Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 889 - 894
Received 15 December 2020; Accepted 05 January 2021.

Immediate Effects of Vibrating Foam Rollers on Neck Pain, Muscle Stiffness, and Cervical Proprioception in Patients with Forward Head Posture

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Abstract

Background/Objectives: This study aimed to investigate the immediate effects of applying non-vibrating and vibrating foam roller exercises on neck pain, the upper trapezius muscle, sternocleidomastoid muscle stiffness, and cervical proprioception in patients with forward head posture (FHP).

Methods/Statistical analysis: In this study, 24 adult male and female patients in their 20s who had FHP were randomly assigned to either a non-vibrating foam roller group (NVFRG; n = 12) or a vibrating foam roller group (VFRG; n = 12). As a pretest, neck pain, muscle stiffness, and cervical proprioception were measured in both groups. After applying one set of intervention in each group, pain, stiffness, and proprioception were measured and analyzed in both groups as a posttest.

Findings: The neck pain and upper trapezius stiffness were significantly decreased in the VFRG ($P < 0.05$). However, no statistically significant difference was found between the sternocleidomastoid muscle stiffness and proprioception ($P > 0.05$). In the NVFRG, we found no statistically significant differences in all the variables ($P > 0.05$). Statistically significant differences in neck pain and upper trapezius stiffness ($P < 0.05$) but no statistically significant differences in sternocleidomastoid muscle stiffness and proprioception ($P > 0.05$) were observed between the NVFRG and VFRG.

Improvements/Applications: Therefore, our results suggest that the application of a vibrating foam roller exercise in patients with FHP would improve neck pain and muscle stiffness.

***Keywords*:** Forward head posture, Vibrating foam roller, Pain, Muscle stiffness, Proprioception

1. Introduction

Forward head posture (FHP) occurs when the head is shifted in front of the trunk and the bending of the lower cervical vertebrae and extension of the upper cervical vertebrae are increased [1]. If FHP is maintained, neck pain can occur. FHP is a typical neck-related condition that has recently been frequently observed in students and office workers who sit at desks for prolonged periods [2,3].

Exercises using a foam roller bring the body into contact with the foam roller. Slow movements of the body while supporting the weight of the foam roller provides pressure on the body and causes the fascia to relax, thereby reducing muscle tone, which results in an increased joint range of motion [4]. Application of a continuous and slow pressure on tissues stimulates the mechanoreceptors that transmit information to the central and automatic nervous systems to relieve muscle tone. It also modifies the flow of body fluids, which affects the tone of smooth muscle cells in the fascia [5]. Previous studies showed that the pressure pain threshold (PPT) increased after applying a foam roller to an iliotibial band [6]. In a study that applied static stretching and a foam roller exercise in 40 patients with hip joint flexion of <90° for 6 months, flexibility was increased in the foam roller exercise group [7]. Moreover, a significant increase in dynamic balance ability and a decrease in pain level were observed when a foam roller was applied in patients with delayed muscle pain [8].

Vibration showed positive effects on muscle contraction [9] and is often applied to control pain and combined with exercise to increase its effect [10]. Microscopic vibrational energy accelerates muscle contraction and relaxation, which leads to increased muscle fibers with a low risk of tissue damage. Moreover, the mechanical effects of vibration include improved circulation, stretching of soft tissue, prevention of adhesion and destruction, increased tissue flexibility, and reduced pain [11]. Previous studies on vibration stimulation reported that when a vibrating foam roller was applied on the lower limbs, no significant improvements were observed; however, it led to a greater improvement in vertical jumping ability. When a foam roller was applied on the hamstrings, the electromyographic activity of the antagonistic muscles was higher in the vibrating foam roller

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group [12]. Moreover, the application of a foam roller after exercise led to significant increases in the pain threshold and passive hip joint range of motion in the vibrating foam roller group [13].

Thus, an intervention method using a foam roller would be effective in increasing the tenderness threshold, joint range of motion, and muscle activity. However, studies that applied a foam roller in patients with FHP and analyzed its effects on various aspects are lacking. Therefore, this study investigated the immediate effects of applying non-vibrating and vibrating foam roller exercises on neck pain, the upper trapezius muscle, sternocleidomastoid muscle stiffness, and cervical proprioception in patients with FHP.

2. Materials and Methods

2.1. *Participants*

A total sample size of 21 was calculated using the G*Power program (*a* error: 0.05, power: 0.8, effect size: 1.1). Twenty-four participants were recruited considering possible dropouts, and the selection criteria were as follows: (1) healthy university students, (2) those with a craniovertebral angle (CVA) of <49° (intraclass correlation coefficient = 0.88) [14], and (3) those without mental illness and orthopedic or neurological symptoms in the cervical spine. The exclusion criteria for the participants were as follows: (1) those who had infectious diseases, chronic inflammatory diseases, neurological diseases, spondylolysis, spinal canal stenosis, or tumors; (2) those who were pregnant; and (3) those who felt severe pain while exercising with a foam roller in a lying position.

2.2. *Procedures*

In this study, 24 adult men and women in their 20s who had FHP were randomly assigned to either a non-vibrating foam roller group (NVFRG) or a vibrating foam roller group (VFRG). To minimize selection bias, the participants were assigned to either group, with 12 participants in each group, using a random assignment tool in advance (Research Randomizer; http://www.randomizer.org/). Before the study, all the experimental procedures and safety precautions were explained to the participants, and written consent was obtained from all the participants. As a pretest, pain in the upper trapezius muscle, sternocleidomastoid muscle stiffness, and cervical proprioception were measured in the two groups. After applying one set of intervention in each group, pain, muscle stiffness, and proprioception were measured and analyzed as a posttest in both groups.

2.3. *Outcome measures*

2.3.1. Pain

In this study, PPT was measured using the Commander Algometer (JTech Medical Industries, USA). The PPTs of the musculi suboccipitales and levator scapulae muscles were measured, and the average value of three measurements was used to reduce any error in the experiments [15].

2.3.2. Muscle stiffness

Myoton PRO (Myoton AS, Estonia) was used to measure muscle stiffness. The reliability and validity of the device in evaluating muscle tone were demonstrated previously [16]. Muscle stiffness was measured three times each in the upper trapezius muscle and the muscle belly of the sternocleidomastoid muscle, and the average value was recorded. Measurements were performed after maintaining a stable state for 10 min to remove any unnecessary muscle tone. Before the measurement, the participant maintained the most comfortable posture in a sitting position. Each muscle belly was marked with a marker that is harmless to the human body, and the average value was recorded and used as data value. After holding the equipment in an upright position, measurements were made five times. During the five vibrations, both hands were supported and maintained perpendicular to the muscle so that the probe of the instrument did not deviate from the marked points, and the average value of two measurements was used as the data value.

2.3.3. Proprioception

The cervical range-of-motion (CROM) instrument (Deluxe 302, MedNet, USA) was used as the measuring tool. Proprioception was measured during left rotation. The participants were asked to face a blank wall and to close their eyes. With the help of the investigators, the participants then rotated their heads at an angle of 30° to the left and maintained this position for 5 s for recognition of the angle. Then, after returning their heads to the neutral position, they were instructed to rotate their heads to the same angle and to return it to the neutral position three times without any help, and the average value was calculated.

2.4. *Intervention*

The two groups performed the respective non-vibrating and vibrating foam roller interventions and then cervical static stabilization exercises.

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2.4.1. Non-vibrating foam roller (NVFRG)

In a supine position, each participant was asked to apply self-massage to the C7 and T1 segments of the neck, using a non-vibrating high-density foam roller (Bodyx, China) for 90 s and then to rest for 30 s. A total of three sets in each session was performed. The massage was applied at a pain intensity of ≤2 on the numerical rating scale (NRS) [17].

2.4.2. Vibration foam roller (VFRG)

In a supine position, each participant was asked to apply self-massage to the C7 and T1 segments of the neck, using a vibration foam roller (Hyperice, Vyper 2.0, Irvine, CA, USA) for 90 s and then to rest for 30 s. A total of three sets were performed. The massage was applied at a pain intensity of ≤2 on the NRS at a frequency of 30 Hz [18].

2.4.3. Cervical static stabilization

For the first exercise, each participant sat upright on a mat, using a sera band to generate resistance at the back of the head and held the head back for 15 s. The participant was then asked to rest for 15 s, and the exercise was repeated six times.

In the second exercise, the participant maintained a posture with the head placed backward in a sitting position. Then, the researcher held the sera band in front of the participant to generate resistance, and the participant grabbed the sera band, spread the shoulders horizontally, and maintained this position for 15 s. The participant was then asked to rest for 15 s. This exercise was repeated six times. The same exercises were applied in both groups.

2.5. *Data analysis*

Data analysis was performed using IBM SPSS Statistics v22.0 (SPSS Inc., Chicago, IL, USA). All data were examined for normality using the K–S test and found suitable for parametric testing. A paired *t* test was used to compare neck pain, muscle stiffness, and cervical proprioception before and after the respective interventions in each group. An independent *t* test was used to compare the homogeneity and amounts of changes in neck pain, muscle stiffness, and proprioception between the groups. Statistical significance was set at P < 0.05.

3. Results and Discussion

3.1. *General characteristics of the Participants*

No significant differences in sex, age, height, weight, and CVA in the homogeneity test were found between the NVFRG and VFRG (Table 1).

Table 1 Characteristics of the study participants (mean ± SD)

General characteristic		NVFRG	VFRG	P
Sex	Male	7	6	0.54
	Female	5	6	
Age (years)		25.63 ± 2.07	25.31 ± 1.97	0.87
Height (cm)		167.97 ± 10.95	167.44 ± 7.34	0.13
Weight (kg)		66.71 ± 14.20	69.90 ± 10.51	0.35
CVA (degrees)		46.80 ± 0.87	47.37 ± 0.61	0.27

NVFRG: non-vibration foam roller group; VFRG: vibration foam roller group; CVA: craniovertebral angle

3.1. *Comparison of neck pain, muscle stiffness, and proprioception*

Neck pain and upper trapezius stiffness were significantly decreased in the VFRG (P < 0.05; Table 2). However, no statistically significant differences in sternocleidomastoid muscle stiffness and cervical proprioception were found between the groups (P > 0.05; Table 2). No statistically significant differences in all variables were found in the NVFRG (P > 0.05; Table 2).

Statistically significant differences in neck pain and upper trapezius stiffness were found between the NVFRG and VFRG (P < 0.05; Table 2). However, no statistically significant differences in sternocleidomastoid muscle stiffness and neck proprioception were found between the groups (P > 0.05; Table 2).

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Table 2. Comparison of neck pain, muscle stiffness, and cervical proprioception between before and after intervention (mean ± SD)

		NVFRG (n = 12)			VFRG (n = 12)			Between-group change (P)
		Pretest	Posttest	P	Pretest	Posttest	P	
Pain (score)		16.12 ± 2.54	16.51 ± 2.91	0.16	17.65 ± 1.92	19.17 ± 2.80	0.01*	0.04*
Muscle stiffness (N/m)	UT	323.67 ± 60.56	325.52 ± 53.99	0.25	339.18 ± 55.11	321.56 ± 49.78	0.04*	0.03*
	SCM	231.83 ± 40.27	228.26 ± 33.85	0.43	229.17 ± 33.68	225.31 ± 30.68	0.18	0.12
Proprioception (degrees)		3.30 ± 3.26	2.82 ± 2.79	0.14	2.89 ± 1.97	2.56 ± 2.08	0.21	0.25

*P < 0.05.

NVFRG: non-vibration foam roller group; VFRG: vibration foam roller group; UT: upper trapezius muscle;

SCM: sternocleidomastoid muscle

FHP induces a forward slouching of the shoulders and an internal rotation of the upper bone and increases thoracic kyphosis [20]. FHP has been reported to cause beck pain, increase muscle tone and muscle fatigue, and decrease coordination and electrical potentials [21, 22]. Moreover, FHP is a major cause of temporomandibular joint problems, including trigeminal neuralgia and temporomandibular joint dysfunction [23].

Joint range of motion and pain were improved when a vibrating foam roller was applied at 30–50 Hz to the hip joint [24]. Moreover, Cheatham et al. (2019) reported that the joint range of motion and pressure pain threshold were improved upon applying a vibrating foam roller to the knee for 2 min in adults [25].

In the present study, in contrast to the NVFRG, decreased pain and muscle tone were observed in the VFRG. Vibration stimulation induced by the vibrating foam roller is thought to stimulate various receptors, including mechanoreceptors (Golgi tendon organs and muscle spindles), of not only the joints but also the surrounding soft tissue. This suppresses alpha motor units and improves blood circulation, reducing muscle stiffness and pain [26].

Vibration reduces abnormal muscle contraction by repeated contraction and relaxation of the muscles and improves muscle relaxation and the joint range of motion by stimulating the Golgi tendon organ [27]. Tonic vibration stimulus induces the activation of sensory nerve fibers such as the Ia and II fibers of the muscle spindle. As a result, alpha motor neurons are activated, which leads to reflex contractions [28]. This tonic vibration reflex quickly shortens the length of the muscles, increasing the sensitivity to involuntary muscle contractions and relaxations [26].

In this study, neck pain and muscle tone were decreased in the VFRG as compared with the NVFRG. This was thought to result from the improved involuntary relaxation sensitivity on account of the tonic vibration reflex [26,27].

This study has the following limitations. It was conducted only in adults in their 20s. In addition, the sample size was too small to generalize the findings of this study. In the future, the timing and frequency of interventions must be changed to investigate the effects of interventions and to study participants of various age groups.

4. Conclusion

This study applied non-vibrating and vibrating foam roller exercises in 24 patients with FHP in their 20s. Neck pain, muscle stiffness, and cervical proprioception before and after the respective interventions were measured, and the following results were obtained.

Before and after the interventions, statistically significant decreases in neck pain and upper trapezius stiffness were observed in the VFRG. Moreover, statistically significant differences in neck pain and upper trapezius stiffness were observed between the NVFRG and VFRG.

Therefore, the application of a vibrating foam roller exercise in patients with FHP could improve neck pain and muscle stiffness. These findings may be used as basic data for therapeutic exercise programs to treat patients with FHP in the future.

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