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Original Article

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Investigating Self-Stretching Impact on Immediately Improved Cognitive Function

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Purpose: The primary aim of this study is to investigate the potential effects of self-stretching exercises on immediate improvements in cognitive function, with a specific focus on attention and memory.

Methods: Thirty healthy subjects participated in the study, meeting the inclusion criteria of having no musculoskeletal or nervous system diseases and the ability to understand and follow the experiment. Cervical range of motion (ROM) was evaluated. Muscle tone and stiffness were measured using the MyotonPRO system. The self-stretching exercises targeted the upper trapezius, levator scapulae, and sternocleidomastoid muscles. Cognitive function was assessed using the Stroop test for selective attention and a memory screening test. The participants underwent baseline assessments followed by education on self-stretching exercises, after which the assessments were repeated. Data analysis included averaging the results from three repeated trials and performing paired t-tests to determine the significance of differences before and after the stretching exercise. Statistical analysis was conducted with p-values less than 0.05 considered statistically significant.

Results: The results showed significant improvements in cognitive function, cervical ROM, reduced muscle tone, and stiffness following the self-stretching exercises.

Conclusion: This study demonstrates that self-stretching exercises can lead to improved not only cervical ROM, reduced muscle tone and stiffness in specific muscles but also potential enhancements in attention regarding cognitive processing speed.

Keywords: Stretching exercise, Cognitive function, Attention, Memory, Muscle tone, Range of motion

INTRODUCTION

Stretching exercises are often associated with enhancing flexibility and mobility.[1,2] Specifically, it has been well-documented that they can improve flexibility, range of motion (ROM), athletic performance, injury prevention, muscle tension and stress reduction, and posture alignment.[1-4] Therefore, due to these mentioned advantages, stretching exercises are widely used in daily life.

Cognitive function plays a pivotal role in our daily lives as it influences our ability to process information, make decisions, and navigate complex tasks.[5,6] Attention and memory, in particular, are cognitive domains critical for optimal functioning in various areas such as work, learning, and performance.[7,8] Deficits in these domains can have far-reaching consequences, affecting effectiveness.[9] Recognizing the significance of cognitive function, it is essential to identify strategies that can enhance and preserve cognitive abilities.

Exercise is associated with a reduction in stress, anxiety, and depression. Further, physical exercise is associated with elevations in mood states, heightened psychological well-being, and cognitive function.[10,11] Because of aforementioned reason, physical exercise has been extensively investigated for its positive effects on not only physical function but also cognitive function, including improvements in attention, memory, and executive functions.[5,6,8,12] However, the immediate impact of physical activity influence cognitive function is less well documented. Most of the studies addressed the long-term impact of exercise on cognitive performance.[5,6,8,12] Just several studies investigated the acute bouts of exercise benefit for cognitive processes.[10,11] Additionally, most of the research for acute bouts of exercise has focused on the exercise of moderate intensities, such as aerobic activities

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and resistance training.[6,13] The potential cognitive benefits of stretching exercises have received comparatively less attention. Then, there are no studies that have investigated the immediate impact of stretching exercises on cognitive function, including attention and memory, before and after the exercises. Thus, the primary aim of this study is to investigate the potential effects of self-stretching exercises on immediate improvements in cognitive function, with a specific focus on attention and memory.

METHODS

1. Subjects

Thirty healthy subjects without any musculoskeletal or nervous system disease participated in the present study. Participant demographics are summarized in Table 1. The following inclusion criteria were adopted: 1) the absence of any lesion that might have affected the experiment; 2) the ability to understand and follow the experiment; 3) inactive (< 2 days per week of structured physical activity) for at least the previous 1 month; 4) no cognitive deficiency. The study was explained in detail to all participants before commencement and all agreed to participate in the experiment.

2. Apparatus

To evaluate the cervical ROM which confirms the physical benefit from stretching, we used CROM device.[12] The CROM device which is head-mounted equipment consists of a plastic frame placed on the head over the nose and the ears, secured by a Velcro strap. Two independent inclinometers, 1 in the sagittal plane and 1 in the frontal plane, are attached to the frame and indicate the position of the head with respect to the line of gravity. A third inclinometer is positioned in the horizontal plane and indicates the position of the head in rotation, with respect to a reference position. This device can measure cervical ROM for rotation, flexion/extension, and lateral flexion using three separate inclinometers attached to a frame resembling eyeglasses. The participants were seated and instructed to perform neck movements for rotation, flexion, and lateral flexion. After three repeated measurements, the average value was recorded as the outcome.

Table 1. General characteristics of subjects

	Number of subjects	Age (year)	Height (cm)	Weight (kg)	Education (year)
Male	18	21.9 (3.2)	175.8 (5.5)	75.9 (15.8)	13.0 (1.1)
Female	12	22.6 (3.3)	164.7 (6.0)	60.8 (8.5)	13.9 (1.1)
Total	30	22.2 (3.2)	171.3 (7.9)	69.9 (15.1)	13.4 (1.2)

Values represent mean (±standard deviation).

To measure muscle tone and stiffness which confirms the physical benefit of stretching, we utilized the MyotonPRO system (MyotonPRO, Myoton AS, Tallinn, Estonia).[13] The subjects were seated, and the muscle belly was marked.[13,14] The target muscle was set as suboccipital, Levator scapulae, sternocleidomastoid (SCM), and upper trapezius muscle. The idle vibration number of the equipment was set to 5, and the equipment was positioned perpendicular to the marked area. After three repeated measurements, the average value was recorded as the outcome.

3. Self-stretching exercises

Stretches were performed on both the left and right sides of each muscle for three repetitions. A 15s period of stretching was followed by a 10s rest interval. A static self-stretching method was used to stretch the suboccipital, levator scapulae, SCM, and upper trapezius muscles. The stretching method for each muscle was as follows. The participants were asked to sit on a chair and keep their necks elongated. SCM muscle stretching: rotate their head to the opposite side as far as possible within a pain-free range to lengthen the target SCM to a pain-free end range. Then, using their opposite hand placed just above the ear, they applied a final stretch without causing pain. Upper trapezius muscle stretching: Sitting with the ipsilateral hand behind the back to stabilize the scapula. Instruct the participant to rotate his neck toward the target side, then side bend away from the target side and then add neck flexion. The participant was asked to use the contralateral arm to grasp his or her own head to apply the stretch. Levator scapulae: Sitting with head side bent and rotated away from the target side. To stabilize the scapula, have the participant reach down and back with the hand on the target side and hold onto the seat of the chair. The other hand is placed on the head to gently pull it forward and to the side in an oblique direction opposite the line of pull of the target muscle. Suboccipital muscle: Instruct the participant to first perform a chin tuck (axial extension), then nod the head, bringing the chin toward the larynx until a stretch is felt in the suboccipital area.[14]

4. Stroop test

The Stroop test which is freely available on the Web (http://psychtoolbox.org/) was well known to measure cognitive function, especially selective attention.[15,16] Thus, the Stroop test was widely used to measure attention. Before the test participants received enough description regarding the Stroop test method and could have time to practice the Stroop test for 1 minute. Specifically, the named color-word (CW) condition in the Stroop test was used in the present study. Color-word is printed in an inconsistent

color ink (for instance the word "red" is printed in green ink). Thus, in this incongruent condition, participants are required to name the color of the ink instead of reading the word as quickly as possible. In other words, the participants are required to perform a less automated task (i.e., naming ink color) while inhibiting the interference arising from a more automated task. Finally, the outcome was measured as response time (ms) and accuracy score (40/40).

5. Memory test

The present study chose the memory screening test (i.e., visual episodic memory test) to evaluate memory ability, as this test is widely used for measuring memory. It is freely available on the Web (https://www.cognifit.com/memory-test). Before the test, participants were provided with a thorough description of the memory test method and were given time to practice the test for 1 minute. In this study, participants are presented with 50 images taken from a pool of 25 unique ones. The participant must tap the screen or press the button as soon as possible if they recognize the image as having been previously presented during earlier trials of the test. Otherwise, they must wait 3 seconds until the next image is shown. The outcome was measured in terms of response time (ms) and accuracy score (50/50).

6. Protocol

Subjects underwent four tests: The Stroop test, memory test, muscle tone and stiffness measurement, and neck ROM measurement, as a baseline assessment on the first day. On the second day, participants received education on self-stretching exercises and performed the exercises themselves. After the self-stretching session, participants underwent the four tests again to mitigate the learning effect. The order of the four tests was randomized. To minimize the learning effect there is at least 48-hour period between the first day and the second day.

7. Data analysis

The data for cervical ROM, muscle tone, and stiffness were averaged from three repeated trials. The Shapiro-Wilk test was used to assess the normal distribution of the participants. A paired t-test was performed to compare the cervical ROM, muscle tone and stiffness, scores, and response time of the memory test and Stroop test before and after the stretching exercise to determine the significance of the differences. These statistical analyses were conducted using IBM SPSS Statistics 22 (IBM Corp., Armonk, NY, USA). Statistical significance was accepted for p-values less than 0.05.

RESULTS

The results regarding the changes in cervical ROM are presented in Table 2. After the stretching exercises, neck flexion, extension, and left and right rotation showed a significant increase compared to before the exercises. However, there were no significant differences in lateral flexion.

Table 3 displays the muscle tone and stiffness results before and after the stretching exercises. The suboccipital muscle exhibited a significant decrease in both muscle tone and stiffness, except for the right side of

Table 2. Changes in cervical ROM

Motion	Condition	ROM	p
Neck flexion	Before	33.83 (9.61)	0.049*
	After	37.73 (6.38)	
Flexion	Before	54.14 (7.53)	0.003*
	After	59.00 (7.51)	
Lateral flexion (left side)	Before	39.55 (7.97)	0.786
	After	39.96 (6.60)	
Lateral flexion (right side)	Before	39.22 (7.97)	0.754
	After	39.67 (5.95)	
Rotation (left side)	Before	60.17 (9.50)	0.008*
	After	65.21 (7.08)	
Rotation (right side)	Before	60.00 (9.52)	0.048*
	After	63.41 (6.69)	

Values represent mean (±standard deviation). *Significant difference between before and after stretching exercises ($p < 0.05$).

Table 3. Changes in muscle tone and stiffness

Target muscle	Condition	Muscle tone (Hz)	p	Stiffness (N/m)	p
Suboccipital muscle (right)	Before	17.89 (2.18)	0.075	370.91 (80.28)	0.004*
	After	17.33 (1.33)		330.47 (31.75)	
Suboccipital muscle (left)	Before	17.89 (2.16))	0.003*	354.18 (59.45)	0.001*
	After	16.97 (1.28)		318.33 (28.57)	
Levator scapulae (right)	Before	14.45 (1.05)	0.036*	227.01 (34.65)	0.006*
	After	14.14 (1.02)		214.70 (33.98)	
Levator scapulae (left)	Before	14.28 (1.07)	0.413	220.03 (35.40)	0.634
	After	14.39 (1.04)		222.13 (35.51)	
SCM (right)	Before	13.11 (0.73)	0.765	206.78 (17.12)	0.656
	After	13.15 (0.73)		205.30 (18.32)	
SCM (left)	Before	13.44 (0.82)	0.829	213.16 (18.51)	0.481
	After	13.40 (0.87)		210.22 (20.20)	
Upper trapezius (right)	Before	16.42 (0.97)	0.246	280.01 (28.74)	0.570
	After	16.59 (0.93)		282.68 (28.28)	
Upper trapezius (left)	Before	16.95 (1.02)	0.361	284.01 (61.35)	0.330
	After	18.27 (7.51)		296.22 (30.27)	

Values represent mean (±standard deviation). SCM: Sternocleidomastoid. *Significant difference between before and after stretching exercises ($p < 0.05$).

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Table 4. Result of Stroop and memory test

Test	Condition	Score/Trial	p	Response time (ms)	p
Stroop test	Before	38.80 (3.93)/40	0.234	1,860.01 (497.79)	0.019*
	After	39.63 (1.10)/40		1,668.01 (383.83)	
Memory test	Before	46.10 (3.10)/50	0.507	840 (160)	0.385
	After	46.53 (2.24)/50		820 (110)	

Values represent mean (±standard deviation). *Significant difference between before and after stretching exercises ($p < 0.05$).

muscle tone. The right side of the levator scapulae muscle showed a significant decrease in both muscle tone and stiffness. However, no significant differences were observed in the SCM and upper trapezius muscles regarding muscle tone and stiffness.

Table 4 presents the comparison of cognitive function test results before and after the stretching exercises. There were no significant differences in the memory test response time and scores. However, there was a significant decrease in response time for the Stroop test. Interestingly, there were no significant differences in scores for the Stroop test.

DISCUSSION

The present study aimed to investigate the effects of self-stretching exercises on immediate improvements in cognitive function, specifically attention, and memory. The summary of results showed significant improvements in cognitive function, cervical ROM, reduced muscle tone, and stiffness following the self-stretching exercises. The improvements were particularly notable in neck flexion, left rotation, and right rotation. The stretching exercises also resulted in significant decreases in muscle tone and stiffness, specifically in the suboccipital and right levator scapulae muscles, indicating a relaxation effect. Additionally, there was a significant decrease in response time observed for the Stroop test, indicating improved cognitive function.

The findings of this study contribute to the existing literature by highlighting the benefits of stretching exercises on cervical ROM, muscle tone and stiffness, and certain aspects of cognitive function, even when performed through self-stretching.[2] The improvements in cervical ROM suggest that stretching exercises effectively enhance joint mobility and flexibility.[2,15] The reduction in muscle tone and stiffness in specific muscles implies that stretching exercises can alleviate muscle tension and promote relaxation in targeted areas.[16,17] Furthermore, despite being self-performed, the study observed immediate improvements in cognitive function, particularly attention and cognitive processing speed. These findings align with previous research that demonstrates the positive impact of physical activity, including aerobic activities and resistance training, on cognitive function.[5,6,8,12] Additionally, a previous study concluded that the immediate effect of walking (about 20 minutes) exercise has a positive influence on reaction time related to processing speed.[11] Furthermore, meta-analysis review studies regarding acute bout of exercise concluded that exercise should affect response speed.[10] Such studies have consistently reported improvements in attention and memory alongside physical improvements. Therefore, self-stretching exercises can have an immediate positive effect on cognitive function, especially processing speed which is regarded as a key component enhancing cognitive function.[18]

However, the self-stretching exercise did not yield significant results in lateral flexion ROM, muscle tone, and stiffness in the SCM and upper trapezius muscles. Previous studies have reported that performing self-stretching exercises for 1 repetition lasting 30 seconds, 3 days per week, is insufficient to significantly increase ROM.[19] Therefore, these results could be attributed to the self-stretching exercises being of short duration. Additionally, the results of the memory tests, including scores and response times, as well as the Stroop test score, did not show any significant differences. It is important to note that the memory test used in this study was designed for patients with cognitive function deficits. Before the self-stretching exercise, participants already exhibited high scores and response speeds in the memory test, as the test was relatively easy for them (average education year: 13.37). A previous study reported that reaction time increased as test difficulty increased.[11] Thus, it is difficult to present the significant difference.

Although the study provided valuable insights, it is important to acknowledge certain limitations. The sample size was relatively small, and the participants were healthy individuals without any musculoskeletal or nervous system diseases, limiting the generalizability of the findings. Additionally, the study focused on immediate effects after a single session of stretching exercises, and the long-term effects regarding the cognitive function of stretching exercises remain to be explored.

In conclusion, the results of this study demonstrate that self-stretching exercises can lead to improved not only cervical ROM, reduced muscle tone and stiffness in specific muscles but also potential enhancements in attention regarding cognitive processing speed. These findings support the inclusion of stretching exercises in rehabilitation programs and physical activity routines to optimize joint function, muscle flexibility, and cognitive performance. Further research is needed to explore the long-term effects of cognitive function and optimal protocols of stretching exercises

in different populations and contexts.

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