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Research Article

The Effects of Reactive Neuromuscular Training on the Upper Quarter Posture in Students with Forward Head Posture: A Randomized Clinical Trial

Hamed Noori[1], MSc; Rahman Sheikhhoseini[1*], PhD; Rasoul Eslami[1], PhD; Moosa-Reza Ghorbani[1], MSc candidate

[1]Faculty of Physical Education and Sport Sciences, Allameh Tabataba'i University, Tehran, Iran

Corresponding author:* Rahman Sheikhhoseini, PhD; Faculty of Physical Education and Sport Sciences, Allameh Tabataba'i University, Western Azadi sport complex boulevard, Hakim Highway, Tehran, Iran. **Tel: +98-21-48394134; **Email:** Rahman.pt2@gmail.com

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Abstract

Background: Reactive neuromuscular training (RNT) is a training method used in rehabilitation. However, its effectiveness on forward head posture (FHP) is still unknown. This study aimed to compare the effects of traditional training with 8-week RNT on the craniovertebral, shoulder, and kyphotic angles in high school students with FHP.
Methods: In this randomized clinical trial, conducted in Urmia city, Iran (2018), we selected a total of 60 male high school students using a convenient sampling technique. We assigned the subjects to one control group and two experimental groups; one of the experimental groups performed traditional exercises while the other did RNT. After the pre-test, the training program performed three days a week under the supervision of a researcher. Posture assessment carried out in two steps: prior to training (pre-test data) and after eight weeks of training (post-test data). We applied a photogrammetric method to evaluate the sagittal angles of the neck and shoulder. Moreover, we conducted the ANCOVA test at a significance level of $P<0.05$ to analyze the data.
Results: Both training methods improved trunk posture ($F=156.07$, $P<0.001$) and the sagittal angles of the neck ($F=35.35$, $P<0.001$) and shoulder ($F=23.31$, $P<0.001$); however, RNT was more effective than the traditional type of training ($P<0.001$).
Conclusion: Eight weeks of traditional and RNT exercises enhanced kyphotic, shoulder, and craniovertebral angles. It seems that RNT might have a better outcome in the management of high school students with FHP.

Keywords: Exercise therapy, Neck, Head, students

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1. Introduction

Often neglected by public health experts, body posture is an important part of body's natural balance (1). Optimal body alignment refers to the proper placement of the spinal column bones and joints so that the muscles and ligaments act naturally; this, in turn, results in the relative coordination of different body parts with each other (2). Thus, incorrect postures might be associated with abnormal muscle activity, and postural correction could contribute to the normal functioning of the internal organs and the nervous and respiratory systems (3). In addition to physical complications, poor posture seemingly had an association with psychological aspects in elementary school students (4). When a component in a system does not function optimally , the entire system is in danger (5). Hence, correcting postural malalignments was considered as a health-promoting method, particularly for younger individuals (6-11).

Forward head posture (FHP) is an inappropriate posture observed in all ages; it was hypothesized that this posture might be associated with several muscle imbalances (3). The overall prevalence of FHP was reported to be 66% in computer-based workers (12). Nowadays, with the frequent use of computers, the prevalence of such postural problems is growing (12). The most common FHP malalignments comprise disorders in the temporomandibular joint, postural control impairment, respiratory issues, and cervical headaches (13). The harmful effects and prevalence of FHP have made it necessary to correct postural malalignments (7).

Because FHP is a postural abnormality, corrective exercises can be effective in its management. In previous studies, different exercises were used to correct this disorder (6, 7, 14). Cho and colleagues investigated the effects of mobility exercise versus stabilization exercise combined with the upper thoracic mobilization; they observed a significant improvement in the craniovertebral angle of subjects with FHP (15). Lee and colleagues found that McKenzie, Kendall, and stretching exercises positively affected the craniovertebral angle (16).

Reactive neuromuscular training (RNT) is a novel technique for improving postural abnormalities. The RNT program is designed to restore dynamic stability and motor control (17). Reactive RNT techniques, along with other common methods for correcting postural abnormalities, are used for optimal efficacy (18, 19). To our knowledge, there is no research regarding the effects of RNT on the management of students with FHP.

Accordingly, the present study aimed to answer this question: in comparison with the control group and traditional exercise, is RNT training more effective in correcting craniovertebral, shoulder, and kyphotic angles in students with FHP?

2. Methods

This study was a randomized clinical trial. The statistical population consisted of male high school students with FHP in Urmia city, Iran. Via convenience sampling method, we selected 60 students aged 14-18 years who volunteered. Afterwards, we allocated the participants to one of three study groups based on simple blocked random method (20 participants per each group), (Figure. 1). All participants received oral and written information concerning the research methodology, and their parents signed informed consent forms. We excluded those with a history of structural scoliosis, heart disease, or other diseases that could interfere with the research. We assigned 15 participants to each group (using 47.77±2.18 for pretest and 37.72±2.05 for post-test) according to a previous study (11), considering α=0.05 and power of 80%, and based on the craniovertebral angle in the corrective exercise group by use of G*Power software (Erdfelder, Faul, and Buchner, 1996, ver 3.1). Considering the possible dropouts, we finally placed 20 participants in each group. The Research Ethics Committee of the University of Social Welfare and Rehabilitation Sciences approved all research processes and methods (coded IR.USWR.REC.1397.138).

We screened the subjects and randomly divided them into control, traditional exercises, and RNT groups (N=20 for each group). We ensured the subjects about the confidentiality of the data; also, the participants were able to leave the research whenever they desired. At the beginning of the study, we performed pre-test measures in all groups. Following the pre-test, the training programs prescribed for both interventional groups under the supervision of the same trainer for three days per week. We planned the first two weeks of training to familiarize the participants with exercise protocols. Postural assessments performed eight weeks

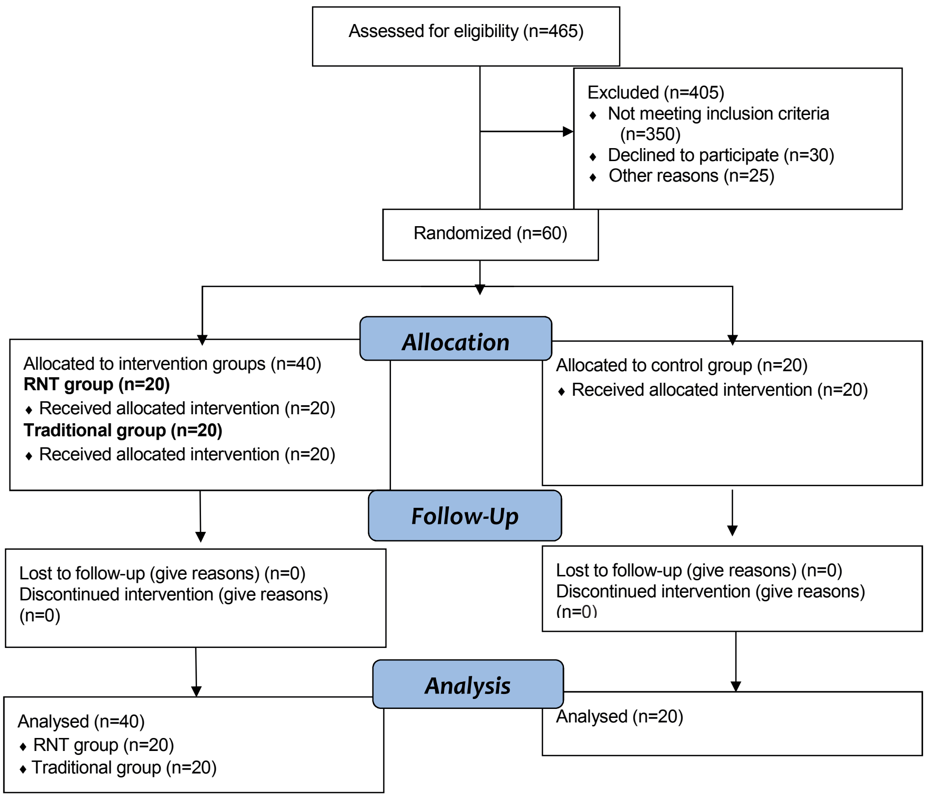

Figure 1: CONSORT flowchart of the participants

after the start of the exercise (post-test data). We measured the height and weight of the subjects with tape measure mounted on the wall and a digital scale, respectively. The photogrammetry method was also used to assess the position of head and neck in standing position. The previous studies confirmed the reliability and validity of this method (20, 21). In the same way, we placed a digital camera at a distance of 1.5 meters from the subjects in a fixed position on the lateral side of the body in the frontal plane. We adjusted the camera height to the participants' shoulder level. The subjects were asked to bend and stand straight three times and look at a point on the front wall at the height of their eyes; next, the examiner took a picture three times. Finally, we processed the images by AutoCAD software and obtained the average angles. A person oblivious to the subject groups obtained the data from images.

Craniovertebral Angle: The angle between the line connecting the C7 to the ear tragus and the horizontal line from the spinous process of C7.

Shoulder Angle: The angle between the line connecting the acromion midpoint and C7 vertebrae and the horizontal line passing through the acromion midpoint.

Kyphotic angle: Based on a previous study, we used a flexible ruler with 50 cm length and 2 cm width to measure the thoracic kyphotic angle from the spinous processes of T2 to T12.

RNT: This is a series of rehabilitation techniques designed to restore dynamic stability and motion control. These exercises should be performed with the least amount of verbal command because trainers may worsen a wrong pattern by use of a claw or rope. In this research, we prescribed a variety of exercises similar to traditional ones. The pattern of these trainings is similar to traditional exercises. The difference is that a participant must place the head and neck in neutral position before performing the exercise and move against the resistance that the trainer inserts to exaggerate postural deformity.

Traditional exercises: In the present study, a set of stretching and strengthening activities prescribed similar to RNT but without feedback for posture correction before starting the exercises.

I. Shoulder lateral rotation in side-lying: While the participants were lying on side position, they were asked to fully adduct and internally rotate the arm with keeping the elbow at 90° flexion. They were Then asked to move the hand towards the ceiling (shoulder lateral rotation).

II. Shoulder horizontal abduction with lateral rotation in the prone position: We asked the participants to lie in a prone position while keeping the arm in horizontal abduction. Afterwards, they were asked to perform arm horizontal abduction while keeping the elbow in extension and the arm in lateral rotation. The participant performed this movement through keeping the neutral position of the head/neck and squeezing bilateral scapulae together.

III. Y to I: While the participants were in prone position with their arms positioned at 90° of abduction, they were asked to retract both scapulae. As the subjects advanced to form Y, they were asked to laterally rotate the shoulders and flex the elbow to 90°. Next, they fully moved both arms to bilateral elevation and both elbows to extension in order to form I.

IV. Chin tuck: We asked the participants to hold maximal craniocervical flexion. This exercise activates the deep neck flexor muscles. The exercise was performed in the supine position with the head resting on the floor.

V. W: The subjects lay on the back of the arm and put their arms and elbows in a horizontal abduction along with a 90 ° bend. They stretched their hands towards the roof and simultaneously threw the chin in.

VI. Static stretching of sternocleidomastoid: While the participants were in an upright standing position with the right upper extremity placed behind the body, they were asked to depress the right shoulder, contract the abdominal muscles, and perform chin tuck. After that, we asked them to move the left ear to the ipsilateral acromion with right head rotation. The participants were allowed to use the left hand for movement guidance and adding some slight pressure on the muscle. The exercise was then done on the opposite side.

VII. Cat stretch: The subjects were asked to assume a quadruped position and pull the body back as far as possible. Stretching exercises were performed in three sets of up to 30 seconds in both groups until the first sensation of pain or stretch was felt. Strengthening training was further done in three sets with eight to 12 repetitions in both groups.

Table 1: Comparison of participants' demographic characteristics using one-way ANOVA					
Variables	**Control group (Mean±SD)**	**Traditional exercise (Mean±SD)**	**RNT group (Mean±SD)**	**F**	**P-value**
Weight (kg)	53.43±9.29	50.47±8.32	51.61±9.05	0.563	0.573
Height (cm)	158.30±8.81	155.78±6.52	160.97±7.98	2.197	0.120
BMI	21.37±3.67	20.84±3.61	19.93±3.22	0.865	0.426

SD: standard deviation CM: centimeters, Kg: kilograms, BMI: body mass index

Table 2: Comparison of upper quarter postural measures in three groups at two time points (before training, after eight weeks of training) using ANCOVA

	Time	Control group (Mean±SD)	Traditional group (Mean±SD)	RNT group (Mean±SD)	F	P value
CVA	Before exercise	1.73±35.05	2.11±34.50	2.15±33.35	35.35	<0.001*
	After 8 weeks	2.97±34.75	1.53±38.40	1.45±40.00		
SA	Before exercise	2.42±45.75	2.64±45.45	2.77±44.70	23.31	<0.001*
	After 8 weeks	1.83±46.75	2.00±48.85	1.98±50.55		
Kyphosis	Before exercise	3.44±52.50	3.81±52.80	2.32±53.40	156.07	<0.001*
	After 8 weeks	3.45±53.45	3.66±48.45	2.29±45.00		

*Statistically significant differences were observed. CVA: craniovertebral angle, SA: shoulder angle, CA: cranial angle, SD: standard deviation

Table 3: The results of Bonferroni's post-hoc tests for the pairwise comparison of craniovertebral, shoulder, and kyphotic angles

Variables	Pairwise comparisons	Mean Difference	SD	P value
CVA	RNT-Traditional	1.89	0.67	0.020*
	RNT-Control	5.67	0.69	<0.001*
	Traditional-Control	3.79	0.66	<0.001*
SA	RNT-Traditional	1.88	0.590	0.007*
	RNT-Control	4.05	0.594	<0.001*
	Traditional-Control	2.17	0.587	0.001*
Kyphosis angle	RNT-Traditional	-3.96	0.52	<0.001*
	RNT-Control	-9.21	0.523	<0.001*
	Traditional-Control	-5.23	0.520	<0.001*

*Statistically significant differences were observed. CVA: craniovertebral angle, SA: shoulder angle, CA: cranial angle, SD: standard deviation

Method of Determining 1 Rep Max (1RM)

We used the Brzycki equation to specify one repetition maximum. A good validity was reported for this equation (22). To obtain the 1 RM of the subjects with their initial estimate, they were asked to select the weights and perform the movement until exhaustion; after that, we estimated the 1 RM via placing the lifted weight and the number of repetitions in the Brzycki equation. The participants were also asked to perform strengthening exercises by adding free weights with 30% of 1 RM at the distal joint of movement arms.

1RM=Weight lifted (Kg) / (1.028 – (the number of reps performed * % 0278))

In this research, we used SPSS software version 23. O**ne-way ANOVA and** ANCOVA tests analyzed the data at a significance level of 0.05. Furthermore, we employed the Shapiro Wilk test to examine the normality of data distribution.

3. Results

At the end of the study, 60 participants took part in the post-tests (N=20 for each group). Table 1 summarizes the demographic data of the study participants. There were no significant differences among groups in terms of demographic data (P>0.05).

We used the analysis of covariance to analyze the data. The results showed that eight weeks of traditional and RNT exercises were effective in improving craniovertebral (P<0.001), shoulder (P<0.001), and kyphotic (P<0.001) angles of students with FHP (Table 2). We conducted the Bonferroni's post-hoc test to draw pairwise comparisons among the three groups. Based on the results, there was a significant difference between RNT and control, and RNT and traditional groups regarding all study variables (Table 3).

4. Discussion

Based on the results, both traditional and RNT exercises influenced the craniovertebral, shoulder, and kyphotic angles in high school students, but it seems that the effectiveness of RNT exercises was more than the traditional ones.

In addition, eight weeks of traditional and RNT trainings affected the correction of craniovertebral angle in students with FHP, which is in agreement with other studies (7, 23). Previous studies showed that head posture improved by corrective exercises (6-8, 24). Kang and colleagues found that respiratory feedback exercises and McKenzie were able to improve the craniovertebral angle and the activity of sternocleidomastoid muscles (25).

In the current study, traditional exercises and RNT had significant effects on the shoulder angle of students with FHP, which is consistent with the results of previous studies (7, 26). HajiHosseini and colleagues prescribed six-week strength, stretching, and comprehensive corrective exercises for female students with FHP. They found a significant reduction in forward head angle concerning all three types of exercises (strength, stretching, and combination) (27). One study examined the efficacy of feedback respiratory exercises; it was found that the electromyographic activity of the selected cervical muscles, craniovertebral angle, and average scores of neck disability index were enhanced in patients with FHP (25). Lynch and colleagues studied the effect of therapeutic exercises on FHP in elite swimmers. They observed that FHP severity significantly decreased with exercises (26).

Our results indicated that traditional stretching exercises and RNT reduced the kyphotic angle in students with FHP, which is in line with the findings of other studies on the possible effects of exercise training on kyphotic angle (11, 28).

The present results, for the first time, showed that RNT training had more impact on all study variables compared with traditional exercises. Some of the previous studies examined the effectiveness of RNT in different medical conditions. For instance, John Guido reported the effect of RNT exercises on shoulder instability (17). Lutch and colleagues observed that RNT techniques could significantly improve hamstring muscle shortening in athletes (19). In other studies, the effectiveness of RNT was reported in patients with Parkinson's disease (18) and those suffering from back pain (29).

The purpose of the RNT program is to stimulate the muscle and joint receptors so that maximum neural signals may regulate CNS output signals. The RNT program involves performing multi-joint and closed-chain exercises, providing a wide range of movements without pain in the rehabilitation (18). Moreover, it seems that the RNT training accelerates muscle contractions, thereby helping athletes recover faster (29).

The present study had no follow-up periods. Therefore, it is suggested that future research include one to assess the durability of these exercises. Furthermore, in our study, the exercises were performed by students who had no pain in the cervical region; thus, the effectiveness of these exercises in people with physical pain is questionable. On the other hand, we conducted these exercises only on high school students; therefore, these results may not be generalizable to adults or children; future research should also consider exercises in postural correction protocols.

6. Conclusion

The results of this study showed that both traditional and RNT exercises affected the craniovertebral, shoulder, and kyphotic angles in high school students; however, the effectiveness of RNT exercises seemed to be more than the traditional ones.

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Ethical Approval

The Research Ethics Committee of the University of Social Welfare and Rehabilitation Sciences approved all research processes and methods regarding ethical considerations (coded IR.USWR.REC.1397.138).

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