

The Effect of Eight Weeks of Self-Myofascial Release on Lumbar Lordosis of Elderly Women

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ABSTRACT

Background: Lumbar lordosis is one of the causes of low back pain (LBP) prevalence among people. **Objective:** This study evaluated the effect of Self-Myofascial Release (SMR) using Foam Roller on lumbar lordosis of elderly women. **Methods:** For this purpose, among the elderly women referred to the rehabilitation center, The sample ($n = 32$) with a curvature angle of more than 30 degrees was categorized into two groups: Experimental group with (mean age $62/3 \pm 3/4$ years old), (mean height 160 ± 4.2 cm) and (mean weight 60.1 ± 5.2 kg) and Control group with (mean age 60.1 ± 4.46 years), (mean height 160.1 ± 4.8 cm) and (mean weight 63.4 ± 4.02 kg). Lumbar arch was measured and recorded with a flexible ruler. The training protocol consisted of eight weeks, three sessions per week (including three one minute exercises with one minute rest between each exercise). To ensure the normality of the data, the Kolmogorov-Smirnov test was used, to evaluate the progress of each group from the pre-test to the post-test used correlate t-test, and to compare the mean of the two experimental and control groups used the independent t-test. **Results:** Furthermore, our results demonstrate that Self-Myofascial Release (SMR) using a foam roller has a significant effect on reducing the lumbar lordosis of elderly women ($P=0.0001$). **Conclusion:** Myofascial Self-Release Method using foam rolling in shortened muscles and joints that have limited mobility, in order to increase flexibility and correction of shortness should be prescribed.

Introduction

Self-Myofascial Release (SMR) is a common self-treatment strategy used by a wide plethora of physically active people, such as the gym or home fitness users (1,2), high-level athletes (3,4,5), and global health and postural trainers (6,7,8). According to the literature, SMR can be defined as a subcategory of myofascial release (4,9,10), which is a series of manipulative techniques where pressure is applied to soft tissue, with regard to muscles and fascia (11). In fact, the main declared goal of SMR is to mobilize the targeted soft tissues with rolling devices, such as foam rollers or hard balls, which are used by applying a certain amount of pressure over the surface of the skin, thus creating a self-induced massage effect. The effectiveness of SMR is well explained in the literature and different authors adduce several mechanisms of action. Compression may increase fascial elasticity thanks to a temporary change in water content (12). After the compression, the local blood flow is increased, facilitating the removal of metabolites and delivering oxygen (13,14,15) as well as the warming of the tissue, ripping the restrictions within layers of the fascia and restoring soft tissue elasticity (16), reducing the inflammation status (9). The pressure on soft tissue also leads to mechanoreceptor stimulation, which is then able to reduce muscular and fascia tension (17). All these mechanisms are well-known and described in detail in previously published reviews (9,10). Although some authors are still dubious about the proper name to use for these techniques applied on the myofascial tissue (18), a growing amount of evidence suggests positive outcomes of SMR, such as decreasing pain, reduction of delayed onset muscle soreness (DOMS), faster physical recovery, and an increase in muscle flexibility and joint range of motion (ROM) without a reduction in force production (9,19,20).

Myofascial Release (MFR) is one of the applications of manual therapy and is performed by a physiotherapist or patient himself with a foam roller (21). John F. Barnes stated that MFR is based on the release of all tensions and painful points, and the main goal is to relieve the pain by eliminating the fascia problems associated with mobility (21). Also, Myers has defined several myofascial meridians (a group of muscles (22)). Those meridians are quite fundamental because when one of the muscles found in those chains is injured, it could directly affect other muscle groups located on the corresponding meridian, leading to LBP via unsecretive properties of the fascia (22). Therefore, MFR is applied to those meridians to eliminate fascial problems effectively. Moreover, recently conducted studies have suggested that MFR could be quite effective in the management of NSLBP (23). In the management of LBP, there are several evidence-based effective healing options, namely pharmacological treatments, and physiotherapeutic approaches such as electrotherapy, kinesiotaping, exercises, and manual therapy (24).

In relation to the effect of various exercises on reducing lumbar lordosis, much research has been conducted abroad and inside the country, among researchers (25) can be mentioned. In his research, he concluded that Pilates exercises reduce the degree of lumbar lordosis in patients with non-specific chronic back pain. Okhli et al. (26) conducted a study on the effect of corrective exercises on the back pain of 19-22-year-old female students with lumbar lordosis in Isfahan University and concluded that 8 weeks of corrective exercise can reduce lumbar lordosis. Akhoudkhah et al. (26) found eight weeks of corrective exercises to be effective in reducing lumbar lordosis in female students. According to the studies, limited research has been done on the effect of self-myofascial release using a foam roller on lumbar back pain reduction and correction of postural abnormalities, such as lumbar lordosis, in elderly women. Therefore, the purpose of this study was an investigation of the effect of 8 weeks of self-myofascial release using a foam roller on the reduction of lumbar lordosis in elderly women.

Methods

Study Design and Participants

Considering the intervening variables and the targeted selection of the subjects based on the entry and exit criteria, the current research is semi-experimental. The initial screening of the subjects was done by the researcher using a checkerboard ($r = 0.89$). The subjects of this research were 32 elderly women who were referred to the rehabilitation center, and were purposefully selected and randomly divided into two equal experimental and control groups ($N = 32$). Lumbar more than 30 degrees; no chronic pain and any history of injuries in the back, neck, or upper limbs; age range 60 to 65 years, and written consent was voluntary. Exclusion criteria: having continuous sports activity and regular, having a history of musculoskeletal problems such as fractures, back pain, lower limb surgery, having a history of blood disease, osteoporosis, cancer, advanced diabetes, orthopedic accidents during the study period, absence of more than three consecutive sessions during exercises. the validity of the flexible ruler was reported by Hart and Rose as 97% and 87%, respectively.

After the screening, a grid page and a flexible ruler were used to accurately measure the curvature of the back vertebrae arch and the degree of lumbar lordosis of the subjects, respectively. To determine the degree of lumbar lordosis, the spinous appendage of the twelfth back vertebra (T12) was considered as the starting point and the spinous appendage of the second sacral vertebra (S2) was considered as the endpoint. Then a flexible ruler was

placed at the T12 and S2 points and the shape of the arc A lumbar curve was obtained. To calculate the angle of the lumbar curve, points T12 and S2 were connected to each other in a straight line. We indicated the size of the straight line with (L) and the deepest point of the arc relative to it with (h). Then, the values of those two in The formula $\theta = 4 \text{ Arc tan } 2h/L$ was placed and the amount of the lumbar arc angle was calculated. The measurement of the lumbar arc was repeated three times for each subject (with a minute of rest between each repetition) and the average of the obtained angles was used as the measurement index was considered (27)

Intervention Procedure

To implement the protocol, a foam roller with the following specifications was used: Full round 90cm × 15-Mmbo max Foam roller- Taiwan

The target muscles include the lumbopelvic region muscles, which mostly focus on the hamstrings and rectus femoris muscles. The exercises lasted for eight weeks (three sessions of 30 minutes each week). According to the American National Academy of Sports Medicine (ANASM), 10 minutes were devoted to warm-up and cool-down before and after exercise. The foam roller moved backward (from the Ischium trochanter to the Popliteal Fossa) and 1 second forward (from the Popliteal Fossa to the Ischium trochanter) at a rate of approximately 1 second. Subjects started their work by sitting on a foam roller, therefore the legs and ankles are in the extension and natural position and facing up respectively. Subjects put their body weight on their hands and were taught to manipulate the pressure on the foam roller and apply as much pressure as possible on the target muscles and the foam roller. The time of the protocol was controlled by the researcher and verbal feedback was also given if needed. The subjects maintained the proper position and direction of the ankle during the movement of the foam roller (20). To increase the pressure on the soft tissue, the subjects were asked to roll the right foot on the foam roller first and put the left foot on the right foot to increase the pressure. Then repeat the same with the left foot. By placing the legs together, more pressure is applied to the hamstring muscles (19). The subjects were taught to manipulate the pressure applied on the foam roller during SMR and apply more pressure to the tissue. (Figure No. 3) (Table 1). After completing the 8-week training program, the subjects' lumbar lordosis was measured.

Statistical Analysis

After collecting the research information, the data related to the characteristics of the subjects such as age, height, and weight along with the research variables were analyzed in two sections of descriptive and inferential statistics in SPSS software version 21 to ensure the normality Data from the Kolmogorov-Smirnov test were used to evaluate the progress of each group from pre-test to post-test using the correlated t-test, and independent t-test was used to compare the averages of the two experimental and control groups. The level of significance throughout the research was considered 0.05

Result

The analysis of research findings showed that the amount of lumbar lordosis of experimental group subjects changed significantly after participating in the foam roller training program ($P=0.0001$), so that the average lumbar lordosis angle of experimental group subjects in the post-test, it was reduced by 3.05% compared to the pre-test (Tables 1, 2). Meanwhile, no significant change was observed in the mean lumbar lordosis of the control group subjects ($P = 0.09$). Also, using the independent t-test, a significant difference was observed in the lumbar arch changes between the control and experimental groups ($P=0.0001$).

Table 1: General characteristics of subjects and descriptive information of research variables

Variable	Standard deviation ± mean	
	Experimental group	Control group
Age (years)	62.3±3.4	60.1± 4.46
Height (cm)	160.0±4.2	160.1 ± 4.8
Weight (kg)	60.1±5.2	63.4 ± 4.02
Lordosis angle: pre-test (degrees)	53.33±5.82	55.40 ± 3.71
Lordosis angle: post-test (degree)	51.47 ± 5.82	55.40 ± 3.71

Table 2: comparison of the lordosis angle Pre and Posttest - percentage (paired test)

	Group	Rate of change(%)	t dependent		t independent	
			T	P-Value	T	P-Value
Pretest–Posttest	Experimental	-3.05	12.24	0.0001		
	Control	+0.29	1.85	0.09	-11.2	0.0001

The purpose of this study was to investigate the effect of 8 weeks of foam roller training on reducing lumbar lordosis in elderly women with Hyperlordosis. Research findings after 8 weeks of exercise showed a significant improvement in reducing the lumbar arch in the experimental group by the use of the SMR method. Also, a significant difference between the lumbar arch of the experimental group and the control was observed after 8 weeks of training, so the lumbar arch of the subjects of the experimental group had decreased from 53.33 degrees to 51.47 degrees.

Discussion

According to Marcelo et al. (2006), basically, in all Abnormalities, one part of the muscles of the body is stretched and the other part of the muscles of the body shrinks or shortens (28). In the case of lordosis, the gluteus·abdomen and hamstrings muscles are stretched and the thigh flexor muscles (Iliopsoas and rectus femoris) and extensor muscles in the spine are shortened in the lumbar region. So by providing stretching exercises for shortened muscles and Strengthening exercises for stretched muscles «these abnormalities can be corrected. From an anatomical point of view, about the relationship between lordosis and range of motion, it can be said that the structure of the spine such as ligaments, the articular surface of the annulus, intervertebral discs, and muscles located in this area play a basic role in the mobility of the lumbar region: In such a way that the damage to the analus section can affect the flexibility of spine and increases the range of motion (19). The joint surface is responsible for preventing hyper extension, It is also shown that the anterior elements of the lumbar region and the surface of Vertebral joints reduce the amount of extension movement (20). Changes in quality or occurrence of damage in these elements; affect the flexibility of the spine (16). Tupenberg and Bullock (1986) stated that the shortness of the hamstring muscles is related to the increase in the curvature of the lumbar vertebrae (2). Bloomfield and Eckland (1994), have considered the cause of the increase in the curvature of the lumbar vertebrae as the anterior rotation of the pelvis, and they acknowledge that in this abnormal position, the abdominal muscles become stretched and weak (3). Therefore, the extensor muscles of the lower back area and the thigh flexor muscles should be given stretched. At a glance, it is clear that some researchers have considered the shortness of Hamstring muscles as a cause of increasing the curvature of the lumbar vertebrae and a group did not find any relationship between this muscle group with the position of the pelvis and the arch of the lumbar vertebrae, from which it is possible to refer to the research of Chen Li and His colleagues pointed out that in their research, they did not find any relationship between the hamstring muscles and the lumbopelvic position.

Kendall and et all (2006), mentioned the shortness of the hamstring muscles as the cause of posterior rotation, and as a result of this rotation, the arch of the lumbar vertebrae is reduced (29). Evans et al. (2014), in their research, stated that the probability of no change in ROM, can be the inappropriate application of pressure on the tissue during the SMR protocol. this issue is supported by reports from several participants who claimed no or little pressure during the SMR protocol. This might be related to the rolling position of the hamstring muscles that people may Put their weight on their hands instead of the foam. Koran et all (2008) compared the amount of pressure of two types of rollers and concluded that applying pressure on soft tissue with a denser roller (high density) increases, it is interesting to note that they did not report any significant correlation between the weight and amount of pressure applied by both types of rollers one reason for the lack of connection between the weight and the pressure applied on

the roller can be related to the pain threshold, people may not apply extra pressure to the roller, and the body weight is not in contact with the roller in all parts of the body(30).

If the amount of weight placed on the roller can be strongly manipulated by people, the relative weight placed on the roller (apart from the density of the roller) can become a potential for the effect of pressure on soft tissue, this is an important point that should be considered in different groups of muscle, although Koran et al. (2008) showed that a dense and stiff roller applies more pressure than a less dense roller, there are other medium density rollers that apply higher degrees of pressure(30). Therefore, the influence of other rollers may have different results. Increasing joint range of motion (ROM) is important for the performance of most sports activities, and it is psychologically important for athletes and sports participants, and in sedentary people can prevent many skeletal and muscular injuries and abnormalities. It is thought that the increase in flexibility is due to mechanical changes in muscle, these mechanical changes include viscoelastic plastic deformation (tissue building ability), sarcomere length increase, and nerve and muscular relaxation. Weppeler (2010) considers increasing the temperature as a possibility to increase the flexibility of the rolling foam board. However, it was not possible to measure surface or muscle temperature during foam rolling (31). It is likely that the sustained motion of foam rolling increases intramuscular tissue temperature and blood flow, both of which can increase muscle viscoelastic properties(7). When the fascia is affected by heat and pressure, it becomes soft and takes on a more liquid-like state, otherwise, it becomes thick, and its viscosity and solid state increase (13). The thixotropic property of fascia is another Possible mechanism to increase flexibility.

Conclusion

Myofascial Release is used for various purposes including central stability, balance, Proprioception, and soft tissue mobility. This method is convenient for the people who implement it because it does not need the help of another person and it is usable at any time and place. Myofascial self-release using a foam roller creates direct pressure throughout the muscle along with rolling on the soft tissue, stretching the muscle, and producing friction between the layers of the fascia. It is useful for breaking fibrous adhesions and the elasticity of soft tissue (7). Another benefit of using a foam roller is that it can apply pressure on different parts of the body and changing people's posture can help to apply foam roller on different parts of the body people use their own body weight to apply pressure. Foam roller corrects imbalance muscles , Reduces muscle pain, increases the range of motion and flexibility, and relieves the stress on the joints (8).

In total, the results obtained in this research showed that the method of self-release Myofascial using the foam roller is an effective program in reducing back arch and increasing the hamstrings' flexibility. Through targeted sports exercises in the form of corrective movements, it is possible to help many people who have an abnormal lumbar arch to prevent the occurrence of abnormalities and pathological complications and to reduce the huge costs of treatment(32). According to the obtained results, it is suggested to use Myofascial Self-Release Method using foam rolling in shortened muscles and joints that have limited mobility, in order to increase flexibility and correction of shortness should be prescribed. It is also suggested to investigate the effects of Myofascial Release using other SMR tools (such as hand cylinder, tennis ball, etc.) on the flexibility index. also in future research, the duration of the effect of such an exercise program in relation to flexibility can be investigated.

References

1. Junker D, Stöggel T. The Training Effects of Foam Rolling on Core Strength Endurance, Balance, Muscle Performance and Range of Motion: A Randomized Controlled Trial. *J Sports Sci Med.* 2019 Jun 1;18(2):229-238. PMID: 31191092; PMCID: PMC6543984.
2. Shariat A, Anastasio AT, Soheili S, Rostad M. Home-based fundamental approach to alleviate low back pain using myofascial release, stretching, and spinal musculature strengthening during the COVID-19 pandemic. *Work.* 2020;67(1):11-19. doi: <https://doi.org/10.3233/WOR-203248>. PMID: 32955470.
3. Hamzeh Shalamzari M, Minoonejad H, Seidi F. The Effects of a Self-Myofascial Release Program on Isokinetic Hamstrings-to-Quadriceps Strength Ratio and Range of Motion of the Knee Joint Among Athletes With Hamstring Shortness. *J Sport Rehabil.* 2022 May 1;31(4):391-397. doi: <https://doi.org/10.1123/jsr.2020-0487>. PMID: 35078150.

4. Sulowska-Daszyk I, Skiba A. The Influence of Self-Myofascial Release on Muscle Flexibility in Long-Distance Runners. *Int J Environ Res Public Health*. 2022 Jan 1;19(1):457. doi: <https://doi.org/10.3390/ijerph19010457>. PMID: 35010717; PMCID: PMC8744627.
5. Hjert, Corall S., and Cynthia J. Wright. The effects of self-myofascial release foam rolling on muscle soreness or pain after experiencing delayed onset muscle soreness: a critically appraised topic. *International Journal of Athletic Therapy and Training* 25.6 (2020): 294-298.
6. Cheatham SW, Stull KR. Knowledge of self-myofascial release among allied health students in the United States: A descriptive survey. *J Bodyw Mov Ther*. 2018 Jul;22(3):713-717. doi: <https://doi.org/10.1016/j.jbmt.2018.01.015>. Epub 2018 Feb 2. PMID: 30100301.
7. Ughreja RA, Venkatesan P, Balebail Gopalakrishna D, Singh YP. Effectiveness of myofascial release on pain, sleep, and quality of life in patients with fibromyalgia syndrome: A systematic review. *Complement Ther Clin Pract*. 2021 Nov;45:101477. doi: <https://doi.org/10.1016/j.ctcp.2021.101477>. Epub 2021 Aug 27. PMID: 34507243.
8. López-Torres O, Mon-López D, Gomis-Marzá C, Lorenzo J, Guadalupe-Grau A. Effects of myofascial release or self-myofascial release and control position exercises on lower back pain in idiopathic scoliosis: A systematic review. *J Bodyw Mov Ther*. 2021 Jul;27:16-25. doi: <https://doi.org/10.1016/j.jbmt.2021.02.017>. Epub 2021 Mar 5. PMID: 34391228.
9. Beardsley C, Škarabot J. Effects of self-myofascial release: A systematic review. *J Bodyw Mov Ther*. 2015 Oct;19(4):747-58. doi: <https://doi.org/10.1016/j.jbmt.2015.08.007>. Epub 2015 Aug 28. PMID: 26592233.
10. Kalichman L, Ben David C. Effect of self-myofascial release on myofascial pain, muscle flexibility, and strength: A narrative review. *J Bodyw Mov Ther*. 2017 Apr;21(2):446-451. doi: <https://doi.org/10.1016/j.jbmt.2016.11.006>. Epub 2016 Nov 14. PMID: 28532889.
11. McKenney K, Elder AS, Elder C, Hutchins A. Myofascial release as a treatment for orthopaedic conditions: a systematic review. *J Athl Train*. 2013 Jul-Aug;48(4):522-7. doi: <https://doi.org/10.4085/1062-6050-48.3.17>. Epub 2013 Apr 3. PMID: 23725488; PMCID: PMC3718355.
12. Dębski, Przemysław, Ewelina Białas, and Rafał Gnat. The parameters of foam rolling, self-myofascial release treatment: a review of the literature. *Biomedical Human Kinetics* 11.1 (2019): 36-46.
13. Aguilera FJ, Martín DP, Masanet RA, Botella AC, Soler LB, Morell FB. Immediate effect of ultrasound and ischemic compression techniques for the treatment of trapezius latent myofascial trigger points in healthy subjects: a randomized controlled study. *J Manipulative Physiol Ther*. 2009 Sep;32(7):515-20. doi: <https://doi.org/10.1016/j.jmpt.2009.08.001>. PMID: 19748402.
14. Lavelle ED, Lavelle W, Smith HS. Myofascial trigger points. *Anesthesiol Clin*. 2007 Dec;25(4):841-51, vii-iii. doi: <https://doi.org/10.1016/j.anclin.2007.07.003>. PMID: 18054148.
15. Montañez-Aguilera FJ, Valtueña-Gimeno N, Pecos-Martín D, Arnau-Masanet R, Barrios-Pitarque C, Bosch-Morell F. Changes in a patient with neck pain after application of ischemic compression as a trigger point therapy. *J Back Musculoskelet Rehabil*. 2010;23(2):101-4. doi: <https://doi.org/10.3233/BMR-2010-0255>. PMID: 20555123.
16. MacDonald GZ, Penney MD, Mullaley ME, Cuconato AL, Drake CD, Behm DG, Button DC. An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. *J Strength Cond Res*. 2013 Mar;27(3):812-21. doi: <https://doi.org/10.1519/JSC.0b013e31825c2bc1>. PMID: 22580977.
17. Schleip R, Müller DG. Training principles for fascial connective tissues: scientific foundation and suggested practical applications. *J Bodyw Mov Ther*. 2013 Jan;17(1):103-15. doi: <https://doi.org/10.1016/j.jbmt.2012.06.007>. Epub 2012 Jul 21. PMID: 23294691.
18. Behm DG, Wilke J. Do Self-Myofascial Release Devices Release Myofascia? Rolling Mechanisms: A Narrative Review. *Sports Med*. 2019 Aug;49(8):1173-1181. doi: <https://doi.org/10.1007/s40279-019-01149-y>. PMID: 31256353.
19. Cornell DJ, Ebersole KT. Influence of an acute bout of self-myofascial release on knee extension force output and electro-mechanical activation of the quadriceps. *Int J Sports Phys Ther*. 2020 Oct;15(5):732-743. doi: <https://doi.org/10.26603/ijsp.20200732>. PMID: 33110692; PMCID: PMC7575145.
20. Ferreira RM, Martins PN, Goncalves RS. Effects of Self-myofascial Release Instruments on Performance and Recovery: An Umbrella Review. *Int J Exerc Sci*. 2022 Jun 1;15(3):861-883. PMID: 35991349; PMCID: PMC9362891.

21. Kalichman, Leonid, and Chen Ben David. Effect of self-myofascial release on myofascial pain, muscle flexibility, and strength: A narrative review. *J Bodyw Mov Ther.* 2017 Apr.4; 46-451. DOI: <https://doi.org/10.1016/j.jbmt.2016.11.006>. PMID: 28532889
22. Myers, Thomas W. *Anatomy trains e-book: myofascial meridians for manual and movement therapists.* Elsevier Health Sciences, 2013.
23. Doğançali, Ufuk, Elif Tuğçe ÇİL, and Feryal SUBAŞI. Comparison of the Effects of Self-Myofascial Release and Combined Core Stabilization Exercises in Physiotherapy and Rehabilitation Students with Non-Specific Low Back Pain. *IJDShS 6.1* (2023): 24-37. <https://doi.org/10.33438/ijdsHS.1224969>
24. Garcia, Alessandra Narciso, et al. McKenzie Method of Mechanical Diagnosis and Therapy was slightly more effective than placebo for pain, but not for disability, in patients with chronic non-specific low back pain: a randomised placebo controlled trial with short and longer term follow-up. *Br J Sports Med.* 2018 May.52.9: 594-600. DOI: <https://doi.org/10.1136/bjsports-2016-097327>. PMID: 28701365
25. Wong, Chi Ming, Bradley Rugg, and Jo-Anne Geere. The effects of Pilates exercise in comparison to other forms of exercise on pain and disability in individuals with chronic non-specific low back pain: A systematic review with meta-analysis. *Musculoskeletal Care.* 2023 Mar. 21.1: 78-96. DOI: <https://doi.org/10.1002/msc.1667>. PMID: 36912214
26. Okhli, Hadiseh, Hamid Hojjati, and Golbahar Akhoundzadeh. Comparing the effect of the corrective exercises of America's National academy of sports medicine and Pilates on the correction of lordosis among female high school students in Golestan Province in 2018. *Int J Sch Health.* 2019. 6.4: 1-6. <https://doi.org/10.30476/intjsh.2019.45883>
27. Seidi, F. O. A. D., et al. The effect of a 10-week selected corrective exercise program on postural thoracic kyphosis deformity. *Sport Sci Health Research.* 2013. 5.1: 5-22. <https://doi.org/10.22059/jsmed.2013.32159>
28. Kerksick, Chad, et al. Effects of a popular exercise and weight loss program on weight loss, body composition, energy expenditure and health in obese women. *Nutr Metab (Lond).* 2009. 6.1: 1-17. doi: <https://doi.org/10.1186/1743-7075-6-23>. PMID: 19442301. PMCID: PMC2693519
29. Fasuyi, Francis Oluwafunsho, Ayodele A. Fabunmi, and Babatunde OA Adegoke. Hamstring muscle length and pelvic tilt range among individuals with and without low back pain. *J Bodyw Mov Ther.* 2017 Apr;21(2):246-250. doi: 10.1016/j.jbmt.2016.06.002. PMID: 28532865.
30. Giustozzi, Antonio. Koran, Kalashnikov, and Laptop. Columbia Univ. Press, 2008.
31. Cynthia Holzman Weppeler, S. Peter Magnusson, Increasing Muscle Extensibility: A Matter of Increasing Length or Modifying Sensation?, *Physical Therapy*, Volume 90, Issue 3, 1 March 2010, Pages 438–449, <https://doi.org/10.2522/ptj.20090012>
32. Sitjà-Rabert M, Rigau D, Fort Vanmeerghaeghe A, Romero-Rodríguez D, Bonastre Subirana M, Bonfill X. Efficacy of whole body vibration exercise in older people: a systematic review. *Disability and rehabilitation.* 2012 Jun 1;34(11):883-93. doi: <https://doi.org/10.3109/09638288.2011.626486>. PMID: 22225483