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The effects of elastic taping for ankle balance on dynamic balance and round kick performance of young taekwondo players

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Abstract

This study aimed to investigate the effects using elastic taping of ankles on dynamic balance and round kick performance of Taekwondo players. Thirty-six young black belt Taekwondo players participated in the study and were screened with inclusion and exclusion criteria. They were randomly allocated into a treatment group (elastic taping) or a placebo group. The star excursion balance test, ankle range of motion, repeated round kick, high round kick, and plantar flexion movement were measured in both groups before and after applying the tape. The normality of the data was evaluated using the Kolmogorov-Smirnov test. Then, an independent t-test was performed to compare the main effect of the elastic tape and placebo-tape interventions. Paired-sample t-tests were performed to compare the pre-test and post-test mean values within each group. The mean differences between the groups were compared using independent t-tests. The results showed that the treatment group gained significantly more balance control than the placebo group (p<0.05), particularly in the posterior, posteromedial, and posterolateral directions. Similarly, a substantially greater degree of plantar flexion movement and number of kicks during round kick performance were found in the treatment group than in the placebo group (p<0.01). These results indicated that elastic taping of ankle joints can enhance round kick performance in young Taekwondo players.

Keywords: Ankle, Athletic tape, Dynamic balance, Taekwondo

1. Introduction

Taekwondo is a Korean illustrative martial art that has been internationally recognized in sports. It consists of kicking swiftly, accurately, and continuously, which requires various motor skills to control the muscles involved [1]. In Taekwondo competition, more than 90% of points are scored by kicking [2]. Therefore, the most common movement performed to score points is a round kick [3]. High-scoring Taekwondo kicks require physical fitness and kicking abilities [4]. A previous study demonstrated that the round kick consists of two essential phases, pre- and post impact. The pre-impact phase refers to the time from when the kicking foot is lifted from the ground until the foot contacts the target (body or the impact protection equipment of a competitor). The post-impact phase is when the athlete's foot touches the target and returns to the initial position or guard posture [5].

In performing a proper round kick, the player must stand on a single leg while kicking either the trunk or the head of the opposing player with the other foot. Repeatedly kicking to the head results in higher scores than the trunk. To achieve a high repeated kick score, the player needs to have good ankle joint stability and control of body balance on the stance foot. Ankle balance taping has been introduced to enhance proprioceptive sensitivity, as it supports weak muscles, improves muscle function, decreases pain, enhances ankle joint stability and provides joint mobility in sports [6,7]. The possible mechanism may be stimulation of ankle proprioception through attachment to the skin. Additionally, the elastic properties of the tape could also provide a dynamic range of joint motion with some restriction of movement to protect against ankle joint injury. However, its effects on the dynamic balance of the ankle joint and round kick performance in Taekwondo have not been verified. This study aimed to investigate the effects of elastic taping of the ankle joints during round kick performance of young Taekwondo

players. The outcomes that were investigated include ankle plantar flexion during round kick performance, repeated round kicking (RRK), high round kicking (HRK), the star excursion balance test (SEBT), and the ankle range of motion (AROM).

2. Materials and methods

The protocol of this study was reviewed and approved by the Khon Kaen University ethics committee for human research. The study design was a parallel randomized controlled trial that is depicted in (Figure 1).

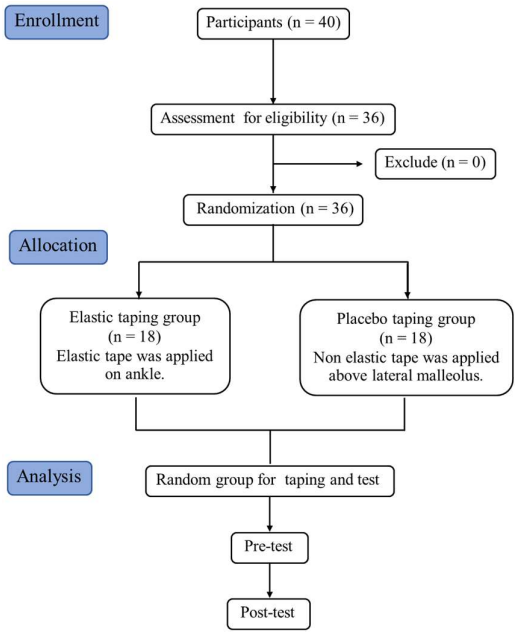

Figure 1 Study flowchart.

2.1 Subjects

Forty young Taekwondo players from the southern border provinces of Thailand volunteered to participate in the current study. They and their parents gave informed consent. Thirty-six players were eligible and passed the screening against inclusion and exclusion criteria. The inclusion criteria required young Taekwondo players who could be male or female, aged 12-15 years with no history of an ankle injury during the previous six months. Each of them had not more than three years of experience in Taekwondo competitions. They were excluded if they met one of the following criteria: they had allergic reactions to acrylic glue, or consumed caffeine, alcohol, energy drinks or antihistamine medication on the test day.

2.2 Procedures and tools

Data collection was performed in the morning (9.00 to 12.30 on October 30, 2020) at the Gymnasium of Thaksin University, Thailand. A research assistant obtained the participants' basic information, including their dominant leg, leg length, gender, age, and measured height and weight. Then, the participants were randomly assigned into two groups, an elastic taping group and a placebo group. They underwent a pre-test data collection and then received ankle taping according to their allocated group. Then, they underwent a post-test data collection immediately after taping. This was a single-blind study as the research assistant had no knowledge of group assignments as he measured the participants' pre-test and post-test outcomes. Data collection included a SEBT, the height of the round kick, range ankle of motion, and the number of repeated round kicks.

2.2.1 Star excursion balance test (SEBT)

Dynamic balance was assessed using the star excursion balance test, while the participant maintained their lower limbs in eight orientations, i.e., anterior, anteromedial, medial, posteromedial, posterior, posterolateral, lateral, and anterolateral positions. These limb positions are separated from one another by a 45° angle. [8]. A

study of young basketball players found that the absolute side-to-side asymmetry injury risk cut-off value was greater than 4 cm [9].

2.2.2 Ankle range of motion (AROM)

AROM was assessed using a goniometer while the participant sat on the table with their legs straight in a neutral position. Standard goniometry was measured where the axis was placed on the lateral malleolus, whereas one arm of the goniometer was parallel to the fifth metatarsal bone and the other was arm parallel to the fibula. Then, the active range of motion in full plantar flexion and dorsiflexion was measured.

2.2.3 Repeated round kick (RRK)

The scores of players' repeated round kicks were recorded and counted using three video cameras placed in three positions which could capture the best movements of the kicking knee and foot on a simulated target (Hitman CR-7). This reflected the round kick performance of the young Taekwondo players. The set-up for recording and counting the RRK is shown in (Figure 2A). The player stood with the non-dominant leg and kicked with dominant leg to touch the target's head and the number of successive kick within 10 sec was counted from the recorded videos. During the test the participants were conditioned as follows. First, they stood with the hands touching their opposite shoulders. This posture was used to restrict compensation by the upper limbs while performing the kicks. Second, the non dominant foot must be in the designated area. Third, after hearing the signal, they repeatedly performed kicks to the targets as fast as possible for 10 sec. The dominant foot must not touch the floor while they kicked the target. Each time the dominant foot touched the floor during RRK, their score was reduced. Each of the participants had five min to warm up. Then, three consecutive trials were recorded and scored. The final score was the average of the three trials.

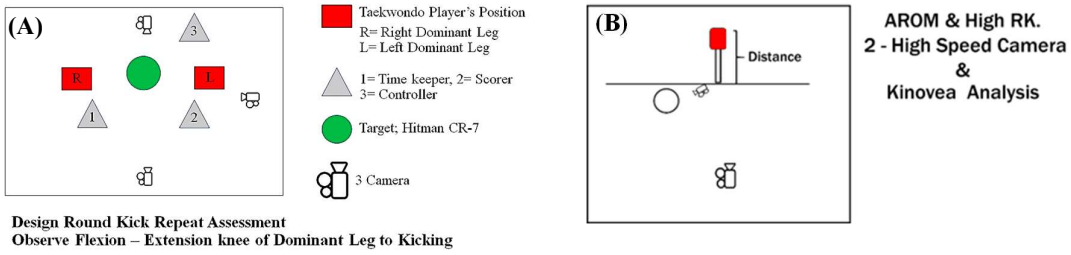

Figure 2 Schematic diagram showing (A) camera placement for capturing and scoring repeated round kicks, and (B) the setting of the high round kick and plantarflexion movement test.

2.2.4 High round kick (HRK)

High round kicks measure kicking height. Participants stood in a guarding posture with the non-dominant foot placed within a marked circle on the floor. The dominant leg can comfortably rest outside the circle. Two video cameras were placed so that they could synchronously capture the non-dominant ankle joint and the kick height (Figure 2B). The research assistant attached red adhesive tape (reflective marker) at the distal part of the dorsal surface of the dominant foot. At a signal, the participants kicked as high as possible on a foam board. Two successive trials were done. The recorded HRK data and the plantar flexion angle were calculated and analyzed using Kinovea software (https://www.kinovea.org/).

2.2.5 Plantarflexion Movement (PFM)

Plantar flexion movement is defined as the angle of the non-dominant ankle joint at the highest kick of the dominant foot (Figure 3). The video recordings were analyzed using Kinovea software.

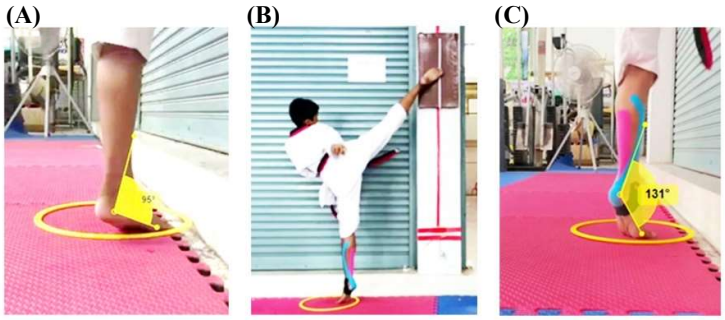

Figure 3 Plantar flexion movement test, (A) Plantar flexion movement before taping, (B) foot movement during the high kick, (C) plantar flexion movement after taping.

2.3 Taping protocol

An ankle balance taping (ABT) technique was used in this study. The participants in the treatment group received elastic taping, whereas the placebo group received non-elastic (rigid) taping. Tape strips that were 5 cm wide, were attached to the skin on both the left and the right ankle joints by a trained researcher. After skin cleansing with alcohol, the researcher applied a strip of non-elastic tape to cover the lateral malleoli up to the middle part of the lower legs of the participants in the placebo group, as shown in (Figure 4).

Figure 4 Non-elastic (rigid) tape was applied on the skin, covering the lateral malleolus.

Participants in the treatment group received elastic taping in a prone position on a table. After the same skin cleansing of the participants' ankle joints and lower legs, the researcher applied three elastic strips. One was at the posterior aspect of the heel (Figure 5), another on top of the first trip with a Y cut attaching on the medial and lateral aspect of the calf (Figure 6), and the third was hooked up under the heal (Figure 7).

Figure 5 The first strip of elastic tape was applied on the posterior aspect of the heel in an I-shape (blue strip).

First, an I-shaped elastic tape was applied to anchor the skin underneath the heel with no tension, after which, the other end of the tape was pulled to approximately 65% of the available tension and attached over the Achilles tendon and calf muscles (Figure 5). The second tape was cut in a Y-shape and attached to the first strip, while the two arms of the tape were pulled to approximately 75% of the available tension and attached to the sides of the calf muscles (Figure 6).

Figure 6 Attachment of the second elastic strip (black strip) with a Y-shape on the heel and calf muscles.

The third strip of elastic tape was cut in an I-shape and attached transversely to the second strip. Both ends of the strip were pulled up with 50% of available tension and attached above the medial and lateral malleoli (Figure 7).

Figure 7 Attachment of the third elastic strip (black strip) with an I-shaped (pink strip) underneath the heel.

2.4 Statistical Analyses

The sample size for this study was estimated from the means and variance of a previous pilot study. Eighteen participants per group were required to accomplish 80% power at p=0.05. The normality of the data distribution was tested using the Kolmogorov-Smirnov test [10]. An independent sample t-test was performed to compare the main effects of the elastic tape and non-elastic tape interventions. Paired-sample t-tests were performed to compare the pre- and post-test means within each group.

3. Results

Thirty-six participants completed the pre- and post-test trials. Of these, 24 were males and 12 were females. The participants' physical characteristics in both groups were similar in terms of age, leg length, height, weight, body mass index (BMI), and years of Taekwondo experience (Table 1). These physical characteristics of the participants showed no statistically significant differences between the two groups (p>0.05).

Table 1 Physical characteristics of the placebo group (PG) and treatment group (TG).

Physical characteristics	PG (n = 18)	TG (n =18)	p (2-tailed)
Age (years)	12.72 ± 0.89	13.44 ± 1.29	0.06
Leg Length (cm)	84.11 ± 6.80	84.22 ± 7.53	1.00
Height (cm)	165.78 ± 10.81	166.00 ± 11.08	0.95
Weight (kg)	54.67 ± 9.03	55.33 ± 9.53	0.83
BMI (kg/m2)	19.79 ± 1.98	19.99 ± 2.16	0.78
Year Experience (years)	1.78 ± 0.81	1.22 ± 1.06	0.08

Note: PG and TG data are presented as Mean ± standard deviation, PG = placebo group, TG = treatment group.

The data was tested to determine that it was normally distributed using the Kolmogorov-Smirnov test. The following variables were normally distributed (p>0.05) in pre- and post-tests: the star excursion balance test, ankle range of motion, high round kick, and plantar flexion movement. However, the repeated round kick score was normally distributed in the treatment group, whereas the placebo group did not have a normal distribution. The researcher transformed the non-normally distributed data by taking its logarithm to obtain a normal distribution before comparing the means using the t-tests.

The means and standard deviation (SD) of ankle range of motion and round kick performance were compared within the groups before and after the interventions (Table 2). In the treatment group, plantar flexion was increased after applying the elastic tape, but no differences were noted for dorsiflexion. The repeated round kick showed a significant difference after taping (p<0.01), but the high round kick did not show a significance in either group. Additionally, after taping, plantar flexion movement was significantly increased (p<.05). In the placebo group after taping, there was a significant increase in repeated round kicking (p<.05), but AROM, HRK, and PFM showed no significant differences among the interventions.

Table 2 Within-group comparison of variables before and after taping in the placebo group (PG) and treatment group (TG) using paired sample t-tests.

Variables	Pre	Post	t	df	*p* (2-tailed)
Ankle range of motion					
DF of PG (°)	11.06 ± 7.18	11.33 ± 5.34	0.41	17	0.34
DF of TG (°)	13.72 ± 6.52	14.78 ± 7.49	1.13	17	0.14
PF of PG (°)	31.61 ± 9.64	34.28 ± 8.82	1.02	17	0.16
PF of TG (°)	29.72 ± 9.74	39.61 ± 6.24	5.89	17	0.001
Round Kick Performance					
RRK of PG (number of kicks)	7.28 ± 5.35	9.94 ± 2.53	2.49	17	0.01
RRK of TG (number of kicks)	6.94 ± 4.608	14.44 ± 3.79	7.81	17	0.001
HRK of PG (cm.)	165.72 ± 11.62	165.83 ± 11.71	0.13	17	0.45
HRK of TG (cm.)	164.06 ± 14.31	166.94 ± 14.83	2.78	17	0.07
PFM of PG (°)	94.56 ± 24.93	98.94 ± 19.53	0.99	17	0.17
PFM of TG (°)	102.94 ± 19.58	117.06 ± 16.55	3.03	17	0.004

Note: DF = dorsiflexion, PF = plantar flexion, RRK = repeated round kick, HRK = high round kick, PFM = plantar flexion movement.

Between-group comparison revealed that plantar flexion showed a significant difference using elastic rather than placebo taping, but no differences were noted for dorsiflexion (Table 3). Repeated round kicking revealed significant differences using elastic rather than placebo taping. Similarly, there was a statistically significant increase in plantar flexion movement (p<.05) in the treatment group over the placebo group.

In the star excursion balance test, after applying the elastic taping to the ankles, there were significant differences in three directions, including posteromedial (p<.05), posterior (p<.05) and posterolateral (p<.05) directions compared to placebo taping. However, no statistically significant differences were noted in the anterior, anteromedial, medial, lateral and anterolateral directions (Table 4).

Table 3 Comparison of AROM and round kick performance between the treatment and placebo groups with independent sample t-tests.

Round Kick Performance	Placebo group (PG)	Treatment group (TG)	t	df	*p* (2-tailed)
Ankle range of motion					
DF/pre (°)	11.06 ± 7.18	13.72 ± 6.52	-1.17	34	0.25
DF/post (°)	11.33 ± 5.34	14.78 ± 7.49	-1.59	34	0.12
PF/pre (°)	31.61 ± 9.64	29.72 ± 9.74	0.59	34	0.28
PF/post (°)	34.28 ± 8.82	39.61 ± 6.24	-2.09	34	0.02
Round Kick Performance					
RRK/pre (number of kicks)	7.28 ± 5.35	6.94 ± 4.608	0.20	34	0.84
RRK/post (number of kicks)	9.94 ± 2.53	14.44 ± 3.79	-4.19	34	0.01
HRK/pre (cm)	165.72 ± 11.62	164.06 ± 14.31	0.38	34	0.70
HRK/post (cm)	165.83 ± 11.71	166.94 ± 14.83	-0.25	34	0.80
PFM/pre (°)	94.56 ± 24.93	102.94 ± 19.58	-1.12	34	0.26
PFM/post (°)	98.94 ± 19.53	117.06 ± 16.55	-3.00	34	0.01

Note: DF/pre = dorsiflexion pretest, DF/post = dorsiflexion posttest, PF/pre = plantar flexion pretest, PF/post = plantar flexion, RRK = repeated round kick, HRK = high round kick, PFM = plantar flexion movement.

Table 4 Comparison of SEBT between treatment and placebo groups with independent sample t-tests.

Direction	Group	Pre-test			Posttest		
		Mean ± SD.	t	*p* (2-tailed)	Mean ± SD.	t	*p* (2-tailed)
Anterior	PG	80.09 ± 9.66	-0.65	0.26	81.87 ± 9.76	0.67	0.50
	TG	81.93 ± 7.07			79.67 ± 9.89		
Anteromedial	PG	2.19 ± 11.11	-0.17	0.43	81.29 ± 11.81	-0.12	0.79
	TG	82.74 ± 7.43			81.71 ± 10.05		
Medial	PG	81.57 ± 9.89	-0.06	0.48	79.05 ± 12.63	-1.12	0.13
	TG	81.38 ± 8.57			83.06 ± 8.51		
Posteromedial	PG	2.23 ± 10.72	-0.52	0.31	76.54 ± 11.17	-2.12	0.04
	TG	83.92 ± 8.83			84.06 ± 10.18		
Posterior	PG	78.85 ± 9.83	-1.01	0.26	78.84 ± 13.65	-2.10	0.04
	TG	81.84 ± 7.73			87.18 ± 9.87		
Posterolateral	PG	7.34 ± 11.13	-0.23	0.41	79.57 ± 12.66	-2.12	0.04
	TG	6.50 ± 11.15			87.34 ± 9.01		
Lateral	PG	1.38 ± 10.31	-0.33	0.36	72.58 ± 12.33	-1.56	0.27
	TG	2.61 ± 12.43			78.14 ± 8.74		
Anterolateral	PG	78.94 ± 9.43	-0.02	0.50	78.90 ± 9.98	-0.26	0.91
	TG	78.89 ± 9.95			79.50 ± 8.21		

Note: PG = Placebo group, TG = Treatment group.

4. Discussion

This study aimed to investigate the effects of ankle balance taping with elastic and placebo taping on dynamic balance and round kick performance. The main finding of this study was a significant increase in repeated round kicking and plantar flexion movement with the non-dominant leg and improved dynamic balance in the posteromedial, posterior, and posterolateral directions. These results may have occurred for several reasons.

A change in round kick performance after tape application is shown in the repeated round kick. When the participants prepare to re-kick, they could firmly stand with the non-dominant leg. The muscles used during single-leg standing kicks, such as the tibialis anterior, soleus, gastrocnemius medialis, and peroneus longus, were activated to establish equilibrium [11]. However, ankle taping may have improved repeated round kick with both mechanical and proprioceptive effects. When elastic tape was applied, it anchored on the skin at the posterior aspect of the calcaneus and was pulled toward the skin on the calf muscles with a relatively high tension. The passive tension of the elastic tape could provide a pulling force in the same direction as contraction of the gastrocnemius, such that it could reinforce plantar flexion.

Moreover, the tape adhering to the rear of the foot could stimulate mechanoreceptors located in the deep skin and fascia layers, which are associated with tactile sensations acting as additional factors supporting player movements. Stimulation of the cutaneous mechanoreceptors enhances neuromuscular transfer about the joint position and movement, including enhancing proprioception. The effectiveness of elastic taping could increase balance when kicking [12], resulting in an increased number of repeated round kicks during the allotted time.

The ankle range of motion showed a significant increase in plantar flexion in both joint movement from a neutral position, and joint movement during high round kicks. The increased stability of the ankle joint resulting from elastic taping might facilitate an increased plantar flexion movement during the high kicks. Therefore, the use of ankle balance taping was shown to affect ankle stimulation, as the mechanoreceptors may contribute to the stability of the ankle. The results are consistent with earlier findings, which reported that using KT tape increases the range of motion during exercise in healthy people [13]. Additionally, studies have shown that kinesiology taping affects lower extremity functions of unstable ankles [14]. In contrast, the study by Refshauge et al. found no significant differences in movement perception in plantar flexion and dorsiflexion movement in taped and untaped conditions [15]. The ankle range of motion is the angular displacement in the function of the joint and the surrounding muscles and ligaments.

Improvement in dynamic balance was found in the posteromedial, posterior and posterolateral directions in the treatment group but not in the placebo group. This phenomenon could be explained by increased stability of the ankle joints after applying elastic tape. Tactile and proprioceptive feedback resulting from elastic taping could provide better balance control and improve dynamic balance. These factors might increase the sensation of joint position during the movements and help them return to their regular positions [16].

There are some imitations of the study to be addressed. First, the study design using two parallel groups might be a disadvantage if there was an imbalance of physical characteristics, especially when the participants are at an age where they are undergoing rapid growth. This imbalance may affect the measured outcomes. However, the physical characteristics of the participants in the current study were similar between the two groups, so that differences in round kick performance should reflect the effects of the elastic taping at the stance ankle joint of young Taekwondo players. Second, capturing and manually synchronizing the two and three video

data recordings could be operator dependent and error prone. A 3D motion analysis system is suggested in a future study to minimize this error.

5. Conclusion

This study investigated the effects of elastic taping for ankle balance on dynamic balance and round kick performance in young Taekwondo players. We found that this taping could increase the dynamic balance in the posteromedial, posterior, and posterolateral directions, as well as improve repeated round kicking and plantar flexion movement. This study shows that elastic taping can enhance the round kick performance of young Taekwondo players.

6. Ethical approval

This study was reviewed and approved by the Khon Kaen University ethics committee for human research (HE632129).

7. Acknowledgments

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