Vinken PM[1]

Performance Impairment with Taping – Objective and Subjective Effects of Elastic Taping on Vertical Jump Performance

Leistungsminderung durch Taping – Effekte elastischer Muskeltapeanlagen auf objektive und subjektive Sprungkraftparameter

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Summary

- **Objectives:** Elastic taping is postulated to support musculoskeletal aspects of athletic performance. Thereby, specific application techniques should affect specific aspects of muscle functioning, thus facilitating or inhibiting tonicity of the taped muscle. This study examines if different application directions of elastic taping on the quadriceps femoris muscle affect vertical jump performance. Additionally, participant's subjective sensation during such facilitative and inhibitory elastic tapings is investigated.
- **Methods:** 30 participants were asked to perform counter movement jumps without, with facilitative, and with inhibitory elastic taping. Tape application conditions were presented randomly. Participants were blinded concerning postulated effects and application techniques. Height of flight during counter movement jumps was measured to indicate vertical jump performance. Vertical jumps were captured with a high-speed camera. Subjective sensation was investigated using an eleven-point Likert-scale (-5=strongly impaired, 0=neither nor, +5=strongly supported) and participants were asked to evaluate elastic tape applications with regard to jump performance and overall leg sensation.
- **Results:** Both elastic tape applications impair jump performance. However, participants evaluate both applications as supportive. There is no difference between facilitative and inhibitory tape application techniques.
- **Discussion:** Hypothesized performance-enhancing effects of elastic taping on jump performance in active, healthy and young participants can be neglected. However, elastic tape applications affect participants' subjective sensation, which should be considered depending on given context and intention.

KEY WORDS:
Kinesiotaping, Counter Movement Jump, Athletic Performance, Videoanalysis, Likert-Scale

Zusammenfassung

- **Problemstellung:** Durch elastische Tapeanlagen werden leistungsunterstützende Effekte auf die muskuloskelettale sportliche Leistungsfähigkeit postuliert. Dabei sollen unterschiedliche Anlagetechniken spezifische Effekte auf die Muskelfunktionsfähigkeit bewirken. In dieser Studie wird untersucht, ob elastische Muskeltapeanlagen am M. quadricpes femoris die vertikale Sprungkraft in Abhängigkeit ihrer Anlagerichtung verändern. Ergänzend wird das subjektive Empfinden bei Applikation solcher tonisierenden und detonisierenden Tapeanlagen untersucht.
- **Methoden:** 30 Versuchspersonen wurden gebeten, jeweils fünf Counter Movement Jumps ohne, mit tonisierender und mit detonisierender Muskeltapeanlage am M. quadricpes femoris durchzuführen. Die Tapebedingungen wurden randomisiert dargeboten und die Probanden waren hinsichtlich der unterschiedlichen postulierten Effekte der Anlagetechniken blind. Als Indikator der Sprungkraft diente die Flughöhe. Die Counter Movement Jumps wurden mittels Highspeed-Kamera aufgezeichnet. Zur Ermittlung der subjektiven Einschätzung wurde eine elfstufige Likert-Skala (-5=stark beeinträchtigt, 0=weder noch, +5=stark unterstützt) eingesetzt. Hier sollten die Probanden die beiden Tapeanlagen jeweils in Bezug auf die allgemeine Sprungkraft, sowie auf das wahrgenommene Beingefühl bewerten.
- **Ergebnisse:** Beide Tapeanlagen mindern die vertikale Sprungkraft, werden jedoch von den Probanden subjektiv als unterstützend eingeschätzt. Es lässt sich kein Unterschied zwischen tonisierenden und detonisierenden Tapeanlagen nachweisen.
- **Diskussion:** Postulierte leistungsfördernde Effekte elastischer Tapeanlagen auf die vertikale Sprungkraft bei gesunden Probanden können demnach widerlegt werden. Ein Einfluss elastischer Tapeanlagen auf das subjektive Empfinden der Probanden ist jedoch gegeben. Die Applikation sollte daher kontextspezifisch genutzt und abgewägt werden.

SCHLÜSSELWÖRTER:
Kinesiotaping, Counter Movement Jump, sportliche Leistungsfähigkeit, Videoanalyse, Likert-Skala

Introduction, Problem and Goal

Elastic tape applications are used in rehabilitation and prevention of sports injuries, to support functionality of muscles and joints, the flow of blood and lymph and sensitivity to pain (10, 13) and are currently enjoying wide use and popularity (12). Performance-enhancing mechanisms of action are also postulated in the context of musculoskeletal sports performance capacity (2, 9, 19). To support muscle functionality, elastic tapings are differentiated with respect to the position in relation to the direction of the muscle. Elastic muscle tapes are thereby applied from the muscle origin to the muscle insertion if they are to have a facilitative effect on the target muscle. An inhibitory effect on the target muscle is to be effected if the elastic tape is applied from the muscle insertion to the muscle origin (10, 13). ›

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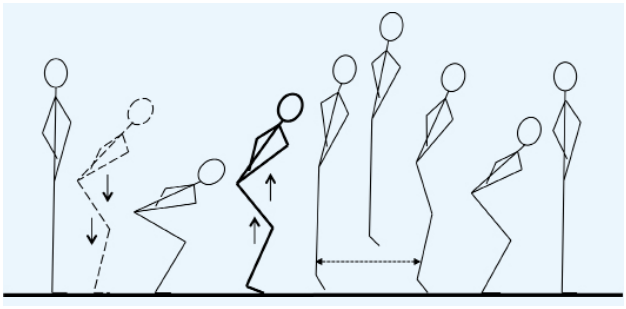

Figure 1

Stick-figure sequence of the counter movement jump. The dashed line exemplarily represent the eccentric phase of the experimental task and the thick line exemplarily represents the concentric phase of the experimental task. The dotted line exemplarily represents the flight time of the jump.

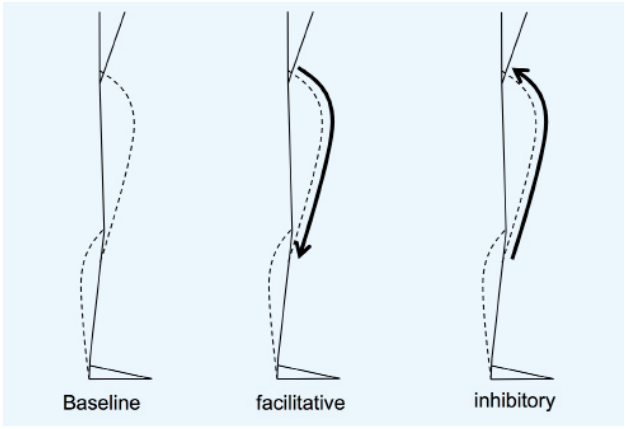

Figure 2

Pictogram of the three tape application conditions on the quadriceps femoris muscle without elastic tape application (Baseline), with elastic tape applied from origin to insertion of the quadriceps femoris muscle (facilitative) and with elastic tape applied from insertion to origin of the quadriceps femoris muscle (inhibitory).

Although only a slight or even no clinical relevance is ascribed to the elastic tape with respect to the relief of complaints (21), supportive effects appear possible with respect to muscle strength (9, 31), which, however, are very specific to task and application (8, 11, 17, 18, 28, 29, 30). Kuo and Huang (14) investigated the influence of facilitative and inhibitory elastic taping on isometric muscle strength in the forearm, but found inconsistent results with respect to time (before, directly after and 24h after tape application) and target musculature (wrist and finger extensors, grip musculature). This may possibly be ascribed to confounding in various application techniques. I-straps were applied in facilitative application on the non-dominant forearm and Y-straps in inhibitory application on the dominant forearm. Vercelli and colleagues (26) found no differences in the isokinetic muscle strength of the quadriceps femoris muscle and the jumping distance in one-legged triple jump in four tape conditions (facilitative, inhibitory, neutral, none). However, the elastic tapings used differed not only in their direction, but also in the width and form of the tape. The participant's subjective sense of perceived muscle strength, however, showed a tendency to improve, independent of the tape conditions (25). Cai and colleagues (5) convinced the participants that they were testing adhesive straps to record muscle activation, but they applied elastic facilitative and inhibitory taping to the wrist extensors, differing only in the direction of application. In the study, no effects could be proved with respect to maximum grip strength, muscle activity (EMG) and self-rated performance (VAS), so that neither facilitative nor inhibitory effects of taping could be proven and a placebo effect ruled out.

In an application-related context, elastic tapes are, however, usually consciously applied by the client and therapist. In this study, in supplement to the studies already cited, the question is addressed of the extent to which the participants' subjectively-perceived sensation corresponds to the objectively-measured parameters. The participants are informed about the application of elastic taping, but are blinded with respect to the different application techniques (facilitative and inhibitory). Moreover, the two different application techniques differ only in the direction of application and are applied to the muscle decisively involved in the motor task examined (4, 7). In addition, the effects of the various tapings are checked using counter movement jumps, which have both an eccentric and a concentric phase. Thus the postulated effects of facilitative and inhibitory tapings and their subjective perception can be examined with respect to the motor task.

It is assumed that elastic muscle tapings on the quadriceps femoris muscle alter the vertical jump performance in dependence on the direction of application. A difference between facilitative and inhibitory application technique is assumed, which manifests in both the jump performance and the participants' subjective perception. Based on the research to date, a direction of the assumed effects cannot be clearly concluded, so that the effect of facilitative and inhibitory tapings on jump performance and the subjective perception is explored in comparison with a baseline condition without taping. It is assumed, with respect to the subjective perception, that the partcipants with taping will report an altered estimate of their jump performance compared to the condition without taping.

Material and Method

Participants

N=30 active and healthy participants (18 women, 12 men; age=23±3 years) were recruited for this study (Power analysis: α-error probability=5%, β-error probability=20%, Cohen's f=0.25) (6). The participants were active sport students, had not suffered any acute injury or damage to the lower extremities during the preceding year and had no or only little prior experience with elastic tape. The participants were always blinded to the taping applied in the various conditions. Prior to the start of the study, the participants granted written consent to participation in the study, which was performed in accordance with the ethics terms of the local university and the Declaration of Helsinki.

Experimental Task

To determine vertical jump performance, the participants were instructed to perform maximum-height counter movement jumps. The arms were bent laterally at hip level. Starting in an upright position, the participants performed a vertical jump starting with a preparatory movement going lower and lower to the individually-preferred knee angle between 70-90° (23) (see Fig. 1). The participants were instructed before each jump to jump as high as possible. In addition, they were told with respect to the taping conditions that all taping applications enhance jumping performance.

Data Recording

The counter movement jumps were recorded using a digital high-speed camera (Casio Exilim EX-ZR200). The camera was positioned in the well-illuminated hall about two meters distant and orthogonal to the participant's line of vision. The recording frequency was 120 Hz (whole image, 480x640 pixel, lens speed 1/500 seconds). The optical axis of the camera was in the middle and perpendicular to the participant's mid-hip when standing upright and covered an image detail of approx. 2x3 meters. The flight time was determined later by computer using the videoanalysis software utilius fairplay 5 (ccc-software, Leipzig). The image frame difference of take-off and landing was calculated in each jump, in which take-off was defined as the final frame before the toes left the floor and landing as the first frame after contact of the toes with the floor. After the flight time (t) in seconds was determined, the height of flight (h) was calculated in meters from the equation $h=0.5*g*(t/2)^2$ (22). If the frames for take-off and landing could not be clearly recognized, a decision was usually taken in favor of flight prolongation and the corresponding previous frame for take-off, or the corresponding following frame in the landing was selected as the timepoint. This results in a – for this investigation –tolerable error of maximum two frames (2/120=0.017s=0.0003m). The assessment of the videos was made randomized and quasi blinded, to avoid serial and study-director effects.

The subjective rating by the test persons was made using an 11-point Likert-scale (from -5=marked impairment through 0=neither/nor to +5=marked support) (15). The subjects were asked to rate the extent to which the two tapings influenced 1. their overall jump performance and 2. their overall leg sensation.

Elastic Taping

Only black tape (K-Tape®, biviax GmbH & Co. KG, Dortmund) was used for the study. The elastic tapes applied in each case to both upper thighs in the test conditions differed solely in the direction of application. In the facilitative elastic tape conditions, an I-strap with Y-segment was applied as follows to both quadriceps femoris muscles of the participant. The anchor of the facilitative elastic tape was applied without stretching proximal at the area of origin of the quadriceps femoris muscle. The base of the I-strap was applied with moderate stretching along the course of the rectus femoris muscle. The Y-segment of the facilitative elastic tape was fitted around the patella, also with moderate stretching. Both ends were applied without stretching distal in the area of insertion of the quadriceps femoris muscle (facilitative muscle application technique; see Fig. 2) (10, 13). In the inhibitory elastic taping condition, an I-strap with Y-segment was also applied, but anchored in the area of the distal muscle insertion and end in the area of the proximal muscle origin. The basis of this taping was also first applied with moderate stretching around the patella and then along the course of the muscle (inhibitory muscle application technique; see Fig. 2) (10, 13).

The elastic tapings were applied by a trained therapist, who completed special training earlier for the tapings used in the study.

Procedure

The participants were asked to perform vertical counter movement jumps in three different taping conditions: 1. without elastic taping (Baseline), 2. with facilitative elastic muscle taping on both quadriceps femoris muscles (facilitative), 3. with inhibitory elastic muscle taping on both quadriceps femoris muscles

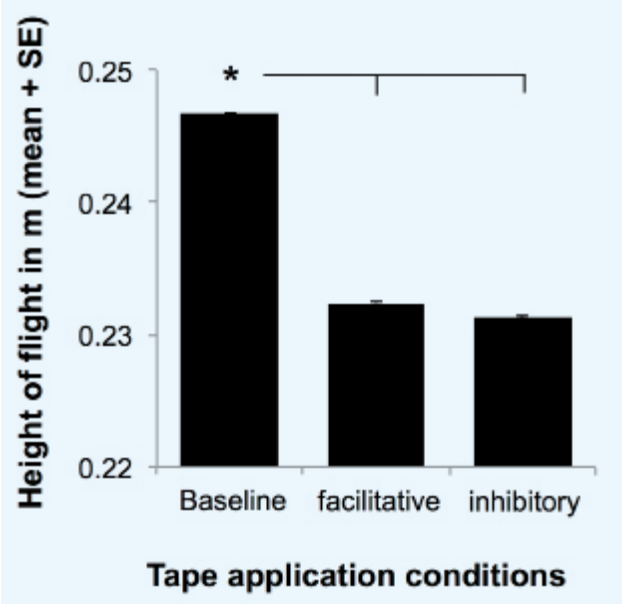

Figure 3

Representation of mean and standard errors of height of flight for the counter movement jumps. *=significant difference after post-hoc-test (Bonferroni).

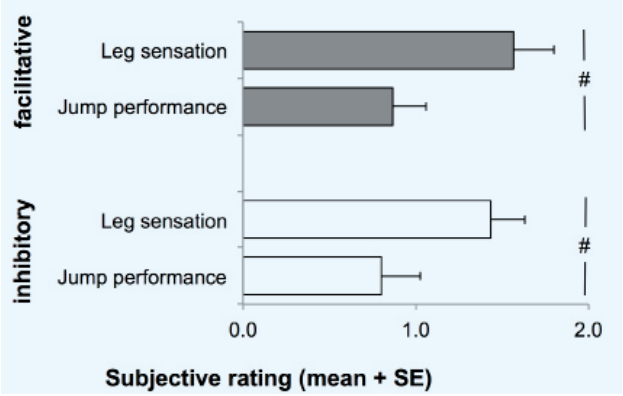

Figure 4

Representation of mean and standard error of subjective sensation with regard to subjective influence of the parameters jump performance and leg sensation during facilitative (grey) and inhibitory (white) muscle tape application. #=significant difference after one-sample t-test against zero and p≤.05.

(inhibitory). The study was performed in the gymnastics hall of the local university, whereby each subject went through the following four phases. The first phase consisted of a short greeting, explanation of the procedure in performing the examination, and granting consent to participation in the study. Then the participant went through a standardized 5-minute warm-up phase consisting of easing, practice runs and various running and jumping exercises. Then the participants were asked to prepare on their own for an additional five minutes for the upcoming task of counter movement jumps. The warm-up phase concluded with three to five test jumps. In these, the subjects were especially made aware of the correct arm and leg position during the jump, so that the arms were bent laterally at hip level during the entire jump movement, the legs not excessively bent in the air and take-off and landing with both legs (23). The second phase consisted of the baseline condition without elastic taping. Here, the participants were asked to perform five ›

Table 1

Frequency distribution of height of flight in the tape application conditions without tape (Baseline), with facilitative elastic tape (facilitative), and with inhibitory elastic tape (inhibitory).

HEIGHT OF FLIGHT (M)	BASELINE	FACILITATIVE	INHIBITORY
Mean	0.25	0.23	0.23
Standard error	<0.01	<0.01	<0.01
Maximum	0.42	0.40	0.39

maximum-height counter movement jumps. In the third phase, the participants received both tapings in randomized sequence (facilitative or inhibitory) on both quadriceps femoris muscles. After a pause of approx. ten minutes to ensure optimal adhesion of the tape to the skin, five maximum-height counter movement jumps were performed in each of the two taping conditions. Once the counter movement jumps with the first taping (for example facilitative) were successful, this taping was removed and the second taping (for example inhibitory) was applied. Five maximum-height counter movement jumps were again performed with the second taping. Then this taping was also removed. In the fourth phase, the subjects were asked to rate the extent to which the taping had influenced their jump performance and their leg sensation, using an 11-point Likert-scale (-5=marked impairment to +5=marked support). The particpiants were asked to rate the Items 1. overall jump performance and 2. overall leg sensation, with the subjectively-perceived influence in each case. This served additionally as a manipulation check, which delivered no differences between the taping conditions. Then the participants were released.

There was no time pressure at any time during the entire performance of the study, and the subjects could take a rest individually at any time as needed. In fact, this was not done by the participants, they did not report fatigue and did not require any individual rests, so comparable time windows between the conditions and measurements can be assumed for all subjects. Questioning about the subjective rating was done immediately after the final jumps of the last condition for both taping conditions. Thus the subjects could submit their subjective ratings comparatively for the first and second taping.

Data Analysis

A significance level of α=5% was set for all presented results. The height of flight in the counter movement jumps served as an indicator of vertical jump performance. To determine the average jump performance of the individual subjects and to reduce subject-internal variations, the means and standard deviations of five jumps in each taping condition were first calculated. To determine differences in means among the three taping conditions (none, facilitative, inhibitory), an analysis of variance with repeated measures was calculated for the parameter height of flight as a dependent variable. The effect size Cohen's f was determined for all results and supplemented by a post-hoc test (Bonferroni) and information on the achieved power in case of significant results.

The ratings in the Likert-scales served as the indicator for subjective rating by the participant. To determine an effect of the subjective rating, one-sample t-tests were calculated to see whether the subjective rating differed from zero (0=neither inhibition nor facilitation). For all significant results, the effect size Cohen's d, and the achieved power were calculated. Differences in the mean between the taping conditions were determined using an analysis of variance with repeated measures (facilitative to inhibitory). Kolmogorov-Smirnov Tests, as well as Mauchly and Levene tests were used to determine normal distribution, sphericity and variance homogeneity. In supplement, a tabular presentation was made of the frequency of the parameters recorded in the study 1. height of flight (see Table 1) and 2. subjective rating (see Table 2).

Results

Figure 3 illustrates the results of the study in the form of means and standard errors in height of flight in the three taping conditions. The means and standard deviations of the three taping conditions in meters at baseline were 0.247m±0.004m, the facilitative taping 0.232m±0.004m and the inhibitory taping 0.231m±0.004m. Analysis of variance with repeated measures and the parameter height of flight as dependent variable shows a significant effect $F(2, 58)=12.88$, $p<.01$, Cohen's $f=0.67$, achieved power >.95. Post-hoc (Bonferroni) shows that the height of flight under conditions with elastic muscle taping decreases significantly compared to baseline without elastic muscle taping ($p<.01$), whereby there was no difference between the two elastic tapings ($p=.75$)

Figure 4 illustrates the means and standard errors of the subjective rating with facilitative and inhibitory muscle taping. The means and standard deviations of the subjective ratings (Likert-scale) show a subjective change in jump performance of 0.87±1.06 for the facilitative taping and for the participant's leg sensation of 1.57±1.28 and a subjective change in jump performance of 0.80±.25 and for the subjective leg sensation of 1.43±1.09 with the inhibitory taping. A multivariate analysis of variance with repeated measures (facilitative vs. inhibitory) shows no global effect: Wilks $\lambda=0.94$, $F(4, 26)=0.42$, $p=.80$. All univariate analyses of variance show no effect ($p\geq.30$).

The subjective ratings all differ significantly from zero $t_{jumpperf\_fac}(29)=4.49$, $p\leq.01$, Cohen's $d=0.82$, achieved power =.46, $t_{jumpperf\_inh}(29)=3.51$, $p\leq.01$, Cohen's $d=0.64$, achieved power=.52, $t_{legsen\_fac}(29)=6.69$, $p\leq.01$, Cohen's $d=1.22$, achieved power >.95, $t_{legsen\_inh}(29)=7.23$, $p\leq.01$, Cohen's $d=1.32$, achieved power >.95.

Discussion

The goal of this study was to investigate the effects of facilitative and inhibitory muscle taping of the quadriceps femoris muscle on the vertical jump performance and the subjective sensation of the participants in the counter movement jump. It was assumed that elastic muscle taping of the quadriceps femoris muscle alters the vertical jump performance in dependence on the application direction, whereby especially a difference between facilitative and inhibitory taping technique was assumed which would affect both the jump performance and the subjective sensations of the participants.

The following results are interesting. Although the participants rate the taping as supportive, it reduces the vertical jump performance in the counter movement jump. Moreover, no difference can be demonstrated between facilitative and inhibitory taping with respect to either the subjective sensations or the jump performance. The definitely low absolute effects in the change of height of flight and subjective ratings can be viewed as consistent with overview articles to date (9, 21). Where there are changes in a specific parameter due to the elastic taping, they are usually of low absolute value and, moreover, sensitive with respect to observable performance-determining parameters.

Table 2

Frequency distribution of subjective sensation in the tape application conditions without tape (Baseline), with facilitative elastic tape (facilitative), and with inhibitory elastic tape (inhibitory).

	FACILITATIVE		INHIBITORY	
SUBJECTIVE RATING (LIKERT SCALE)	JUMP PERFORMANCE	LEG SENSATION	JUMP PERFORMANCE	LEG SENSATION
Mean	0.87	1.57	0.80	1.43
Standard Error	1.06	1.28	1.25	1.09

The results of this study contradict the treatment information from practice with elastic tapings, when these are to be used as an intervention to enhance performance in active and healthy subjects. Studies to date with identical muscle tapings on the anterior upper thigh and comparable task requirements usually find no effects (16, 26). Thus it can be postulated that the use of elastic muscle tapings are neither advantageous nor detrimental for the participants and with subjective satisfaction may be advantageous for the test person/athlete, as long as the height of flight is not a performance-decisive factor in the requirements profile of the type of sport/exercise task. For sports-typical and exercise tasks in which the height of flight in two-legged take-off may be decisive for performance, elastic tapings like those used in this study should not be applied. This has also been proven in active and healthy gymnasts, whose vertical jump performance decreased when facilitative muscle taping was applied to the rectus femoris muscle (27). Therefore, it must be precisely considered whether the effect of elastic muscle taping, even with positive rating and sensation, can compensate for possible negative effects on the athletic performance capacity. The intended effect on muscle tone, which is supposed to be achieved by different taping direction, cannot apparently at present be proven with respect to a performance-enhancing effect. However, Pamuk and Yokesoy (20) could demonstrate by MRI analyses that elastic taping results in mechanical soft-tissue alterations, whereby the local deformation on the target muscle did, in part, actually occur in the direction of the applied taping. Other parts of the target muscle and neighboring tissue, however, showed deformations in other directions. This might possibly explain why there was a reduction in jump performance in the current study, but this can only be speculated given the details of the present study. If the muscle taping applied presents deformation on the target muscle which also affects neighboring tissue, this possible leads overall to a structural change, resulting in an inappropriate interaction of the musculoskeletal structures involved. This could result in performance reduction which, however, is below the subjectively-perceivable threshold. In addition, the positive subjective sensation may possibly be explained by a placebo effect, implicit conviction or social desirability (3, 24).

The following limitations must be taken into account in interpreting this study. On the one hand, only active, healthy and young adults were examined. The extent to which the results can be applied to other target groups – such as persons with demonstrable muscular dysbalances of the target musculature – should be examined in subsequent studies. In addition, elastic taping was only applied to the quadriceps femoris muscle. Whether other or combined elastic taping affect the vertical jump performance and the subjective sensations remains open. The same applies for the recorded parameter height of flight. Whether possibly muscle activity, body angle, ground reaction force or parameters of fatigue change due to the taping, was not addressed in this study and thus providing impetus for additional studies. The same is true for questions of the mechanism of action behind the objective and subjective effects observed in this study of various tapings on the vertical jump performance. Moreover, the selected test design cannot rule out serial or fatigue effects below the subjectively-perceived threshold, even though 15 counter movement jumps is known to be a low-threshold stress stimulus for the selected group of participants (1, 23).

Overall, the following practical implications can be noted: compared to baseline condition without tape, facilitative and inhibitory elastic muscle tapings on the quadriceps femoris muscle are rated subjectively as positive with respect to their efficacy. However, possible negative physiological effects must be taken into context-specific account. The direction of taping, from the muscle origin to the muscle insertion or vice-versa, had influence on neither changes in jump performance nor on subjective sensation.

Postulated performance-enhancing effects of elastic tapings on the vertical jump performance of healthy subjects can thus be rejected. Their influence on the participant´s subjective sensation is, however, given and use should be made of this in a context-specific manner.

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Conflict of Interest

The authors have no conflict of interest.

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