Research Article

The Effect of Kinesio Taping on Lumbar Kinematic After Static Lumbar Flexion in Healthy Subjects

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ABSTRACT

Introduction: The application of Kinesio taping (KT) is a rehabilitation technique used to provide muscle and joint support and stability, without limiting the range of motion (ROM). No study evaluated the effects of KT on lumbar flexion relaxation phenomenon and kinematic details after static flexion. This study aims to find out the results of KT on erector spinae (ES) muscle activity, flexion relaxation pattern, and trunk, lumbar, and hip range of motion in healthy subjects during static flexion.

Materials and Methods: This study used a two-factor within-group design. Twenty-two healthy female students participated in this study. We used surface electromyography (EMG) to assess ES muscle activity and measured kinematic information with data from the camera. Variables related to muscle activity and angles in forward bending movement before and after creep were investigated. The test was performed in two situations with and without the use of KT.

Results: KT reduced the time of muscle activity during bending. Also, KT increased trunk, and hip angles at the end of forward flexion. In the lumbar extension phase, the ES muscles were activated later.

Conclusion: KT can prevent the increase of lumbar spine flexion angle due to the creep effect. It can be used to protect the strained viscoelastic structures and increase the involvement of cutaneous receptors. KT can act as a protector in the dynamic stabilization system of lumbar joints in flexion positions in healthy people.

Keywords:

Athletic tape; Lumbar vertebrae; Electromyography; Biomechanical phenomena

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Introduction

The lumbar flexion movement is controlled by the eccentric contraction of the erector spinae (ES), hamstrings, and hip extensors muscles [1]. Also, posterior ligaments and capsules passively stretching play a role in controlling trunk flexion. During trunk flexion and extension motions, load sharing between the lower back active elements (muscles) and the passive viscoelastic elements (ligaments, tendons, intervertebral discs, etc.) has been explicitly reported [2]. Decreasing or turning off the activity of the lumbar ES muscles in the last 20%-30% of the full flexion range of motion (ROM) is called the flexion-relaxation phenomenon (FRP) [3]. In the fully flexed position, passive elements support the body weight by generating a passive extensor moment [4, 5]. Lumbar FRP has rarely been observed in low back pain (LBP) patients [6, 7].

The absence of FRP in the LBP patients can result in an alternation of motor control strategy to increase lumbar stabilization [7, 8]. When a constant load is applied to passive tissues, due to the high proportion of viscoelastic components, they deform at a low speed, first elongating to a certain length, and if the load continues over time, it gradually continues to lengthen until it reaches its maximum value. This elongation over time is called a creep [5]. Creep occurs in the passive tissues of the lumbar spine following prolonged static lumbar flexion. Creep deformation in lumbar passive tissues (ligaments, intervertebral discs, joint capsule, etc.) increases the intervertebral joint's laxity, reduces resistance to the moment of flexion, allows the increased relative motion, and destabilizes their natural alignment with the increased potential for consequent injury and pain [5, 9, 10].

In spinal stability studies, the response of the ES muscle to creep is one of the interesting models. Solomonow et al. studied the effects of 10-minute static lumbar full flexion on FRP in a seated position on a mat. By comparing the pre-creep and post-creep responses, similar FRP responses were observed in men and women. These results showed that the capacity to produce extensor torque in passive tissues following creep decreases and causes the extensor muscle to remain active for a longer time in the forward bending motion. It has shown that the changes following the creep in women are more than in men [11].

Long-term FRP reduces the stability of the lumbar spine and may increase the risk of low back injuries. Rogers and Granata's study recognized that the paraspinal muscle reflexes are controlled by receptors in the spinal ligaments. These authors hypothesized that spinal reflexes decreased by loosening of lumbar passive tissues during prolonged trunk flexion activities, thus decreasing the sensitivity of the mechanoreceptors and causing errors in the neuromuscular reflexes [12].

In summary, the changes in FRP with prolonged trunk flexion revealed laxity in the passive tissues that can be a significant indication of spinal instability and increased risk of spinal buckling [11].

Kinesio taping (KT) is a rehabilitation technique used to support and stabilize muscles and joints to restore the body mechanism without much restriction of the ROM [13]. KT is a relatively new, convenient, and interesting method used to treat musculoskeletal diseases. KT is a thin and elastic adhesive tape. This strip can be stretched up to 40% of its length [14].

KT can also improve blood and lymphatic drainage, reduce pain, realign joints, reduce muscle tension, increase ROM, and improve functionality. Additionally, it can change the muscle fiber's activation pattern. The use of KT seems to prevent the overuse of the paravertebral muscles in response to pain, breaking this vicious pain-muscle guard activation cycle [15].

Paoloni et al. studied the effects of KT on lumbar muscle activities in chronic LBP patients and stated that KT can decrease pain immediately and alter the lumbar muscle activation pattern [16]. Castro-Sanchez et al. conducted a randomized clinical trial and demonstrated the effects of KT on decreasing pain and disability of chronic non-specific LBP patients [17]. Yoshida et al. studied the effects of KT on the ROM of the lumbar spine of healthy subjects. The ROM of flexion and lateral flexion extension were investigated in two states with and without the use of KT. The results showed that the use of KT increased the ROM of trunk flexion [15].

Up to now, we do not have strong evidence to approve the effects of KT on the FRP and kinematic details during forwarding bending before and after static flexion in healthy subjects. Understanding whether KT can affect the trunk, lumbar, and hip angles in full forward flexion before and after the creep phenomenon and how the ES muscles activation pattern was influenced by these changes can help assess the KT efficiency and creep phenomenon disadvantages and choose a preventive strategy for LBP. This study was conducted to investigate the effects of KT on FRP and trunk, lumbar, and hip angles after 10 minutes of static flexion in healthy subjects.

Materials and Methods

Study design

Study participants

This study used a two-factor within-group design. According to a previous study, the sample size was calculated to be 15 people [15]. Considering dropout samples, 22 subjects were studied. The inclusion criteria included accessible and volunteer women aged 18-30 years to neutralize the effect of gender as a confounding factor. The exclusion criteria included people with a history of problems in the trunk or back, inflammation of the spine, spondylolisthesis, collagenosous, osteoarthritis, osteoporosis, neuromuscular disease, spine surgery, tumor, musculoskeletal injuries of the lower limbs, infection, high blood pressure, radiculopathy, myelopathy, progressive neurological deficit, and lumbar disc herniation [11]. All participants completed the procedures.

Study instruments

An 8-channel surface electromyography (EMG) device (CT8MIE Medical 5 Research Ltd.UK) was used to record the electromyographic activity of ES muscles. The EMG signals were recorded by pre-gelled silver-silver chloride (AG/AGCl) surface electrodes applied at the L3-4 level over the left and right erector spinae muscles (about 4 cm lateral to the midline) [18]. Center-to-center electrode spacing was 2.5 cm. The electrodes were longitudinally oriented along the fibers of the ES muscle. The reference electrode was placed on the right iliac crest [19].

The characteristics of the EMG device to record EMG signals were sampling frequency: 1 000 Hz, gain: 100 mV/div, high pass filter: 500 Hz, low pass filter: 20 Hz, CMRR: 90 dB. The maximum acceptable skin impedance level was set at 5 kU. The data was digitally stored on a 12-bit A/D board. Before the signal accumulation, excess hair on the back was shaved and the area was cleaned with alcohol pads.

A digital camera (JVC-gz-mg50as) was placed at a distance of 1 m from the subjects at the iliac level. The camera collected biomechanics information at the rate of 30 frames per second in the sagittal plane. The markers used to measure the segment angles are attached to the subjects as follows, three square markers were attached to the right greater trochanter, lateral midline along the iliac crest, and the lower palpable edge of the rib cage [11]. Video and EMG data were synchronized by an electrical circuit, which triggered them at the same time.

Study protocol

All the study procedure was explained to the participants and they voluntarily signed the informed consent and were included in the study. Before the experimental task, the researcher examined their posture, spinal alignment, and ROM to make sure that they were healthy subjects. Then the participants were asked to perform the trunk flexion-extension task and were given verbal instructions and practice trials. The subjects stood in an upright position with arms crossed over their chests. Then they were instructed to bend forward as far as possible during a 3-s movement period (flexion phase). Next, they were required to hold the fully flexed position for 3-s and then return to the initial upright position (extension phase). The extension phase lasted 3 s. The speed and the duration of all movement phases were standardized by a metronome. Each participant completed three flexion-extension cycles, followed by static standing to the end of the recording. Finally, one of the trials was chosen depending on the signal quality of the data analysis [19].

Application of static lumbar flexion

The participants were asked to sit on the floor and fully bend their trunks. To reduce hamstring strain, a half-

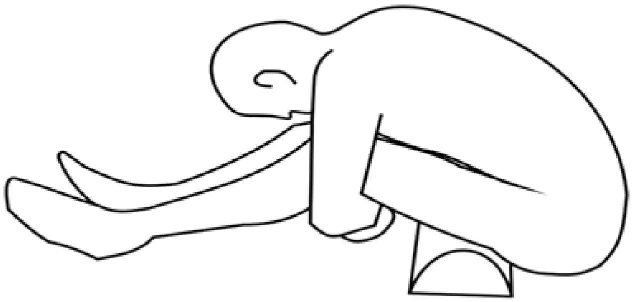

Figure 1. Schematic representation of a subject during the 10 minutes of static lumbar flexion

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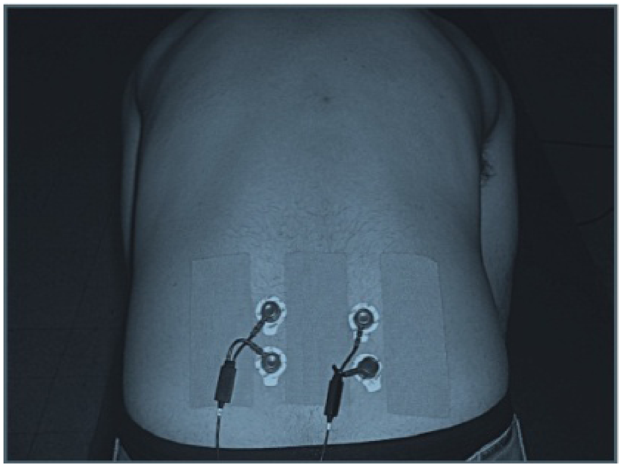

Figure 2. Application of KT during forwarding bending

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cylindrical foam pad was placed under their thighs to tilt the pelvis backward [11] (Figure 1).

Participants remained in this position for 10 consecutive minutes. Immediately, they were asked to stand and perform the same flexion-extension tasks as before the static flexion period.

Application of Kinesio tape

Three adhesive tapes 20×5 cm were attached to the lumbar area. These tapes were cotton, thin, and elastic without latex, with the ability to stretch up to 40% of their original length. One of the tapes was placed along the line corresponding to the spinous processes of the vertebrae from T12 to L5. Two other strips were placed on both sides of the spine on the ES muscles, with a distance of 4 cm from the first strip (Figure 2) [17]. During the application of the KT procedure, the subjects were asked to bend forward until their hands reached their knees [16]. Immediately after applying KT, the participants performed the above steps of trunk flexion-extension tasks.

The sequence of tests with and without using the Kinesio tape was determined randomly by drawing a lot. Subjects were tested using KT before and after 10 minutes of static flexion in one session of approximately 60 minutes in the laboratory. The time interval between the two tests was 20 minutes.

Data analysis

Raw EMG signals were converted to root mean square signals with a 50 ms moving window. The EMG signals were normalized using the maximum EMG magnitude during the trunk extension task [19]. To record the maximum EMG magnitude of the ES muscles, participants

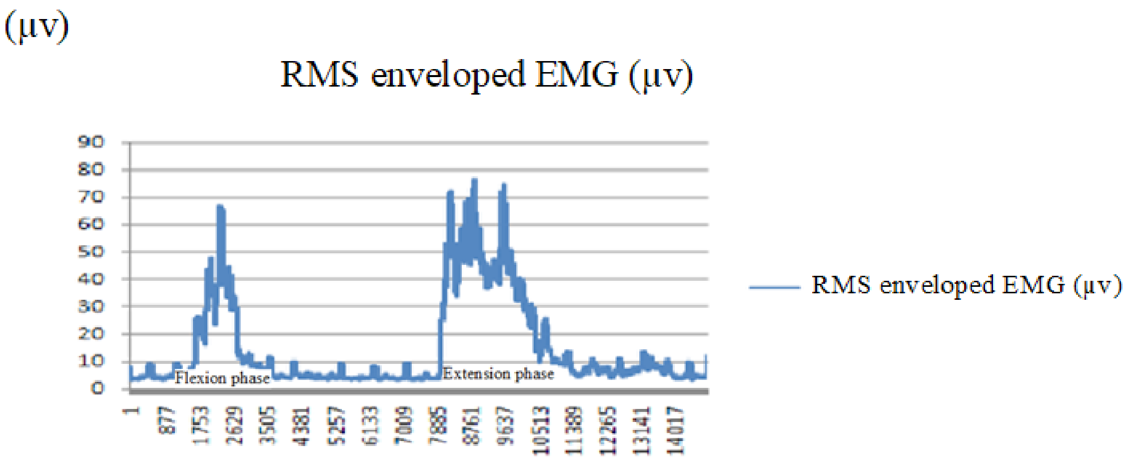

Figure 3. Sample of flexion relaxation phenomenon in EMG record

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Table 1. Descriptive statistics of 22 participants

Variables	Mean±SD	Maximum	Minimum	KS (P)
Height (cm)	168.81±6.09	173	151	0.58
Weight (kg)	53.95±7.16	65	42	0.59
BMI (Kg/m²)	19.18±4.39	26.41	11.68	0.93
Age (y)	27±2.71	29	20	0.28

BMI: Body mass index; KS: Kolmogorov-Smirnov.

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needed to raise the trunk for 1 s, maintain this position for 3 s, and lower the trunk for 1 s. The mean intensity of muscle activity in 3 s of contraction was selected to determine the maximum EMG magnitude during trunk extension activity [19].

A threshold level of 10% of the magnitude during the expansion phase was used to determine the start and end of FRP [10]. In the flexion phase, when the magnitude of the EMG signal was lower than the threshold level, it was considered the start of FRP (EMG-off). During the extension phase, the point when the EMG signal magnitude exceeded the threshold level was defined as the end point of the FRP (EMG-on) [19] (Figure 3).

Video information was converted to picture frames using video-to-picture software applications. By matching the frames with the corresponding EMG signals, the frames related to the EMG-off and EMG-on were selected for angle analysis. Considering the markers, the desired angles were measured in each specific frame with Auto CAD software [5].

The trunk, hip, and lumbar angles were measured by lateral markers. The trunk angle was defined as the angle between the vertical line crossing the ilium marker and the line connecting the rib and ilium markers. The hip angle was defined as the angle between the vertical line passing through the ileum marker and the line that connects the greater trochanter and ilium markers and the lumbar flexion angle was defined as the difference between the trunk and hip angle [11]. The dependent variables included angles of the trunk, lumbar, and hip in EMG-off and EMG-on two times before and immediately after 10 min creep in two conditions with and without KT.

Statistical analysis

The Kolmogorov-Smirnov test was used to evaluate the normal distribution of the data. Parametric tests were used to analyze the data. Two-way analysis of variance was used to investigate the main and reciprocal effects of the independent variables of static flexion and KT on the dependent parameters (time, trunk, hip, and lumbar angles). One-way analysis of variance and paired t-test were used to determine the effect of independent factor static flexion and KT on the studied parameters. The α level was set at 0.05 [3].

Results

Table 1 presents the descriptive statistics of 22 participants. Before static lumbar flexion, FRP was observed in the ES muscles of all participants. Also, after static lumbar flexion, FRP was observed in all participants and the data of all subjects were statistically analyzed.

Table 2 presents the test results of EMG-off and EMG-on in two conditions (with and without application of the KT) before and immediately after the static lumbar flexion. Static lumbar flexion for 10 minutes increased the time of the EMG-off point and decreased the time of the EMG-oN point ($P<0.05$). After static flexion, the ES muscles remain active for a longer time in the flexion phase and are activated earlier in the extension phase. In other words, static lumbar flexion for ten minutes decreased FRP time in ES muscles (Table 2).

Before the creep, the application of KT led to decreased EMG-off point time and increased EMG-on point time ($P<0.05$). This means that following the application of KT, the ES muscles are silenced earlier in the flexion phase and reactivated later in the extension phase. In other words, the use of KT before the creep increased the FRP time in ES muscles (Table 2).

In a non-KT state, 10 minutes of static lumbar flexion increased the trunk and the lumbar angle at the EMG-off point in the flexion and the EMG-on point in the extension ($P<0.05$). No significant difference was observed in the hip angle before and after the creep (Tables 3 and 4).

Table 2. The effect of Kinesio taping and creep on EMG-off and EMG-on time

Parameter	Mean±SD				P		
	Without KT		With KT				
	Before the Creep Condition (I)	After the Creep Condition (II)	Before the Creep Condition (III)	After the Creep Condition (IV)	Condition I, II	Condition III, IV	Condition I, III
EMG off, (s)	4.64±0.61	5.12±0.87	4.34±0.64	4.79±0.75	0.039	0.011	0.047
EMG on, (s)	9.26±1.04	8.88±0.099	9.97±0.77	9.33±0.80	0.046	0.000	0.001

Statistical test by: Mixed two-way analysis of variance, one-way analysis of variance, and paired t-test.

EMG: Electromyography.

Before the static flexion, KT application increased trunk and hip angle at the EMG-off point. No significant difference was observed in the lumbar angle with and without KT(Table 3).

After the static flexion with KT application, the time points of EMG-off and EMG-on and trunk, lumbar, and hip angles after the creep were compared with before the creep and yielded no significant difference. According to the time of EMG activity by applying KT in two states before and after creep, the ES muscles were silenced and reactivated at the same time and angles.

Discussion

This study was conducted to investigate the effect of KT on trunk, lumbar, and hip angles in forward bending movement before and after the static lumbar flexion (creep phenomenon). FRP is a well-known biomechanical event showing the performance of the lumbar muscles near the full flexion position [2]. FRP was described as a muscular appearance for load distribution in synergy between ES muscles and passive components of the lumbar spine [4, 20].

When a subject begins to bend forward, the ES muscles gradually increase their contraction due to the upper trunk and the head weight, until at some point, the passive forces created by the strained viscoelastic structures are sufficient to withstand the load. At this point, the muscle activity is turned off [11].

The results of this study showed that the application of KT can make significant changes in FRP. KT caused the ES muscles to relax earlier and increase trunk and hip angles during forwarding flexion. Also, it leads to a delay in the activation of the ES muscles during the extension phase. Although it is beyond the scope of this study to discover the mechanism of the KT effect, here are some hypotheses to understand how KT affects FRP.

According to a study conducted by Paoloni et al., the use of KT led to the discovery of FRP in 43.6% of LBP patients without FRP before the treatment [16]. In their study, no correlation was observed between pain reduc-

Table 3. The effect of KT and creep on, trunk, lumbar, and hip angles in EMG-off time

Parameter EMG OFF	Mean±SD				P		
	Without Kinesio Tape		With Kinesio Tape				
	Before the Creep Condition (I)	After the Creep Condition (II)	Before the Creep Condition (III)	After the Creep Condition (IV)	Condition I, II	Condition III, IV	Condition I, III
Trunk angle (degree)	46.82±16.33	55.71±17.68	53.53±18.20	50.31±12.33	0.004	0.298	0.020
Lumbar angle (degree)	35.38±14.34	38.93±12.13	36.42±15.13	34.23±15.29	0.031	0.289	0.359
Hip angle (degree)	15.52±9.40	13.30±10.50	19.55±10.34	17.59±10.94	0.206	0.393	0.050

Statistical test by: Mixed two-way analysis of variance, one-way analysis of variance, and paired t-test.

EMG: Electromyography.

Table 4. The effect of KT and creep on trunk, lumbar, and hip angles in EMG-on time

Parameter EMG oN	Mean±SD				P		
	Without KT		With KT				
	Before the Creep Condition (I)	After the Creep Condition (II)	Before the Creep Condition (III)	After the Creep Condition (IV)	Condition I, II	Condition III, IV	Condition I, III
Trunk angle (degree)	35.35±15.88	41.91±13.80	34.98±17.27	32.66±13.24	0.024	0.351	0.842
Lumbar angle (degree)	30.19±11.49	33.73±12.33	27.67±13.50	27.18±11.61	0.046	0.809	0.157
Hip angle (degree)	11.44±8.04	10.27±7.09	11.48±5.87	9.78±6.39	0.534	0.239	0.740

Statistical test by: Mixed two-way analysis of variance, one-way analysis of variance, and paired t-test.

EMG: Electromyography.

tion and the appearance of FRP. This result is consistent with previous studies that found no relationship between pain status and EMG results in chronic LBP patients [21-23]. They stated that the normalized FRP in patients following the application of KT may be due to the correction of sensory feedback, reduced fear of movement, and improved back muscle function [16].

In this regard, the use of three KT stripes in our protocol may lead to increased involvement of cutaneous receptors. The sensory stimulation provided by KT may also represent a dynamic stabilization system of the lumbar joints in a flexion position that may help to reflexive inhibition of muscle activity [4, 11,16].

With KT application, the ES muscle activity relaxed earlier and trunk and hip angles increased. Perhaps due to compensation of flexion of the trunk or hip, the degrees of the trunk and hip angles increased. The KT may have worked like a belt, supporting and limiting the lumbar region. Due to limitations in forward flexion, subjects are bent over the trunk and hip.

Yoshida et al. in a study showed that trunk angle increased with the application of KT. One of their theories was that KT increases blood flow and these physiological changes can alter muscle activities and myofascial performance. The other theory was that the use of KT may increase the involvement of cutaneous receptors, and this involvement affected ROM [15].

One of the causes of stability in the vertebra is neural control, which determines the intensity and time of action of the trunk muscles. Decreased activity in ES muscles after KT application caused the passive component alone to take control of trunk stability at the end of flexion [2]. Therefore, to create proper tension in passive tissue, the trunk angle was increased. Also, the silence of EMG activity of ES muscles, one of the stability factors, can increase the trunk angle.

Static lumbar flexion for 10 minutes produced significant changes in the FRP response. After that, the muscles remain active for a longer time at the end of the forward flexion phase and are activated earlier in the extension phase.

However, ES muscles' activation and maintenance of the active force are necessary to compensate decreased capacity of the viscoelastic tissues to generate passive forces. This process shows the neural synergy between muscles and viscoelastic tissue to control movements and maintain body stability. Viscoelastic tissue creep seems to be associated with micro-damage to the collagen structure. Changes in FRP are expected following the application of larger loads or holding static flexion for longer periods [11].

According to the effects of KT on reducing the duration of the muscle activity before the creep, KT can be used to reduce muscle spasms and the duration of lumbar ES muscle activity in people whose FRP has not been observed and are predisposed to LBP. However, more research is required on this topic. It is also necessary to check other factors, such as the electrical activity of other muscles. Although the use of KT cannot compensate or neutralize the effects of constant lumbar flexion for 10 minutes on trunk and hip angles during FRP on and off, considering its effects on lumbar angle, it can be used to protect and stress reduction on viscoelastic structures.

Conclusion

KT can prevent the increase in the lumbar spine angle due to the creep effect. It may be used to protect viscoelastic structures and increase the stimulation of skin receptors. The results showed that KT can act as a protector in the dynamic stabilization system of lumbar joints in flexion positions in healthy people.

Limitations

The current research was conducted only on people aged 20-30 years. Also, researching people with LBP was impossible due to possible injury caused by creeping.

Suggestions

It is suggested to conduct the research with a larger sample size. Another study on people with different occupations that are mostly performed in a forward bending position, such as gardening, is highly recommended. It is also suggested to simultaneously record the electrical activity of other crucial muscles that play an essential role in the lumbopelvic rhythm. Finally, prospective cohort studies are suggested.

Ethical Considerations

Compliance with ethical guidelines

This study has been approved by the Ethics Committee of the Tabriz University of Medical Sciences (Code: IR.TBZMED.REC.1401.937).

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Authors' contributions

Conceptualization and Supervision: Fariba Ghaderi; Methodology: Saeed Talebian; Investigation, writing–original draft, and writing- review & editing: All authors; Data collection: Zahra Chakeri; Data analysis: Saeed Talebian.

Conflict of interest

The authors declared no conflict of interest.

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