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The immediate effects of tissue flossing during active isolated stretching on hamstring flexibility in young healthy individuals

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Abstract

Introduction. Tissue flossing is increasingly popular among sportspersons for enhanced flexibility in both prehabilitation and rehabilitation programs. Nevertheless, there is a lack of evidence about this compression technique during stretching intervention. The purpose of this study was to determine the immediate effects of tissue flossing during active isolated stretching on hamstring flexibility.

Methods. Overall, 16 healthy young male adults (aged 18–25 years) of low to moderate activity were randomly allocated to the tissue flossing or non-tissue flossing group during hamstring active isolated stretching intervention. The participants stretched the hamstring by performing 3 sets of 10 repetitions. Traditional sit-and-reach, back saver sit-and-reach, active knee extension, and passive knee extension tests were conducted before and instantly after stretching.

Results. After the stretching intervention, the results revealed that the back saver sit-and-reach and passive knee extension tests resulted in a statistically significant improvement in both groups ($p < 0.05$). On comparing the effects of these 2 interventions, the results indicated that the tissue flossing group had a statistically significantly higher score of the traditional sit-and-reach test than the non-tissue flossing group ($p < 0.05$).

Conclusions. The application of tissue flossing as a compression strategy during hamstring active isolated stretching has a significant effect on the traditional sit-and-reach test and tends to be better or not worse than stretching without flossing on overall hamstring flexibility.

Key words: application, compression, knee extension, sit-and-reach, tightness

Introduction

Stretching is a type of physical activity used in both prehabilitation and rehabilitation programs for athletes, healthy person, patients, or individual who suffer from sports-related or work-related injuries, such as muscle strain, muscle spasm, myofascial trigger point, and muscle tightness due to muscle overuse [1–3]. Flexibility can be described as the ability to move all body parts and joints freely without causing any pain or restriction through its full range of motion (ROM). Besides, flexibility is an essential component of health-related, and especially skill-related, physical fitness for everyone [4].

An individual's flexibility depends upon several factors. A previous study showed that in a person with a sedentary lifestyle, with low activity levels, flexibility can decline to a higher extent than in people leading a physically active lifestyle. During periods of prolonged inactivity, e.g. sitting for a long time during study hours in the same position, muscle fibres may shorten and tighten up [5, 6]. Research of muscular flexibility, especially that of hamstring, found that the loss of flexibility within muscle fibres might increase the risk of injury since muscles are unable to withstand the raised tensile force during muscle lengthening or contracting of a particular movement [7]. Moreover, the proportion of hamstring tightness was observed to be as high as 54% in people with lower flexibility, especially in males with low activity. Besides, there is a high correlation between muscle flexibility and injury rate, which is around 1.6 times higher than in those with normal muscle length [7]. Muscle tightness is also commonly a reason for low back pain and eventually leads to alteration of lumbopelvic rhythm and spinal alignment [7]. Many clinical observations have suggested that hamstring tightness influences lumbar pelvic rhythm [8].

Choosing a technique or principle of stretching is usually based on the interest, expertise, and experience of the therapists [9]. There are various methods aimed at improving muscle flexibility, such as active, passive, ballistic, dynamic stretching, and proprioceptive neuromuscular facilitation techniques. Proprioceptive neuromuscular facilitation has been well-documented to improve muscle flexibility and increase ROM in healthy individuals [10]. Contrarily, an active stretching technique is more commonly used in sport and clinic, as well as in home-based exercise owing to its simplicity. Most therapists usually prescribe active stretching and self-stretching as a home program in order to maximize the clinical outcomes and desired goals.

Active isolated stretching (AIS) is a specific program for improving flexibility [11]. During AIS, the agonist muscle allows the relaxation of the antagonist via the reciprocal inhibition reflex and causes the muscles (antagonist) to relax without inducing tension within muscles. However, each stretch must not hold for more than 2 seconds [12]. Movement during stretching must be carefully monitored in order to prevent activation of the stretch reflex [11, 12]. Vernetta-Santana et al. [13] indicated that AIS was effective in improving hamstring flexibility and ROM in healthy individuals.

Tissue flossing is becoming a popular strategy in sports medicine and sports physical therapy [14]. This compres-

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sion technique was introduced in the past few years to promote the short-term effects on increasing ROM in individuals suffering from musculoskeletal disorders. For the technique, a thick rubber band is wrapped around the muscle or joint, and then an active movement is performed within 1–3 minutes [15]. Previous studies revealed that the tissue flossing band applied to the ankle joint had a significant effect on dorsiflexion and plantarflexion ROM and improved single-leg jump performance [15, 16]. Plocker et al. [17] investigated the effects of tissue flossing on muscle power and upper extremity ROM but found that there were no significant effects. They discussed that in the scapulothoracic region, the tissue flossing band was unable to cover its all areas. Contrarily, Kiefer et al. [18] implied that the perceptions of flexibility increased more with compression band therapy, which indicated a psychological, but not substantial, increase in shoulder flexion.

To date, there are insufficient evidence-based management strategies for tissue flossing with equivocal findings on ROM, and there is no evidence for the effect of tissue flossing during AIS on human hamstring flexibility. AIS and tissue flossing techniques involve active ROM of a particular joint, but a tissue flossing band adds an extra compression to muscles or joints during specific movements. This combination technique is similar to what therapists experienced when applying tension in the area of tenderness, fibrosis, or adhesion in muscles during the active release technique [9].

This study hypothesized that AIS with tissue flossing would increase hamstring flexibility more than that AIS without tissue flossing, so those techniques were compared. Therefore, this study aimed to examine the immediate effects of tissue flossing as a compression strategy during AIS on hamstring flexibility.

Subjects and methods

Participants

Participants were recruited from Thammasat University students (Rangsit campus). The G*Power software, version 3.1.9.4 (Germany) was used to estimate the sample size. The calculations were based on data from a study by George et al. [9], who investigated hamstring flexibility after the active release technique. The alpha level of 0.05, power of 0.95, and effect size of 0.75 were used. The minimum requirement was 26 subjects after calculation. Unfortunately, because of the COVID-19 pandemic in Thailand, we could recruit just 16 participants. The inclusion criteria involved no flexibility training within the previous 6 months, not having limited knee extension more than 20° during the active knee extension (AKE) test, body mass index of 18.5–22.9 kg/m^2 [19, 20], and the total scores of physical activity MET-minutes per week lower than 3000 as determined with the Global Physical Activity Questionnaire. The participants provided a ‘no’ answer to all questions in the Physical Activity Readiness Questionnaire. In terms of health, subjects were excluded if they had known cardiovascular diseases, pathologies or histories of injury of lower extremities or spine, dermal pathologies of the lower limbs, or allergy to the rubber band or latex. The participants were informed about the experimental protocol.

Experimental design

A randomized control trial was performed. The participants were randomly allocated by using the method of lottery (simple random sampling) to groups of tissue flossing (TF) (*n* = 9) or non-tissue flossing (NTF) (*n* = 7) intervention, as shown in Figure 1. Before conducting the assessment, for the determination of leg dominance, the preferred leg for kicking a ball towards a target was defined as a dominant leg in this experiment [21]. Baseline assessments were conducted as follows: (1) characteristics of the participants (age, weight, height, body mass index, and physical activity level); (2) sit-and-reach test (traditional and back saver variations); and (3) knee extension test (AKE and passive knee extension [PKE]). After the completion of pre-assessments, all subjects performed hamstring AIS, either with or without tissue flossing applied to hamstring muscles, depending on the experimental condition. Post-intervention assessments were conducted instantly after stretching, similar to pre-intervention assessments. The investigator responsible for recording the study outcome measures was blinded to participant group allocation. Before the baseline assessment session, all individuals were instructed to abstain from any muscle relaxant agents, vigorous exercises, alcohol, energy drinks, or caffeine for at least 48 hours and from drinking for at least 30 minutes before the test and during the test.

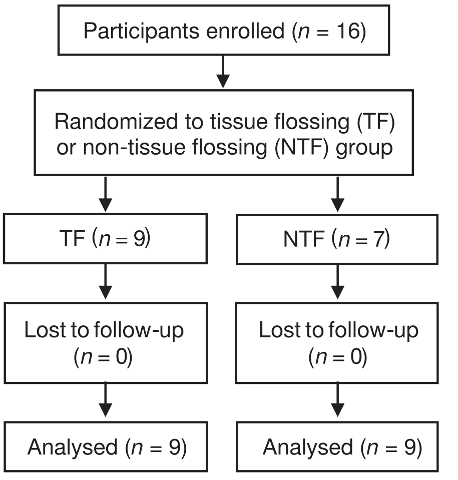

Figure 1. CONSORT flow chart of the randomized controlled trial

Sit-and-reach test [9, 22]

The sit-and-reach test consisted of the traditional and back saver sit-and-reach. For the traditional sit-and-reach test, all participants were asked to sit on the ground with both feet straight against a measuring box, and both palms were facing downward. The subjects were asked to bend forward as far as possible, holding the stretch for 2 seconds during each attempt. In turn, the back sit-and-reach test was conducted to assess the flexibility of the dominant leg separately. The individuals were asked to bend the non-dominant leg so that the plantar surface of the foot remained flat on the ground. The dominant leg was fully extended, the foot was against the end of the measuring box, both hands were placed on the top of the ruler, and a slow forward bend was performed along the measuring board [23]. The same investigator recorded the length of the participant’s reach. The investigator did not know the participant group allocation. Overall, 3 trials of measurements were recorded with a 1-minute within-trial resting period and a 2-minute rest between the 2 tests. The data were averaged among trials for the data analysis.

Active and passive knee extension test

AKE and PKE tests were used to assess ROM during terminal knee extension and hamstring muscle length. All participants were positioned on a table without a pillow underneath the head. The dominant leg was flexed in the 90/90 position. The thigh was placed in contact with the stabilizing bar at the distal anterior surface of the lower thigh. The same investigator confirmed 90° of hip flexion and knee flexion with a goniometer before the testing session [24]. The inclinometer (model 12-1056, Fabrication Enterprises, White Plains, NY, USA) was positioned at the anterior tibial boundary halfway between the inferior pole of the patella and the line between the malleoli [25, 26]. This position was marked with a permanent pen for the post-intervention test, which indicated the amount of knee extension ROM, also reflecting the hamstring muscle length. The pelvis and non-dominant thigh were fixed by using a strap to prevent posterior pelvic tilt during the knee extension movement [25]. For the AKE test, the participants were then asked to actively extend the knee while maintaining contact with the stabilizing bar. They performed 3 trials with a 1-minute rest between trials. The average was used for data analysis. Likewise, in the PKE test, the same investigator passively extended the knee to the end of the range, at which point the knee angle was measured via a bubble inclinometer [27]. The investigator then conducted 3 trials with a 1-minute rest between them and a 2-minute rest between the difference test. The average was used for data analysis. All data were then recorded and served for analysis.

Application of tissue flossing

The dominant thigh of each participant in the TF group was measured from greater trochanter to lateral epicondyle of the femur with a standard measuring tape as divided into 3 parts: upper, middle, and lower thigh, and indicated with a marker [28]. The tissue flossing band was implemented by using a Flossband (Sanctband Active & Sanctuary Health Sdn Bhd, Chemor, Malaysia) with a length of 2.1 m, width of 5 cm, and thickness of 1.3 mm. This method was modified and applied in a previous study by Prill et al. [14] by wrapping around the thigh from distal to proximal with a stretch of about 50% of the band's maximum stretch. The band was then stretched and exerted a compressive force on the hamstring muscle. The therapist again reduced the stretch to about 25% of the band's maximum stretch when wrapping around the quadriceps femoris muscle. The tissue flossing band was wrapped around the lower, middle, and upper thigh during stretching and was removed instantly in the rest period between the sets. The method is to increase the deep tension to most of the hamstring musculatures during the AIS technique. Therefore, the tension was stimulating the compression force by the therapist's hand (manual therapy) of active release technique but by using elastic recoil instead.

Hamstring active isolated stretching [11, 12]

Before the stretching session, the investigator explained and demonstrated the hamstring AIS technique to each participant. The subjects were positioned on a table as in the hamstring flexibility test. However, only the dominant leg received an intervention to stretch the hamstring musculature. Then, the individuals were instructed to extend their knee actively as much as possible while relaxing plantar flexor groups. Each stretch was held for no more than 2 seconds; it was recommended to exhale on the stretch and inhale on the release/relax [13]. The investigator then monitored and mastered every movement during active hamstring stretching. The stretching consisted of 3 sets of 10 repetitions with a 2-second rest between the repetitions and a 5-minute rest between the sets. The inter-set rest periods increased from the previous study because we needed more time to wrap and unwrap the tissue flossing band in another area of the thigh during stretching.

Statistical analysis

For the reliability of the test, the intraclass correlation statistic was used to determine intratester reliability with all measurement protocols. The intrarater agreement was 68% for wrapping tissue flossing band and 92% for measuring ROM. The distribution of the data was evaluated by using the Shapiro-Wilk test. Owing to the small sample size, the data were not normally distributed. The Mann-Whitney *U* test served to establish statistically significant differences between the 2 groups. The Wilcoxon signed-rank test was applied to determine whether there were any differences between pre- and post-intervention scores in the sit-and-reach, AKE, and PKE tests. The SPSS program v. 21.0 (IBM SPSS Inc., Chicago, IL, USA) was used. Statistical significance was set at $p < 0.05$ for all analyses.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethics Committee Board of Thammasat University No. 3 (COA No. 073/2561). The study has been approved for registration in the Thai Clinical Trials Registry (identification number: TCTR 20200601005).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Characteristics of participants

There was no statistically significant difference between the 2 groups concerning the characteristics of participants ($p > 0.05$), as shown in Table 1.

Table 1. Characteristics of participants

Characteristics	TF group (n = 9)	NTF group (n = 7)
Age (years)	20.33 ± 1.22	20.43 ± 0.97
Weight (kg)	62.11 ± 1.711	62.43 ± 2.448
Height (cm)	171.56 ± 0.081	172.29 ± 2.168
Body mass index (kg/m^2)	20.93 ± 1.25	20.871 ± 1.46
GPAQ (MET-min/week)	570 ± 336.89	571.43 ± 414.06

TF – tissue flossing, NTF – non-tissue flossing,
GPAQ – Global Physical Activity Questionnaire
Values are presented as a mean ± standard deviation.
No significant difference between the groups.

Sit-and-reach test

The traditional sit-and-reach test of the TF group showed a statistically significant increase after stretching ($p < 0.05$). The NTF group achieved some improvement after stretching as well, although without a statistically significant difference from baseline ($p > 0.05$). The results revealed that the TF

Table 2. Changes of the variables of the sit-and-reach test and knee extension test after hamstring active isolated stretching

Variables	TF group (*n* = 9)			NTF group (*n* = 7)			*p*
	Before stretch	After stretch	Mean difference	Before stretch	After stretch	Mean difference	
(1) Traditional sit-and-reach test (cm)	–10.97 ± 6.17	–6.08 ± 6.20*	4.88 ± 4.71	–6.67 ± 5.70	–5.31 ± 5.64	1.36 ± 1.32	0.017#
(2) Back saver sit-and-reach test (cm)	–9.63 ± 6.20	–4.62 ± 5.79*	5.01 ± 2.89	–8.36 ± 6.09	–3.89 ± 5.86*	4.47 ± 2.66	0.791
(3) Active knee extension test (°)	46.18 ± 7.05	50.74 ± 3.10	4.55 ± 6.41	41.61 ± 10.78	47.14 ± 10.04	5.52 ± 8.70	0.916
(4) Passive knee extension test (°)	54.14 ± 6.64	63.11 ± 2.99*	8.96 ± 6.41	49.61 ± 9.14	56.14 ± 10.04*	6.52 ± 5.06	0.559

TF – tissue flossing, NTF – non-tissue flossing
Values are presented as mean ± standard deviation.
* $p < 0.05$, Wilcoxon signed-rank test; # $p < 0.05$, Mann-Whitney *U* test

group exhibited a greater mean change as compared with the NTF group ($p < 0.05$).

The back saver sit-and-reach test of both groups showed a statistically significant increase after stretching ($p < 0.05$). However, the comparison between the 2 groups demonstrated no statistically significant difference ($p > 0.05$).

Active and passive knee extension test

The AKE test showed no statistically significant difference between baseline and post-intervention status in both groups ($p > 0.05$). Moreover, there was no statistically significant difference between the 2 groups ($p > 0.05$).

The PKE test revealed a statically significant increase after stretching in both groups ($p < 0.05$). It appeared to be slightly higher in the TF group than in the NTF group. Nevertheless, there was no statistically significant difference between the 2 groups ($p > 0.05$). The mean and standard deviation of all variables related to hamstring flexibility are presented in Table 2.

Discussion

The main findings revealed a statistically significant difference between the application of tissue flossing during hamstring AIS and hamstring AIS alone in the traditional sit-and-reach test. With insufficient evidence-based management strategies for a tissue flossing band for muscle flexibility, to our knowledge, this is the first study that determines the benefit of using a tissue flossing band as a compression strategy during active stretching. Hamstring flexibility increased by using AIS techniques may hypothetically reduce sports-related and work-related injuries in healthy young male adults of low to moderate activity [13].

A limited number of studies thus far have evaluated the effects of compression strategy by using a tissue flossing band (elastic band). The precise physiological mechanism of flossing has not been well determined yet [29], but one of the most promising mechanisms to this type of compression technique may be related to the fascial shearing mechanism [15, 16]. Another possible mechanism related to manual therapy is that flossing during AIS appears similar to the 'pin and stretch,' the methodology of massage therapy, except that AIS and active release technique involve an active rather than passive movement provided by the physical therapist. Many studies assumed that the mechanical pressure or interface pressure caused by the elastic band might allow stretched muscles to properly elongate or extend through decreasing fascial viscoelasticity [15, 16, 29, 30].

In both groups, PKE was found to be significantly increased from baseline, which is in line with the findings by Vernetta-Santana et al. [13]. They observed that the AIS technique consisting of 4 sets of 12 repetitions applied for the hamstring muscles was effective in improving both acute active ROM and acute passive ROM and caused no significant changes in the peak isometric force of knee flexors. However, Costa et al. [31] indicated that quadriceps peak torque at 60°/s and hamstring peak torque at 60°/s and 180°/s started to decline immediately after completing static hamstring stretching. It may imply that AIS involves repetitions of AKE movements superior to those observed in static hamstring stretching. Hence, quadriceps muscle fatigue may eventually limit the clarity of observing changes in the AKE test of both groups. Moreover, there may be a frequent repetition of AKE movements before, during, and after the stretch intervention in this study. Wang et al. [32] indicated that muscle force and total work during knee extension were not affected by the compression, despite the compression garment group showed a lower electromyography amplitude of the quadriceps muscle to a greater extent than in the control group. It should be mentioned that when the flossing band was applied during the stretching intervention, the floss band might increase the rate of perceived exertion, which is typically found in blood flow restriction training [33]. However, our applied method aimed only to compress all the hamstring musculature as much as possible during stretching, in a way similar to that conducted by a well-trained, experienced physical therapist during the active release technique or 'pin and stretch' in manual therapy. The method does not intentionally cause blood flow occlusion or restriction as observed in blood flow restriction low-load resistance training [34]. Nonetheless, in our study, we believed that we relied on the fascial shearing mechanism. Involuntarily, we might somehow rely on blood flow restriction as well. This could be due to psychological factors alone or a combination of psychological and physiological factors associated with compression band therapy [18]. We then observed that external compression provided from the tissue flossing band might have a significant effect on the PKE movement in the TF group, which appeared to be slightly higher than in the NTF group. However, the rate of perceived exertion is beyond the scope of this investigation. It can be supposed that passive ROM is usually slightly higher than active ROM in most circumstances. In this context, a muscle weakness is likely to occur [35], which might affect the agonist muscle (quadriceps muscle) in our study. This might be relevant to the autogenic inhibition of knee extensors upon the development of high-tension force within the muscles [36] during the period of compression and after tissue flossing band unwrapping (retention effect) or during the isometric contraction of the quadriceps at the end range of knee extension.

The back saver sit-and-reach test results were significantly increased from baseline in both groups, as hamstring AIS improved muscle flexibility. This test is comparable with the traditional sit-and-reach test, but each leg is examined separately. The participants were asked to bend the non-dominant leg so that the plantar surface of the foot remained flat on the ground, and the knee was flexed at 90° while the hip was flexed at around 45°. Hence, the greater posterior pelvic tilting in the back saver sit-and-reach test is presumably relevant to the position of the contralateral hip (non-evaluated leg) and ultimately limits the forward bending movement and increases compensation at the thoracic angle [23]. López-Miñarro et al. [37] revealed that anterior pelvic tilt and lumbar flexion increased while thoracic kyphosis decreased after stretching when the traditional sit-and-reach test was executed. Since traditional sit-and-reach involves lumbopelvic rhythm, increased hamstring flexibility results in increasing the forward bending movement [38]. It can be assumed that the compression force provided from the tissue flossing band appeared to be similar to that observed in the active release technique of the hamstring. Practically, to perform the active release technique for the hamstring muscle, the therapist must apply gentle pressure to the entire length of the hamstring muscle, at the origin and insertion, to hip adductors and gluteal muscles while the leg is actively stretched in many positions [39].

The hamstring active release technique was developed to decrease muscle tightness, modulate pain, and help the hamstring recover to its best functions [9, 39]. Hence, the muscles beneath the tissue flossing band were also compressed, but to a higher degree as compared with the gentle pressure applied by an experienced therapist. The AIS technique, active release technique, and tissue flossing technique involve an active ROM. For this reason, in our study, tissue flossing was applied as a compression strategy similar to compression from the therapist's hand in the active release technique using elastic recoil of the tissue flossing band instead of the therapist's hand and with active movements replicated by using the AIS technique. The participants with hamstring tightness were previously investigated with the active release technique by Kage and Ratnam [39]. It was observed that the active release technique had a significant effect on the traditional sit-and-reach test and ROM. George et al. [9] obtained similar results. They studied the effects of the active release technique on hamstring flexibility and found an improvement in the traditional sit-and-reach test after the intervention. In line with our observations, a recent study by Kaneda et al. [30] indicated that flossing applied to hamstring muscles was more beneficial than dynamic stretching with respect to increasing ROM and muscle exertion. We revealed that there was a statistically significant difference between the 2 groups in the traditional sit-and-reach test when the tissue flossing band was implemented with hamstring AIS.

Limitations

This study reveals the tissue flossing combined with hamstring AIS has a significant effect on the traditional sit-and-reach test results. We acknowledge that there are some limitations to our study. Firstly, the sample size was small. A considerable variation in the individual response to the application of tissue flossing during the stretching intervention may limit the clarity of the observed changes. With a larger sample size, as well as a matched pairs parallel-group design based on hamstring flexibility, we might be able to find a statistically significant difference between the 2 interventions in variables other than the traditional sit-and-reach test. Secondly, we had no objective measure of the compression achieved in our study for real-time measuring of the interface pressure beneath the tissue flossing band. The consistency of compression might vary in each individual. However, we attempted to limit the potential variations in compression by ensuring that all wrapping procedures were performed by a single experienced investigator throughout the study.

Conclusions

The application of a tissue flossing band as a compression strategy in the hamstring AIS technique has a significant effect on the traditional sit-and-reach test results. This compression technique is either better or not worse than that without flossing in a stretching intervention for overall hamstring flexibility. The flossing band is simple and practicable and may be used as a supplementary intervention to the stretching routine in order to improve flexibility in individuals suffering from hamstring tightness. Further studies should focus on the pressure force, as well as long-term effects of tissue flossing on flexibility and ROM. The investigators may vary the tissue flossing band size, location, duration, and period of application. Moreover, future research may investigate individuals with injuries of the lower limbs and/or the spine. The results may be useful in clinical work with patients after injuries.

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Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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