The Immediate Effects of Static versus Proprioceptive Neuromuscular Facilitation Stretching with Kinesiology Taping on Hamstring Flexibility in Teenage Taekwondo Players

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Abstract

Introduction: This study evaluated the acute responses to static stretching versus the proprioceptive neuromuscular facilitation stretching technique with and without applying kinesio tape on hamstring muscle flexibility, as scarce evidence exists in this field. **Materials and Methods:** Twenty teenage professional black/red belt taekwondo players participated in this study. Proprioceptive Neuromuscular Facilitation (PNF) and static hamstring stretching was performed for both legs of each subject. Then a Y-shape Kinesio Tape (KT) with 30% tension was applied over one leg chosen randomly. Active Knee Extension Test (AKET) and Passive Straight Leg Raise (PSLR) were performed at base line, immediately and 24 hours after interventions. **Results:** Repeated measures ANOVA was used to statistically analyze the data. PSLR test results demonstrated a significant increase in hamstring flexibility over time, while the AKET results showed no significant changes. No significant differences were observed between PNF and Static stretch (SS) or the KT and Non-Taped (NT) groups immediately or after 24 hours. **Conclusion:** The current study showed that there is no superiority in SS or PNF stretching techniques for increasing hamstring flexibility, and using KT over stretched muscles could not help improve flexibility.

Keywords: Flexibility; Kinesiology taping; Stretching; Taekwondo player

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Introduction

Taekwondo is a contact sport that was first introduced at the 1988 Olympic Games in South Korea. In this sport, athletes try to gain points by punching and kicking the torso and head of their opponents (1). To obtain higher scores, taekwondo players tend to use kicking rather than punching techniques (2). Thus, thigh muscles activity and flexibility are key factors for taekwondo players. Some researchers have provided an isokinetic and cinematic analysis of the role of lower limb muscles during a kick (1, 3). According to Rafael A. Favarani, an adequate ROM in the hip and knee joints is of great importance during a kick; muscle stiffness may conversely affect the task by increasing passive resistance (3). Luciana De Michelis Mendonça pointed out the significance of hamstring muscle flexibility in extreme ROM during a high kick (1). Many studies have indicated that posterior thigh muscles, especially the hamstring, are vulnerable to injuries such as strains in sports, and many studies have implied that decreased flexibility is a risk factor (1, 4, 5). As a result, athletes take advantage of stretching exercises as part of their warm-up program to improve flexibility and performance and to prevent injury (5, 6).

Among various stretching techniques, the static and PNF stretch techniques are widely used by athletes and are reported to have both short-term and immediate effects in increasing ROM (7, 8). Static stretch is defined as holding the muscle in an elongated position while feeling slight discomfort for a period of 5 to 120 seconds. The number of repetitions can vary from 1 to 10 stretches

Table 1. Demographic information of the subjects

Group	Static (n=10)			PNF (n=10)		
	Min	Max	Mean (SD)	Min	Max	Mean (SD
Age (year)	10	15	12.2 (1.81)	9	18	12 (2.62)
Height (cm)	144	178	162 (10.28)	136	174	154 (11.65)
Weight (kg)	32	61	49.7 (7.76)	28	64	44 (11.74)
BMI	15.43	20.86	18.81 (1.66)	15.13	21.75	18.45 (2.48)

Table 2. Mean (SD) of all measurements

Measurement	Group	Baseline	Immediately	24 hours after
SLR	Static	101.75(8.80)	107.1 (9.00)	107.45 (8.46)
	PNF	99.05 (14.74)	105.15 (12.27)	106.0 (12.16)
	Taped	99.9 (12.23)	105.8 (10.49)	105.95 (10.98)
	Non-taped	100.9 (12.18)	106.45 (11.10)	107.50 (9.94)
AKET	Static	114.8 (9.86)	112.65 (11.31)	113.7 (12.01)
	PNF	107.85 (26.79)	107.55 (26.34)	106.55 (28.38)
	Taped	110.85 (15.29)	110.75 (16.899)	109.45 (19.62)
	Non-taped	111.8 (24.61)	109.45 (23.44)	110.8 (24.31)

Table 3. Normal distribution of variables

Groups	PNF	Static	Sig.
PSLR-KT	98.9±13.45	100.9±11.53	0.906
PSLR-NKT	99.3±16.66	102.6±5.40	0.085
AKET-KT	105.80±18.87	115.9±8.99	0.178
AKET-NKT	109.9±33.90	113.7±11.05	0.102

Table 4. Repeated measures ANOVA

Flexibility measurement	Variable	Effect	Value	F	Hypothesis	Sig.
PSLR	Time	Wilks' lambda	0.558	13.874	2	0.000
	Time*stretch group	Wilks' lambda	0.991	0.156	2	0.856
	Time*KT group	Wilks' lambda	0.990	0.170	2	0.844
	Time*stretch group*KT group	Wilks' lambda	0.976	0.438	2	0.649
AKET	Time	Wilks' lambda	0.978	0.390	2	0.680
	Time*stretch group	Wilks' lambda	0.980	0.356	2	0.697
	Time*KT group	Wilks' lambda	0.967	0.593	2	0.558
	Time*stretch group*KT group	Wilks' lambda	0.984	0.278	2	0.759

(9, 10). Among the many types of PNF stretching methods, contract-relax is a popular inhibitory technique in which a voluntary contraction of the target muscle before applying static stretch causes a reduction in reflexive components (7).

To explain immediate responses to stretching exercises, alterations in the viscoelastic properties of the musculotendinous unit or modifications in stretch tolerance have been suggested by previous studies (3). However, Konard (2014) implied that a reduction in the firing rates of mechanoreceptors and proprioceptors as a response to acute stretch resulted in sensory adaptation of the nociceptor nerve endings and increased range of motion (8).

Kinesiology taping is a technique that utilizes an elastic therapeutic tape developed by Dr. Kenzo Kase (a chiropractor) in Japan more than 25 years ago and introduced into the United States in the 1990s. It has been reported that to facilitate muscle function, the tape should be applied with 25%-50% of the available tension (moderate) in the direction from origin to insertion (11). In recent years there has been a trend toward the use of KT in different fields of rehabilitation and sports for different purposes, among which are pain reduction, muscle strengthening, injury prevention, functional improvement, and alterations in muscle activity and extensibility (5, 12, 13).

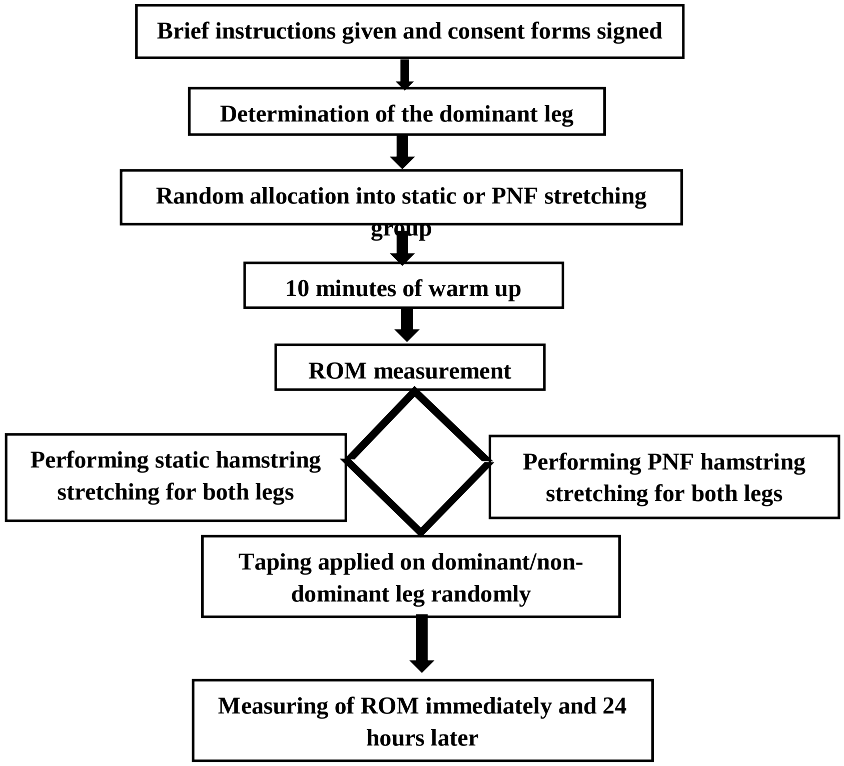

Figure 1. Flow chart of study procedure

Changes in the mechanoreceptor's activity or modifications in blood circulation have been proposed as probable mechanisms of KT (13). In spite of its extensive use, the evidence on the efficacy of KT on muscle flexibility is controversial, possibly because of variations in participants, the muscle which is taped, or outcome measures (12-14). Different muscles may react differently to KT application (12). The current study examined the acute effect of KT application on hamstring muscle extensibility immediately after stretching exercises in taekwondo athletes.

Material and method

Participants

Twenty professional teenage taekwondo players with no history of fracture or injury in their lower extremities and no experience of neuromuscular problems in the year prior to the study were enrolled (3, 15). Participants' demographic information is shown in Table 1. All subjects had been practicing taekwondo for one hour in 3 sessions each week for at least 2 years. Moreover, their belt color was either black or red. This provided sport proficiency homogeneity. Participants were excluded from the study if they used painkillers during their participation in this research (5). The study method and procedure were approved by the Research Council and Ethics Committee affiliated with Iran University of Medical Sciences. Subjects had the right to quit the survey at any point in the study.

Procedure

The researcher gave brief instructions about the study to each athlete, and participants signed informed consent forms. Then, the dominant leg was determined by means of kicking a ball (Ball-kick test) (16). Each subject was randomly allocated into either the SS or the PNF group, and hamstring flexibility was assessed by PSLR and AKET tests following 10 minutes of warm up including running, submaximal kicking, squatting, and jumping (2). In the next step, based on the participant's group, static or PNF stretching was performed on both legs, and then KT was applied on either the dominant or non-dominant leg chosen at random. Range of Motion (ROM) were reassessed immediately and 24 hours after taping. The study procedure is demonstrated in the flow chart in Figure 1.

Flexibility Assessment

In this study passive SLR and modified AKET tests were used as the index with which to evaluate the hamstring muscle flexibility (Figures 2 and 3). In the passive SLR test, the athlete laid supine and the examiner passively flexed the hip joint to the point where further flexion was unbearable by the subject, while the

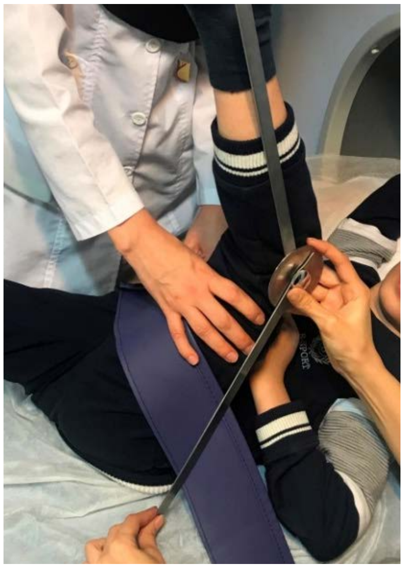

Figure 2. Active Knee Extension Test

ipsilateral knee joint and contralateral hip and knee joints were maintained in 0 degrees of extension to avoid posterior pelvic tilt. The angle was measured manually using a goniometer (5). In the modified AKET test, the participant laid supine and flexed the hip joint to 120 degrees; a belt was used to prevent hip joint movement toward extension. The examiner then asked the subject to actively extend the knee joint from full flexion into extension while maintaining the contralateral hip and knee joint in 0 degrees of extension. The amount of maximum knee joint extension that the participant was able to hold for at least 2 seconds was manually measured by goniometer (3, 17).

Stretching protocol

Hamstring stretching was done by holding the knee joint in full extension and flexing the hip joint to the extent that the subject reported a feeling of slight discomfort. The researcher held the limb in this position for 30 seconds and performed the process 5 times with 30-second intervals of rest (5). For hamstring PNF stretching, the contract-relax technique was applied as such: the researcher flexed the hip joint to the limit of discomfort, meanwhile keeping the contralateral hip, knee joints, and ipsilateral knee joints in 0 degrees of extension. At this point, the subject performed a maximum hamstring isometric contraction for 5 seconds with a subsequent 10-second rest. Subsequently, the researcher moved the hip joint into further hip flexion reaching a new stretch limit and held the position for 30 seconds. Four sets of PNF stretching were performed with 30-second intervals of rest (6).

Figure 3. Passive Straight Leg Raise Test

Kinesio taping method

Standard kinesio tape (5-cm width, K-Active Company) was applied by a professional physiotherapist for all participants. KT was applied on the hamstring muscle from origin to insertion direction. While the subject was in standing position with trunk in flexion to put hamstring in stretch, two I strips were applied originating from the ischial tuberosity and following the way over the hamstring muscle, inserting on medial and lateral borders of the popliteal fossa. Tension of 30% was applied, but the origin and insertion of the tape was off-tension (12).

Results

According to the K-S test results, the variables had a normal distribution. The mean and SD of all measurements are shown in Table 2. No significant difference was seen in the variables between groups at baseline (*P*>0.05) (Table3, Figures 4, 5).

Repeated-measures ANOVA showed no difference between the PNF and static groups or the KT and NT groups immediately or 24 hours after stretching. The PSLR results showed a significant difference over time, while the AKET results showed no significant changes over time (*P*>0.05) (Table 4).

Discussion

The results of the current study showed that flexibility of the hamstring muscle was improved over time in all groups when measured by PSLR. When it was assessed actively using AKET, however, no significant difference was observed over time. Among the many various factors proposed in previous studies for muscle flexibility improvement following stretching exercises, viscoelastic modifications in the musculotendinous unit and changes in stretch tolerance are the most supported ones (10).

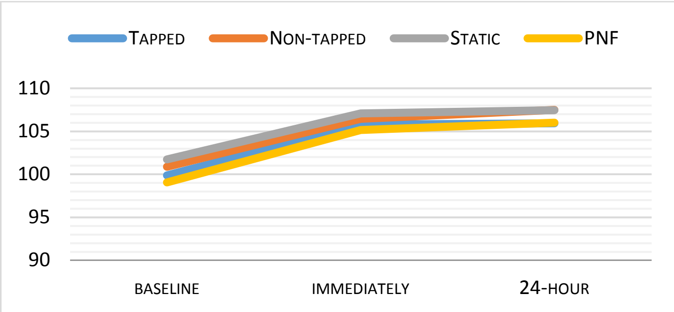

Figure 4. PSLR test results

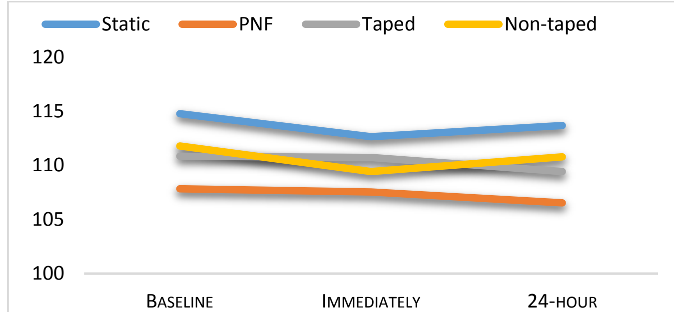

Figure 5. AKET results

Konard *et al.* investigated the probable structural modifications in muscle and tendon properties following static stretching of the gastrocnemius medialis muscle in 2014. They evaluated ROM, passive resistive torque, maximum voluntary contraction, EMG, and measurements of elongation of muscle-tendon structure (fascicle length and pennation angle). Based on their results, they concluded that static stretch increased ROM but had no influence on the structural properties of the gastrocnemius medialis musculotendinous unit (8).

Changes in the musculotendinous unit properties following stretching have been reported to be dependent on the factors of stretching technique, time of stretch, hold and rest, time between stretching, and assessment (5). In a study by Bandy *et al.*, 30 seconds of static hamstring stretch was enough to increase range of motion; 60 seconds of stretch resulted in no further increase in flexibility. Moreover, the authors came to the conclusion that increasing stretch frequency from one to three times a day had no effect on hamstring flexibility (18). It should be considered that in their study, their outcome measures were restricted to ROM assessment and did not evaluate structural properties.

Although it has been stated that lower stretching repetitions do not change muscle viscoelastic properties (5), Wayne Johnson believed that the total duration of stretching matters more than the number of repetitions. According to his research in 2014, changes in perceived stretch sensation is the most accepted explanation for range of motion improvement. He also states that as in the passive knee extension test, which was used to assess hamstring flexibility in their methodology, the end point was determined by both the examiner and the participant. It is not clear whether these improvements were attributed to stretch tolerance modifications (10).

The current study employed both PSLR and AKET tests in its methodology. In entire AKET procedure was performed by the participant, and the examiner had no role in applying force or monitoring the end point. It was expected that if there was a change in the stretch tolerance of the participant, active assessment of range of motion would approve the passive test results, but this was not the case. In addition to the subjective results, the quadriceps muscle strength may also play a role in this test, according to Fredriksen (1997) (17).

Conversely, Favarani states that changes in individual stretch tolerance can only be considered in passive flexibility tests and believes that flexibility improvements following stretching exercises are attributable to modifications in the viscoelastic properties of the musculotendinous unit (3). Although AKET has been proposed as the golden standard (19), it seems that hamstring flexibility assessment, whether active or passive, may be influenced by pelvic tilts or quadriceps muscle strength (17), which may interfere with our justifications of underlying mechanisms of changes in ROM. In this case, the inconsistencies in the results obtained from active and passive tests may be more comprehensible.

Many studies have indicated that both PNF and static stretching increase hamstring flexibility with no significant difference observed between the stretching groups (4). The findings of the current study are consistent with those of previous studies. However, some studies have also reported superior results for PNF stretching in increasing ROM than static stretching within one session (20). Autogenic and reciprocal inhibition have been reported to be the underlying neurophysiological explanation for the superior effects of PNF stretching in increasing ROM (21). On the other hand, Behm *et al.* suggested that PNF and static stretch probably have similar mechanisms in increasing ROM.

Based on the results of the current study, improvement in ROM was observed not only immediately after stretching exercise, but also after a 24-hour interval for both static and PNF stretch groups. These findings of the current study are similar to those obtained by Eftekhari *et al.* They reported that hamstring flexibility increased after PNF, static, and dynamic stretching, and this increase was maintained only in the PNF and static groups 24 and 48 hours post-stretch (22).

The current study also compared the kinesio taped group and the non-taped group. Based on the outcomes, it is concluded that applying kinesio tape on the stretched hamstring muscle did not change its flexibility. Ozmen *et al.* has conducted some studies in this field. In 2016, they investigated the effect of kinesio tape application to the quadriceps after squat exercises on flexibility, pain, and sprint performance. Their results demonstrated that the application of kinesio tape to the quadriceps muscle could have a beneficial effect in avoiding decreased ROM following squat exercises and maintaining flexibility as the baseline, but it did not influence the pain or sprint performance (23). In another research in 2017, they evaluated the effects of static and PNF stretching and kinesio taping in separate groups on hamstring flexibility and recovery from delayed onset muscle soreness. It was concluded that none of these interventions could affect hamstring flexibility after DOMS (5).

In 2013, Chen *et al.* investigated the effects of two stretching protocols (static stretch + PNF stretch versus static stretch + kinesio tape) on hamstring muscle stiffness, peak torque, and ROM. According to their study, hamstring muscle flexibility was improved in both groups, but only applying kinesio tape by static stretch could avoid the decrease in peak torque of the hamstring muscle following the stretching exercises (24).

In 2013, Dedi Lumbroso *et al.* studied the effect of applying kinesio tape on ROM and the peak force of hamstring and gastrocnemius muscles in healthy young adults. Their investigations showed that gastrocnemius muscle flexibility was improved immediately after kinesio tape application, but for hamstring muscle, an increase in the passive knee extension angle was observed after 72 hours while the passive SLR angle was improved immediately and became insignificant after 72 hours. They concluded that different muscles probably respond differently to kinesio tape application (12).

In the current investigation, applying kinesio tape over the stretched hamstring muscle after both static and PNF stretching exercises did not affect muscle flexibility immediately or after 24 hours. The results at 48 and 72 hours after interventions were not evaluated, and this is one of the limitations of this study. Moreover, the subjects were teenage professional taekwondo players with proper muscle flexibility, so different results may be obtained when investigating adults or subjects suffering from muscle tightness. Therefore, it is recommended that research be performed on the possible effects of kinesio tape on athletes experiencing muscle tightness.

Conclusion

The current study showed that there was no superiority in either the SS or the PNF stretching technique for increasing hamstring flexibility, and using KT over stretched muscle could not help improve flexibility.

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None

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Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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