduction of 80% (Table I). However, taping as well as its interaction with fatigue did not reveal a significant effect on any parameters analysed (Table I). In more detail, effect sizes for the main effect fatigue are for 10 out of 12 parameters high ($\eta_p^2 > 0.14$), which is further underpinned by Cohen's d effect sizes being high (d > 0.50) for seven out of nine individual comparisons (Figure 3). No statistical significance was detected for the main effect taping, and also individual comparison showed trivial and small effect sizes (Cohen's d) for the performance outcome parameters (Figure 3). The interaction effect between taping did not reveal a statistical significant effect with η_p^2 being trivial for CMJ jump height (0.01), small for DJ height (0.02) and medium for 20-m sprint time (0.13).The 95% confidence interval of the mean difference for each comparison of the three different taping conditions, underpin the presented results, that fatiguing yielded a change in performance parameters, while the comparison between the different taping conditions both prior and post-fatigue did not show a statistical consistent effect (Figure 3).

Discussion

The aim of this study was to investigate, if gluteal kinesio-taping increases sprint and jump performance in a non-fatigued condition and diminishes the effect of fatigue. The results suggest an effective fatigue protocol as sprint and jump performance decreased. However, these effects were not due to taping (Kinesio or Placebo), and showed no evident effect for improved performance compared to an untaped condition in both, non-fatigued and fatigued, situations. The effect of the Kinesio-tape® might be dependent on the contribution of the kinesio-taped muscle to the overall outcome of the movement. The movement tasks in this study each had a different level of contribution from the gluteal

Table I. Mean (SD) parameters for the conditions NT, KT, PT for pre- and post-test with detected ANOVA effects and effect sizes

	NT		KT		PT		ANOVA	
Parameter	Pre mean ± SD	Post mean ± SD	Pre mean ± SD	Post mean ± SD	Pre mean ± SD	Post mean ± SD	Effect	Sig (η_p^2)
20 m sprint								
t_{sprint} [s]	3.09 ± 0.13	3.21 ± 0.24	3.09 ± 0.10	3.18 ± 0.24	3.10 ± 0.15	3.16 ± 0.18	F	0.029 (0.43)
CMJ								
h_{max} [m]	0.33 ± 0.06	0.28 ± 0.07	0.32 ± 0.05	0.27 ± 0.06	0.33 ± 0.06	0.29 ± 0.07	F	<0.001 (0.77)
Fz_{max} [N/kg]	11.13 ± 1.36	11.02 ± 1.22	11.17 ± 1.34	10.86 ± 1.14	11.64 ± 1.57	11.36 ± 1.33		
W_{total} [J/kg]	1.95 ± 0.51	1.78 ± 0.55	1.90 ± 0.49	1.71 ± 0.48	2.06 ± 0.59	1.86 ± 0.58	F	0.003 (0.80)
W_{hip} [J/kg]	0.60 ± 0.38	0.52 ± 0.32	0.57 ± 0.28	0.48 ± 0.2	0.61 ± 0.34	0.49 ± 0.24	F	0.035 (0.41)
W_{Knee} [J/kg]	0.59 ± 0.27	0.51 ± 0.24	0.53 ± 0.24	0.46 ± 0.26	0.64 ± 0.22	0.58 ± 0.19	F	0.028 (0.43)
W_{Ankle} [J/kg]	0.90 ± 0.16	0.86 ± 0.16	0.88 ± 0.13	0.82 ± 0.12	0.9 ± 0.17	0.83 ± 0.18	F	0.003 (0.63)
DJ								
h_{max} [m]	0.22 ± 0.05	0.19 ± 0.05	0.21 ± 0.06	0.19 ± 0.05	0.21 ± 0.05	0.18 ± 0.06	F	0.003 (0.69)
Fz_{max} [N/kg]	30.31 ± 7.92	29.21 ± 7.54	28.64 ± 7.54	28.38 ± 6.82	29.35 ± 6.82	28.55 ± 6.53		
W_{total} [J/kg]	0.61 ± 0.44	0.43 ± 0.34	0.63 ± 0.47	0.40 ± 0.29	0.63 ± 0.22	0.34 ± 0.36	F	0.005 (0.76)
W_{Hip} [J/kg]	−0.14 ± 0.07	−0.09 ± 0.08	−0.10 ± 0.14	−0.04 ± 0.19	−0.13 ± 0.11	−0.08 ± 0.12		0.079 (0.43)
W_{Knee} [J/kg]	0.24 ± 0.23	0.08 ± 0.20	0.33 ± 0.27	0.04 ± 0.3	0.29 ± 0.14	0.05 ± 0.24	F	0.003 (0.79)
W_{Ankle} [J/kg]	0.51 ± 0.21	0.47 ± 0.14	0.41 ± 0.26	0.40 ± 0.15	0.46 ± 0.14	0.38 ± 0.16		0.157 (0.30)
RSI [m/s]	59.43 ± 9.51	60.49 ± 10.84	58.09 ± 8.38	60.01 ± 11.66	55.08 ± 7.16	57.4 ± 9.46	F	<0.001 (0.81)

ANOVA: T, Taping effect; F, Fatigue effect; TF, Interaction Taping and Fatigue.

muscle to the total outcome (DJ < 10%, CMJ approx. 25%, 20-m sprint 35%, Johnson & Buckley, 2001). However, no significant alteration of the performance in any of the movement tasks was observed. Hence, these findings do not support the hypothesis that Kinesio-tape® would have a benefit on sprint and jump performance neither in non-fatigued nor in fatigued situation.

To our knowledge, this study is the first to investigate the potential of Kinesio-tape® to resist muscle fatigue in a complex movement situation. Even though some studies suggest an enhancement of muscle strength in a non-fatigued situation, the tests to underpin this statement have mainly been isometric isolated muscle testing (Fu et al., 2008; Vithoulka et al., 2010; Wong et al., 2012), with little implication to a complex sport situation. Only few studies investigated complex sport tasks in healthy athletes, and those only in non-fatigued situation, such as the study by Mostert-Wentzel et al. (2012) reporting a positive effect of gluteal taping on the jump height of CMJs. Due to the absence of a control condition and the possibility of learning effects, however, these results must be interpreted with caution. An et al. (2012) screened the functional movement of hurdle steps, deep squats and in-line lunges, and suggested that KT intervention might be beneficial in movements incorporating non-weight bearing segments such as the hurdle step. Even though the Kinesio-tape® might initiate an increase in peripheral blood flow (Kataoka & Ichimaru, 2005) and a decrease in pressure over the lymphatic channels in order to provide a path for the removal of exudates (Kase et al., 2003), other factors influencing performance such as fatigue and slower energy transport of the remaining muscles may mask the possible effect on the isolated muscle. In general, the findings of the present study indicate that the

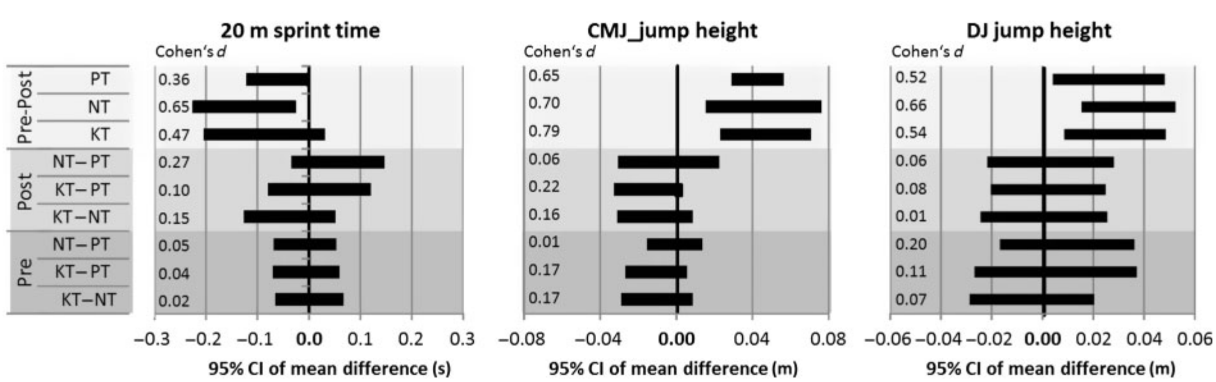

Figure 3. 95% CI interval of mean difference and effect sizes (Cohen's *d*) for parameters 20m sprint: time, CMJ: jump height, DJ: jump height.

effect of the gluteal Kinesio-tape® in maintaining explosive and reactive muscle strength during fatiguing is insignificant when looking at sport-specific movements of healthy participants.

Research investigating the influence of Kinesio-tape® in healthy non-fatigued athletes via complex movements also indicates that the findings are independent of taping location. This was demonstrated in the current study and supported by de Hoyo et al. (2013) and Lins et al. (2013), who showed that kinesio-taping the quadriceps muscle did not enhance performance of CMJ, sprinting and hop jumping. Further evidence is provided by Huang et al. (2011), who showed that kinesio-taping the mm. triceps surae did not reveal an improvement of maximal vertical jump heights.

An additional aspect to be considered is the population the Kinesio-tape® is applied to. Participants vary in their activity level ranging from inactive to collegiate sport-level activity, which might influence the muscles ability to produce force and react to additional stimuli. The highly active population of the present study might already use most of the muscle potential to create force, while inactive participants might be more susceptible to additional stimuli (Stedge et al., 2012).

Last it should be noted though that psychological factors might play an important role when athletes use Kinesio-tape® to increase their performance. Vercelli et al. (2012) reported that while kinesio-taping did not increase performance outcome measures, 45% of the participants felt stronger in the kinesio-taped condition. This provides a further platform to investigate possible implications on injury and performance using Kinesio-tape®.

This study is limited as the sample size was with 10 participants rather small, and only covers university rugby players. Due to the lack of published data a post-hoc power calculation was conducted (G*power 3.1. software; Faul, Erdfelder, Lang, & Buchner, 2007) after 10 participants were tested. A sample size of 10 players provided for the fatigue effect in the untaped condition for the performance measures of CMJ, DJ and sprint time a test-power of 0.90, 0.85 and 0.60, respectively, while the taping effect in the fatigued situation provided a power below 0.11 for these parameters in all comparisons: NT–KT, NT–PT, KT–PT. This indicates an underpowered trial for the taping effect, hence the probability of detecting a significant difference between the taping conditions and the untapped situation was very unlikely. Due to the small effects we might not have been able to detect possible difference and commit a type-2 error with our interpretation. However, given the small effect sizes (out of 18 possible comparisons 9 reached small effect sizes, while the other 9 did not reach the level for small effects) and the 95% CI of mean differences data (Figure 3), we speculate that even if undetected differences exist between the conditions, these are too small to contribute to an overall performance enhancement.

Even though some effort was put into keeping the 48 hours prior to testing standardised, some participants might have experienced changes in fatigue or muscle conditioning due to, e.g., a harder training week or match play. The authors tried to control for that error by randomising the taping conditions over all participants. Other movement tasks such as scrummaging, might be influence by kinesio-taping but investigation was beyond the scope of this paper and needs further analysis. Also it remains unknown, if stimulating the entire extensor chain, taping gluteal musculature in combination with mm quadriceps and gastrocnemius, would support performance. As participants could feel the application of the tape they might have been influenced by the knowledge that tape is applied.

Conclusion

The fatiguing protocol was effective in reducing sprint, CMJ and DJ performance, but neither kinesio-taping nor placebo-taping the gluteal muscle was found to improve the performance outcomes of these tests for rugby players in a non-fatigued condition. Further, taping the gluteal muscle with kinseio-tape or placebo-tape did not lead to an evident reduction of fatiguing effects after the rugby specific fatigue protocol. Hence, this demonstrates no benefit for using Kinesio-tape® for these strength tests in rugby athletes. These findings are consistent across a range of complex movements with different gluteal contributions of the taped muscles. Therefore, the influence of the Kinesio-tape® on the gluteal muscles might have been too little to effectively alter the performance of these athletes.

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