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Optimizing ankle performance when taped: Effects of kinesiology and athletic taping on proprioception in full weight-bearing stance

Zhi Long[a], Renwei Wang[a,*], Jia Han[a,b,*], Gordon Waddington[b], Roger Adams[b], Judith Anson[b]

[a] School of Kinesiology, Shanghai University of Sport, China
[b] Research Institute for Sport and Exercise, University of Canberra, Australia

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ABSTRACT

Objectives: To explore the effects of kinesiology taping (KT) and athletic taping (AT) on ankle proprioception when tested in functional, full weight-bearing stance.
Design: Cross-sectional study.
Methods: Twenty-four healthy university students participated. Proprioception was measured using the Active Movement Extent Discrimination Apparatus (AMEDA). The three testing conditions: no-taping, KT, AT, and foot tested were randomly assigned. Perceived comfort, support and proprioceptive performance under two taping conditions were recorded.
Results: Proprioceptive discrimination scores with 95% CIs for no-taping, KT and AT were 0.81 (0.79–0.84), 0.81 (0.79–0.83), and 0.79 (0.77–0.81). Repeated measures ANOVA showed neither any significant difference associated with taping compared with no-taping ($p = 0.30$), nor any difference between KT and AT ($p = 0.19$). The group was then divided, according to their no-taping scores, into two sub-groups: with scores below the no-taping mean ($n = 13$), and above the mean ($n = 11$). ANOVA revealed a significant interaction ($p = 0.008$) indicating that above-average no-taping performers proprioception scores were worse when taped, whereas below-average performers improved. For both KT and AT, only ratings of perceived comfort when taped were significantly associated with actual proprioceptive performance (both $r > 0.44$, $p \leq 0.03$). Other perception ratings (support and performance) were significantly inter-correlated (both $r > 0.42$, $p < 0.04$), but neither was significantly correlated with actual performance (both $p > 0.31$).
Conclusions: Taping of the foot and ankle may amplify sensory input in a way that enhances proprioception of poor performers but produces an input overload that impairs proprioception in those who originally performed well when no-taping. Screening of ankle proprioception may identify those who would benefit most from taping.

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1. Introduction

Proprioception has been defined as one's ability to integrate the sensory signals from different mechanoreceptors to thereby determine body or body segment position and movement in space.[1,26] Ankle proprioception plays an essential role in sport performance and sport injury.[2] For example, Han et al.,[3,4] found ankle proprioceptive scores were significantly correlated with sport competition level, and a significant predictor of sport performance. In addition, poor ankle proprioception has been identified as an important intrinsic factor associated with increased risk of ankle injuries.[5] Ankle proprioception is impaired after ankle injury and this may promote functional ankle instability and functional performance deficits.[6] Consequently, optimizing ankle proprioceptive function is an important goal in sport and exercise.[2]

A number of studies have investigated the effects of active and/or passive interventions on ankle proprioception.[7–9] The role of taping, as a passive intervention aimed at enhancing ankle proprioception, has been extensively explored.[10–12] However, results from these studies are inconclusive. Some found that ankle taping improved foot position sense,[12] while others found that ankle taping impaired the sensitivity of detecting passive motion at the ankle.[13] Two systematic reviews suggested that ankle proprioception was not enhanced with the use of ankle tape or braces in athletes suffering repeated ankle sprains or with functional

* Corresponding authors.
E-mail addresses: renwwang@163.com (R. Wang), Jia.Han@canberra.edu.au, Dr_hanjia@yeah.net (J. Han).

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ankle instability.[14,15] However, most studies were conducted under a non-weight-bearing condition, and the results generated from these studies are thus limited in terms of ecological validity[1,16] and may not reflect the effect of taping on ankle proprioception in functional weight-bearing conditions.

It is possible that ankle taping may alter structural loading around the ankle joint when in a standing position, and thus affect the proportional contribution of each mechanoreceptor to proprioceptive performance.[17] In sports and daily functional activities, the brain integrates all sensory information generated from mechanoreceptors around the joint to determine ankle movements and positions,[18,19] although the muscle spindle is thought to play a major role.[20] Therefore, an ankle proprioception test undertaken in a weight-bearing stance that ensures activation of muscles, joint capsule compression and skin stretch has more ecological validity in comparison to a non-weight bearing posture, either lying or sitting, and is therefore more meaningful for sports and functional activities.[1,16]

In addition, it has been found that characteristics of the shoe insole can have a positive effect on ankle proprioception measured in a weight-bearing stance in soccer players,[21] suggesting that the use of textured insoles may produce additional proprioceptive feedback in the central nervous system. A recent study investigating the effect of textured shoe insoles on ankle proprioception in ballet dancers found that the ankle proprioceptive performance of dancers with low ankle inversion discrimination ability was enhanced with the use of textured insoles, when the ankle proprioceptive assessment was conducted in full weight-bearing.[22] The application of taping on the foot and ankle may have a similar effect.

Not all types of insoles, however, were found to improve ankle proprioception,[21,22] presumably because only some proprioceptive signals combine to enhance perception of proprioceptive information.[23] If this is the case, then although both kinesiology taping (KT) and athletic taping (AT) are used in sports and exercise,[24] because they differ in their texture and elasticity, these different types of taping may have different effects on ankle proprioceptive performance. Specifically, KT has good elasticity but is designed only for a longitudinal stretch; while AT is adhesive but rigid to restrict undesired motion of the taping joint. Accordingly, the purpose of this study was to investigate the effects of KT and AT on ankle proprioception tested in a full weight-bearing stance, in young healthy university students.

2. Methods

Twenty-four healthy university students (12 male and 12 female, mean age 22.0 years, SD ± 1.5, range 19–24), without musculoskeletal injury in the previous 6 months, volunteered to take part. All participants in this study were right-footed. The study was approved by the Shanghai University of Sport Ethics Committee and written informed consent was obtained from each participant before data collection.

The study involved testing under three conditions: no-taping, or with KT or AT around the foot and ankle. The three conditions were conducted in random order, and the left or right foot was randomly assigned for testing.

For KT, ROCKTAPE™ 5 cm × 5 m kinesiology tape was used; For AT, LP™ Trainers tape 38 mm × 13 m Model 657 was used. Both KT and AT procedures were conducted by the same therapist, who was not involved in data collection and analysis. The KT technique used was consistent with Kenzo Kase's clinical therapeutic applications of the KT method[10] (Fig. 1A). The AT technique used was a conventional ankle taping that involved a figure eight taping, followed with a heel lock and a stirrup to the heel (Fig. 1B). The taped leg was not shaved and nothing was used under tape.

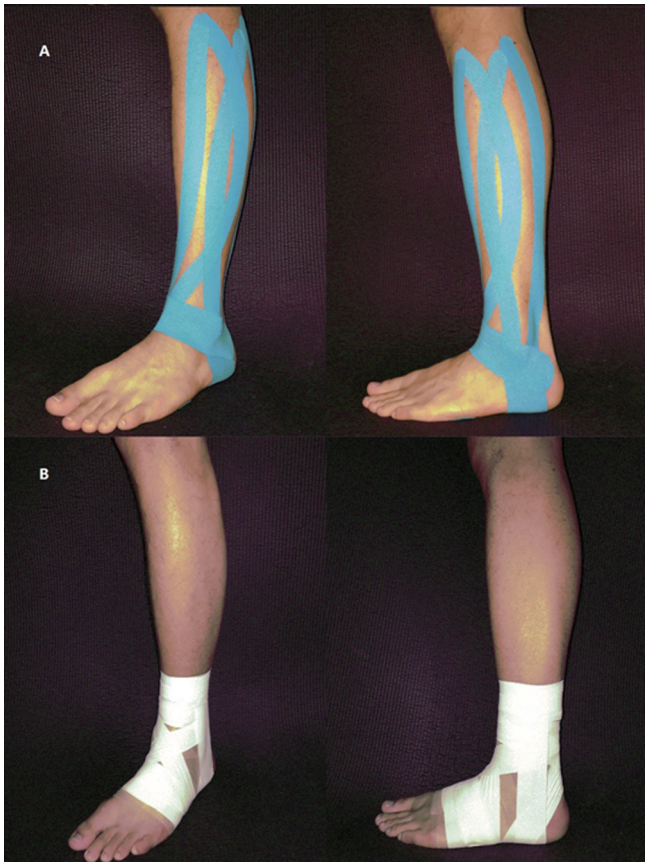


Fig. 1. Depicts the taping techniques for both kinesiology taping (A) and athletic taping (B).

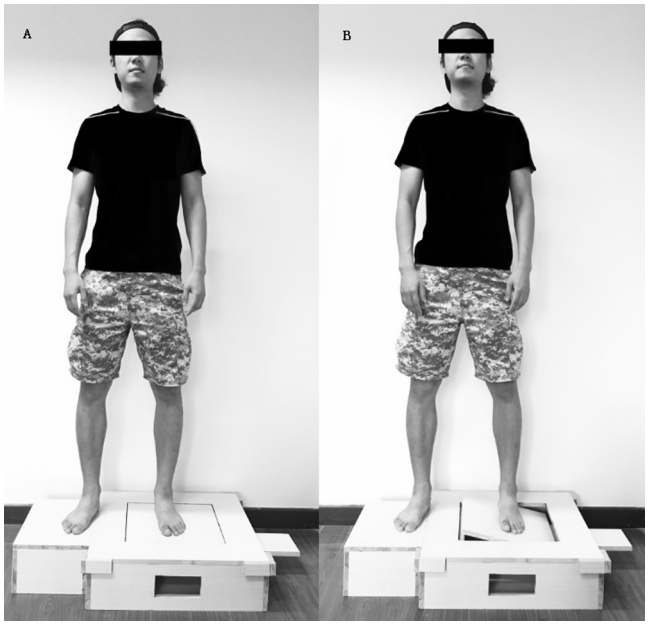


Fig. 2. Depicts the Active Movement Extent Discrimination Apparatus (AMEDA) used for ankle proprioceptive testing in standing. (A) demonstrates the fixed start position and (B) demonstrates one of the four possible ankle inversions.

An Active Movement Extent Discrimination Apparatus (AMEDA) was employed for testing ankle proprioception in a full weight-bearing stance[1] (Fig. 2). The AMEDA consists of a fixed wooden platform housing a swinging square wooden plate that rotates

Table 1
Ratings of perceived comfort, perceived support and perceived proprioceptive performance for both kinesiology and athletic taping techniques.

	Kinesiology taping	Athletic taping	Paired sample t-test	
	(Mean ± SD)	(Mean ± SD)	95% CI	p
Perceived comfort	2.80 ± 1.45	1.19 ± 2.43	0.617–2.617	0.003
Perceived support	5.84 ± 2.09	6.71 ± 1.91	−2.034–0.326	0.148
Perceived proprioceptive performance	1.19 ± 2.30	−0.35 ± 1.71	0.686–2.397	0.001

about an axle aligned to the long axis of the foot being tested. During the test, participants were instructed to look forward and stand astride on the device, with one foot on the fixed platform and the foot being tested centered over the axle of the swinging plate. For each trial, participants were required to make an active ankle inversion that rotated the swing plate from a horizontal start position until the rim of the swing plate contacted a height-adjustable wooden stop, then to actively return the swing plate back to the start position. The height-adjustable wooden stop could generate 4 inversion extents from horizontal: position 1 = 10°, position 2 = 12°, position 3 = 14°, and position 4 = 16°.

Before data collection in each testing condition, participants experienced the 4 ankle inversion positions in order, from the smallest (position 1, 10°) to the largest (position 4, 16°) for three rounds. During the test, participants were required to identify the 4 different ankle inversion positions based on proprioceptive information, without visual information about their ankle movement. For each testing condition, the 4 possible positions were randomly presented to the participants, 10 times for each position, and participants were asked to give a number (1–3, or 4) indicating the ankle inversion position that they had just experienced, without feedback being given as to the correctness of the judgment. Therefore, this task was an absolute judgment task, where there were four possible responses (positions 1–4) to each of the four possible ankle inversion extents (10°, 12°, 14°, and 16°). The ecological validity of AMEDA has been tested. Previous studies have shown that ankle proprioception tested in the same weight-bearing position is significantly and strongly correlated with sports performance.[3,4]

After the ankle proprioception tests, participants were asked to give a number rating their perceived comfort, perceived support and perceived proprioceptive performance for both taping techniques, by marking three separate visual analog scales. A −5 to 5 scale was used to indicate their subjective feeling of taping comfort, with a score of −5 representing "very uncomfortable", and a score of 5 representing "very comfortable". A 0–10 scale was used by participants to indicate level of feeling of support from taping, with a score of 0 representing "not supportive at all", and a score of 10 representing "very supportive". Participants used another −5 to 5 scale to indicate their subjective feeling of proprioceptive performance when the ankle was taped, with a score of −5 representing "much worse", and a score of 5 representing "much better" compared to the no-taping condition.

SPSS V.21 was used for data analysis. Raw response data was cast into a 4 × 4 matrix representing the frequency with which each response (position number) was made for each stimulus (degree of inversion). Non-parametric signal detection analysis was applied to the stimulus rows pair-wise, to produce Receiver Operating Characteristic (ROC) curves.[25] Then the mean Area Under the ROC Curve (AUC) was calculated to give each participant an ankle movement discrimination score as their measure of proprioceptive function. Mean AUC values range from 0.5, which is equivalent to chance responding, to 1.0, representing a perfect ability to distinguish the 4 different ankle inversion extents.

To determine the effects of different taping techniques on ankle proprioception, a repeated measures ANOVA was conducted. Paired sample t-tests were employed to examine the differences between the two taping techniques in terms of subjective ratings of perceived comfort, perceived support and perceived proprioceptive performance. Pearson's correlations were used to determine the relationship between ankle movement discrimination scores and subjective ratings of comfort, support and proprioceptive performance, for both taping techniques.

3. Results

AUC proprioceptive discrimination scores with 95% confidence intervals (CI) for no-taping, KT and AT were 0.81 (0.79–0.084), 0.81 (0.79–0.83), and 0.79 (0.77–0.82). When these data were analyzed in a repeated measures ANOVA, with orthogonal planned contrasts comparing firstly the AUC discrimination scores under no-taping condition with the two taping conditions, then the KT condition with the AT condition, there were neither significant differences associated with taping ($F_{1,23} = 1.112$, $p = 0.303$) nor any difference between KT and AT ($F_{1,23} = 1.863$, $p = 0.185$).

For comparison with previous research,[26,27] the group was then divided according to their no-taping scores into a group of 13 participants with scores below the no-taping mean, and 11 with scores above. When a further repeated measures ANOVA was conducted using this group structure, there was a significant interaction ($F_{1,22} = 8.618$, $p = 0.008$) indicating that above-average performers when no-taping were made worse when wearing taping, whereas below-average performers when no-taping were improved by taping. Type of taping did not cause any significant effect ($F_{1,22} = 2.045$, $p = 0.167$).

Subjective ratings of perceived comfort, perceived support and perceived proprioceptive performance for both KT and AT techniques, and paired sample t-tests results are presented in Table 1. It was evident that participants felt significantly more comfortable and more confident about their proprioceptive performance when being taped by KT than by AT. There was no significant difference in perceived support between the two forms of taping.

Pearson's correlations were calculated between participants' actual performance (mean AUC movement discrimination scores) and participant ratings of perceived comfort, perceived support and perceived proprioceptive performance. When this was done for the KT condition, only ratings of comfort when taped were positively and significantly associated with actual performance ($r = 0.444$, $p = 0.03$). Ratings of perceived support and perceived performance were significantly correlated ($r = 0.485$, $p = 0.016$), but neither was significantly correlated with actual proprioceptive performance ($p > 0.358$). When these correlations were calculated for AT, a similar pattern of results emerged. For AT, ratings of comfort when taped were also positively and significantly associated with actual performance ($r = 0.456$, $p = 0.025$). As previously, ratings of perceived support and perceived performance were correlated with each other ($r = 0.427$, $p = 0.038$), but neither was significantly related to actual proprioceptive performance ($p > 0.315$).

When correlations between KT and AT performance and ratings were examined, actual performance under the two conditions was not significantly correlated ($r = 0.2$, $p = 0.36$) nor was perceived comfort ($r = 0.34$, $p = 0.10$) or perceived support from the two forms of taping ($r = 0.03$, $p = 0.90$), however ratings of perceived performance with the two forms of taping were significantly correlated ($r = 0.52$, $p = 0.009$).

4. Discussion

The current study constitutes the first investigation of both KT and AT on ankle proprioception in full weight-bearing stance. It has been argued that lower limb proprioception testing undertaken in a weight-bearing condition improves the ecological validity of the tests, and thus the results obtained here may be more meaningful for sport and functional activities.[1,16]

Consistent with the findings from recent systematic reviews,[14,15] our initial data analysis found that there were no significant differences associated with taping nor was there a significant difference between KT and AT. However, subsequent analysis showed a significant effect in that above-average performers when no-taping were made worse when wearing taping, whereas below-average performers when no-taping were improved by taping. Similar findings have been reported in a leg swing proprioception study for Australian football players, and in an ankle inversion proprioception study for elite ballet dancers, where wearing neoprene shorts or textured insoles respectively made above-average participants worse, while improving the proprioceptive performance of below-average participants.[27,28] These findings suggest that taping around the foot and ankle may influence proprioceptive signals so as to enhance the proprioceptive ability of those who originally perform poorly when no-taping but for those who originally performed well on the proprioception test, the altered sensory information from taping may impair proprioceptive ability. An implication of this finding is that a pre-screen of ankle proprioceptive performance in no-taping, weight-bearing conditions may be needed prior to taping, in order to identify those who may actually benefit most from taping.

Another interesting finding of the present study was that although ratings of perceived support and perceived performance were significantly correlated, neither of them was significantly correlated with actual ankle proprioceptive performance. In contrast, the ratings of comfort when taped were found to be positively and significantly associated with actual proprioceptive performance. More importantly, these findings were evident for both KT and AT techniques. These findings suggest that although taping may provide external mechanical support of the ankle[11] and participants thought that their proprioceptive performance was enhanced with additional support from taping, perceived support and perceived performance are not necessarily associated with actual proprioceptive performance. In contrast, our data showed that only perceived comfort is positively and significantly correlated with actual proprioceptive performance. This may be because the CNS interprets the optimal proprioceptive information load when wearing taping as “comfort”. Similarly, it has been noted that rating of comfort of footwear is significantly associated with postural stability, in both young and old people.[29] The finding here suggests that clinicians, coaches and athletes may use comfort when taped as an indicator to guide the application of taping.

Subjective ratings of perceived comfort, perceived support and perceived proprioceptive performance for the two forms of taping showed that, during the ankle movement discrimination test, participants felt more comfortable and more confident about their performance when taped by KT. In addition, although participants felt the KT taping was slightly less supportive than the AT, the rating difference in terms of support between the two taping techniques was not statistically significant. These findings suggest that, when taping is needed, KT may be preferred over the AT, as it provides superior comfort to AT, without significant compromising perceived foot and ankle support. However, the actual mechanical support provided by the two forms of taping was not determined in the present study, which may play a role in ankle injuring prevention in sports.[11]

The current study only investigated the immediate effect of taping on ankle proprioception, and it is unknown if wearing taping for a longer period of time improves ankle proprioception. Steinberg et al.,[30] found that wearing textured insoles during non-class time for 4 weeks could improve ankle proprioception in ballet dancers, in both ankle eversion and inversion movements. If wearing tape for a longer period of time induces a similar adaptive change of the proprioceptive system, then athletes and dancers could benefit in terms of both proprioceptive enhancement and mechanical support from foot and ankle taping, regardless of the type of taping.

5. Study limitations and future directions

This study has revealed the effects of both KT and AT on ankle proprioception in healthy young adults without ankle injuries in the past 6 months. It is undetermined if the results from this study can be applied in people with ankle injuries, such as recurrent ankle sprains and chronic ankle instability (CAI). Researchers[8] have found that compared to able bodied controls, CAI patients improve their ankle proprioceptive performance more slowly upon repeated AMEDA testing, suggesting that CAI may affect patients’ learning strategies in proprioceptive control. More research is needed to examine what sources of information (e.g., support, comfort) from taping are beneficial for ankle proprioceptive performance.

In addition, recent study has shown that there are both side-general and site-specific effects in proprioceptive performance.[19] In the current study, only right-footed participants were included and their tested leg was randomly assigned, thus it is unknown if there is hemispheric specialization in utilizing cutaneous signals from foot-ankle taping. Future study is needed to investigate the effects of footedness when taped.[19]

6. Conclusion

Taping around the foot and ankle may amplify sensory input in a way that enhances proprioceptive performance of poor performers but overloads input and impairs proprioception of those who originally performed well when no-taping. Thus screening of ankle proprioception under no-taping, weight-bearing conditions may be needed in order to identify those who would benefit from taping. In addition, clinicians, coaches and athletes may use comfort when taped as an indicator to guide the application of taping, as it is positively and significantly correlated with actual proprioceptive performance.

Practical implications

- Screening of ankle proprioception under no-taping, weight-bearing conditions may be needed to identify those who would benefit from taping.
- Perceived comfort when taped could be used as an indicator to guide the application of taping.
- Perceived support when taped should not to be used to guide taping for the improvement of ankle proprioception.

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