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Acute effect of inhibitory kinesio tape on range of motion, dynamic balance, and gait in athletes with hamstring shortness

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ABSTRACT

Objective: The goal of the present study was to investigate the acute effects of kinesio tape on range of motion (ROM), perceived stiffness, and kinetic parameters in athletes with hamstring shortness.
Methods: Fifteen athletes with bilateral hamstring shortness were divided randomly into intervention (inhibitory application of kinesio tape plus static stretching) and control (static stretching) groups. Outcome measures were straight leg raise (SLR), active knee extension (AKE) tests for ROM, visual analogue scale (VAS) for perceived stiffness and kinetic parameters which are recorded and calculated by Moticon SCIENCE insoles during four functional performance task of single leg stance (SLS), slow and fast walking and running.
Results: ROM, stiffness, and kinetic parameters examined with insoles during SLS and walking tasks changed in both the intervention and control groups ($P < 0.05$). Furthermore, study groups were different in some variables. The increase in ROM in SLR test and the decrease in perceived stiffness in the intervention group were more evident than in the control group ($P = 0.03$ and $P = 0.001$, respectively). There was no difference between the intervention and control groups for the variables in SLS test, slow and fast walking, and running tasks, except for the mean swing duration (MSWD) ($P = 0.002$) in fast walking.
Conclusion: The static stretching alone and the kinesio tape plus static stretching could change many of the kinetic parameters during walking and balance tasks, but the rate of these changes were more significant with kinesio tape plus stretching compared to the stretching alone.

1. Introduction

Muscle flexibility is a vital component of the muscle function. Decreased flexibility is commonly seen in two-jointed, fast twitch muscles, leading to muscle strain and overuse injuries. Maintaining normal muscle length is important to prevent muscle stiffness, increase physical performance, and reduce the risk of injury. Hamstring muscles are one of the most common two-jointed muscles, which are injured. Hamstring shortness increases the risk of hamstring strain especially following eccentric training and subsequently decreased athletic performance, as well as back pain, and patellofemoral pain syndrome [1]. Also, increasing the shortness of the hamstring induces long-term loading on the forefoot, and through the windlass mechanism causes plantar fasciitis [2].

Since the foot is generally the only part of the body that comes in contact with the ground, little information is needed about the kinetics and dynamics of the foot in many areas of research. Therefore, quantification of the forces at the foot region is a valuable method for analyzing the movement of the human body. Force plates or pressure mats, and wearable sensors such as insoles and socks are two devices for measuring this information [3]. In this regard, the force plate is a Gold-Standard and accurate method for analyzing gait. However, this method is usually limited to laboratory environments and also the number of force plates limits the number of steps to be taken. Conversely, insoles with sensors provide a practical result for data collection, both in the laboratory and outdoors, with almost no restrictions on their use and have high efficiency, flexibility, and mobility [3]. Moticon SCIENCE insoles, a new wearable tool for measuring foot pressure distribution, can be used in this regard [3].

There are currently several ways to increase range of motion (ROM) that are supported by articles. The most common methods include stretching, heat therapy, and massage. Stretching over time may increase elasticity or muscle length and reduce pain. Therefore, it will help prevent injury and rehabilitation after injury [1,4].

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On the other hand, the use of kinesio tape has been increased since its introduction in 1995 in the United States, and is commonly seen in professional sports competitions. Kinesio tape lifts the skin, causes convolution, and also increases fluid exchange between layers of the tissue. It supports the following effects: improving circulatory system function, reducing edema, pain and fatigue, and increasing ROM and sensory awareness [4]. Limited studies have been conducted to evaluate its benefits, and the present results are inconsistent. Further studies are needed to determine the benefits of kinesio tape for its various effects and its role for recovering injured muscles. Akbas et al. stated that hamstring extensibility significantly increases after the use of Kinesio tape compared to conventional exercises in patients with patellofemoral pain syndrome. As well as, Lemos et al. showed that the use of kinesio tape increased the angle of hip flexion in healthy individuals, and Lee et al. Showed that the use of kinesio tape increased the anterior pelvic tilt on both sides in healthy individuals. These studies only measured the effect of kinesio tape on a joint [5].

Due to the limitations of the biomechanical studies on the effectiveness of kinesio tape on the hamstring muscles shortness, the present study by using Moticon SCIENCE insoles, which are valid, reliable and applicable tools in sports environments, considered the effects of two types of treatment protocols (static stretching (control group) and kinesio tape in addition to static stretching (intervention group) in athletes with hamstring shortness.

2. Material and methods

The study was conducted at the Biomechanics Research Laboratory of the School of Rehabilitation, Tehran University of Medical Sciences (TUMS) and approved by Ethics Committee of TUMS and Iranian Registry of Clinical Trials (IRCT20130121012210N7). The sampling method was simple non-probability sampling.

2.1. Participants

Fifteen female athletes (age = 29.53 ± 3.40 years, Weight = 60.87 ± 8.14 kg, Height =165.20 ± 4.41 cm, and BMI = 22.28 ± 2.66 kg/m^2) with hamstring shortness were tested for the study. Before starting the procedure, the participants were briefed on the study protocol (the duration of each session, the type of evaluation and intervention, and its harmlessness). Then they completed and signed the informed consent form and a personal information and demographic questionnaire.The inclusion criteria included the following: 1) non-professional aerobic athletes aged 18–32 who exercised three times a week for at least two hours each time at the gym, 2) no history of previous hamstring injuries, 3) bilateral hamstring muscles shortness, so the popliteal angle of -30° and higher in the active knee extension (AKE) test, and straight leg raise (SLR) were less than 90°. The exclusion criteria were as follows:1) history of lumbar and neurological symptoms, 2) history of musculoskeletal disorders of the lower extremities during the last 12 months, 3) medical conditions that may alter muscle flexibility, and 4) skin sensitivity to kinesio tape.

2.2. Assessments

Participants underwent a session of evaluation and intervention, after being randomly divided into two intervention and control groups. The assessment time for each participant was before the daily exercises. Participants underwent initial assessments in terms of SLR, AKE, perceived stiffness, and functional performance tasks.

2.2.1. SLR

the participant was asked to lie supine and slowly lift one leg while the other leg was on the bed. The participant was asked to keep her knee straight and to raise his leg as high as possible. The tester was standing next to the bed and placed the goniometer axis on the greater trochanter, the fixed arm parallel to the trunk and the movable arm along the lateral side of the femur and recorded the hip flexion angle [6].

2.2.2. AKE

the participant was in a 90–90 position (the hip and knee at a 90-degree angle). The participant was then asked to extend her knee as much as possible without moving the hip joint. The axis of the goniometer was placed on the lateral condyle of the femur, and its two arms were placed parallel to the femur and leg. When the participant straightened her knee, the movable arm was moved along with the lateral edge of the fibula to the lateral malleolus and the angle was recorded. It should be noted that two belts were used over the ASIS and the tibia tuberosity to stabilize the participant during this test [7].

2.2.3. Perceived stiffness

Visual Analogue Scale (VAS) was taken subjectively from zero (no stiffness) to 10 (maximum stiffness) to measure perceived stiffness. The scale was shown to participants and they were asked how much stiffness they felt in their hamstring muscles during SLR test [4].

2.2.4. Functional performance tasks

participants were asked to wear their running shoes of their appropriate size (the Sketch-knit shoe of the Sketchers brand), while they removed the sole of their shoe and placed the Moticon SCIENCE insoles inside them. The functional performance tasks included: 1) slow walking, 2) fast walking, 3) running on the 15-meter walk way, and 4) 20 s of single leg stance (SLS) on each foot [3]. In the slow and fast walking and also running tasks, the speed was chosen by the individuals and they were not given any feedback to adjust the speed.

Mean length of gait line (MLGL), mean width of gait line (MWGL), mean x start point of gait line (MXSPGL), mean y start point of gait line (MYSPGL), mean x end point of gait line (MXEPGL), mean x end point of gait line (MYEPGL), mean total force of stance phase (MTFSP), Max total force of stance phase (MaxTFSP), mean double support duration (MDSD), mean stance duration (MSTD), and mean swing duration (MSWD) were reported in the slow and fast walking tasks. In the 15-meter running task, mean total force (Mean TF), Max total force (Max TF), and mean swing duration (MSWD) were reported. Eight variables were also reported for the SLS task, including the following: mean of center of pressure displacement in anteroposterior direction (MCOPAP), mean of center of pressure displacement in mediolateral direction (MCOPML), standard deviation of pressure displacement in anteroposterior direction (SDCOPAP), standard deviation of pressure displacement in mediolateral direction (SDCOPML), bounding box of center of pressure displacement in anteroposterior direction (BBCOPAP), bounding box of center of pressure displacement in mediolateral direction (BBCOPML), mean of center of pressure velocity (MCOPV), and COP trace length (COPTL) [3].

The measurements were performed three times and the mean was recorded for higher repeatability.

2.3. Intervention

A kinesiology tape (Tmax, South Korea) administered by a certified therapist. One leg of the participants was in the intervention group (kinesio tape and static stretching) and the other leg was in the control group (static stretching). The selection of the leg on which the intervention was initially performed, as well as the test group (intervention or control), was random and using coins.

In the control group, the resistance barrier was found by the AKE, and the hamstring stretching was kept in the same position for 30 s, with a 10-second interval between each stretch and this procedure was repeated three times.

In the intervention group (kinesio tape and static stretching), participants were asked to clean the hamstring area for adhesion of the kinesio tape. Kinesio tape was applied from insertion to the origin with

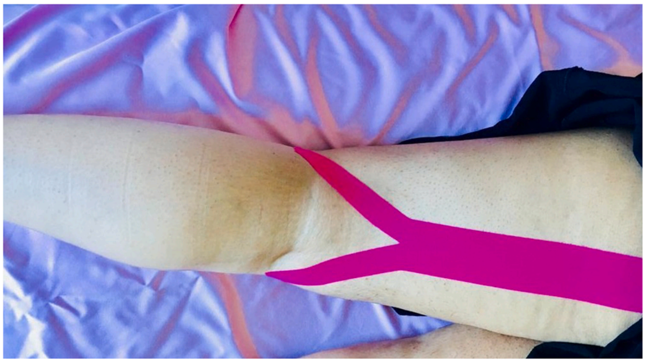

Fig. 1. Inhibitory Kinesio tape technique for hamstring muscles.

15–25% tension. Participants lied in a prone position with the knee extended and the hip in a flexed position to stretch the hamstring muscle group. The kinesio tape was cut in a Y-shape with two tails, starting at the bottom of the popliteal fossa and passing through the knee joint and ending at the gluteal fold. No tension was applied to the tails and the end (Fig. 1) [4]. After applying kinesio tape in this group, participants stretched their hamstring muscle as same as the control group (30 s stretching for three times with a 10 s intervals). After 30 min, re- assessments were done in both groups.

2.4. Statistical analysis

The data for the insoles were collected using the Moticon software and then the study variables was calculated using the same software. SPSS software version 19 was used for data analysis. First, the Kolmogorov-Smirnov test was performed to investigate the normal distribution of variables. Paired t-test was used to compare the pre- and post- values in each group (intervention group, control group). To compare the two groups, the mean differences of the pre- and post- values in each group were compared using Independent samples t-test. Alpha level was set at 0.05 in all of the statistical tests.

3. Results

The K-S statistical test was used to evaluate the distribution of numerical variables in terms of compliance with normal distribution and it showed that all the variables in the study followed the normal distribution ($P > 0.05$).

According to Table 1, the values of SLR, AKE, and VAS had changed in both the control and intervention groups ($P = 0.00$). MCOP has changed in the intervention and control groups ($P = 0.00$, $P = 0.01$, respectively). There were difference between pre- and post- values of MCOP and SDCOPML in the control group during SLS test ($P = 0.01$, $P = 0.00$, respectively).

In slow walking, the pre- and post- values MLGL (intervention: $P = 0.02$, control: $P = 0.03$), MYSPGL (intervention and control: $P = 0.04$), MYEPGL (intervention: $P = 0.01$, control: $P = 0.03$), MDS (intervention: $P = 0.04$), and MSTD (control: $P = 0.00$) had changed (Table 2).

In fast walking, MYSPGL (intervention and control: $P = 0.01$), MYEPGL (intervention: $P = 0.00$, control: $P = 0.02$), MSTD (intervention and control: $P = 0.00$), and MSWD (control: $P = 0.00$) had changed (Table 2).

There was no difference between the pre- and post- values of the studied variables during running in each of the groups (Table 3).

On the other hand, the two groups were different in some cases. The increase in ROM in SLR test and the decrease in perceived stiffness in the intervention group (kinesio tape and stretching) were more evident than in the control group (static stretching alone) ($P = 0.03$ and $P = 0.001$, respectively). There was no difference between the intervention and control groups for the variables in slow and fast walking, and running tasks, except for the MSWD ($P = 0.002$) in fast walking.

In summary, the combined use of kinesio tape and stretching changed many of the parameters which are reported in the tables.

Table 1
Before- after values of range of motion (ROM), and center of pressure (COP)- related variables in single leg stance (SLS), both in the intervention and control groups and the comparison of the mean differences by independent t- test (n = 15).

Variables	Group	Mean ± SD		t (Sig.)	Mean difference t (Sig.)
		Before	After		
SLR (degree)	**Intervention**	82.39 ± 2.26	85.49 ± 2.63	8.70 (0.00 *)	1.29 ± 2.00
	Control	82.47 ± 2.68	84.38 ± 3.21	5.80 (0.00 *)	2.40 (0.03 *)
AKE (degree)	**Intervention**	-33.7 ± 2.57	-30.07 ± 3.59	8.70 (0.00 *)	1.20 ± 2.28
	Control	-33.71 ± 2.36	-31.20 ± 2.00	8.64 (0.00 *)	2.04 (0.06)
VAS	**Intervention**	5.82 ± 1.24	4.36 ± 1.26	-16.14 (0.00 *)	-0.51 ± 0.49
	Control	5.89 ± 1.42	4.93 ± 1.56	-10.47 (0.00 *)	-4.07 (0.00 *)
SLS Test					
MCOPAP (mm)	**Intervention**	-39.39 ± 8.48	-47.59 ± 7.29	-3.56 (0.00 *)	-2.40 ± 10.88
	Control	-39.78 ± 9.05	-45.58 ± 6.86	-2.78 (0.01 *)	-0.86 (0.41)
MCOPML (mm)	**Intervention**	-6.30 ± 1.20	-5.89 ± 1.15	1.16 (0.26)	-0.70 ± 1.82
	Control	-6.68 ± 1.09	-5.56 ± 1.47	2.91 (0.01 *)	-1.49 (0.16)
SDCOPAP (mm)	**Intervention**	8.87 ± 2.39	7.99 ± 2.48	-1.18 (0.26)	-1.04 ± 4.23
	Control	8.04 ± 1.57	8.20 ± 2.78	0.22 (0.83)	- 0.95 (0.36)
SDCOPML (mm)	**Intervention**	2.64 ± 0.58	2.04 ± 1.22	-1.74 (0.10)	0.29 ± 1.56
	Control	2.69 ± 0.61	1.80 ± 0.92	-3.49 (0.00 *)	0.71 (0.49)
BBCOPAP (mm)	**Intervention**	45.02 ± 12.26	51.38 ± 28.24	1.04 (032)	3.30 ± 29.58
	Control	44.06 ± 11.09	47.12 ± 16.78	0.77 (0.45)	0.43 (0.67)
BBCOPML (mm)	**Intervention**	12.78 ± 2.12	11.03 ± 6.70	-1.01 (0.33)	1.09 ± 7.91
	Control	13.14 ± 2.73	10.30 ± 4.94	-2.11 (0.5)	0.53 (0.60)
MCOPV (mm/s)	**Intervention**	31.82 ± 12.09	37.62 ± 27.91	1.38 (0.61)	5.09 ± 16.91
	Control	29.87 ± 8.32	30.57 ± 8.96	0.52 (0.61)	1.17 (0.26)
COPTL (mm)	**Intervention**	0.69 ± 0.35	0.85 ± 0.80	1.43 (0.17)	0.05 ± 0.47
	Control	0.62 ± 0.12	0.74 ± 0.24	2.07 (0.06)	0.43 (0.67)

Abbreviations: SLR: straight leg raise, AKE: active knee extension, MCOPAP: mean of center of pressure displacement in anteroposterior direction, MCOPML: mean of center of pressure displacement in mediolateral direction, SDCOPAP: standard deviation of pressure displacement in anteroposterior direction, SDCOPML: standard deviation of pressure displacement in mediolateral direction, BBCOPAP: bounding box of center of pressure displacement in anteroposterior direction, BBCOPML: bounding box of center of pressure displacement in mediolateral direction, MCOPV: mean of center of pressure velocity, and COPTL: COP trace length.

Table 2
Before- after values of the studied variables during slow and fast walking tasks, both in the intervention and control groups and the comparison of the mean differences by independent t- test (n = 15).

Variables	Group	Mean ± SD		t (Sig.)	Mean difference t (Sig.)
		Before	After		
Slow Walking					
MLGL (mm)	**Intervention**	110.84 ± 17.67	125.83 ± 12.35	2.70 (0.02 *)	2.33 ± 29.77
	Control	111.39 ± 24.67	124.04 ± 21.43	2.38 (0.03 *)	0.30 (0.77)
MWGL (mm)	**Intervention**	5.87 ± 1.30	5.77 ± 1.50	-0.02 (0.98)	-0.18 ± 2.45
	Control	6.39 ± 2.42	6.19 ± 2.19	-0.41 (0.68)	0.29 (0.77)
MXSPGL (mm)	**Intervention**	-4.18 ± 1.35	-4.29 ± 0.99	-0.37 (0.72)	-0.41 ± 1.42
	Control	-4.38 ± 1.30	-4.08 ± 1.00	1.04 (0.32)	-1.13 (0.28)
MYSPGL (mm)	**Intervention**	-75.02 ± 10.21	-82.47 ± 6.22	-2.29 (0.04 *)	-1.23 ± 15.01
	Control	-73.56 ± 18.40	79.78 ± 16.28	-2.33 (0.04 *)	-0.32 (0.75)
MXEPGL (mm)	**Intervention**	-2.69 ± 2.19	-2.96 ± 1.96	-0.54 (0.60)	-0.77 ± 3.05
	Control	-3.19 ± 2.41	-2.69 ± 2.83	0.97 (0.35)	-0.97 (0.34)
MYEPGL (mm)	**Intervention**	34.67 ± 10.71	43.02 ± 7.91	2.84 (0.01 *)	0.95 ± 16.79
	Control	33.28 ± 14.59	40.68 ± 17.02	2.42 (0.03 *)	0.22 (0.83)
MTFSP (N)	**Intervention**	902.20 ± 101.22	852.89 ± 85.53	-1.73 (0.11)	-22.63 ± 142.16
	Control	888.95 ± 15.693	862.00 ± 112.35	-0.70 (0.49)	-0.61 (0.55)
MaxTFSP (N)	**Intervention**	1305.60 ± 129.72	1361.51 ± 16.56	1.43 (0.17)	-2.71 ± 165.37
	Control	1323.22 ± 197.8	1362.31 ± 90.86	0.77 (0.45)	0.06 (0.95)
MDSD (s)	**Intervention**	0.23 ± 0.13	0.16 ± 0.04	-2.23 (0.04 *)	-0.003 ± 0.09
	Control	0.21 ± 0.11	0.15 ± 0.04	-1.72 (0.11)	-0.12 (0.91)
MSTD (s)	**Intervention**	0.71 ± 0.08	0.67 ± 0.80	-2.31 (0.05)	0.03 ± 0.08
	Control	0.71 ± 0.10	0.64 ± 0.07	-3.54 (0.00 *)	-0.12 (0.91)
MSWD (s)	**Intervention**	0.38 ± 0,06	0.38 ± 0.04	-0.32 (0.76)	0.03 ± 0.08
	Control	0.39 ± 0.07	0.38 ± 0.06	-1.21 (0.24)	1.57 (0.14)
Fast Walking					
MLGL (mm)	**Intervention**	76.27 ± 55.69	81.59 ± 37.15	0.48 (0.64)	15.77 ± 69.68
	Control	85.42 ± 58.90	75.39 ± 38.94	-0.85 (0.41)	0.88 (0.39)
MWGL (mm)	**Intervention**	4.83 ± 1.82	4.98 ± 2.33	0.43 (0.67)	0.97 ± 2.59
	Control	5.36 ± 2.48	4.55 ± 1.87	-1.24 (0.24)	1.45 (0.17)
MXSPGL (mm)	**Intervention**	-3.73 ± 1.35	-3.48 ± 0.86	0.86 (0.40)	-0.15 ± 1.17
	Control	-3.73 ± 1.28	-3.32 ± 1.05	1.68 (0.12)	-0.50 (0.62)
MYSPGL (mm)	**Intervention**	-78.15 ± 7.95	-85.90 ± 5.64	-3.05 (0.01 *)	-2.82 ± 11.05
	Control	-73.56 ± 18.40	-85.34 ± 5.18	-2.92 (0.01 *)	-0.99 (0.34)
MXEPGL (mm)	**Intervention**	-4.05 ± 2.82	-4.51 ± 2.52	-0.91 (0.38)	0.27 ± 2.60
	Control	-3.74 ± 2.84	-4.47 ± 2.12	-0.91 (0.38)	0.40 (0.69)
MYEPGL (mm)	**Intervention**	8.10 ± 18.52	43.02 ± 7.91	4.37 (0.00 *)	13.07 ± 33.66
	Control	15.19 ± 39.65	-10.19 ± 38.92	-2.75 (0.02 *)	1.50 (0.15)
MTFSP (N)	**Intervention**	973.73 ± 123.84	912.78 ± 79.58	-1.96 (0.07)	-21.62 ± 114.63
	Control	976.58 ± 165.06	937.24 ± 118.08	-1.13 (0.28)	0.73 (0.48)
MaxTFSP (N)	**Intervention**	1305.60 ± 129.72	1224.96 ± 105.72	-1.78 (0.10)	-54.71 ± 139.85
	Control	1310.22 ± 183.28	1294.29 ± 151.57	-0.34 (0.74)	-1.51(0.15)
MDSD (s)	**Intervention**	0.13 ± 0.07	0.09 ± 0.05	-1.46 (0.17)	-0.03 ± 0.16
	Control	0.13 ± 0.07	0.12 ± 0.06	-0.41 (0.69)	-0.66 (0.52)
MSTD (s)	**Intervention**	0.40 ± 0.07	0.67 ± 0.08	15.28 (0.00 *)	0.05 ± 0.09
	Control	0.41 ± 0.06	0.35 ± 0.07	-3.76 (0.00 *)	2.15 (0.05)
MSWD (s)	**Intervention**	0.43 ± 0.06	0.44 ± 0.06	0.83 (0.42)	0.07 ± 0.07
	Control	0.43 ± 0.08	0.38 ± 0.06	-3.89 (0.00 *)	3.69 (0.00 *)

Abbreviations: MLGL: mean length of gait line, MWGL: mean width of gait line, MXSPGL: mean x start point of gait line, MYSPGL: mean y start point of gait line, MXEPGL: mean x end point of gait line, MYEPGL: mean x end point of gait line, MTFSP: mean total force of stance phase, MaxTFSP: Max total force of stance phase, MDSD: mean double support duration, MSTD: mean stance duration, and MSWD: mean swing duration.

Table 3
Before- after values of the studied variables during running tasks, both in the intervention and control groups and the comparison of the mean differences by independent t- test (n = 15).

Variables	Group	Mean ± SD		t (Sig.)	Mean difference t (Sig.)
		Before	After		
Mean TF (N)	**Intervention**	120.9 09 ± 161.52	1163.82 ± 103.25	-1.17 (0.26)	31.78 ± 68.30
	Control	1230.56 ± 150.97	1153.51 ± 113.38	-2.08 (0.06)	1.80 (0.09)
Max TF (N)	**Intervention**	1794.04 ± 211.60	1743.69 ± 160.71	-0.94 (0.36)	-299.36 ± 1171.03
	Control	1804.73 ± 190.31	1730.02 ± 192.97	-1.25 (0.23)	-0.99 (0.34)
MSWD (s)	**Intervention**	0.48 ± 0.13	0.46 ± 0.03	-0.33 (0.75)	-0.01 ± 0.12
	Control	0.46 ± 0.05	0.45 ± 0.03	-0.39 (0.70)	-0.21(0.84)

Abbreviations: Mean TF: mean total force, Max TF: Max total force, and MSWD: mean swing duration.

4. Discussion

The results of the present study showed that static stretching not only affects the ROM of the knee and hip in AKE and SLR tests and perceived stiffness, it can also affect many parameters, including the Y coordinates of the starting and ending point of the gait line, the duration of the standing phase (in both slow and fast walking tasks), the mean length of the gait line (in slow walking) and the duration of the swing phase (in fast walking). However, the values examined in the running task did not change after static stretching. Also, static stretching was able to change the mean values of the COP displacement in the anteroposterior direction, and the mean and standard deviation of the COP displacement in the mediolateral in the SLS test.

Also the intervention and control groups were significantly different in some variables. The increase in ROM in the SLR test and the decrease in the perceived stiffness in the intervention group were more evident than in the control group. In slow and fast walking, both groups behave similarly except for the swing duration in fast walking. In addition, there was no significant difference between the groups in terms of the examined variables in the running and SLS tasks.

Active and passive flexibility can be measured either by stiffness (increased resistance to deformation of a muscle) or the degree of ROM in a joint due to increased length of muscle fibers and soft tissues. The flexibility of muscle groups, such as hamstrings, is manipulated by methods such as warming up and stretching. In athletes, methods such as static, ballistic, PNF and dynamic stretching are used. Static stretching is the most widely used method, because it is easier to understand and use. It causes a viscoelastic response to the muscle-tendon unit [8].

Studies about the effect of stretching on the ROM of the knee joint and hip are aligned and all indicate the effectiveness of this intervention [9,10]. But in terms of the effectiveness of stretching application in improving postural balance and stability, the findings are contradictory [11–14]. The observed differences in the articles can be related to the type of stretching used, such as static, dynamic and PNF stretching. Different age groups and different populations have been studied, such as young and elderly participants and athletes and non-athletes. The tasks examined are different, with some static and some dynamic. In the present study, young female athletes were evaluated using static stretching and in the dynamic balance task of SLS. Therefore, the result of this type of intervention cannot be generalized to other stretching interventions with different evaluation techniques in different populations.

The results of Hammonds et al. study [8] were consistent with the present study and showed the effectiveness of static stretching on kinetic variables and gait cycle duration. Our study was consistent with Allison et al. study [15], because both showed that static stretching could not affect running. Although different outcome measures during walking and running tasks were evaluated.

In general, stretching can increase the ability to tolerate increasing ROM. When applying interventions such as stretching, the frequency, number, and duration of stretching should be considered. In our study, the immediate effects of static stretching were examined after three 30-second stretch, while in some studies the stretching was applied for several weeks or months. On the other hand, warm-up itself can increase flexibility. Thus, it cannot be concluded that stretch is the only factor that increases flexibility [8]. Unlike this fact, new studies have shown that different types of stretch during warm-up may have adverse effects on physical performance [16]. Therefore, it is suggested that static stretching should not be used as part of a routine preparation program for physical activity, as it has negative effects on running performance [17]. However, contrary to the findings of these articles, in our study no adverse effects were observed after the application of static stretching.

On the other hand, taping is commonly used in sports and rehabilitation, not only for treatment but also to increase performance. Despite the recent popularity of the taping methods, there have been few studies supporting or refuting the claims of Kase and his colleagues about muscle inhibition. Due to the lack of conclusive evidence in support of the use of kinesio tape, it is important to further evaluate its effects on different muscle groups [18].

The Merino-Marban found that applying kinesio tape to the leg muscles could decrease pain in athletes that did not have obvious musculoskeletal disorders, but did not affect the extensibility of the leg muscles [19]. Ozmen et al. found that the use of kinesio tape and pre-workout stretching had no effect on flexibility in 24 and 48 h after exercise, but could reduce soreness [6]. They used facilitation technique with 30% tension. A study by Marban et al. showed that the use of X-shaped taping technique with 10% tension on the hamstring muscle could not increase the ROM of the hip joint flexion [20]. The results of another study showed that the use of inhibitory kinesio tape on the hamstring muscle failed to increase the flexibility of this muscle in the Sit-N-Reach test. It has been suggested that measurements should be performed one week later instead of 24 h later [21]. In the mentioned study, three techniques of facilitatory, inhibitory and no type were used on the biceps femoris muscle. In a study comparing the three methods of static stretching, PNF and kinesio tape to influence hamstring flexibility, there was no difference between static stretching and PNF stretching, and the use of facilitation technique of kinesio tape did not increase flexibility [22]. So far, the results of these studies have shown that kinesio tape cannot affect pain, flexibility, ROM. But unlike the above articles, the following articles emphasized the effectiveness of kinesio tape application.

In 2014, Çinar Medeni et.al showed the use of the muscle technique of kinesio tape both increases flexibility and reduces pain during stretching in acute conditions. Therefore, it can be used by physiotherapists in people with hamstring shortness to achieve an immediate effect [1]. Chen et al. showed that stretching protocols could improve the flexibility of hamstrings, but after exercise, the maximum hamstring torque decreased in the static and PNF stretching group, but did not change in the taping and static stretching group. This means that static stretching and taping can prevent the negative effects of exercise, which in turn may prevent injury [23]. In a study, German examined the inhibitory effect of kinesio tape on hamstring muscles, and found that over time, all participants [24] had improved popliteal and SLR angles. It should be noted that between the 8th and 12th days, there was a greater improvement in SLR (the tape was renewed every two days) [4]. The results of a study by Choi et al. showed that all three methods of taping, stretching, and joint exercises could be effective in increasing flexibility and ROM [25]. Taping was applied on vastus lateralis, biceps femoris, gastrocnemius, and the medial malleolus. Espejo-Atunez et al. evaluated the effect of kinesio tape and electrical stimulation (Electrical Muscle Elongation) on amateur athletes with hamstring shortness. Both methods had an acceptable improvement over the control group. Clinically, recovery was better in electrical stimulation, but statistically there was no significant difference between the use of kinesio tape and EMS [26]. Seung-Woong Lee and Juns-Hoon Lee studied the effects of PNF stretching and modified anterior pelvic tilt taping (APTT) on extending both knees from a sitting position. The results of this study showed that most direct interventions such as PNF stretching are effective. However, this taping technique can also be used to reduce pelvic movements following hamstring shortening [27]. Zulfikri et.al conducted a study to determine the effect of kinesio tape on controlling fatigue and maintaining dynamic balance. Adapted Functional Agility Short Term Fatigue Protocol (fast-FP) was used to relieve fatigue in male recreational players. The kinesio tape was applied to rectus femoris muscle, biceps femoris, and medial gastrocnemius of the dominant leg. It has been suggested that fatigue has a reducing effect on dynamic balance. The use of the kinesio tape inhibits the effects of fatigue and the amount of SEBT retained in the lateral and posterior directions [28]. Rebolledo et al. analyzed the short-term effects of kinesio tape on height and GRF during vertical jump, as well as the delay and recruitment of the trunk and limb muscles during vertical jump. The findings suggest that kinesio tape may improve neuromuscular and kinetic function during jumping only 72 h after the application of kinesio tape on healthy, non-injured athletes [29].

In summary, the results of the above seven studies were consistent with our study, all of them showed the positive effects of kinesio tape on stiffness, ROM, flexibility, and neuromuscular function. What is clear from all the studies is that, firstly, little is known about the effectiveness of kinesio tape on the kinetics of the lower limbs while walking and balance, and secondly, different muscle groups are taped and most importantly the technique used, the kinesio tape cut, the percentage of tension, and the time of application do not follow a specific method, as the different facilitatory or inhibitory techniques with variable percentages of tension have been used, which are the factors which can lead to conflicting study results.

On the other hand, the benefits of kinesio taping are influenced by a number of eccentric factors, including the environment, the nature of the injury, population, sport demands, physiological, psychological and biomechanical characteristics, as well as the therapist's experience. Effectiveness is considered in terms of how the technique is performed, duration, intensity, and repeatability of the application [24]. It is possible for certain muscles to react differently to the use of kinesio tape, so the results of application on one muscle and one particular technique cannot be generalized to all muscles and techniques [30]. Also, the effectiveness of kinesio tape on flexibility may be greater in individuals with muscle shortness [20].

Although the results of the present study showed that static stretching can change many of the neuromuscular parameters, it can be more effective when combined with kinesio tape intervention. Mechanisms involved in the effectiveness of these interventions vary, including increased tolerance and blood flow, stimulation of cutaneous mechanoreceptors, and postsynaptic inhibition in the motor neuron pool and finally placebo, which is due to psychosomatic mechanisms, should not be overlooked [18].

Our limitation was that the study procedure was too long, so it could be tedious for the participants. On- field evaluation with considering both gender of participants, and medium and long term effects of kinesio taping are suggested future studies.

5. Conclusion

Both static stretching and kinesio tape plus stretching interventions can change many of the parameters examined with insoles during walking and balance tasks, but the rate of these changes were more dramatic in the intervention group (kinesio tape plus stretching) compared to the control group (stretching alone). The results of this study can be generalized to a larger community according to the age and gender of the participants, the degree of hamstring shortness, the type and duration of stretching, and the technique of applying kinesio tape.

5.1. Implications for physiotherapy practice

It is recommended that the Moticon SCIENCE system and its sensors be used to examine for other lower limb injuries, foot deformities, and abnormalities, as well as to determine the effects of rehabilitation interventions. It is recommended that before and after the competition season, athletes from different disciplines be evaluated with the Moticon SCIENCE system and its sensors, and the rate of sports injuries in the lower limbs and their relationship to the examined kinetic indicators be calculated.

Conflict of interest

None.

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