

Research Paper: Effect of Kinesio Tape on Symptoms Induced by Delayed Onset Muscle Soreness in Hamstrings



Mehrad Rezaei¹, Seyed Mohsen Mir^{1*}, Naštaran Ghotbi¹, Kazem Malmir¹, Shohreh Jalaie¹

1. Department of Physiotherapy, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran.



Citation: Rezaei M, Mir SM, Ghotbi N, Malmir K, Jalaie S. Effect of Kinesio Tape on Symptoms Induced by Delayed Onset Muscle Soreness in Hamstrings. Journal of Modern Rehabilitation. 2020; 15(1):33-40. <http://dx.doi.org/10.32598/JMR.15.1.5>
doi <http://dx.doi.org/10.32598/JMR.15.1.5>



Article info:

Received: 07 Sep 2020

Accepted: 19 Sep 2020

Available Online: 01 Jan 2021

Keywords:

Delayed onset muscle soreness, Pain, Range of motion, Kinesio tape, Hamstring muscles

ABSTRACT

Introduction: Delayed Onset Muscle Soreness (DOMS) refers to the skeletal muscle pain that follows the novel eccentric exercise. Although this condition is self-limiting, it can temporarily affect the function and interrupt training. This study aimed to determine the efficacy of Kinesio tape on pain intensity, range of motion, and function during delayed onset muscle soreness in the amateur hamstring muscles.

Materials and Methods: This study is a clinical trial conducted on 32 untrained individuals with a Mean±SD age of 24.16±3.049 years. At first, the participants were assessed with an active knee extension range of motion, distance in triple hop test, pressure-induced pain, and overall pain before Kinesio tape intervention, and then Kinesio tape intervention was applied to the hamstrings from origin to insertion (proximal to distal) in a Y shape with a tension of approximately 30%. The study variables were evaluated again 24, 48, and 72 hours after the intervention (4 times totally)

Results: Kinesio tape could significantly reduce pain intensity 24 hours and 48 hours after the intervention compared to before the intervention ($P<0.05$). Also, Kinesio tape intervention increases the range of motion of active knee extension in the first 24 hours compared to before the intervention ($P=0.04$). Besides, the effect of using Kinesio tape intervention on the variable of the triple hop test was significant 24 and 48 hours after the intervention compared to before the intervention ($P<0.05$). Kinesio tape increase in the threshold of compressive pain after the intervention was not significantly different from before the intervention ($P>0.05$).

Conclusion: According to the present study results, the Kinesio tape possibly reduced DOMS-induced parameters like pain, range of motion limitations, and function, but it had no significant advantage in other DOMS-induced parameters like pressure pain threshold. Kinesio tape application before exercise or competition should be considered by exercise trainers and athletes. Future studies may evaluate different strategies or therapeutic applications to prevent and manage DOMS.

* Corresponding Author:

Seyed Mohsen Mir, PhD.

Address: Department of Physiotherapy, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran.

Tel: +98 (21) 77536586

E-mail: smmir@tums.ac.ir

1. Introduction

Delayed Onset Muscle Soreness (DOMS) is a self-limiting condition that can temporarily affect a person's performance and interfere with an athlete's training and performance [1]. During their careers, most athletes experience DOMS, usually after an uncommon or eccentric workout [2, 3]. Eccentric exercises can trigger micro-injury, particularly in the distal musculotendinous junction of the muscles [2, 4]. Signs and symptoms of DOMS include pain, edema, increased passive stiffness, reduced range of motion [5, 6]. Also, the deficiency of proprioception can begin within 12-24 hours and plateau at 48 hours after the exercise [5, 6]. Complete recovery can last 10 days or more [6]. The problem can vary from mild pain to extreme limitations, which can affect the performance of an athlete or prohibit them from engaging in sports activities [5]. Hamstrings are also impaired by DOMS [7, 8]. The muscle strains of the hamstrings are frequently caused by eccentric loading during repetitive extensions in a soccer match. Eccentric workouts will reduce the risk of hamstring strain injury. The same exercises can cause DOMS in hamstrings if done regularly, or the athlete is not trained for exercise [7].

Several pathways have been identified that lead to DOMS, including lactic acid accumulation, muscle spasm, muscle and connective tissue injury, and the release of enzymes and inflammation [3]. Therefore, different strategies for treating these issues have been proposed, including non-steroidal anti-inflammatory medications and rehabilitation as a whole [6, 9]. The potency of the medications has not been decided upon yet [9]. Conservative administration, on the other hand, has shown some progress, including cryotherapy, ultrasound, electrical stimulation, relaxation, stretching, immobilization, and rest [9]. For the treatment of acute soft tissue injury, rest, ice, relaxation, and elevation regimens have commonly been used.

Today, using Kinesio tape to prevent some muscle injuries and to treat skeletal muscle injuries is standard and available and is a widespread technique among athletes that has been widely used in recent years in sports and rehabilitation communities. Kinesio tape has been used in various fields such as reducing pain, increasing muscle strength, preventing re-injury, improving function, and increasing range of motion [1, 10, 11].

In recent years, studies on the effect of Kinesio tape on joint range of motion and functional activities in different sports communities and people with musculoskeletal

disorders have been reported [11, 12]. It should be noted that some studies attribute the differences in the results observed to the various responses of different muscles to the Kinesio tape [10].

In various articles, the positive effects of Kinesio tape can be found in exercise training, sports injury prevention, and injury treatment [13-17].

Many authors have reported positive results from the use of Kinesio tape in the physiotherapy treatment process [18-22].

Achieving an effective protocol in reducing delayed muscle soreness symptoms seems to be one of the most challenging issues in Kinesio tape use. According to previous studies [6-8], delayed onset muscle soreness treatments fall into two general categories: medication and rehabilitation [8]. Medication includes the use of Non-steroidal Anti-inflammatory Drugs (NSAIDs) both prophylactically (pre-workout) and therapeutic (post-workout) [7]. Common rehabilitation treatments include cryotherapy, ultrasound waves, electrical stimulation, massage, stretching, light exercise, immobility, and simple rest, mentioned in various studies [1].

According to previous studies, DOMS symptoms include increased pain intensity, decreased function, and decreased range of motion [1, 23]. On the other hand, according to previous studies, Kinesio tape can reduce pain due to inflammation, increase range of motion, and improve function [24, 25]. So this study aims to investigate the therapeutic effects of Kinesio tape on delayed onset muscle soreness symptoms.

2. Materials and Methods

This study is a clinical trial, and its statistical population consisted of male amateur sports athletes. They had visited Imam Reza Sports Complex Center in Tehran with no musculoskeletal disorder in 2019. The present study was conducted on 32 participants. The inclusion criteria were as follows: aged between 18 and 35 years, stay away from any exercise or strenuous activity for six months, no muscle problems in the lower limbs, no joint involvement in the lower limbs, no skin lesions in the hamstring area, no radicular pain, not taking anticoagulants, no vascular disease, no diabetes, no history of migraine, no previous history of infectious diseases such as fibromyalgia and myopathy, no malignancy or patients prone to infection, absence of central and peripheral neurological disorders. The exclusion criteria were as follows: intolerance of treatment by the participant, feeling dissatisfied,



Figure 1. The Nordic hamstring exercise

JMR

withdrawal from cooperation by the participant. Based on the above criteria, 32 participants were selected.

The research method and purpose were explained in simple and complete language to the patients, and then they read and signed the conscious consent forms. First, forms for patients' characteristics and initial examinations were recorded by a therapist, and then the participants were required to perform eccentric exercises before the intervention. In the present study, the exercise protocol of Mendiguchia et al. was used [26]. Nordic hamstring exercise requires eccentric contractions and is assumed to cause muscle soreness. To perform this exercise, the participant had to kneel on the floor with the upper body vertical and straight, while the partner applied pressure on the heels to keep the feet in touch with the floor during the exercise.

Subsequently, the participants slowly covered their upper bodies against the floor (knee extension) while attempting to avoid falling by contracting the hamstring muscles (knee flexion). The elbow joints were held flexed with the hands close to the shoulders for as long as possible, and the elbow joints would be extended only during the final stages of the action to cushion the fall (Ozmen et al., 2017) (Figure 1). The Nordic exercise consisted of 5 sets of 8 repetitions. The participant was allowed to rest for 10 s between each repetition and had a break of 2 to 3 min between each set.

Measurement of study variables

The Visual Analog Scale (VAS) was used to measure pain. VAS is a pain-sensitive scale that has validity and reliabil-

ity [27]. The scale was a 10-cm long measuring line that the patient had to determine the pain on the measuring line from 0 (painless) to 10 (the most severe imaginable pain).

In the present study, a goniometer was used to record the active knee extension range of motion, including a fixed and a movable arm.

For measuring the PPT, we used Lutron FG-5020 digital algometer; the algometer tool is used to evaluate the threshold of compressive pain in the muscle, which has been reported to be moderate to good in terms of reliability ($R=0.67$) [28].

For measuring the distance of the triple hop test, we used a tape meter.

The participants were assessed with an active knee extension range of motion, distance in triple hop test, pressure-induced pain, and overall pain before the Kinesio tape intervention and again evaluated 24, 48, and 72 hours after the intervention (Figure 2).

Intervention

A standard 2-inch (5-cm) Kinesio tape was used for all applications. The participants were taped with a facilitation technique by a certified physiotherapist. Kinesio tape was applied to the hamstrings from origin to insertion (proximal to distal) in a Y shape manner with a tension of approximately 30% [29, 30]. The participants were positioned with the knee in extension and the hip flexed to put the hamstrings in a supine lying posture. The base of the tape was attached over the ischial tuberosity to the skin. After stabilizing the base of the tape, Kinesio tape was removed from the paper backing to the base of 'Y' tails and placed on the skin. The 'Y' tails were applied to the skin over the medial and lateral epicondyle of the tibia (Figure 3).

Statistical analysis

SPSS v. 26 was used for the statistical analysis. The Shapiro-Wilk test was utilized to evaluate the distribution of numerical variables in terms of compliance with the normal theoretical distribution. The central tendency and dispersion indices were used to describe the binary variables. The paired t test was also used to evaluate the

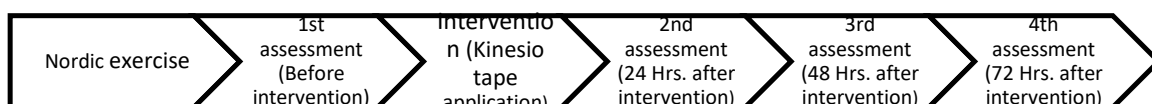


Figure 2. Flowchart of this study

JMR



JMR

Figure 3. Kinesio tape application on hamstring muscles

significance of each variable before and after the treatment in the Kinesio taping group. Furthermore, the 1-way ANOVA repeated measures were used to compare changes in the VAS and Range of Motion (ROM) and Pressure Pain Threshold (PPT) and the triple hop test between individuals. All results are shown as the mean \pm SD. The significant level was considered as $P < 0.05$.

3. Results

The research was conducted on 32 participants with a mean age of 24.16 ± 3.049 years. The results of the subjects' demographic indicators, including age, height, and weight, can be seen in [Table 1](#).

The mean and standard deviation of the variables before the intervention are shown in [Table 2](#).

Results of [Table 3](#) indicated the significant therapeutic effect of Kinesio taping on the VAS ($P < 0.001$) and active knee extension range of motion (AKEROM) ($P < 0.001$), and Triple Hop ($P = 0.02$), and PPT ($P = 0.050$); so that Kinesio tape intervention significantly reduced VAS and increased the ROM and increased triple hop distance, but it did not show a significant change in PPT.

The results of [Table 4](#) showed that the use of Kinesio tape for the VAS variable could significantly reduce pain intensity after 24 hours and 48 hours compared to before the intervention ($P < 0.05$), but did not show a significant effect during 72 hours after the intervention ($P = 0.067$). Also, Kinesio tape intervention increases the range of motion of active knee extension in the first 24 hours compared to before the intervention has been significant ($P = 0.04$), but during 48 hours and 72 hours after the intervention, it does not show a significant difference ($P > 0.05$). Also, the Kinesio tape effect in increasing the threshold of compressive pain after the intervention was not significantly different from that before the intervention ($P > 0.05$). The effect of using Kinesio tape intervention on the variable of triple hop test was significant in 24 hours and 48 hours after the intervention compared to before the intervention ($P < 0.05$). Still, after 72 hours after the intervention compared to before the intervention, there was not a significant difference in increasing the average jump distance ($P = 1.0$).

Table 1. Demographic indicators of the subjects

Variable	Mean \pm SD	Minimum	Maximum
Age (y)	24.16 \pm 3.049	20	30
Height (cm)	176.06 \pm 5.599	163	188
Weight (kg)	8.424 \pm 1.59	52	90

JMR

Table 2. Statistical indices of the mean of variables in the Kinesio tape group before the intervention

Variable	VAS (cm)	AKEROM (degree)	Triple Hop (cm)	PPT (N/cm ²)
Mean	7.59	176.19	498.06	34.1206
SD	1.073	1.712	41.365	3.27334

JMR

VAS: Visual Analog Scale (cm); AKEROM: Active Knee Extension Range of Motion (degree); Triple Hop, triple hop test (cm); PPT: Pressure Pain Threshold (N/cm²).

Table 3. The therapeutic effects of Kinesio taping on the VAS and active knee extension range of motion and triple hop test and PPT after the intervention

Variable	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
VAS(cm)	2.005	43.301	35.695	< 0.001	.535	1.000
AKEROM (degree)	2.066	17.336	14.290	< 0.001	.316	.999
PPT (N/cm ²)	1.452	6.885	3.557	.050	.103	.543
Triple Hop (cm)	1.796	1375.758	7.444	.002	.194	.910

JMR

VAS: Visual Analogue Scale (Unit=cm); AKEROM: Active Knee Extension Range of Motion (Unit=degree); Triple Hop: Triple Hop Test (Unit= cm); PPT: Pressure Pain Threshold (Unit= N/cm²).

Table 4. Pairwise comparison of therapeutic effects of Kinesio taping before and after the intervention sessions on the VAS and active knee extension ROM and PPT and triple hop test

Variable	Intervention Session	Mean Difference	Std. Error	Sig.	95% Confidence Interval for the Difference	
					Lower Bound	Upper Bound
VAS (cm)	After 24 h	-1.437	0.185	<0.001	-1.958	-0.917
	After 48 h	-0.875	0.280	0.023	-1.663	-0.087
	After 72 h	0.719	0.267	0.067	-0.032	1.470
AKEROM (degree)	After 24 h	1.125	0.300	0.004	0.278	1.972
	After 48 h	0.406	0.245	0.647	-0.285	1.098
	After 72 h	-0.281	0.150	0.427	-0.705	0.143
PPT (N/cm ²)	After 24 h	0.601	0.291	0.284	-0.219	1.421
	After 48 h	0.297	0.330	1.000	-0.633	1.226
	After 72 h	-0.120	0.325	1.000	-1.037	0.797
Triple Hop (cm)	After 24 h	11.969	2.088	<0.001	6.085	17.852
	After 48 h	5.000	1.657	0.030	0.330	9.670
	After 72 h	3.094	3.670	1.000	-7.249	13.437

JMR

VAS: Visual Analog Scale (cm); AKEROM: Active Knee Extension Range of Motion (degree); Triple Hop: Triple Hop Test (cm); PPT: Pressure Pain Threshold (N/cm²).

4. Discussion

The findings of the present study, according to the evaluated variables, were as follows.

Pain intensity

In the present study, the intensity of pain based on the visual analog scale in the two periods of 24 hours and 48

hours after the Kinesio tape operation showed a significant decrease in the severity of pain before the Kinesio tape operation; however, after 72 hours, no significant difference was seen between before the intervention and 72 hours after the intervention. The results of the present study in the Kinesio tape group were similar to those obtained in the study of Z. Hazar et al. That the effect of Kinesio tape on muscle tenderness in the middle of the muscle and tenderness on MTJ and licking and creatine

kinase level and myoglobin were done to create symptoms of delayed muscle soreness from 100 jumps from a height of 60 cm and return immediately to the same height, which is a kind of eccentric exercise, were performed in 5 sets and 20 repetitions.

After this exercise, a Kinesio tape was used on the quadriceps muscle. The mentioned variables were checked before the intervention and 48 and 72 hours after the intervention [24], and another study by J. Kim et al. aimed at investigating the longer-term effect of Kinesio tape on post-exercise muscle injury symptoms, such as maximal isometric strength, muscle soreness, range of motion, and level of blood creatine kinase in three control groups, 30-min Kinesio tape, and 24-h Kinesio tape, in which the preacher curl machine was performed in 2 sets of 25 repetitions to cause delayed muscle irritation [31]. In this study, the parameter listed before the intervention, immediately after, and then 24, 48, 72 h after the intervention were measured similarly after exercise.

Range of motion

In the present study, the mean value of active knee extension range of motion 24 hours after Kinesio tape intervention showed a significant difference compared to before the intervention, and the range of motion has been improved than before the intervention. But after that, no significant changes are seen to improve the range of motion of active knee extension before the intervention. Results of the present study were similar to the results of the survey conducted by J. Kim et al. to investigate the more prolonged effect of Kinesio tape on symptoms of post-exercise muscle injury such as maximal isometric strength, muscle soreness, range of motion, blood creatine kinase levels were different in three groups: control, 30-min Kinesio tape and 24-h Kinesio tape, in which the preacher curl machine was performed in 2 sets of 25 repetitions to cause delayed muscle irritation. In the mentioned study, the range of motion in the 24-h Kinesio tape group and the 30-min Kinesio tape group were better than the control group with a more active range of motion over time. In response to this difference, the area of intervention may be affected, in which the brace biceps muscle. In the present study, the intervention on the hamstring muscle was examined.

Pressure pain threshold

In this study, there was no significant difference in PPT before and after the intervention. The results obtained in the present study on the effect of Kinesio tape on the pressure pain threshold with Ozmen study, which was

a study to investigate the effects of constant traction, proprioceptive neuromuscular facilitation, and Kinesio tape on the amount of muscle pain and flexibility. To induce delayed onset muscle soreness, Nordic exercises were used in 5 sets of 8 repetitions, and the symptoms were evaluated after 24 and 48 hours [25], which were different. Perhaps the reason for this difference could be related to the difference between the algometer used in this study and other studies in which the part that was in contact with the body in the algometer used was very annoying for the participants.

Triple hop test

In the present study, the mean distance traveled in the single-leg triple hop test in the two periods of 24 hours and 48 hours after the Kinesio tape operation showed a significant increase compared to before the Kinesio tape operation. However, after 72 hours, no significant difference was seen between before the intervention and 72 hours after the intervention.

A triple hop test was used to evaluate performance changes following delayed muscle irritation. Studies show that this test is a good criterion for assessing the strength and power of the lower extremities [32]. The present study results were different from the results of the Baştürk study that was to investigate the effects of Kinesio taping on functional performance in 18 football players that subjects performed vertical jump, standing broad tests, triple-hop test, and agility test with and without Kinesio tape [33].

Study limitations

One of the limitations of this study was the lack of long-term follow-up of treatment results. Also, we did not examine the effects of sham tape in this experiment. An experiment with a sham group may further enhance the understanding of its working mechanism. Lack of a control group was another limitation of this study and it is recommended that it be investigated in future studies. The absence of blinding can potentially trigger a bias in expectations where the expectations/beliefs of the researchers have an unconscious effect on the participants. While we attempted to design the measurements as objective and consistent as possible, there was a chance of bias in the calculation.

Study Suggestions

Similar studies should be conducted with the same number of male and female volunteers in the Kinesio tape

group. Also, adding the control group and comparing the Kinesio tape group with the control group is suggested.

5. Conclusion

According to the present study results, the Kinesio tape possibly reduced DOMS induced parameters like pain, range of motion limitations, and function, but it had no significant advantage in other DOMS-induced parameters like PPT. Exercise practitioners and athletes should consider applying the Kinesio tape before exercise or activity. Future studies can test various methods or therapeutic applications for the prevention and treatment of delayed-onset muscle soreness.

Ethical Considerations

Compliance with ethical guidelines

The study received the approval of the Ethics Committee (IR.TUMS.FNM.REC.1399.004) from Tehran University of Medical Sciences. All ethical considerations were maintained during the collection of data, and written informed consent was taken before participation.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-profit sectors.

Authors contributions

All authors contributed in preparing this article.

Conflict of interest

The authors declared no conflict of interest.

References

- [1] Cheung K, Hume PA, Maxwell L. Delayed onset muscle soreness. *Sports Medicine*. 2003; 33(2):145-64. [DOI:10.2165/00007256-200333020-00005] [PMID]
- [2] Hilbert JE, Sforzo GA, Swensen T. The effects of massage on delayed onset muscle soreness. *British Journal of Sports Medicine*. 2003; 37(1):72-5. [DOI:10.1136/bjism.37.1.72] [PMID] [PMCID]
- [3] Oakley ET, Pardeiro RB, Powell JW, Millar AL. The effects of multiple daily applications of ice to the hamstrings on biochemical measures, signs, and symptoms associated with exercise-induced muscle damage. *The Journal of Strength & Conditioning Research*. 2013; 27(10):2743-51. [DOI:10.1519/JSC.0b013e31828830df] [PMID]
- [4] Nelson N. Delayed onset muscle soreness: is massage effective?. *Journal of Bodywork and Movement Therapies*. 2013; 17(4):475-82. [DOI:10.1016/j.jbmt.2013.03.002] [PMID]
- [5] Cleak MJ, Eston RG. Delayed onset muscle soreness: mechanisms and management. *Journal of Sports Sciences*. 1992; 10(4):325-41. [DOI:10.1080/02640419208729932] [PMID]
- [6] Connolly DAJ, Sayers SP, McHugh MP. Treatment and prevention of delayed onset muscle soreness. *Journal of Strength and Conditioning Research*. 2003; 17(1):197-208. [DOI:10.1519/1533-4287(2003)0172.0.CO;2] [PMID]
- [7] Isabell WK, Durrant E, Myrer W, Anderson S. The effects of ice massage, ice massage with exercise, and exercise on the prevention and treatment of delayed onset muscle soreness. *Journal of Athletic Training*. 1992; 27(3):208-17. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1317248/pdf/jathtrain00035-0018.pdf>
- [8] Vaile J, Halson S, Gill N, Dawson B. Effect of hydrotherapy on the signs and symptoms of delayed onset muscle soreness. *European Journal of Applied Physiology*. 2008; 102(4):447-55. [DOI:10.1007/s00421-007-0605-6] [PMID]
- [9] Pineo, M., Cryotherapy and the Treatment and Prevention of Delayed Onset Muscle Soreness (DOMS).
- [10] Boguszewski D, Oko B, Adamczyk JG, Białoszewski D. Evaluation of the effectiveness of kinesiotaping in reducing delayed onset muscle soreness of the biceps brachii. *Biomedical Human Kinetics*. 2016; 8(1):88-94. [DOI:10.1515/bhk-2016-0013]
- [11] Puentedura EJ, Huijbregts PA, Celeste S, Edwards D, In A, Landers MR, et al. Immediate effects of quantified hamstring stretching: hold-relax proprioceptive neuromuscular facilitation versus static stretching. *Physical Therapy in Sport*. 2011; 12(3):122-6. [DOI:10.1016/j.ptsp.2011.02.006] [PMID]
- [12] Bicić S, Karatas N, Baltacı G. Effect of athletic taping and kinesiotaping® on measurements of functional performance in basketball players with chronic inversion ankle sprains. *International Journal of Sports Physical Therapy*. 2012; 7(2):154-66. [PMID] [PMCID]
- [13] Białoszewski D, Woźniak W, Zarek S. Clinical efficacy of kinesiology taping in reducing edema of the lower limbs in patients treated with the ilizarov method—preliminary report. *Ortopedia, Traumatologia, Rehabilitacja*. 2009; 11(1):46-54. [PMID]
- [14] Boguszewski D, Szkoda S, Adamczyk JG, Białoszewski D. Sports massage therapy on the reduction of delayed onset muscle soreness of the quadriceps femoris. *Human Movement*. 2014; 15(4):234-7. [DOI:10.1515/humo-2015-0017]
- [15] Castro-Sánchez AM, Lara-Palomo IC, Matarán-Peñarrocha GA, Fernández-Sánchez M, Sánchez-Labraca N, Arroyo-Morales M. Kinesio Taping reduces disability and pain slightly in chronic non-specific low back pain: A randomised trial. *Journal of Physiotherapy*. 2012; 58(2):89-95. [DOI:10.1016/S1836-9553(12)70088-7]
- [16] Grudzień M. [Możliwości zastosowania metody PNF i kinesiotapingu w leczeniu młodzieńczej kifozy piersiowej. *Acta Bio-Optica et Informatica Medica (Polish)*]. *Inżynieria Biomedyczna*. 2009; 15(2):106-7. <http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BSL7-0032-0025>

- [17] Wiecheć M, Szczegielniak J, Łuniewski J, Bogacz K, Krajczyk M, Banik D, et al. Evaluation of the changes of some motor features in swimmers after using Kinesiology Taping. *Polish Journal of Sports Medicine*. 2009; 25(4):237-46. <https://journals.indexcopernicus.com/search/article?articleId=19747>
- [18] Arjang N, Mohsenifar H, Amiri A, Dadgoo M, Rasaeifar G. The immediate effects of static versus proprioceptive neuromuscular facilitation stretching with kinesiology taping on hamstring flexibility in teenage taekwondo players. *Journal of Clinical Physiotherapy Research*. 2018; 3(4):132-8. <https://journals.sbm.ac.ir/physiotherapy/article/view/23941>
- [19] Feland JB, Myrer JW, Merrill RM. Acute changes in hamstring flexibility: PNF versus static stretch in senior athletes. *Physical Therapy in Sport*. 2001; 2(4):186-93. [DOI:10.1054/ptsp.2001.0076]
- [20] Kawczyński A, Mroczek D, Chmura P, Madeleine P, Chmura J. Influence of a professional football game on delayed onset muscle soreness development in dominant and non-dominant legs. *Medycyna Sportowa*. 2013; 29(1):55-61. [DOI: 10.5604/1232406X.1046810]
- [21] Khamwong P, Pirunsan U, Paungmali A. A prophylactic effect of Proprioceptive Neuromuscular Facilitation (PNF) stretching on symptoms of muscle damage induced by eccentric exercise of the wrist extensors. *Journal of Bodywork and Movement Therapies*. 2011; 15(4):507-16. [DOI:10.1016/j.jbmt.2010.07.006] [PMID]
- [22] Ostiak W, Peretiatkowicz A, Krystkowiak I. The effectiveness of kinesiotaping in treatment of the soft tissue injuries in adolescent football players. *Postępy Nauk Medycznych*. 2012; 25(6):501-7. <https://www.cabdirect.org/cabdirect/abstract/20123300993>
- [23] Gulick DT, Kimura IF, Sitler M, Paolone A, Kelly IV JD. Various treatment techniques on signs and symptoms of delayed onset muscle soreness. *Journal of Athletic Training*. 1996; 31(2):145-52. [PMCID] [PMID]
- [24] Hazar Z, Çitaker S, Demirtaş CY, Bukan NÇ, Kafa N, Çelik B. Effects of kinesiology taping on delayed onset muscle soreness: A randomized controlled pilot study. *Journal of Exercise Therapy and Rehabilitation*. 2014; 1(2):49-54. <http://www.jetr.org.tr/2014/zeynep-hazar.pdf>
- [25] Ozmen T, Gunes GY, Dogan H, Ucar I, Willems M. The effect of kinesio taping versus stretching techniques on muscle soreness, and flexibility during recovery from nordic hamstring exercise. *Journal of Bodywork and Movement Therapies*. 2017; 21(1):41-7. [DOI:10.1016/j.jbmt.2016.04.001] [PMID]
- [26] Mendiguchia J, Arcos AL, Garrues MA, Myer GD, Yanci J, Idoate F. The use of MRI to evaluate posterior thigh muscle activity and damage during Nordic hamstring exercise. *The Journal of Strength & Conditioning Research*. 2013; 27(12):3426-35. [DOI:10.1519/JSC.0b013e31828fd3e7] [PMID]
- [27] Bijur PE, Silver W, Gallagher EJ. Reliability of the visual analog scale for measurement of acute pain. *Academic Emergency Medicine*. 2001; 8(12):1153-7. [DOI:10.1111/j.1553-2712.2001.tb01132.x] [PMID]
- [28] Fischer AA. Pressure algometry over normal muscles. Standard values, validity and reproducibility of pressure threshold. *Pain*. 1987; 30(1):115-26. [DOI:10.1016/0304-3959(87)90089-3]
- [29] Kase K. Clinical therapeutic applications of the Kinesio taping methods. Albuquerque: Kinesio Taping Association. 2003. https://books.google.ro/books/about/Clinical_Therapeutic_Applications_of_the.html?id=uiX5PgAACAAJ&redir_esc=y
- [30] Bravi R, Cohen EJ, Quarta E, Martinelli A, Minciocchi D. Effect of direction and tension of kinesio taping application on sensorimotor coordination. *International Journal of Sports Medicine*. 2016; 37(11):909-14. [DOI:10.1055/s-0042-109777] [PMID]
- [31] Kim J, Kim S, Lee J. Longer application of kinesio taping would be beneficial for exercise-induced muscle damage. *Journal of Exercise Rehabilitation*. 2016; 12(5):456-62. [DOI:10.12965/jer.1632702.351] [PMID] [PMCID]
- [32] Hamilton RT, Shultz SJ, Schmitz RJ, Perrin DH. Triple-hop distance as a valid predictor of lower limb strength and power. *Journal of Athletic Training*. 2008; 43(2):144-51. [DOI:10.4085/1062-6050-43.2.144] [PMID] [PMCID]
- [33] Baştürk D, Gökdemir K, Kaya M, Üntüvar BS, Taşkın H, Erkmen N. Effect of kinesio taping on functional performance in football players. *Sport Scientific and Practical Aspects*. 2015; 12(2):39-44. <http://sportspa.ftos.untz.ba/images/dec2015/Article-06-dec-2015.pdf>