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Acute effects of rigid ankle taping on the mechanics of the single-leg drop jump in college/university combat athletes: a quasi-experimental study

Efectos agudos del vendaje rígido en el tobillo sobre la mecánica del salto unipodal con caída en deportistas universitarios de combate: un estudio cuasi-experimental

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Ruano Cárdenas, OD [1ABCF]; Carabalí Chará, L[2ABCF]; Lasprilla-Bueno, JA[3ACD]; Mazuera Yepes, KJ[4ACF]; Pechené Rengifo, LV[5BC]

[1]Universidad del Valle, Colombia, oscar.ruano@correounivalle.edu.co
[2]Universidad del Valle, Colombia, laura.carabali.chara@correounivalle.edu.co
[3]Universidad del Valle, Colombia, lasprilla.julian@correounivalle.edu.co
[4]Universidad del Valle, Colombia, karen.mazuera@correounivalle.edu.co
[5]Universidad del Valle, Colombia, lina.pechene@correounivalle.edu.co

Responsibilities. (A Study design; B Data collection; C Manuscript drafting; D Statistical analysis; E Financial support; F Original idea and overall research coordination)

Corresponding author: Oscar Daniel Ruano Cárdenas. oscar.ruano@correounivalle.edu.co

ABSTRACT

Objective: To analyze the acute effects of rigid ankle taping on kinematic, kinetic, and performance variables during the single-leg drop jump in university combat sport athletes. Method: Thirty participants took part in a quasi-experimental within-subject design, performing single-leg drop jumps with and without rigid ankle taping. Measurements were obtained using the My Jump 2 application and the free motion analysis software Kinovea, recording jump height, stiffness, knee dynamic valgus, and maximum ankle dorsiflexion. Statistical analysis was conducted with the Wilcoxon signed-rank test, with significance set at $p < 0.005$. Results: Rigid ankle taping significantly reduced maximum ankle dorsiflexion during landing (32.2° vs. 29.9°; $\Delta = 2.97$; $p < 0.005$). No relevant changes were observed in knee dynamic valgus. In terms of performance, increases were noted in jump height and stiffness, although these differences were not statistically significant. Conclusion: Rigid ankle taping restricts ankle dorsiflexion without producing relevant changes in immediate performance, providing useful evidence for sports physiotherapy practice in combat sport athletes.

KEY WORDS: kinematics, kinetic, vertical jump, athletic tape, sports biomechanics.

RESUMEN

Objetivo: analizar los efectos agudos del vendaje rígido de tobillo sobre variables cinemáticas, cinéticas y de rendimiento durante el salto unipodal en deportistas universitarios de disciplinas de combate. Método: Treinta participantes participaron en un diseño cuasi-experimental intrasujeto, realizando saltos unipodales con y sin vendaje rígido en el tobillo. La medición se efectuó mediante la aplicación My Jump 2 y el software gratuito de análisis de movimiento Kinovea, registrando altura del salto, stiffness, valgo dinámico de rodilla y dorsiflexión máxima de tobillo. En análisis estadístico se realizó con la prueba de rangos con signo de Wilcoxon, estableciendo significancia en $p < 0{,}005$. Resultado: El vendaje redujo significativamente la dorsiflexión máxima de tobillo durante el aterrizaje (32,2° vs. 29,9°; $\Delta = 2{,}97$; $p < 0{,}005$)., No se observaron cambios relevantes en el valgo dinámico de rodilla . Se observaron aumentos en la altura del salto y el stiffness, aunque sin significancia estadística. Conclusión: El vendaje rígido restringe la dorsiflexión sin afectar de manera relevante el rendimiento inmediato, aportando evidencia útil para la práctica fisioterapéutica en deportes de combate.

PALABRAS CLAVE: cinemática, cinética, salto vertical, vendaje rígido; vendaje atlético, biomecánica deportiva.

INTRODUCTION

Ankle sprain is one of the most common injuries of the musculoskeletal system, particularly among young individuals involved in sports practice (1). Among university athletes in the United States, it has been reported as the most frequent diagnosis, with a higher incidence during competitions than during training sessions (2).

In combat sports, the lower extremity represents the anatomical region with the highest prevalence of injuries. In taekwondo, for example, 76.8% of injuries affect this region (3,4), and recent studies confirm that sprains account for more than 25% of recorded injuries (5). National data from Colombia reflect a similar trend, with lateral ankle sprains being the most frequent injuries reported during the ASCUN University Games (6). In judo, a high incidence of ligament injuries and tendinopathies in the lower limbs has also been documented.

Due to this high frequency, the implementation of preventive strategies is crucial. One of the most commonly used strategies is rigid ankle taping (7), particularly in combat sports, where constant contact, frequent jumps, and repeated landings increase the risk of excessive inversion and ankle sprains (8,9). However, although taping aims to reduce the recurrence of injuries, it may also produce biomechanical alterations that affect ankle dorsiflexion and knee dynamic valgus, modifying the absorption and redistribution of forces during movements involving high mechanical demands (10–13). Likewise, neuromuscular parameters such as lower-limb stiffness may also be affected, potentially limiting the capacity to dissipate forces and increasing the risk of overload (14).

In combat sports such as judo, rigid ankle taping is widely used as a preventive strategy and for joint support. Nevertheless, biomechanical evidence indicates that its effects are not always beneficial. Kwon et al. (2022) reported that although taping may increase joint stiffness and reduce center-of-pressure oscillation in certain postures, it may also limit ankle flexibility and negatively affect postural stability under dynamic conditions (15). Similarly, a recent study showed that the effectiveness of taping decreases with prolonged use, and that both new and reused tapes may alter lower-limb biomechanics during specific sport movements, affecting joint loading patterns (16).

This paradox raises an important concern: taping, which is intended to improve safety and performance, may compromise the adaptive capacity of the musculoskeletal system during high-demand movements such as jumps and landings that are characteristic of combat sports (15). Therefore, it is necessary to critically analyze its acute effects on kinematic, kinetic, and performance variables in university combat sport athletes, a population for which evidence remains limited.

Therefore, the aim of this study was to compare the acute effects of rigid ankle taping on knee dynamic valgus, ankle dorsiflexion, jump height, and stiffness between taped and non-taped conditions during a single-leg drop jump (SLDJ) in university combat sport athletes. The hypothesis was that taping would restrict dorsiflexion and alter mechanical parameters without significantly affecting immediate performance.

MATERIALS AND METHODS

Study Design

A quasi-experimental within-subject study was conducted in which participants were evaluated under two conditions: without taping (WT) and with rigid ankle taping (RT). This design allowed the analysis of the acute effects of rigid ankle taping on biomechanical and performance variables during the execution of a Single-Leg Drop Jump (SLDJ). Data collection was carried out over three weeks in April 2025.

Participants

The sample consisted of 30 university athletes (18 men and 12 women) belonging to combat sport disciplines (taekwondo, karate, judo, and Muay Thai) from Universidad del Valle, Meléndez campus. The sample size was determined by convenience according to the inclusion criteria. The inclusion criteria were: age between 18 and 25 years, a minimum of two years of experience in their discipline, and absence of lower limb injuries during the previous six months, as well as adequate ankle function determined using the Foot and Ankle Ability Measure (FAAM) scale, with scores above 80% (17).

Participants were excluded if they presented musculoskeletal disorders, acute pain, skin allergy to adhesive tape, open wounds in the taping area, a positive result according to the Ottawa ankle and knee rules (18), a difference greater than one centimeter in ankle measurement according to the Figure-of-Eight Ankle Measurement Test technique (19), or pain in the dominant lower limb when performing the 90° to 45° squat protocol of the Aspetar protocol (20).

All participants signed an informed consent form. The study was approved by the Ethics Committee of the Faculty of Health at Universidad del Valle (internal approval code 128-024), following the ethical principles established in the Declaration of Helsinki.

Instruments

Two validated tools were used:

- My Jump 2 (iOS): a validated application used to measure jump height and stiffness.
- Kinovea 0.9.5: free software used for kinematic analysis of dynamic valgus and ankle dorsiflexion through slow-motion video (240 fps).

Variables

The variables were:

- Dependents: Ankle dorsiflexion angle (°), Dynamic valgus angle (°), Jump height (cm), Stiffness (kN/m)
- Independent: taping condition (WT vs. RT)

Procedure Phases

- Preparation: Informational meeting and informed consent.
- Initial assessment: Application of inclusion/exclusion criteria.
- Non-taping condition: Execution of the single-leg jump and audiovisual recording.
- Intervention: Application of rigid ankle taping.
- Taping condition: Repetition of the test and audiovisual recording.

Intervention Protocol

The procedure was carried out in a single session lasting approximately 40 minutes. It began with a standardized warm-up consisting of five minutes of jogging, followed by the placement of anatomical markers at specific points of the lower limb, adapting the Helen Hayes protocol. The locations included nine bony landmarks: anterior superior iliac spine, greater trochanter, lateral femoral condyle, superior border of the patella, fibular head, tibial tuberosity, lateral malleolus, dorsum of the foot, and head of the second metatarsal (Figure 1).

To ensure accuracy in marker placement, two researchers acted as independent evaluators and systematically verified the correct location of the anatomical reference points for each participant. Subsequently, the same evaluators measured the angles by digitizing coordinates using the Kinovea software, based on previously established points. This methodological procedure ensured that the results related to dorsiflexion and dynamic valgus were based on consistent and reproducible recordings.

Figure 1. Location of anatomical points in frontal and lateral view

The cameras (iPhone 16 Pro Max and iPhone 13 Pro Max, 4K at 60 fps) were positioned in frontal and lateral planes, at a height of 1.00 m and at a distance of 1.80 m from the jump platform (Figure 2).

In the initial condition without taping, each participant performed three SLDJ attempts from a 30 cm platform, with 30 seconds of rest between jumps. The best attempt was selected and jump height and stiffness were recorded using My Jump 2.

Figure 2. Camera locations

Subsequently, boot-type rigid taping was applied to the talocrural joint, with the ankle positioned in neutral position (90°), using Leukoplast adhesive tape. The technique included prior cleaning with alcohol, application of benzoin tincture, and placement of three vertical stirrups from distal to proximal, starting from the calcaneus toward the medial and lateral malleoli. Stirrups 2 and 3 were also applied in an ascending direction passing over the malleoli; however, the second stirrup was directed toward the anterior aspect of the leg, whereas the third stirrup was oriented toward the posterior aspect, partially surrounding the Achilles tendon. Finally, two circular locking strips were added to secure the fixation (Figure 3). The taping was applied by one of the researchers, a physiotherapist certified in functional taping and kinesiotaping, with more than one year of experience in the field.

With the taping applied, the three SLDJ attempts were repeated. The joint variables (knee dynamic valgus and ankle dorsiflexion) were analyzed using Kinovea software. All measurements were performed on the dominant lower limb of each participant. The order of the conditions was not randomized (WT followed by RT), which is acknowledged as a methodological limitation.

a *b* *c* *d*

Figure 3. Application of rigid tape. From left to right: a, b, c: sequence of stirrups. d: closure strips.

Statistical Analysis

The statistical analysis was performed using RStudio software (v.4.3; R Foundation for Statistical Computing). Initially, data normality was assessed using the Shapiro–Wilk test, which indicated a non-normal distribution (N = 30); therefore, a non-parametric approach was adopted.

For the descriptive characterization of the sample (age, height, and weight), values are presented as median, minimum, and maximum, differentiated by sex. The comparison between the taping condition (RT) and the non-taping condition (WT) for the variables jump height, stiffness, knee dynamic valgus, and maximum ankle dorsiflexion was performed using the Wilcoxon signed-rank test for paired samples. The level of significance was established at $p < 0.005$.

95% confidence intervals (95% CI) were calculated for the differences, as well as the effect size (Wilcoxon r), interpreted according to the thresholds proposed by Cohen (1988) and Lakens (2013): negligible: $r < 0.10$; small: $0.10 \leq r < 0.30$; moderate: $0.30 \leq r < 0.50$; large: $r \geq 0.50$ (21–23).

The reported difference (Δ) corresponds to the median of the individual differences (WT – RT) calculated for each participant, rather than the direct subtraction of the global medians of each condition.

The central objective of this research was to analyze the intrinsic mechanical effect of functional taping on the musculoskeletal system, without considering sex as a primary interaction variable. Consequently, a repeated-measures (within-subject) design was used, in which each participant acted as their own control. Results are presented for the total sample (N = 30) in order to maximize the statistical power of the study and avoid an increase in Type II error derived from segmentation into smaller subgroups (n < 20) (21,23).

Finally, a post-hoc power analysis was conducted, confirming that the sample size was sufficient to detect significant differences in ankle dorsiflexion, with statistical power greater than 80%. However, for the remaining variables the statistical power was insufficient, which is acknowledged as a methodological limitation.

RESULTS

Initially, 31 participants were evaluated; however, one participant was excluded due to the presence of pain during the application of the Aspetar protocol. The final sample consisted of 30 combat sport athletes, of whom 63.3% were male. Participants were distributed across four disciplines, with taekwondo representing the highest proportion (30%). Regarding competitive level, the largest proportion of participants (40%) were classified as beginners, while 16.7% reported not having a defined competitive level because they had not participated in official competitions.

The descriptive characteristics of the sample (age, height, and weight) are presented in Table 1, differentiated by sex in order to contextualize the studied population and confirm homogeneity among participants. Similar median ages of 21 years were observed for both men and women. Regarding anthropometric characteristics, women presented median values of 1.61 m in height and 55 kg in weight, whereas men showed higher values, with medians of 1.75 m in height and 71.5 kg in weight.

The normality analysis using the Shapiro–Wilk test revealed that, in the female group, age did not follow a normal distribution ($p = 0.019$), whereas height and weight did follow a normal distribution ($p = 0.864$ and $p = 0.741$, respectively). In the male group, the three variables (age, height, and weight) showed a normal distribution ($p > 0.05$). These results can be observed in greater detail in Tables 1 and 2.

The normality test (Shapiro–Wilk) was conducted in an exploratory manner by sex (Table 2); however, since the design was within-subject and each participant acted as their own control, the results are presented collectively for the total sample (N = 30).

Table 1. Distribution of absolute frequencies of the general characteristics of the sample: sport practiced, competitive category, gender, and laterality.

Sport	**Frequency**	**% of total**
Judo	7	23,3 %
Karate	8	26,7 %
Muay thai	6	20 %
Taekwondo	9	30 %
Competitive category	**Frequency**	**% of total**
Advanced	8	26,7 %
Intermediate	5	16,7 %
None	5	16,7 %
Beginner	12	40 %
Gender	**Frequency**	**% of total**
Female	11	36,7 %
Male	19	63,3 %
Laterality	**Frequency**	**% of total**
Right	27	90 %
Left	3	10 %

Table 2. Descriptive statistics and normality test (Shapiro-Wilk) for age, height, and weight of participants according to gender

						Shapiro-Wilk
Variables	**Gender**	**N**	**Median**	**Minimum**	**Maximum**	***p***
Age (years)	Female	11	21	18	30	0,019
	Male	19	21	18	29	0,121
Height (m)	Female	11	1,61	1,55	1,69	0,664
	Male	19	1,75	1,63	1,90	0,705
Weight (kg)	Female	11	55	47,50	68,50	0,741
	Male	19	71,50	55,50	87	0,976

The comparative analysis using the Wilcoxon test showed no statistically significant differences in the reactive power performance variables. Jump height presented a minimal difference in medians (Δ = −0.10 cm; $p = 0.800$; $r = 0.04$, negligible effect). Regarding the parameters related to the mechanical efficiency of the stretch–shortening cycle (SSC), muscle stiffness showed a result of $Z = -1.366$; $p = 0.182$; $r = 0.25$, indicating a small effect size. It is noteworthy that the negative sign of the Z statistic in these variables suggests a non-significant tendency toward higher values when taping was applied.

With respect to the kinematic analysis, no significant variations were found in knee dynamic valgus ($Z = -0.797$; $p = 0.431$; $r = 0.14$). In contrast, a statistically significant effect was identified in ankle dorsiflexion at maximum knee flexion (Δ = 2.97°; 95% CI: 1.50 to 4.44; $p < 0.001$). The Z statistic value ($Z = 4.132$) and the fact that the confidence interval did not include zero confirm that the taping effectively restricted the joint range of motion, representing the only biomechanical modification of relevance produced by the intervention (Table 3).

These findings suggest that taping does not substantially modify reactive power performance or dynamic knee stability, while ankle dorsiflexion emerged as the only biomechanical variable significantly affected by the intervention.

Table 3. Comparison of kinematic and kinetic variables between WT and RT conditions

Variable	Medians		Median Diff. (Δ)	IC 95%	Z	p-valor	r de Wilcoxon	Magnitud
	WT	RT		[Inf, Sup]				
Dynamic valgus (°)	8,5	8,5	-0,81	[-2,91, 1,27]	-0,8	0,431	0,14	Negligible
Ankle dorsiflexion (°)	32,2	29,9	2,97	[1,50, 4,44]	4,132	< 0,001*	0,75	Big
Jump Height (cm)	12,7	13,6	-0,1	[-0,97, 0,76]	-0,26	0,8	0,04	Negligible
Stiffness (kN/m)	5,8	6,4	-0,47	[-1,18, 0,23]	-1,37	0,182	0,25	Small

Note: Δ corresponds to the median of the individual differences (WT − RT). Data were analyzed using the Wilcoxon signed-rank test. Statistical significance was established at $p < 0.05$.

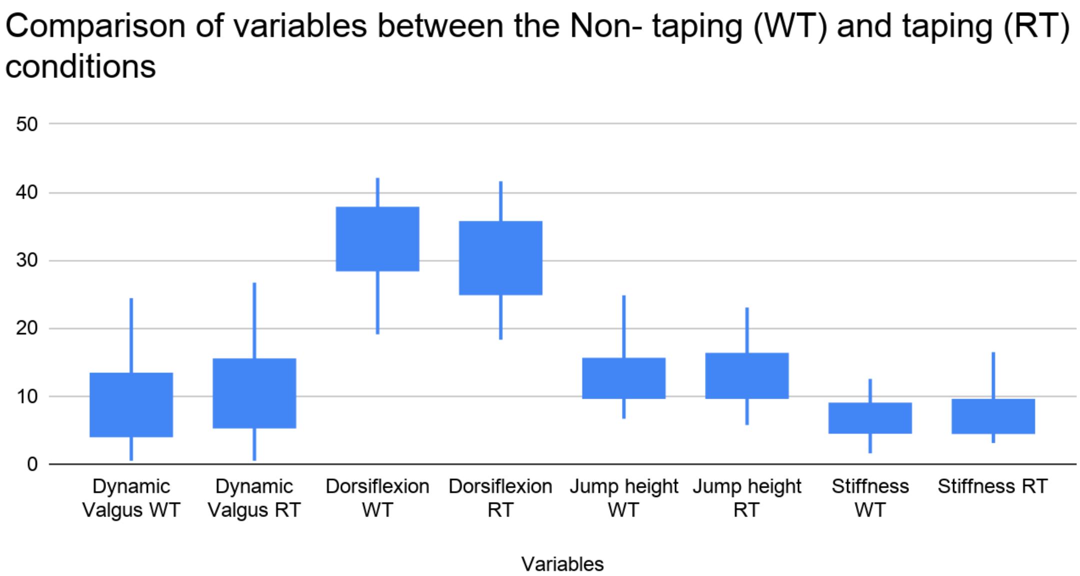

Figure 4. Biomechanical comparison between WT and RT conditions (n = 30). The boxes represent the interquartile range (Q1–Q3) and the whiskers represent the minimum and maximum values. A significant reduction was observed only in ankle dorsiflexion (p = 0.0011), demonstrating the mechanical restriction produced by taping without affecting the remaining variables (p > 0.05).

DISCUSSION

The present study analyzed the acute effects of rigid ankle taping on kinematic and performance variables in university combat sport athletes. The findings obtained offer a relevant perspective on the influence of this intervention on movement mechanics, allowing interpretation of its effect on the modulation of biomechanical patterns and on the functional balance dynamics between joint stability and motor efficiency.

The sociodemographic and anthropometric characterization of the 30 participants evaluated in this study made it possible to establish an overview of the profile of combat sport athletes from the Universidad del Valle, Meléndez campus. The sample consisted predominantly of men (63.3%), who presented higher values of height (1.75 m) and weight (71.5 kg) compared to women (1.61 m and 55 kg respectively). These differences are consistent with what has been reported in the literature, where male athletes have been documented to usually present greater height and weight than females, which is associated with a higher risk of suffering ankle sprains, especially in contact disciplines or those with high mechanical demands, such as combat sports (24).
Our results showed that maximum ankle dorsiflexion was the only variable significantly affected, whereas knee dynamic valgus, jump height, and stiffness did not show significant differences between conditions.

Rigid ankle taping demonstrated a significant reduction in dorsiflexion. Although an increase in knee valgus was recorded during the single-leg drop jump (SLDJ), this did not reach statistical significance. These findings are similar to those reported by Romero-Morales et al., who demonstrated that prophylactic ankle taping decreases dorsiflexion and tends to increase knee valgus in drop-jump tasks in healthy active participants of both sexes (11). Previous evidence supports this relationship, indicating that limitations in dorsiflexion tend to be associated with an increase in knee dynamic valgus. In the present study, a kinematic response in the same direction was observed, although it did not reach statistical significance (10).

The reduction of 2.3° in dorsiflexion, although small, has clinical relevance, confirming the restrictive effect of taping on joint mobility. This may modify the mechanics of impact absorption and increase knee dynamic valgus during jumps and landings, increasing the risk of injuries in the knee and hip (10) (11) (14). For physiotherapy practice, this finding suggests that taping fulfills its function of providing mechanical support without drastically compromising functionality, at least immediately. Therefore, it should be used selectively, prioritizing athletes with a history of sprain or instability rather than as a routine preventive strategy.

Regarding stiffness, no significant differences were observed, which is consistent with the findings reported by Golmohammadi Qadikolai M et al., who also found no significant changes in vertical stiffness after the application of tape or rigid taping during the analysis of the jump shot in semi-professional basketball players. This suggests that taping does not immediately affect the efficiency of the stretch-shortening cycle or the athlete's power output (25).

With respect to the variable jump height, a slight increase was found after the application of taping, although it was not statistically significant. This result agrees with what was reported by Quackenbush K. E. et al., who found non-significant increases in jump height (CMJ and DJ) after applying different taping techniques in collegiate basketball athletes (26). Bosco et al. proposed that greater musculotendinous stiffness could improve performance in the stretch-shortening cycle and increase jump height (27). This reasoning is consistent considering the findings regarding the increase in stiffness produced by taping, which limits ankle mobility and could generate a faster stretch-shortening cycle, possibly increasing jump height. However, it should be noted that this is a mechanistic hypothesis and not an explicit finding of our research.

Additionally, factors such as differential muscle activation between the quadriceps and hamstrings can influence the height and quality of the jump, as demonstrated by Peng H. T. et al. (28). Although our study did not consider factors other than those caused by rigid taping, these may alter jump quality and therefore the results. Future research should include electromyographic analyses in order to better understand these patterns in combat sport athletes.

The use of My Jump 2 and Kinovea in this study provided validity and reliability to the measurements performed. The My Jump 2 application has been shown to be accurate and reliable for evaluating vertical jump performance, demonstrating high correlation with force platforms (29) (30). Complementarily, Kinovea has been validated for the analysis of angles and distances from different perspectives, confirming its usefulness in biomechanical field studies (31). The integration of both tools allowed a rigorous interpretation of the significant reduction in dorsiflexion and the absence of changes in dynamic valgus, jump height, and stiffness, ensuring that the findings were based on reliable instruments applicable in university sports contexts.

Practical Implications

The limited ankle dorsiflexion found in this study with the use of taping may negatively affect lower-limb mechanics during landing, according to the findings of Mason-Mackay et al. (10). However, Motaz-Alawna et al. found that both rigid taping and kinesiotape can provide benefits for individuals with chronic ankle instability (32). These results suggest that the clinical judgment of the sports physiotherapist should go beyond the simple mechanical application of taping and become an individualized decision-making process. Since the restriction of dorsiflexion may alter the global mechanics of landing, it is essential that the professional evaluates whether the stability provided by taping is a priority according to the athlete's injury history and the presence of chronic instability. Consequently, the implementation of these tools should be based on a contextual analysis of each individual's physical conditions, ensuring that preventive ankle support does not compromise the biomechanical efficiency of the lower limbs during the sports gesture.

CONCLUSIONS

The acute application of rigid ankle taping specifically modified kinematic patterns, showing a significant reduction in ankle dorsiflexion. Although an increase in dynamic knee valgus during the jump was observed, it was not statistically significant; therefore, the results should be interpreted with caution. The literature supports the association between reduced dorsiflexion and increased dynamic valgus, but in our university sample this effect was not confirmed.

No significant changes were found in stiffness or jump height, suggesting that explosive performance is not immediately compromised by ankle taping. These findings indicate that, although taping provides ankle stability, it may also induce additional loads on proximal segments. Therefore, its use should be evaluated in a functional and individualized manner, considering the athlete's injury history and the specific demands of each discipline.

LIMITATIONS

The study presented some limitations that should be considered when interpreting the results. First, the limited availability of specific literature on kinetic variables restricts the depth of the discussion. In addition, the application of the taping may have varied among subjects, since the tests were conducted over a three-week period, which makes it difficult to guarantee absolute uniformity in the technique.

Acute training factors, such as previous sessions or accumulated fatigue, were not controlled and may have influenced the performance variables. Likewise, the research was restricted to university athletes from the same institution, which limits the generalization of the findings. Other relevant limitations were the reduced sample size, the absence of a control group, and the lack of randomization in the compared conditions (WT and RT).

For future research, it is recommended to include subjective variables such as perceived stability, comfort, and safety reported by athletes before and after the intervention. It would also be pertinent to evaluate the fatigue of rigid taping under conditions of prolonged use or real competition, as well as to conduct comparative studies between different types of preventive taping. Finally, it is suggested to analyze the effects by sport discipline in order to provide greater specificity and clinical applicability to the conclusions.

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no financial, personal, or institutional conflicts of interest that may have inappropriately influenced the conduct of this research, the interpretation of the data, or the preparation of the manuscript.

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