Original Article

HEALTH SCIENCES
MEDICINE

DOI: 10.32322/jhsm.1218197
J Health Sci Med 2023; 6(3): 623-629

The impacts of Kinesio taping on muscular fatigue and proprioception following fatigue among adolescent basketball players

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Cite this article as: Poyraz İ, Vergili Ö. The impacts of Kinesio taping on muscular fatigue and proprioception following fatigue among adolescent basketball players. J Health Sci Med 2023; 6(3): 623-629.

Received: 13.12.2022 ◆ **Accepted**: 12.05.2023 ◆ **Published**: 31.05.2023

ABSTRACT

Aim: The present study attempted to investigate the impacts of Kinesio taping on proprioceptive responses of the knee joint before and after muscular fatigue.

Material and Method: Thirteen healthy basketball players were recruited for this study. A fatigue protocol was designed with a load of 70% of the maximum quadriceps muscle strength and applied to the dominant lower extremity, including repetitive knee flexion and extension in a sitting position between 0°-90°. Fatigue was assessed using the Borg scale. The protocol was administered to the same participants twice at a one-week interval. Proprioception in the knee joint was assessed using the angle reconstruction test. In the evaluation of proprioception, the target angle was set as 45° of knee flexion and was measured with a digital goniometer. In the second-week measurements, the same protocol was repeated immediately following Kinesio tape application to the quadriceps femoris muscle with the facilitation technique.

Results: The findings revealed no significant within-group differences between the proprioception measurements before and after fatigue ($p > 0.05$). It was also the case in the evaluation with Kinesio taping ($p > 0.005$). However, the number of movement repetitions significantly differed between the groups in the fatigue protocol ($p < 0.05$).

Conclusion: The proprioception values of pre- and post-fatigue did not significantly differ when Kinesio taping was applied. Overall, it was concluded that Kinesio taping was an effective factor in reducing fatigue and contributed to endurance by delaying the onset of fatigue.

Keywords: Adolescent, quadriceps muscle, athletic tape, proprioception, basketball

INTRODUCTION

Kinesio taping (KT) is a method that has grabbed substantial attention substantial attention for its widespread use as a therapeutic tool in physiotherapy and rehabilitation in recent years. Tapes are widely used in clinical practice. While having a thickness similar to the epidermis layer of the skin, they bear flexibility overlapping with the elastic properties of human skin (1-3). To accomplish a desirable result from the application, it is key to assess the patient to be treated well, to determine the ultimate purpose, to choose the appropriate region, and to apply the appropriate tension and angle to the region (4). KT techniques can be applied with I, Y, X, web, fan, or ring-shaped tapes (4). Although the impacts of KT on proprioception have not been fully elucidated (5-7), it is thought that KT may improve performance by enhancing proprioception (8). The ability to sense the location or movement of the body or body part in space is called proprioception (9).

Proprioception helps with the proper functioning of posture, balance, coordination, and joint stabilization (10). Many receptors (e.g., mechanoreceptors) can sense proprioception (11), and it is often proposed that there may be an increase in proprioception by stimulating mechanoreceptors with KT (8). It is thought that physical fatigue (e.g., muscular fatigue) adversely affects joint proprioception and impairs neuromuscular control. Although the literature hosts a plethora of studies investigating the changes within proprioception following fatigue, they have not been able to reveal what components in the proprioception pathway do not function adequately following fatigue (5,12,13). Generally it is accepted that local muscular effects arising from fatigue may have negative effects on proprioception (5). The present study aimed to have a contribution to the literature by focusing on

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this perspective by exploring the impacts of KT applied to the quadriceps femoris muscle with the facilitation technique on the proprioceptive sense during and after fatigue. The acute effect of KT is evaluated in this study. Because no consensus is available in the literature whether the KT application increases muscle strength in the acute phase following application, it is intended in this study to find out whether KT has (15-17).

MATERIAL AND METHOD

The study was carried out with the permission of Kırıkkale University Medical Faculty Non interventional Clinical Researches Ethics Committee (Date: 26.06.2019, Decision No: 2019.06.18). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The participants and their parents provided informed consent after receiving a brief explanation of the purpose and scope of the research. Thirteen healthy adolescent athletes from the An Kavra Sports Club were recruited for the study. Eligibility was confirmed by reviewing each participant's case report. The study included 13 adolescent healthy individuals who had been playing amateur basketball with the club for at least a year. Moreover, the participants were required not to develop an allergic reaction to 5 cm wide tape attached to their forearm area. The tape was kept on the arm for 10-15 minutes (17). Then, the participants' demographic characteristics such as age, height (cm), body weight (kg), and dominant side were noted down.

The inclusion criteria were set as follows: playing basketball, being an adolescent (10-19 years), having no history of lower extremity injury, and volunteering to participate in the study. Nevertheless, those with a history of lower extremity injury, fractures, and surgery history, neuromusculoskeletal disorders, and cardiovascular issues in the last six months were excluded from the study (14). When needed, the termination criteria were renouncing voluntary participation in the study and withdrawal from/not being able to fill out the data collection tool.

The present study aimed to investigate the impacts of fatigue in the quadriceps femoris muscle on the proprioception of the knee joint. Hence, a fatigue protocol was designed where one's quadriceps muscle needs to be exhausted till it can no longer move. This protocol was planned to be performed with a load of 70% of the maximum quadriceps muscle strength. It was planned to be carried out with a weight that was 70% of maximal isometric muscle strength of the quadricesp femoris muscle (**Picture 1**). To settle the protocol, each participant's quadriceps muscle strength during knee extension was first measured with a hand-held muscle strength dynamometer (Baseline Evaluation System, New York). To prepare the muscle for the measurement, the participants were recruited for five minutes of brisk walking and a short (3× 30 sec) stretching exercise on their quadriceps femoris muscle (18). Extension strength was measured in the sitting position with the hip and knee joints flexed to 90°. The test was performed isometrically, and the results were recorded in kg-force (19). The procedure was replicated three times, and the mean of the three measurements was recorded. The results also helped to confirm the participants' dominant side. The protocol was implemented by asking each participant to bring their knee from 90° flexion to full extension in the sitting position based on the pre-determined load. The protocol was repeated until each participant could no longer move their thigh, and the number of repetitions was recorded throughout the protocol (20).

Picture 1. Isometric quadriceps muscle strength measurement (A picture was taken by author)

This fatigue protocol was applied to same individuals twice with a one-week interval. In the first week, it was performed without KT and in the second week it was repeated by applying KT to the Quadriceps Femoris muscle with facilitation technique. The evaluation in the first week was assigned as control group, while the second evaluation was the study group and comparisons were made between them regarding fatigue and proprioception. The protocol was administered to the same participants twice at a one-week interval. The first-week protocol was performed without KT and marked as the control measurement (group). The second-week protocol,

on the other hand, was administered with KT to the quadriceps muscle with the facilitation technique and considered the experimental measurement (group). The groups were then compared regarding fatigue and proprioception.

KT was performed using 5 cm wide standard tape. The tape was attached to the clean and moisture-free skin of the quadriceps femoris muscle with the facilitation technique from the origin to the insertion. After securing the anchor at the origin of the muscle, the quadriceps muscle was taken to its most tense position upon the knee joint with max flexion, and the I-shaped tape was attached to the patellar tendon without applying tension from the spina iliaca anterior superior (SIAS) (**Picture 2**).

Picture 2. Application of kinesio tape to the quadriceps muscle with facilitation technique (A picture was taken by author)

The joint position sense test (angle reconstruction test) was utilized to evaluate the proprioceptive sensation of the knee joint, and proprioception was evaluated using a digital goniometer (14). The test procedure was performed while participants were seated with bare legs. During the measurement, the participants' eyes and ears were closed. At a knee flexion angle of 90°, the goniometer was adjusted and fixed as the fixed arm was aligned with the thigh, the movable arm was aligned with the lateral malleolus, and the pivot point was the lateral femoral condyle. The target angle for proprioception measurement was set at 45° (**Picture 3**). First off, each participant was recruited for a demo to teach the target angle. The knee was passively brought to the target angle, the movement was stopped, and the participant was asked to concentrate for three seconds, and the knee was brought back to the starting position. The demo was performed actively and passively 3-7 days before the actual measurement until each participant grabbed the idea. The target angle was reminded to the participants during the first-week measurement, and they were asked to close their eyes and ears, find the target angle, and maintain that angle for three seconds. The test was repeated five times. Afterward, the values when they felt to accomplish the target angle were recorded in these trials, and the mean and error values were noted (5, 21-24). Measurements were taken in a quiet and ventilated environment to minimize distractions.

Picture 3. Evaluation of proprioception of the knee joints (A picture was taken by author)

The perceived level of fatigue during the tests was assessed using the modified Borg CR-10 scale (25, 26). Individuals were asked to rate the level of fatigue they felt between 0 (no fatigue) and 10 (motionless). The loading was maintained until the participants' perceived fatigue reached a score of 9 or 10 points (25). The protocol was terminated upon reaching such a score, and the proprioception values were remeasured and recorded.

Statiscal Analysis

Prior to this study, power analysis has been conducted. Comparison of pre- and post-fatigue was conducted via t-test. The effect size value, Cohen's d was 3.4 which was calculated based on the Absolute error (degree) of similar study (27). The outcome of this analysis conducted with 80% power and 5% error has revealed that the number of participants that required to be evaluated was 3. Therefore, 13 participants have been involved in this study. Descriptive statistics for quantitative variables were presented as mean±standard deviation and frequency (percentages) for qualitative variables. The paired samples t-test was used to compare the pre- and post-fatigue proprioception values. P-values of <0.05 was considered statistically significant.

RESULTS

The sample consisted of thirteen healthy athletes of An Kavra Sports Club, 2 (15.38%) females and 11 males (84.61%). The study was performed between January to April in 2019. While the dominant side of 12 (92.3%) participants was the right extremity, it was the left extremity in only one participant (7.7%). The participants had a mean age of 12.38 years (12-14 years), a mean height of 163.76 cm, a mean body weight of 53 kg, and a mean body mass index (BMI) of 21.05 kg/m². It was found that all participants attended secondary school, played basketball for more than a year, and had no history of lower extremity injury. **Table 1** presents the participants' physical and demographic characteristics.

Table 1. Participants' physical and demographic characteristics

Physical Characteristics	**Mean**
Age	12.38
Height (cm)	163.76
Weight (kg)	53
BMI (kg/m²)	21.05
Demographic Characteristics	**n (%)**
Sex	
Female	2 (15.38)
Male	11 (84.51)
Educational attainment	
Secondary school	13 (100.0)
High school	0 (0.0)
Dominant extremity	
Right	12 (92.3)
Left	1 (7.7)

First, the comparison of pre- and post-fatigue proprioception values at the target angle (45°) of knee flexion without KT yielded no significant differences between the mentioned values (p>0.05. Similarly, there was no significant difference between the pre- and post-fatigue proprioception values at the target angle of knee flexion with KT application (p>0.05; **Table 2**).

On the other hand, the pre-fatigue proprioception values at the target angle of knee flexion did not significantly differ between two weeks of the measurements (p>0.05). The findings also revealed no significant difference between the post-proprioception values at the target angle of knee flexion without KT and the mentioned values with KT in the second week (p>0.05; **Table 2**). The findings also demonstrated a significant difference between the number of movement repetitions during fatigue loading without KT in the first week and with KT in the second week (p<0.05; **Table 2**).

Table 2.

	Pre	**Post**	**Difference**	**p**
	Mean±SD	**Mean±SD**	**Mean±SD**	
First-week PV	45.19+3.22	43.13+6.35	2.06±5.41	0.195
Second-week PV	44.85+1.61	44.97+4.73	-0.12±4.42	0.923
First-week and second-week PRE-PV	45.19+3.22	44.85+1.61	0.33±2.69	0.662
First-week and second-week POST-PV	43.13+6.35	44.97+4.73	-1.84±5.08	0.215
First-week and second-week NoR	46.85+23.31	58.31+18.75	-11.46±12.14	0.005*

(*p < 0.05; PRE-PV: Pre-fatigue proprioception value; POST-PV: Post-fatigue proprioception value, NoR: Number of repetitions)

DISCUSSION

The findings revealed that the proprioception measured at 45° of knee flexion before and after fatigue had no significant impact in the group playing basketball for more than a year. The effect of KT on proprioception was not found to be statistically significant. However, the number of repetitions recorded in the fatigue protocol in both weeks differed significantly. In other words, the participants were able to perform a higher number of movements in the second week, implying that KT may be effective in facilitating the muscle and, thus, help releasing a higher number of movements. The literature offers diverse findings regarding the impacts of taping on muscle strength and endurance (28,29). While some studies argued that it contributes to increased muscle strength and endurance, others proposed vice versa (30,31). A relatively small sample size and random selection of the participants in these studies may have caused insufficient evidence for the effect of taping (4,31). A power analysis was conducted prior to the evaluation. The results of this analysis revealed that the number of individuals required to participate was three. Since we evaluated 13 participants in this study, it was thought to have enough participants. This showed that a sufficient number of individuals participated in this study. Han and Lee (32) designed a study with 30 healthy adults to investigate the impacts of KT on knee joint proprioception after quadriceps muscle fatigue. They evaluated knee joint proprioception on the dominant side at 30°, 45°, and 60° with and without taping before and after fatigue. Their findings showed that quadriceps fatigue adversely affected proprioception and that KT improved reduced proprioception due to fatigue (32). The results of the study of Han and Lee, which are similar to ours, are different. This may be because in our study, we evaluated proprioception only at 45° knee flexion and, in addition, Han and Lee did not evaluate fatigue.

Álvarez et al. (33) studied the impacts of KT on the fatigue of the lumbar extensor musculature among 99 healthy young people. As a result, they found that KT affected the processes leading to muscular fatigue (33). Similarly, in our study, it was found that KT had effect on muscular fatigue. Ahn et al. (34) carried out a study with 45 participants to investigate the effects of KT on the quadriceps muscles immediately after muscular fatigue. The participants were divided into three groups: the KT group, the placebo group, and the no-taping group. The groups were then recruited for the quadriceps strength test, the single-leg hop test, the active joint position sense test, and the single-leg static balance test. The authors concluded that the results of the strength test and the single-leg hop test were significantly better in the KT group, but taping did not have a significant effect on the results of the active joint position sense test and the single-leg static balance test. The common point of this study with the research of Ahn et al. (34) is the evaluation of proprioception and similarly the effect of KT on proprioception was not statistically significant. Another study proposed that KT may help restore reduced muscle strength following muscular fatigue; therefore, it may be beneficial for tired muscles (34). Choi and Lee (35) aimed to determine the impacts of the application direction of KT on the strength of the tired quadriceps muscles. Accordingly, they applied tapes to the quadriceps femoris muscle of 15 individuals. While seven tapes were applied from the origo to the insertion, eight were attached from the insertion to the origo. The results showed no significant difference by the application direction of KT, but it was thought that it could promote the strength of tired quadriceps muscles regardless of the application direction (34). Based on these studies, KB was found to have positive effects on fatigue in several research (33-35). In general, the findings mentioned above suggest that KT may reduce muscle fatigue by promoting endurance and be used as a supportive method to elevate endurance in a clinical context.

The present findings yielded no significant difference between the pre- and post-fatigue proprioception values in the first-week measurements, leading to the conclusion that this level of fatigue did not affect the proprioception values of the trained group (36). Moreover, the same was observed in the second-week measurements. Therefore, this finding then implies that proprioception might be less affected following fatigue in KT-applied participants; therefore, KT may be utilized to protect the joint and reduce the risk of injury, particularly among athletes. Besides, the comparison of the first- and second-week pre-fatigue proprioception measurements yielded no significant difference, as expected, since both measurements were performed under the same conditions. Contrary to expectations, there was no significant difference between the post-fatigue proprioception values in the first- and second-week measurements. Hops et al. (37) previously evaluated the joint position sense of 20 healthy female individuals pre- and post-KT under a fatigue protocol at knee flexion angles of 20° and 70°. Overlapping with the present findings, they found that taping in the participants with poor proprioception provided a significant improvement in joint position sense values before and after taping (37). In discordance with our study, proprioception was evaluated in various knee flexion angles in this study. It should be noted that adolescents engaging in sports activities for a long time bear a good level of proprioception, which may be the reason why the impact of KT was not statistically significant in the participant group (37). Bayramoğlu et al. (38) also found that fatigue from light and moderate exercise did not affect proprioception (38). In our study, the focus was the acute effects of KT, but different results were presented in which the focus was chronic effects of KT (8,39,40). Torres et al. (8) applied KT to the quadriceps femoris muscle (from the origin to the insertion) of 30 healthy young participants with the facilitation technique and measured proprioception at 30 and 60 degrees on an isokinetic dynamometer immediately and 24 hours after the application. Although they concluded with no significant findings, the results suggested that it may affect proprioception positively by improving passive movement sense (8). In their study, Callaghan et al. (39) evaluated the impacts of patellar taping on proprioception in patients with patellofemoral pain syndrome (PFPS). In conclusion, the authors found that patellar taping did not improve proprioception in all PFPS patients, but proprioception could be supported by patellar taping in PFPS patients with weaker proprioception (39). Yeong Sook et al. (40) applied KT to a study group of 30 people for four weeks, three times a week (totally 12 times) and found that KT increased range of motion and had analgesic effect on the knee joints in the elderly. In this study, apart from the other studies, proprioception and fatigue were evaluated in the same time. In addition, the population selection (adolescent basketball players) makes this study original. Depending on this scientific basis, it is thought that, this study both supports the other researches available in the literature and guide the researchers to develop new projects on this topic.

Limitation of This Study

This study was conducted on adolescent basketball players in order to find out the acute effect of KT on fatigue and proprioception following fatigue. So, it was our limitation not to have evaluated the effect of KT in a longer period. Another limitation is that proprioception was evaluated just while the knee joint

was going through flexion and just one flexion angle was chosen as target angle. In addition, not having a placebo group can be considered as another limitation. Because this study included healthy adolescent basketball players, it was not known how the results would have been in symptomatic individuals in different age ranges. Designing new research by using same protocol on individuals with different knee pathologies and between different age ranges can be recommended.

CONCLUSION

Within-group comparisons of pre- and post-fatigue proprioception values revealed no significant difference between both groups. While there was also no significant difference in pre-fatigue proprioception values between groups, it was also the case for post-fatigue proprioception values. However, the number of repetitions in the fatigue loading protocol significantly differed between the groups. Although Kinesio taping (KT) is not found to have effect on fatigue- related proprioceptive response, it was found to increase muscular endurance which was presented by the number of movement repetitions. This means that , KT may have valuable clinical effect on increasing the level of threshold of sports related injuries.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Kırıkkale University Medical Faculty Non-interventional Clinical Researches Ethics Committee (Date: 26.06.2019, Decision No: 2019.06.18).

Informed Consent: Written consent was obtained from the patient participating in this study.

Referee Evaluation Process: Externally peer reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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