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ORIGINAL ARTICLE

Does ankle Kinesio Taping® application improve static and dynamic balance in healthy trained semi-professional soccer male players? A single blinded randomized placebo controlled crossover study

L'équilibre statique et dynamique des footballeurs semi-professionnels en bonne santé s'améliore-t-il avec l'application de Kinesio Taping® à la cheville? Une étude croisée contrôlée par placebo, randomisée en simple aveugle

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KEYWORDS
Kinesio taping;
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Summary
Objectives. — Purpose of this study was to investigate the effects of Kinesio Taping (KT) in healthy semi-professional soccer players in both static and dynamic balances thorough a single blinded randomized placebo controlled crossover study.

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Equipment and methods Fifteen healthy male soccer players from the same team (A.C. Fucecchio) were recruited on a voluntary basis and evaluated in mid-season. A force platform was used to record forces and centre of pressure (CoP) data. Twenty seconds one-legged stance test was used to analyse static balance. For dynamic balancing test, subjects performed maximal vertical jump with both legs, landing on dominant limb, trying to balance as quickly as possible. Tasks were evaluated using CoP derived data as sway area, displacements in anterior-posterior and medio-lateral directions, total path length. In addition, time-to-stabilisation and jump height were evaluated only for dynamic task. Participants completed proposed tasks in three different conditions: tape, no-tape and placebo conditions, whose sequence was selected using computer-generated randomization.

Results. — No significant differences between testing conditions were founded for all parameters investigated ($P > 0.05$).

Conclusion. — KT was not effective in improving both static and dynamic balances, otherwise showing no significant difference when compared to no-tape and placebo conditions. This may suggest that KT should not be used when the aim is to improve balance in healthy players focusing on ankle injury prevention.

MOTS CLÉS
Kinesio taping ;
Cheville ;
Équilibre ;
Football

Résumé

Objectifs. — L'objectif de ce travail était d'examiner les effets du Kinesio Taping (KT) sur les joueurs de football semi-professionnels en bonne santé sur l'équilibre statique et dynamique à travers une seule étude croisée randomisée contrôlée par placebo en aveugle.

Équipement et methods. — Quinze joueurs de football en bonne santé de la même équipe (A. Fucecchio) ont été recrutés sur une base volontaire et évalués en milieu de saison. Une plate-forme de force a été utilisée pour enregistrer les forces et les données du centre de pression. Le test d'équilibre monopodal a été utilisé pour évaluer l'équilibre statique. Pour le test d'équilibre dynamique, les sujets ont été invités à effectuer un saut vertical maximum avec les deux jambes, en se posant sur le membre dominant et en essayant de trouver l'équilibre le plus rapidement possible. Les tests effectués ont été évalués en analysant les données dérivées du mouvement du centre de pression. En particulier, la zone de confiance, les mouvements dans les directions antéro-postérieure et médio-latérale, la longueur totale du trajet ont été évalués. De plus, le temps requis pour la stabilisation et la hauteur de saut n'a été évalué que pour l'essai dynamique. Les participants ont terminé les tâches proposées dans trois conditions différentes: Kinesio Taping®, sans bande et placebo, dont la séquence a été sélectionnée à l'aide d'une randomisation générée par ordinateur.

Résultats. — Aucune différence significative entre les conditions de test n'a été établie pour tous les paramètres étudiés ($p > 0,05$).

Conclusion. — Le KT n'a pas été efficace pour améliorer l'équilibre statique et dynamique, aucune différence significative n'ayant été constatée entre les différentes conditions. Cela peut suggérer que le KT ne devrait pas être utilisée lorsque l'objectif est d'améliorer l'équilibre chez les joueurs en bonne santé afin de prévenir les blessures à la cheville.

1. Introduction

Balancing ability has a great importance in performing several daily living activities [1]. It has also an important role in injury prevention and improving performance in athletes [2,3]. Especially in soccer, where while one leg provides support to the whole body the other leg performs different tasks (kicking, passing, dribbling, etc.) [4].

Foot and ankle injuries are common in active people [5], with ankle sprain, in particular, representing more than 30% of total lower leg injuries [6] especially in the athletic population, with high incidence in soccer players [7].

In the context of injury prevention, static and dynamic postural control tests were used to assess balancing abilities [8], and their reduction was associated to higher risk for ankle injury [9,10] and reduced sport performance [11]. Generally, static postural sway has been quantified though centre of pressure (CoP) motion measures, while dynamic balance has been assessed using time-to-stabilisation (TTS), measuring the time that a subject needed to stabilise after a certain task (e.g. after a jump) [2,12,13]. Dynamic test allows for quantification of balance during sport specific manoeuvres, conversely static test evaluates change in dynamic restraint mechanisms [2]. For soccer players, postural sway analysis during standing showed to be reliable to discriminate players level [14] and maturation [15], with some authors finding a positive correlations between static postural sway and injury risk [16]. However, recent studies showed that dynamic and static balancing performances were not correlated, implying that to better understand overall balancing performance both tests are needed [2].

As mentioned previously, balance has been related to higher performance [11] and reduced injury risk [9,10], therefore different methods have been proposed to improve both static and dynamic postural control.

Porous adhesive non-elastic tape [17] and braces [6,17] were used for ankle joint stabilization, limiting inversion and eversion of the foot providing stability to the joint without compromising normal joint mechanics [18], especially in previously injured athletes [19], but controversial results were found regarding proprioception and balance enhancement [20].

In addition, ankle stabilisers seemed to affect functional performance, reducing athletic abilities, mostly in elite athletes [18]. Recently, kinesiotape® (KT), which was created by a Japanese chiropractor in 1980, has gained popularity in clinical environment [21]. KT is made of polymer elastic strand wrapped by 100% cotton fibres with a thickness comparable to epidermis, allowing perspiration, ideal for sport. The tape has been designed to be felt as a part of the skin, with no latex used, 100% acrylic and heat-activated glue, it can be stretched up to half of its resting length and worn for 3-5 days, with waterproof adhesive [21,22]. Contrarily to non-elastic tape, which may cause skin discomfort and joint mobility reduction [23], KT provides a tensile force without compromising joint range of motion [22,24]. In particular, for its mechanical properties, KT has low stiffness when the joint starts to move, but it increases its stiffness when the movement get closer to the joint end range and it keeps its mechanical properties longer than athletic tape, making KT ideal for use during repetitive joint tasks [25]. Furthermore, manufacturer also claims different therapeutic benefits, including reduction of pain and inflammation, which is obtained by increasing lymphatic and blood flow [22,24]. Moreover, manufacturer claims also sensorimotor function benefits including improvement of proprioceptive feedback, mechanical support of the joint and facilitation of neurological activity in the cutaneous mechanoreceptors [21,26—28]. It has been suggested that mechanical properties and facilitatory effect may enhance postural control during balancing task when KT is applied on the ankle joint, however, current research showed contrasting results regarding positive KT influence on ankle proprioception [26,27,29], and balance [13,26,30]. The effect of KT is controversial also for symptomatic patients. A meta-analysis by William and co-workers [28] confirmed that evidence for KT efficacy in sport injury prevention was disputable and limited. The most documented effect of KT was pain reduction for injured subjects [31].

Purpose of this study was to investigate possible beneficial effects of KT on balancing performance in healthy, semi-professional soccer male players using both static and dynamic methods, which showed to be satisfactory for soccer players balance assessment [2]. It is hypothesised that static and dynamic balancing performance may be improved by KT application when compared to no-tape and placebo conditions.

2. Equipments and methods

2.1. Subjects

An a priori power calculation from pilot study data was performed with G*Power software [32] to evaluate a condition main effect considering a statistical power of 0.80, α level of 0.05, and, as a consequence the minimum required sample size of 15 semi-professional soccer players from the same team (A.C. Fucecchio), were recruited for the study.

15 semi-professional soccer players from the same team (A.C. Fucecchio), were recruited for the study on a voluntary basis. The Italian version of the Foot and Ankle Ability Measure questionnaire (FAAM), with both activities of daily living (ADL) and sports subscales, were administered to evaluate ankle joint functionality [33,34]. Exclusion criteria included individuals with history of ankle injury, fracture, or surgery to the legs, lower extremity injuries over the previous six months, health issues that would interfere with a subject's safety during exercise, auditory/vestibular impairments, uncorrected visual problems and open wounds in area of KT application. Each participant regularly performed three ninety-minute soccer-training sessions per week, plus a match during competitive season, from September to June. All subjects were evaluated in March (mid-season). The CESAT institute (Centro di Eccellenza Sostituzioni Articolari Toscana) Ethics Committee approved the study in accordance with the principles outlined in the Declaration of Helsinki [35] and all subjects were asked to read and sign an informed consent form prior to their inclusion in the study.

2.2. Instrumentation

A force platform (P6000D, BTS Bioengineering, Milan), with a sampling rate of 500 Hz, was used to record forces and centre of pressure (CoP) data during both static and dynamic tasks. Optoelectronic motion tracking system (SMART DX-700, BTS Bioengineering, Milan), consisting of eight infrared cameras, was used to evaluate jump height, acquiring at sampling rate of 250 Hz.

2.3. Procedure

Participants performed static and dynamic balancing tests with the dominant leg. During the static balance test, participants were asked to stand on the dominant limb with eyes opened as still as possible for 20s, with the supporting foot placed on the force platform, as described previously[2].

For the dynamic balancing test, participants were required to perform a maximal vertical jump with both legs, landing on the force platform with the dominant limb and trying to balance as quickly as possible with the help of the arms.

Each participant performed both tasks in three conditions; tape, no-tape and placebo tape. Participants were allowed to familiarise with the testing procedure (posture/movements) and a passive reflective marker was

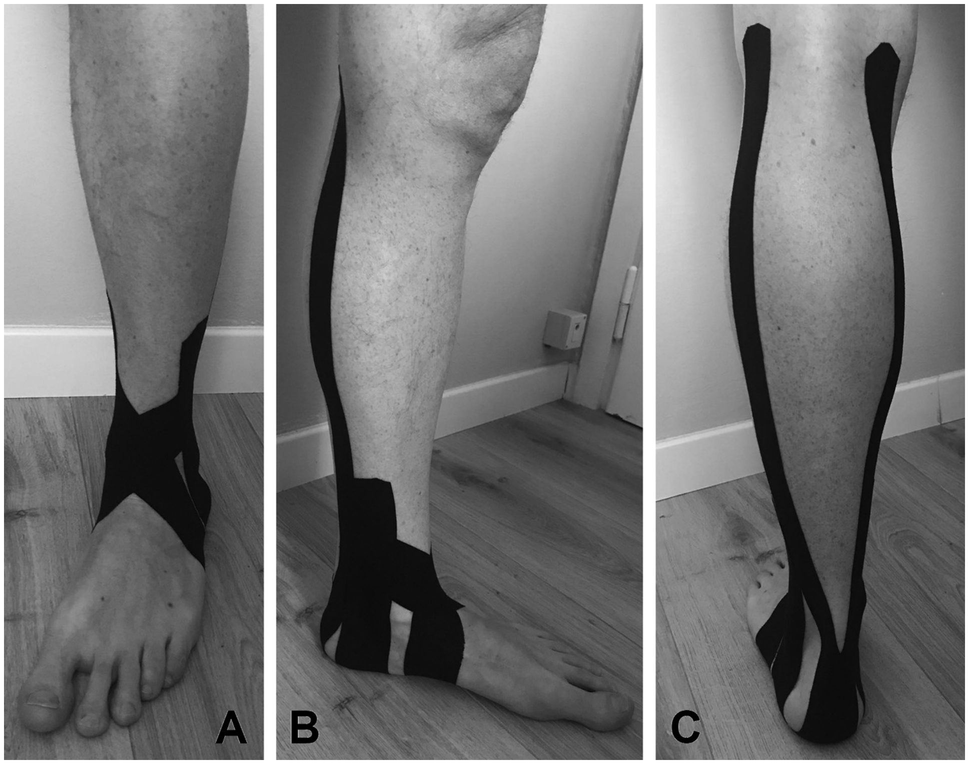

Figure 1 Frontal (A), lateral (B) and back (C) views of Kinesio Taping application to the dominant leg.

placed at level of S1 vertebrae prior starting data collection. The condition sequence was randomly processed for each participant to avoid bias using a computer-generated randomization code. Participants were blinded for taping type. Three trials for static task and three trials for dynamic task were collected for each condition. 20 minutes rest were given between testing conditions. Participants were asked to report any presence of pain during the entire procedure.

2.4. Kinesio taping application

The technique followed manufacturer's guidelines, which is described in the Kinesio taping® method [21] and it is shown in Fig. 1 Fig. 1. According to the manufacturer, the controllable variables in KT application included degree of pre-stretch applied to the tape, the location and treatment goals.

The subject laid supine, with the ankle on the dominant side in neutral position. A Y shaped KT strip was applied from the heel to lateral and medial femoral condyles. A I shaped KT strip was applied from medial malleolus to lateral malleolus, passing under the heel. Another I shaped KT strip was applied from slightly above the medial malleolus to slightly above the lateral malleolus, crossing on the instep at the malleoli level [21]. The same certified KT Practitioner completed each tape application for all participants to maintain consistency throughout the study.

2.5. Placebo application

The same tape used for the interventional application was used. Two strips were used, one from the heel to the proximal third of the leg, the other from the lateral malleolus to the medial malleolus crossing on the instep, both with 0 tension (Fig. 2 Fig. 2).

2.6. Data Processing

COP force platform data were analysed through a custom-made MatLab software (The MathWorksInc., Natick, MA, USA) routine to get the following parameters for both static and dynamic balancing tests:

- Sway area, evaluated as 95% confidence ellipse area (CEA);
- COP total path (TP), calculated as the cumulative displacement of the CoP during the trial;
- COP maximal excursion for the ML plane (MLmax) as the difference between the most medial and the most lateral point;
- COP maximal excursion for the AP plane (APmax) as the difference between the most anterior and the most posterior point.

In addition, for the dynamic balancing test, time-to-stabilisation in the vertical (vTTS), anterior-posterior (APTTS) and medial-lateral (MLTTS) directions were calculated taking all the three components of the GRFs. For all directions, data from the initial fourteen seconds after landing were used to calculate means and SDs of each trial and TTS was defined as the time when cumulative average of the relevant component of the GRF signal remained within mean + 0.25 SD of the trial [13,36].

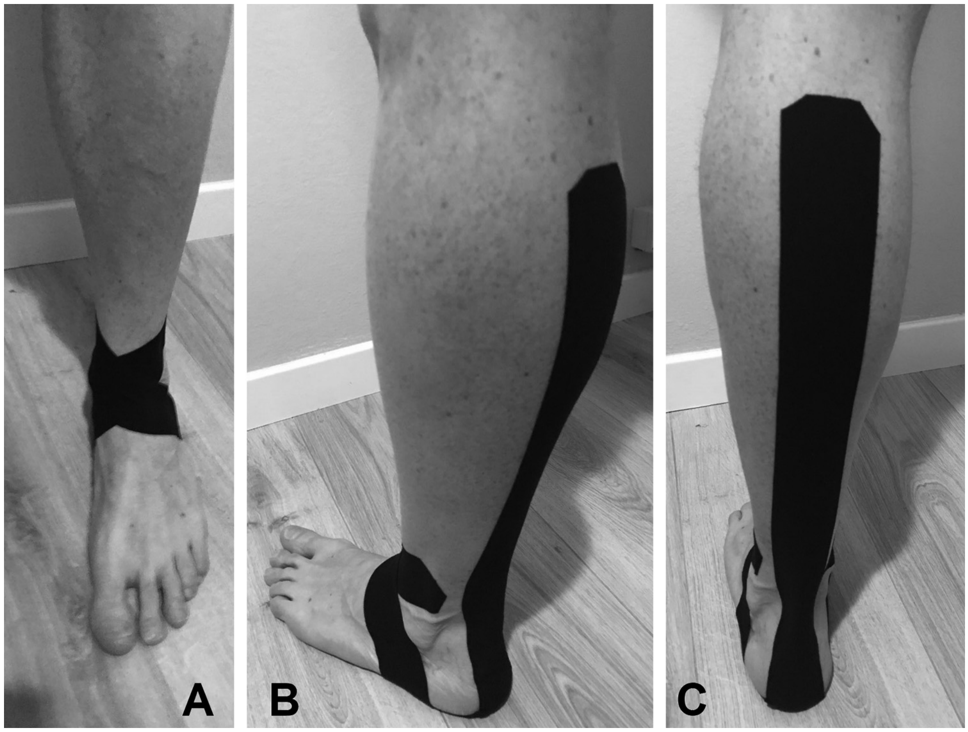

Figure 2 Frontal (A), lateral (B) and back (C) views of placebo application to the dominant leg.

Maximum vertical landing force (Fmax) were evaluated for each trial using vertical GRF data while maximum jump height (JH) was taken from marker vertical displacement data.

2.7. Statistical analysis

Analysis by ANOVA for repeated measures (3 conditions) was used to assess the overall effect of different conditions on static and dynamic balancing data. Shapiro-Wilk test was used to assess normal distribution of the data. Mauchly's Test was used to verify that sphericity assumption was met, in case this assumption was violated, Greenhouse-Geisser correction was applied. Post-hoc using Bonferroni correction was applied in case of significant difference among the three assessments. SPSS (SPSS: An IBM Company) was used for statistical analysis.

3. Results

In total, 15 healthy semi-professional soccer male players participated in the study (age = 25.6 ± 5.1 years; height = 1.79 ± 0.05 m; body mass = 74.5 ± 7.3 kg; BMI = 23.2 ± 1.7 kg/m^2). Questionnaire results were respectively $99.1 \pm 1.5\%$ for the FAAM ADL subscale and $98.6 \pm 3.0\%$ for the FAAM Sport subscale, implying good functionality for all participants. No subjects complained of pain or discomfort after completion of all tasks. Results of the repeated measures ANOVA for all parameters investigated are summarised in Table 1 for static balancing test and in Table 2 for dynamic balancing test. For the static balancing task, there were no significant effect of different conditions on the CEA, APmax, MLmax and TP parameters, with $P > 0.05$ for all parameters (Table 1). Similar results were obtained for the dynamic balancing task, as different conditions demonstrated no significant effect ($P > 0.05$) for CEA, APmax, MLmax, TP, Fmax, JH, vTTS, APTTS, MLTTS parametes (Table 2). The presence and the type of the tape did not influence performance of both tasks.

4. Discussions

Purpose of this study was to evaluate possible improvements in jump performance, static and dynamic balance in semi-professional soccer male player with KT application to the dominant leg.

Results of the study showed that KT application did not improved/worsen results when compare to no tape and placebo conditions.

Both static and dynamic balance were evaluated distinctly because these abilities cannot be correlated as they are regulated by different mechanisms, as explained by Pau et al. [2]. In addition, dynamic balancing assessment may be more appropriated with a sport-related method (e.g. jump landing evaluation) [2,12,13,26,36] even if some authors claimed to evaluate dynamic balancing through static postural control or joint position sense reproduction tests [37].

Regarding injury prevention, it has been shown that balancing performance may be related to injury incidence [9,10], as for example, a quicker stabilisation time was found favourable in enhancing players safety [2,4]. Moreover, balancing was found crucial in enhancing performance in soccer player, as in different game situations, one limb provides body support and stability to the other limb, for example during kicking [2,4]. Regarding balancing measurement method, CoP analysis was chosen for both static

Table 1 Parameters means and standard deviations for the static balancing task in all conditions.

	Static Balancing Task						
	Condition			Statistics			
	Tape	No-Tape	Placebo	F	Df	Df (error)	*P*-value
	Mean (sd)	Mean (sd)	Mean (sd)				
CEA (mm^2)	202.95 (104.42)	198.28 (84.95)	184.86 (75.88)	0.205	1.94	27.2	0.809
APmax (mm)	42.40 (12.74)	43.36 (13.73)	39.58 (11.67)	0.501	1.8	25.9	0.597
MLmax (mm)	33.17 (7.82)	31.62 (6.16)	35.35 (8.04)	1.065	1.9	26.7	0.356
TP (mm)	685.42 (191.40)	754.32 (246.60)	718.63 (252.67)	1.281	2.0	27.5	0.293

Not significant differences between the conditions ($P. > 0.05$). CEA: confidence ellipse area; APmax: anterior-posterior maximal excursion; MLmax: medio-lateral maximal excursion; TP: total path; F indicates the F statistic for the ANOVA; Df indicates degrees of freedom.

Table 2 Parameters means and standard deviations for the dynamic balancing task in all conditions.

	Dynamic Balancing Task						
	Condition			Statistics			
	Tape	No-Tape	Placebo	F	Df	Df (error)	*P*-value
	Mean (sd)	Mean (sd)	Mean (sd)				
CEA (mm^2)	644.36 (215.95)	692.84 (336.78)	675.26 (182.94)	0.187	1.7	23.9	0.797
APmax (mm)	241.24 (62.79)	260.94 (73.37)	245.09 (40.38)	0.613	1.9	27.1	0.544
MLmax (mm)	90.33 (33.97)	90.99 (35.79)	84.48 (29.81)	0.312	1.5	20.4	0.667
TP (mm)	1350.68 (354.42)	1352.79 (292.01)	1364.94 (233.52)	0.027	1.4	19.6	0.932
Fmax (N/BW)	3.82 (0.66)	3.80 (0.38)	3.85 (0.55)	0.094	1.7	24.4	0.886
JH (mm)	418.55 (71.40)	419.55 (48.74)	419.74 (63.27)	0.007	1.9	26.0	0.991
vTTS (s)	3.91 (0.43)	3.94 (0.63)	3.96 (0.34)	0.146	1.6	22.4	0.819
APTTS (s)	1.32 (0.42)	1.32 (0.51)	1.29 (0.47)	0.027	1.5	21.1	0.943
MLTTS (s)	1.36 (0.45)	1.32 (0.36)	1.33 (0.29)	0.056	1.5	20.4	0.897

Not significant differences between the conditions ($P. > 0.05$). CEA: confidence ellipse area; APmax: anterior-posterior maximal excursion; MLmax: medio-lateral maximal excursion; TP: total path; Fmax: maximal vertical landing force; JH: Jump height; APTTS: time to stabilisation in the anterior-posterior direction; MLTTS: time to stabilisation in the medio-lateral direction; F indicates the F statistic for the ANOVA; Df indicates degrees of freedom.

and dynamic tasks as it has already shown to be reliable, appropriate and sensitive to measure changes in interventional[38], observational [2,39], pretest-posttest [39] and crossover [13,29,37] study designs.

Results of the actual work were in accordance with previous studies, which evaluated KT influence in proprioception, balancing and performance. Proprioception, evaluated using reproduction of joint position sense test was not influenced by KT application in general healthy subjects [3,27]. Moreover, static and dynamic balancing and functional performance results showed not to improve with KT application in athletes from different sports [40], healthy subjects [3,22], but different methods were used to evaluate balancing performance. In previous studies, similar methodology was used to assess static and dynamic balance in general healthy population [13,37] and in athletes from different sports [40], with no improvement/worsening of balance found with the use of KT.

Chang et al. [30] found some improvements with KT use in general athletic population for dynamic balancing during one-legged multiple hops test, but they used a score calculated using distance from ideal points of landing and number of time that the contralateral limb touched the floor, rather than CoP movements. Moreover, they only compared KT to athletic tape, without considering no-tape condition and they used two different groups rather than evaluating effects of different conditions on the same group [30]. However, these results could not be directly related to soccer players as these athletes demonstrated different balance ability than healthy subjects and other athletes [41].

Some studies already evaluated effects of ankle joint KT on soccer players with contrasting results. In particular, Brogden et al. [29] and Bailey et al. [26] focussed on proprioception, with joint position sense test and results were contrasting, with Bailey et al. [26] showing not significant improvements for the KT group while Brogden et al. [29] reporting significant effect on joint position sense of KT, but with an improvement lower than 1°, which make KT efficacy disputable for clinicians.

In addition, regarding static balance both studies showed similar results to the actual study, with no improvements using KT.

In addition, Brogden et al. [29], similar to our study, evaluated dynamic task as drop landing, but only time to completion, which is a measure of performance rather than balancing, however without any difference between KT and no tape conditions, was used as assessment.

As described previously, there are different manner to evaluate proprioception and balance. For this reason, result of this work maybe in contrast with previous studies. However, methodology chosen to assess both static and dynamic balance shown to be reliable and to fully analyse balancing for soccer players, adding information to possible effects of KT on this ability [2].

It needs to be highlighted that for dynamic balancing test results may be influenced by jump performance, with a lower jump resulting in facilitated balancing task, which, in turn, leading to CoP oscillations and TTS reduction. However, jump height, as reported in Table 2, was similar for all three conditions, implying that jump performance was consistent.

Overall results showed that all conditions returned similar balancing performance, in details, during one-leg stance oscillations and ellipse area were not significantly reduced by using KT. In the same manner, for dynamic balancing, KT usage did not improve performance, as ML and AP excursions, together with ellipse area and TTS were not reduced after KT application. In addition, jump height and landing force were not enhanced by KT application. As a clinical implication, we could not confirm that KT improved static and dynamic balancing in semi-professional healthy soccer players.

There are several limitations in the current study. Firstly, only semi-professional healthy soccer male players participated, as such, no conclusions can be drawn on the effect of KT when applied to other population, including, for example, female or injured athletes, in particular subject with ankle instability. Secondly, the study only evaluated the immediate effects on balancing as testing was performed on the day of KT application. At last, KT application method may have affected results, for this reason the methodology recommended by tape manufacturer [21] and already used in similar studies[3,13,26,27,29,30], was chosen.

Future investigation may focus in evaluating outcomes related with KT usage including follow-up evaluation, different population and application methodology.

5. Conclusion

In conclusion, results of this study showed that both static and dynamic balance were not enhanced by KT application in healthy semi-professional soccer male players as no significant differences were found when tape was compared to no-tape and placebo conditions. This may suggest that KT should not be used when the aim is to improve balance focusing on ankle injury prevention.

Disclosure of interest

The authors declare that they have no competing interest.

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