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Research article

The effect of patellar taping on some landing characteristics during counter movement jumps in healthy subjects

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Abstract
The aim of the present study was to determine the effect of patellar taping (PT) on landing characteristics of the vertical ground reaction force (VGRF) and on flight time during a counter movement jump (CMJ). Eleven healthy male subjects (age: 31.1 ± 4.2 years) volunteered for the study. Each subject performed six CMJs under two different jumping conditions: with PT and without PT (WPT). The order of the two conditions was randomized. All of the measured variables had fair-to-good reliability (intra-class correlation coefficient > 0.75). When we compared the PT and WPT groups, we did not find a significant difference in the magnitude of the first (F1) and second (F2) peaks of the VGRF. We also did not find a significant difference in the time to production of these peaks (T1 and T2), and the time to stabilization (TTS) ($p < 0.05$). Furthermore, the flight time was similar in the two groups (0.475 ± 0.046 and 0.474 ± 0.056 s, respectively, for PT and WPT). These results suggest that PT does not jeopardize performance during CMJ. Furthermore, it also does not soften the VGRF generated during the landing, indicating that PT may be of limited utility in preventing injuries associated with this type of movement.

Key words: Biomechanics, force platform, vertical ground reaction force, landing phase.

Introduction

Taping has been observed to be effective in the prevention and rehabilitation of lower limb injuries (Brandon, 2011; Burns and Lowery, 2011; Cools et al., 2002; Engstrom and Renstrom, 1998; Halseth et al., 2004). Furthermore, it has been shown to reduce pain (Aminaka and Gribble, 2008; Halseth et al., 2004; Hinman et al., 2003; Mostamand et al., 2010, 2011; Salsich et al., 2002). As a result, taping is widely used among athletes (Brandon, 2011). Nevertheless, given the observed association between patellar taping (PT) and decreased neuromuscular activity (Ng and Cheng, 2002; Ng and Wong, 2009), it has been suggested that PT may hinder performance (Ng and Wong, 2009). Because counter movement jumps (CMJs) are associated with performance in ground-based sports and are usually evaluated to assess athletic ability (Bobbert et al., 1996; Harman et al., 1991; Sayers et al., 1999), it would be of practical interest to determine the effect of PT on flight time during a CMJ.

Sports, particularly those that involve lower limb impacts, can potentially lead to overuse injuries (Lequesne et al., 1997; Molloy and Molloy, 2011; Thelin et al., 2006). Lower limb impacts during sports and exercise mainly occur during the landing phase of a jump, and they are characterized by a vertical ground reaction force (VGRF) that comprises two distinct peaks corresponding to forefoot and rearfoot contact with the ground (Dufek and Bates, 1990; 1991; Rojano et al., 2010). The magnitude of these peaks is associated with the production of injuries (Dufek and Bates, 1991; Lian et al., 1996; Richards et al., 1996). Jumps are very common in ball sports, and it has been observed that athletes competing in handball, volleyball, basketball, and soccer are prone to developing lower limb injuries (Lequesne et al., 1997; Vrezas et al., 2010). Gymnasts, due to the high magnitude impacts that occur during the landing phase, are also susceptible to lower limb injuries (Caine and Golightly, 2011). Furthermore, elite athletes seem to be more prone to developing lower limb injuries than recreational athletes (Lequesne et al., 1997). PT has been observed to reduce the magnitude of the first peak of the VGRF during fast walking (Bennell et al., 2006). Nevertheless, to the best of our knowledge, no studies have analyzed the effect of PT on the VGRF during the landing phase of a jump. Because high magnitude forces acting on the body can be deleterious (Dufek and Bates, 1991), using PT to decrease the VGRF during the landing phase could be beneficial in terms of injury prevention. Therefore, the aim of the present study was to determine the effect of PT on landing characteristics of the VGRF and on flight time during a CMJ.

Methods

Eleven healthy male subjects (mean ± SD age = 31.1 ± 4.2 yr; height = 1.74 ± 0.07 m; body mass = 73.6 ± 5.9 kg) took part in the study. All of them were physically active and had no history of musculoskeletal injuries. Prior to their involvement in the research, all of the subjects provided informed consent, as outlined by the declaration of Helsinki. The study was approved by the Ethics Committe of the Hospital of Basurto and meets the ethical standards described by Harriss and Atkinson (2009).

Experimental design

Two days before the testing session, the subjects underwent 30 min of technical training on how to perform CMJs correctly. During the takeoff phase of the jump participants were instructed to perform a knee flexion of approximately 90°. The hands were placed on the hips during the takeoff, flight, and landing phases of the CMJ,

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and a minimal flexion of the trunk during the takeoff phase was permitted, as described by Komi and Bosco (1978). On the testing day, the subjects performed a standardized warm up prior to data collection (Canavan, 2004). The trials consisted of six CMJs performed under two different jumping conditions: with PT (BodyArmor; DARCO International, USA) and WPT. Medial glide taping of the patella was applied as described by McConnell (1986). The resting time between jumps was 45–60 s (Berthoin et al., 2001; Krol and Mynarski, 2010). The order of the two jumping conditions was randomized.

VGRF data at 1,000 Hz were collected using a force platform (Dinascan/IBV 8.2; Instituto de Biomecánica de Valencia, Spain) embedded in the ground. Jumps were excluded if the feet did not land entirely on the force platform, or if the jumping technique was incorrect.

Variables

We recorded the first (F1) and second (F2) peaks of the VGRF during the landing phase (Figure 1). From the temporal data, the time to the production of F1 (T1), the time to the production of F2 (T2), the flight time (FT), and the time to stabilization (TTS) were obtained (Figure 1). The TTS was determined during the landing phase, beginning with the first contact of the feet with the ground and ending when the VGRF reached and stayed within 5% of the subjects' body weight (Colby et al., 1999; McKinley and Pedotti, 1992) (Figure 1). We also calculated the loading rates of the first and second peaks of the landing phase (LR1 and LR2, respectively) determined by the ratio between the magnitudes of F1 and F2 and the time elapsed from the initial contact of the feet with the ground at the landing phase to the production of these peaks (Decker et al., 2002). F1 and F2 were normalized according to the subjects' body weight (BW).

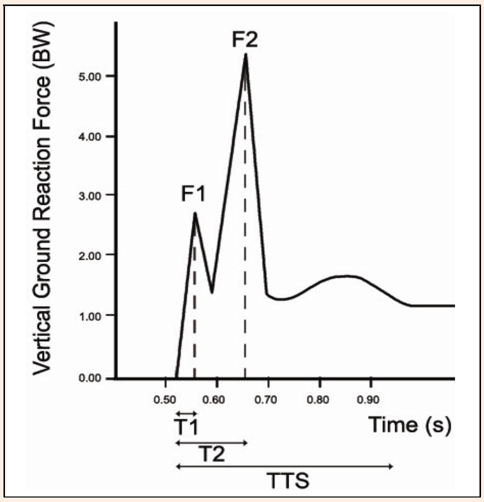

Figure 1. Variables of the vertical ground reaction force during the landing phase. Legend: F1: magnitude of first peak, F2: magnitude of second peak, T1: time to production of F1, T2: time to production of F2, TTS: time to stabilization.

Statistical analysis

For descriptive purposes, the variables are reported as means ± standard deviation (SD), SD). Paired sample *t*-tests were used to compare the magnitude of the parameters during PT and WPT jumping. We used the Shapiro-Wilk test to test the null hypothesis that the sample came from a normally distributed population. The inferential statistics Levene's test was conducted to assess the equality of variances. We determined the trial-to-trial reliability of the parameters using intraclass correlation coefficients (ICC). Differences were considered significant when $p < 0.05$. Statistical power (1-β), or failing to reject a false null hypothesis, was calculated for each statistical analysis. The power was estimated using a two-tailed *t*-test design with α=0.05, the sample size and the effect size index (d_z). d_z was calculated from the means and SDs of two random variables and the correlation between them. The results of statistical power for each dependent *t*-test for paired samples ranged from 0.85 to 0.91 for F1 and LR1, respectively. The rest of the *t*-tests showed a power lower than 0.80 and consequently, a high probability of making a type II error. In these cases, the sample size should be increased accordingly in following studies to test this relationship further. The Statistical Package for Social Sciences (version 15.0; SPSS Inc., USA) was used for statistical analysis.

Results

As shown in Table 1, the parameters that characterize the landing phase (F1, F2, T1, T2, LR1, LR2, and TTS), demonstrated fair reliability (ICC > 0.75). The FT demonstrated good reliability (PT: ICC = 0.97; WPT: ICC = 0.98). The highest reliability under PT condition was obtained in T2 and under WPT condition in F2. The lowest reliability in both conditions was obtained in TTS.

Table 1. Intraclass correlation coefficients of variables measured during the landing phase of counter movement jumps.

Parameter	ICC value	
	PT	WPT
F1	.81	.76
F2	.81	.86
T1	.78	.85
T2	.88	.77
LR1	.78	.77
LR2	.82	.76
TTS	.76	.75

Legend: ICC: intraclass correlation coefficient, F1: magnitude of first peak, F2: magnitude of second peak, T1: time to production of F1, T2: time to production of F2, LR1: loading rate of F1, LR2: loading rate of F2, TTS: time to stabilization.

The mean values of the parameters characterizing the VGRF during the landing phase and the FT are presented in Table 2. Although LR1 and F1 with PT were respectively 13.12% and 12.36% lower than WPT, no significant differences were obtained between both jumping conditions.

Discussion

In the present study, we observed that the landing characteristics of the VGRF during CMJs with the application of PT were not significantly different compared to WPT

Table 2. Effect of patellar taping on mean values of vertical ground reaction force parameters.

Parameters	Mean (SD)		Sig. Dif.	% Change
	PT	WPT		
FT (s)	.475 (.046)	.474 (.056)	n.s.	.22
F1 (BW)	3.482 (.571)	3.053 (.855)	n.s.	12.36
F2 (BW)	5.701 (1.994)	5.386 (1.812)	n.s.	5.62
T1 (s)	.027 (.004)	.026 (.002)	n.s.	3.71
T2 (s)	.053 (.022)	.060 (.021)	n.s.	11.67
LR1 (BW·s^{-1})	117.932 (36.112)	135.753 (29.953)	n.s.	13.12
LR2 (BW·s^{-1})	98.622 (84.245)	112.143 (76.531)	n.s.	12.06
TTS (s)	.433 (.082)	.435 (.083)	n.s.	4.61

Legend: PT: patellar taping, WPT: without patellar taping, sig. dif: significant difference, FT: flight time, F1: magnitude of first peak, F2: magnitude of second peak, T1: time to production of F1, T2: time to production of F2, LR1: loading rate of F1, LR2: loading rate of F2, TTS: time to stabilization, n.s.: not significant.

landing characteristics. Furthermore, the FT with PT was not significantly different from the FT WPT.

Hard landings, characterized by high magnitude forces acting on the body and short times leading to the production of these forces, have been associated with injuries in the lower limbs (Dufek and Bates, 1991; McNair et al., 2000). Landing techniques that increase T1, T2, and TTS and decrease F1 and F2 have been observed to soften the impact, diminishing the probability of injury (Wikstrom, 2003). One such technique was adopted by subjects with anterior cruciate ligament reconstruction, who were compared with uninjured subjects (Decker et al., 2002). The authors noted longer times to the production of F1 (T1: 13.70 ± 2.68 ms vs. 9.15 ± 3.60 ms) and F2 (T2: 51.80 ± 8.32 ms vs. 36.42 ± 10.21 ms), and lower magnitudes of LR1 (114.12 ± 35.26 BW·s^{-1} vs. 192.50 ± 88.25 BW·s^{-1}) and LR2 (70.97 ± 36.66 BW·s^{-1} vs. 134.04 ± 71.53 BW·s^{-1}) in subjects with anterior cruciate ligament reconstruction.

The lack of any significant effect of PT on the landing characteristics of the VGRF suggests that the decreased risk of injuries associated with the use of taping is due to factors other than softening of the VGRF during landing. Among these factors, increased joint stability and knee joint proprioception have been mentioned (Callaghan et al., 2002; Larsen et al., 1995; Stoffel et al., 2010; Wilkerson, 1991). The results of the present study do not exclude the possibility that other knee taping techniques may have a significant influence on the VGRF.

In the present study, T1 and T2 were higher compared to the times reported by previous authors (Decker et al., 2002). Furthermore, F1 and F2 were lower compared to the results obtained in a study of 30 semiprofessional football players (Rojano et al., 2010). Jump height (JH) is positively related to the magnitude of F1 and F2 and negatively related to T1 and T2 (Seegmiller and McCaw, 2003). Thus, the lower JH of our subjects (PT: 0.28 ± 0.06 m and WPT: 0.27 ± 0.05 m *vs*. 0.33 ± 0.03 m (Rojano et al., 2010) and 0.60 m (Decker et al., 2002)) may explain the lower F1 and F2 and the longer T1 and T2 in the present study. The mean TTS under PT and WPT conditions in the present study was also markedly different compared to the TTS reported in a previous study (PT: 0.433 ± 0.082 s and WPT: 0.435 ± 0.083 s *vs*. 2.059 ± 0.056 s (Wikstrom, 2003)). The shorter TTS that we observed is likely due to differences in the protocol; in the present study, the subjects performed two-legged landings, while in Wikstrom's study, single-leg landings were performed.

A previous study investigated the influence of PT on FT and found that due to a decrease in the relative activity of the vastus medialis obliquus with PT, the subjects' performance appeared to be hampered (Ng and Cheng, 2002). We observed similar FTs with PT and WPT (Table 2), suggesting that PT does not jeopardize performance. Our results are consistent with the findings of a previous study, which found that PT of subjects with patellofemoral pain syndrome had no influence on FT (Ernst et al., 1999).

Conclusion

According to the results of the present study, the mean flight time during counter movement jumps did not change with the application of patellar tape. Furthermore, we did not observe any effect of patellar taping on the landing characteristics of the vertical ground reaction force. These results suggest that although patellar taping does not actually soften the landing phase, it also does not appear to jeopardize performance during counter movement jumps.

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Key points

- We investigated whether patellar taping interferes with athletic performance, as has been suggested by previous studies.
- We also explored the effect of patellar taping on the forces generated during the landing phase of counter movement jumps.
- Patellar taping had no effect on the flight time during counter movement jumps.
- Patellar taping also had no effect on the vertical ground reaction force variables measured during the landing phase of counter movement jumps.
- This information may be relevant to athletes and trainers who are concerned about the effects of patellar taping on performance.

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