Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

The Effect of Eight-Week Water-Based Corrective Exercises on Forward Head, Rounded Shoulder, Thoracic Hyperkyphosis Posture, and Neck Pain: A Randomized Controlled Trial

Hossain Ahmadi
Bu Ali Sina University
Ali Yalfani (aliyalfani2019@gmail.com)
Bu Ali Sina University https://orcid.org/0000-0003-3696-7208
Farzaneh Gandomi
Razi University

Research article

Keywords: Forward head, Rounded shoulder, Hyper kyphosis, Water-Based, Neck pain

Posted Date: December 16th, 2019

DOI: https://doi.org/10.21203/rs.2.18600/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Abstract

Background: The lifestyle and long-term use of communication technologies have led to the prevalence of neck pain and concurrent forward head posture (FHP), Rounded shoulder posture (RSP), and hyperkyphosis (HK) deformities. The present study aimed to determine the effects of the eight-week water–based corrective exercises on FHP, RSP, HK deformities, and neck pain.

Methods: After screening the 200 students, 30 students with FHP, RSP and HK were selected. They were assigned randomly to experimental (n=14) and control (n=16) groups. Imaging from lateral view and AutoCAD software were used to evaluate the FHP and RSP angles and HK was measured by flexible ruler. Moreover, Visual Analog Scale (VAS) was used to assess shoulder, and neck pain. These variables were assessed before and after 8-week intervention period.

Results: statistical analysis indicated a significant group by time interaction in the FHP (P=0.001), RSP (P=0.001), HK (P=0.001) angels and in terms of the pain (P=0.001) which indicated a decrease in kyphosis and forward head angels, and Rounded shoulder displacement. But no significant decrease was observed in control group measures (all P>0.05).

Conclusions: Based on the results, probably performing 8-week corrective exercises in the water environment could have more effect on FHP, RSP, HK angels decreasing and neck and shoulder pain reduction. This corrective exercises protocol can be suggested to professionals in order to correct these concurrent malalignments.

Trial registration: The protocols were also registered in the Iranian Registry of Clinical Trials (Registration no.: IRCT20170615034554N2). https://www.irct.ir/trial/26381. 2018-05-07.

1. Background

Muscle imbalances occur when muscles weaken, tighten, or become inhibited, thereby leading to soft tissue changes that may result in impaired patterns of movement [1]. Prolonged repetitive motions and poor postures have been emphasized as causing defects and alterations to motor patterns [2]. One of the most common muscle imbalances in the upper extremity are concurrent postural deformities, such as Forward Head Posture (FHP), Rounded Shoulder Posture (RSP) and Hyper Kyphosis (HK) [3]. These deformities have become typical postural problems because of recently formed lifestyle patterns, such as the long-term use of cellphones, computers, and laptops [4]. These postural malalignments are characterized by tight and short posterior superior and anterior chest muscles as well as weakened and elongated middle and inferior trapezius, serratus anterior, and longus colli muscles [3]. These muscle imbalances result in extensive changes, including FHP, increased cervical lordosis, thoracic kyphosis, RSP, scapular winging, abduction, and decreased stability in the glenohumeral joint [2]. When exacerbated, these postural problems give rise to poor breathing patterns, pain accompanying deep breathing, difficulty swallowing, chronic headaches, decreased lung volumes, and reduced cervical flexor and extensor muscle endurance [5–13].

The above-mentioned skeletal deformities have been examined in previous research, which also introduced approaches to correcting the malalignments [14–16]. However, these defects were explored separately despite the fact that many people experience RSP, FHP, and HK simultaneously as a result of repeated movements and sustained misalignments associated with everyday activities. Recent studies also focused on correcting these deformities individually through intensive stretching–strengthening exercises [14–18], disregarding the reality that these deformities are linked conditions [3, 19–21]. Some other studies used therapeutic regimens, such as physiotherapy combined with corrective exercises, but their results cannot be attributed to the corrections alone [22]. A more effective approach is for a therapist to prescribe integrated corrective interventions for the aforementioned deformities. Specialists should also look into the potential advantages presented by the water-based correction of such deformities.

Given the lack of investigations into rehabilitative physical activities performed in water for concurrent deformities in the upper extremity, the present study examined the benefits of these interventions to uncover strategies for correcting such deformities. The researchers have hypothesized that implementing corrective exercises in a water environment can serve as effective rehabilitation for people suffering from FHP, RSP, HK, and neck pain.

2. Method

2.1 Study design

We conducted an assessor-blinded, parallel-group (1:1 allocation ratio) randomized controlled trial. Data were collected at the Sport Rehabilitation Laboratory. The study's protocols were approved by the research ethics committee of the Medical Sciences (Registration no.: IR.UMSHA.REC.1395.470). The protocols were also registered (Registration no.: IRCT20170615034554N2). The subjects provided informed consent forms.

2.2 Participants

Community participants were recruited between Jun 2018 and October 2018. They were screened using the posture assessment grid. RSP and FHP were defined as the anterior displacement of the middle point between the anterior borders of the acromion and tragus in relation to a vertical reference line, and HK was defined as the posterior displacement of the middle point between the thoracic curve apex in relation to a vertical reference line [23]. The inclusion criteria were an FHP >46 degrees; an RSP >52 degrees [24] and kyphosis >42 degrees [25]; pain in the head and neck, shoulder, and spine during laptop or cellphone use; and an age range of 18 to 22 years old [26]. The exclusion criteria were a history of elite exercise; membership in professional sports clubs; a history of fractures, surgery, or joint diseases, especially in the spine, shoulder girdle, and pelvis; skeletal malalignment in the ankle and knee; visual impairment irreparable through glasses; vestibular system impairment; obesity, water allergy, respiratory problems, or cardiovascular disease; and a history of migraines and analgesic usage. The screening identified 34 eligible subjects with concurrent deformities (Fig. 1). G*Power 3.1 software [27], a testing power of 0.85, an effect size of 0.8, and a significance level of 0.05 were used to estimate the minimum sample size, which, for this study, was 12 [27,28]. Allowing for the possibility of dropouts, we selected all the 34 individuals and divided them randomly into experimental (17 males) and control (17 males) groups (Table 1). Out of this sample, four withdrew from participation for various reasons, leaving us with a final sample of 30 (14 in the experimental group and 16 in the control group).

Fig. 1. CONSORT flow diagram *(insert here)*

2.3 Randomization and Masking

The subjects were randomized using the Random Number Generator, after which they were assigned to experimental and control groups on the basis of allocation concealment via the sequentially numbered, opaque sealed envelopes method by an uninvolved person and stored in a locked location. Another independent person opened the next sequential envelope and informed the therapist of treatment allocation by phone. The assessor was unaware of the exercises and interventions prescribed for the groups, but blinding could not be imposed on the subjects and the statistician with respect to the correctional training and the grouping and their assigned exercises, respectively.

2.4 Interventions

Water-Based Corrective Exercises

Previous research recommended treatment to be performed in three stages: the normalization of peripheral structures (inhibition), the restoration of muscle balance (elongation and activation), and the facilitation of afferent system and sensory motor training (integration) [3]. In the present study, the exercises involved over the course of these steps were carried out in a water environment. In the first stage, trigger points were released through massage in water, and the myofascial release of stiff muscles was induced using a foam roller. In the second stage, static stretching exercises were implemented to relieve muscle tightness. Given the tightness in respiratory accessory muscles owing to concurrent deformities, muscle stretching was combined with corrective exercises related to breathing patterns. Then, strengthening exercises (activation) were performed. Finally, proprioceptive exercises were conducted for neck and shoulder joints. Because the last stage of the interventions was functional (integrative) in nature, the subjects were asked to participate in a game in water while assuming correct posture. The eight-week training program involved three sessions per week, which comprised warm-up exercises (10–15 minutes), water-based corrective exercises (35–45 minutes), and cool down activities (5–10 minutes) (Appendix 1).

2.5 Outcome measures

2.5.1. FHP and RSP Postural Assessment

Imaging, which has been used in numerous studies, has been found to exhibit good reliability [16, 24 and 29]. In the current work, lateral view images were used to evaluate FHP and RSP angles. Three anatomical landmarks (the tragus, C7, and the acromion) were marked (Fig. 2), and a digital camera (Sony Cyber-shot DSC-RX100VI, Japan) mounted on a tripod was placed at a distance of 265 cm from the wall, aligned with the shoulder of a subject. He was then asked to stand in a position with which he was completely comfortable and directed to look at the point (a cross) on the wall (eyes along the horizon). After five seconds, the examiner took three images from the lateral view [16] and inputted them into a computer. AutoCAD 2013 was used to measure the angle of the perpendicular line connecting the tragus to C7 (FHP angle) and the angle between the perpendicular line running from the acromion process to C7 (RSP angle). The means of three angles obtained for each deformity were recorded as the desired angles for FHP and RSP (Fig. 2) [16, 24].

Fig. 2. Calculation of FHP and RSP angles using AutoCAD software *(insert here)*

2.5.2. Measurement of Thoracic Kyphosis Angle

Different studies showed that a flexible ruler has better sensitivity and validity (r = 0.72) than that exhibited by a radiograph [30, 31]. Accordingly, the present research employed a flexible ruler (24-inch Staedtler Mars, Nurnberg, Germany) in measuring thoracic kyphosis angles. Before measurement was initiated, the T2 and T12 vertebrae were marked. First, the T2 vertebra was identified by asking a subject to flex his head forward, at which position the spinous processes of the C6 and C7 vertebrae could be visibly recognized. The examiner placed two index and middle fingers on these segments, and as the subject returned to a normal posture. The remaining spinous process was thus indicated as relating to C7. Counting was subsequently initiated from the spinous process of C7 downward to determine the location of the T2 vertebra. Second, to identify the spinous process of T12, the examiner touched the lower edge of the 12th rib on two sides using his thumb and then simultaneously moved two fingers on both sides of the body upwards and inwards until the rib disappeared. The distance between the two fingers was connected, and the middle point was marked as the spinous process of T12 [32]. The ruler was placed on T2 and T12 and placed entirely on the spine by hand. The curvature was drawn on A3 paper, and the kyphosis angle was measured using equation (1) (Fig. 3) [33]. The ICC of the flexible ruler was 0.92 [34].

[Due to technical limitations, the formula could not be displayed here. Please see the supplementary files section to access the formula.]

Fig 3. Measurement of kyphosis angle using flexible ruler *(insert here)*

2.5.3. Assessment of Neck and Shoulder Pain

The intensity of neck and shoulder pain was assessed using a 10 cm visual analog scale (VAS), which presents good reliability and validity (intraclass correlation = 0.92) [35]. Along this scale, 0 indicates the absence of pain, 1 denotes minimal pain, and 10 is equivalent to intolerable pain. The participants were asked about the severity of pain that they experience during daily activities, when they use a mobile phone or laptop for a long time, and when they study for long periods. The intensity of subjective pain was measured before, during, and after the interventions.

2.6 Statistical Analysis

The Shapiro–Wilks test and Levene's test were carried out to assess the normal distribution of data and the homogeneity of variances. An independent sample t-test was performed to evaluate intergroup differences before the interventions. Repeated measures ANOVA with a 2 × 2 (group × time) mixed design was used to analyze intergroup changes over time. Cohen's *d* was adopted in calculating effect size in the pre- and post-test comparison. Values of 0.01, 0.06, and 0.14 were regarded as corresponding to small, moderate, and considerable effects, respectively [36]. The data were analyzed using the SPSS software (version 20), and a P value of 0.05 was considered statistically significant.

3. Results

Data distribution in the two groups was normal (P>0.05), and variances were homogeneous (P> 0.05). The results of the comparison of demographic characteristics and HK, RSP, and FHP angles in the pre-test for the experimental and control groups are presented in Table 1. The independent sample t-test showed that these elements did not significantly differ between the groups in the pre-test (all P>0.05).

Table 1. insert here

3.1 HK, FHP, RSP, and Pain

The repeated measures ANOVA reflected significant group-by-time interactions in relation to changes in HK [$F_{(1, 28)}$=397.59, (P=0.001), effect size=0.8]. A post-hoc analysis, which was conducted to compare the pre- and post-test findings, indicated a significant decrease in HK (P=0.001, effect size=0.97) in the experimental group and a significant difference between this group and the controls during the post-test (P=0.001). The experimental group showed a smaller kyphosis angle during the post-test than did the control group.

The repeated measures ANOVA also showed significant group-by-time interactions as regards changes in FHP [$F_{(1, 28)}$=306.02, P=0.001, effect size=0.9]. The post-hoc analysis of the pre- and post-tests showed a significant decrease in FHP (P=0.001, effect size=0.98) in the experimental group. A significant difference was likewise found between the experimental and control groups at the post-test (P=0.001). The former presented with a smaller forward head angle at the post-test than did the controls.

As revealed as well by the repeated measures ANOVA, significant group-by-time interactions occurred with respect to changes in RSP [$F_{(1, 28)}$=130.69, P=0.001, effect size=0.9]. The post-hoc analysis showed a significant decrease in the condition (P=0.001, effect size=0.98) among the participants who were subjected to the interventions. A significant difference was found between the experimental and control groups at the post-test (P=0.001), with the former exhibiting a smaller Rounded shoulder angle than that measured for the control participants (Table 3). No significant decrease in RSP was observed in the control group (P > 0.05) (Fig. 4).

The results of the repeated measures ANOVA showed significant group-by-time interactions with regard to changes in VAS [$F_{(1, 28)}$=187.8, P=0.001, effect size=0.8], and the post-hoc analysis reflected a significant decrease in neck and shoulder pain (P=0.001, effect size=0.96) among the exercise participants. A significant difference was found between the experimental and control groups at the post-test (P=0.001), during which the former group presented with less severe neck and shoulder pain than that experienced by the control group (Table 2).

Table 2. (insert here)

Fig. 4. Mean FHP, RSP, HK, and pain in the post-test compared with values derived in the pre-test *(insert here)*

4. Discussion

The results showed that the water-based corrective exercises significantly decreased postural deformities and neck and shoulder pain among the male students. The large effect size (0.9) confirmed that the interventions effectively corrected the postural deformities and relieved pain in the upper extremities. Sahrmann (2011), belived that exercises intended to correct movement and malalignment result in appropriate neuromuscular and musculoskeletal adaptations [20]. She also considered the most important stage of correction to be the training of individuals on maintaining proper alignment when they accomplish repetitive tasks and assume certain postures for prolonged durations [2]. Correspondingly, the first session of the corrective exercise protocols implemented in the current work revolved around training the participants on maintaining alignment in their activities.

In this research, the significant correction of concurrent deformities and muscle imbalances that occurred in relation to FHP, RSP, and HK can be attributed to two factors: the properties of water environments and the protocols for corrective exercises. Performing corrective exercises in water seemed to be one of the determinants of interventional effectiveness in this study. The turbulence effect from water during movement appeared to clear the way for different proprioception and sensory responses-patterns that are not induced by land-based exercises [37]. An alternative explanation is that the warmth and hydrostatic pressure of water increase blood flow, inhibit pain receptors, and stimulate trigger points, thereby enabling correction and eliminating muscle tightness [38]. The warmth of water can also be beneficial in restoring the flexibility of muscles and the range of motion of joints through muscular expansion and relaxation [38]. Although no previous study explored water-based corrective exercises for postural deformities, certain evidence supports our findings. Kamioka, for example, reported that aquatic exercises exert small but statistically significant effects on pain relief and related outcome measures for locomotor diseases [39]. Neira additionally affirmed the effectiveness of aquatic therapy for balance and pain in women with fibromyalgia [37].

The significant correction of deformities and relief of pain in the present research could have stemmed from the corrective exercise protocols applied in this work. The first stage involved the release of trigger points through deep muscular massage in water and the myofascial release of stiff muscle via a foam roller [40, 41]. These interventions may have improved the participants’ flexibility, blood flow, arterial function, vascular endothelial function, and parasympathetic nervous system activity. [41].

Muscle imbalances involve muscular tightness on one side of the body and the crossing of muscular elongation on the opposite side. The resistive forces (bow, drag, and cohesive forces) of water can strengthen muscles and reduce muscle imbalances [38]. In this study, stretching exercises were administered for the pectoralis, superior trapezius, levator scapulae, sternocleidomastoid, and scalene muscles to minimize such imbalances. The static stretching likely induced mechanical and neural adaptations, ultimately increasing the range of motion of the participants and reducing the muscle stiffness that they were experiencing [41]. Static stretching seems to influence the mechanically viscoelastic components of the neuromyofascial tissue. Neurobiologically, the static stretching of neuromyofascial tissue up to the end of range of motion may reduce the excitability of motor neurons through the inhibitory effects of the Golgi tendon organ and the Renshaw recurrent loop [42]. In these abnormalities, long-term poor posture results in some muscles exceeding neutral physiological length. Long-run muscular elongation, in turn, inhibits muscle spindle activity and the creation of additional sarcomeres; this condition is also called “stretch weakness” [3]. With consideration for these issues, this study’s participants were instructed to execute chin tuck exercises to strengthen deep neck flexors, rowing to strengthen the rhomboid and inferior trapezius muscles, and combo exercises in the scaption position as well as the T and cobra positions on a gym desk in water [42]. These exercises may facilitate movement in the muscles and strengthen them by stimulating and increasing the response of muscle spindles [3]. Previous studies corroborated the effects of exercises on the correction of postural deformities. Harman et al., for instance, studied the effects of an exercise program on improving FHP and found that a short, home-based targeted exercise regimen can enhance postural alignment related to FHP [16]. Park et al. discovered that complex training effectively corrects FHP, RSP, HK, and lumbar lordosis in children [18]. Finally, Bae et al. attested to the effectiveness of strengthening exercises as a means of rehabilitating the middle and inferior trapezius muscles and stretching exercises for the levator scapulae and superior trapezius muscles amid upper crossed syndrome [17].

Another source of effectiveness in this work was the proprioception exercises. Decreased proprioception has been identified as another side effect of postural deformities [3, 43]. Thus, the proprioception exercises implemented in this work can give rise to significant improvement in deformity correction as such activities may enhance the response of the central nervous system to afferents for the reorganization and coordination of muscles. After the administration of the sensory motor exercises, integration was performed as the last component of the corrective exercise protocols. Integrated dynamic motions are controlled motions that impose a weak load on individuals as they assume a good postural position. This helps maintain correct joint alignment and enables muscles to function appropriately in activities that involve interaction between length and tension [42]. Integration was implemented by instructing the participants to take part in a purposeful game in water.

The findings likewise pointed to the effectiveness of the protocols in relieving neck and shoulder pain. The significant reduction in pain severity can be attributed to the contribution of the water environment to the blocking of pain receptors or the effects of myofascial release for stiff tissues and the reduction in painful trigger points or the correction of muscle imbalances. The results are consistent with the findings of Lau et al. (2010), who inquired into the relationships between the sagittal postures of thoracic and cervical spine, the presence of neck pain and disability. The authors averred that the upper thoracic angle is a better predictor of neck pain than the craniovertebral angle [44]. Lluch et al. (2014) investigated the immediate effects of active versus passive scapular correction on pain threshold in patients with chronic neck pain. They reported that active scapular correction exercise immediately reduces pain sensitivity in those suffering from scapular dysfunction [45]. These results are consistent with the findings of the present study.

5. Study Limitations

Certain limitations remained in the current work, namely, the focus on only male subjects, the small sample size and the small number of groups, the lack of a land-based exercise group, the insufficient time to measure lung volumes for an assessment of how they are affected by deformity correction.

6. Conclusion

The results demonstrated that the implementation of eight-week water-based corrective exercises significantly reduced simultaneously occurring FHP, RSP, and HK. The interventions also significantly minimized the highly prevalent pain accompanying these conditions. The corrective exercise protocols implemented in this work can be adopted by professionals in correcting the aforementioned concurrent malalignments.

List Of Abbreviations

FHP:Forward head posture; RSP:Rounded shoulder posture; HK:Hyper kyphosis; VAS:Visual Analog Scale.

Declarations

Ethics approval and consent to participate

The study’s protocols were approved by the research ethics committee of the Medical Sciences University (Registration no.: IR.UMSHA.REC.1395.470). The protocols were also registered in the Registry of Clinical Trials (Registration no.: IRCT20170615034554N2). The informed consent obtained was written.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Source of Funding

No external funding was received for this study.

Authors’ contributions

All authors contributed to the study design. HA collected the data. Data analysis was conducted by FG, the interpretation and discussion of findings were performed by all authors. AY and HA drafted the manuscript and also, all authors reviewed drafts of the paper and approved the final submission.

Acknowledgments

We thank our colleagues from all students who participated in this research and completed the corrective exercises protocol exactly and we would like to express my heartfelt thanks to M.Sc. students who help us in this research.

Author details

[1] Sport injury and corrective exercises department, physical education faculty, Bu Ali Sina University, Hamedan, Iran.

[2] Sport injury and corrective exercises department, physical education faculty, Bu Ali Sina University, Hamedan, Iran.

[3] Sport injury and corrective exercises department, physical education faculty, Razi University, Kermanshah, Iran.

References

1. Lee HM. Rehabilitation of the proximal crossed syndrome in an elderly blind patient: a case report. J Can Chiropr Assoc. 2000;44(4):223.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2485516/
2. Sahrmann S, Azevedo DC, Van Dillen L. Diagnosis and treatment of movement system impairment syndromes. Braz J Phys Ther. 2017;21(6):391-9. https://doi.org/10.1016/j.bjpt.2017.08.001
3. Page P, Frank C, Lardner R. Assessment and treatment of muscle imbalance: The Janda approach. Hum Kinet. 2010;38-56.
4. Neupane S, Ali U, Mathew A. Text Neck Syndrome-Systematic Review. Imperial J Interdiscipl Res. 2017;3(7):141-8.
5. Perri MA, Halford E. Pain and faulty breathing: a pilot study. J Bodyw Mov Ther. 2004; 8(4):297-306. https://doi.org/10.1016/S1360-8592(03)00085-8
6. Scoppa F. Glosso-postural syndrome. Ann Stomato. 2005; 54(1): 27-34.
7. Arboleda BM, Frederick AL. Considerations for maintenance of postural alignment for voice production. J Voice. 2008; 22(1):90-9. https://doi.org/10.1016/j.jvoice.2006.08.001

8. Minguez-Zuazo A, Grande-Alonso M, Saiz BM, La Touche R, Lara SL. Therapeutic patient education and exercise therapy in patients with cervicogenic dizziness: a prospective case series clinical study. J Exerc Rehabil. 2016; 12(3):216. doi:10.12965/jer.1632564.282
9. Kim MS, Cha YJ, Choi JD. Correlation between forward head posture, respiratory functions, and respiratory accessory muscles in young adults. J Back Musculoskelet Rehabil. 2017; 30(4):711-5. DOI: 10.3233/BMR-140253
10. Kahlaee AH, Ghamkhar L, Arab AM. The association between neck pain and pulmonary function: a systematic review. Am J Phys Med Rehabil. 2017; 96(3):203-10. doi:10.1097/PHM.0000000000000608
11. Wirth B, Amstalden M, Perk M, Boutellier U, Humphreys BK. Respiratory dysfunction in patients with chronic neck pain–Influence of thoracic spine and chest mobility. Man Ther. 2014;19(5):440-4.
12. Oliveira AC, Silva AG. Neck muscle endurance and head posture: a comparison between adolescents with and without neck pain. Man Ther. 2016;22:62-7. https://doi.org/10.1016/j.math.2015.10.002
13. McMaster MJ, Glasby MA, Singh H, Cunningham S. Lung function in congenital kyphosis and kyphoscoliosis. Clin Spine Surg. 2007;20(3):203-8.
14. Kamali F, Shirazi SA, Ebrahimi S, Mirshamsi M, Ghanbari A. Comparison of manual therapy and exercise therapy for postural hyperkyphosis: a randomized clinical trial. Physiother Theory Pract. 2016;32(2):92-7. https://doi.org/10.3109/09593985.2015.1110739
15. Ruivo RM, Pezarat-Correia P, Carita AI. Effects of a resistance and stretching training program on forward head and protracted shoulder posture in adolescents. J Manipulative Physiol Ther. 2017;40(1):1-0. https://doi.org/10.1016/j.jmpt.2016.10.005
16. Harman K, Hubley-Kozey CL, Butler H. Effectiveness of an exercise program to improve forward head posture in normal adults: a randomized, controlled 10-week trial. J Man Manip Ther. 2005;13(3):163-76. https://doi.org/10.1179/106698105790824888
17. Bae WS, Lee HO, Shin JW, Lee KC. The effect of middle and lower trapezius strength exercises and levator scapulae and upper trapezius stretching exercises in upper crossed syndrome. J Phys Ther Sci. 2016;28(5):1636-9. https://doi.org/10.1589/jpts.28.1636
18. Park HC, Kim YS, Seok SH, Lee SK. The effect of complex training on the children with all of the deformities including forward head, rounded shoulder posture, and lumbar lordosis. J Exerc Rehabil. 2014;10(3):172. doi: 10.12965/jer.140113
19. Quek J, Pua YH, Clark RA, Bryant AL. Effects of thoracic kyphosis and forward head posture on cervical range of motion in older adults. Man Ther. 2013;18(1):65-71. https://doi.org/10.1016/j.math.2012.07.005
20. Sahrmann S. Movement system impairment syndromes of the extremities, cervical and thoracic spines-e-book. Elsevier Health Sciences; 2010: 22-67.
21. Singla D, Veqar Z. Association between forward head, rounded shoulders, and increased thoracic kyphosis: a review of the literature. J Chiropr Med. 2017;16(3):220-9. https://doi.org/10.1016/j.jcm.2017.03.004

22. Valli J. Chiropractic management of a 46-year-old type 1 diabetic patient with upper crossed syndrome and adhesive capsulitis. 2004; J Chiro Med, 3(4), 138-144https://doi.org/10.1016/S0899-3467(07)60101-3
23. Murta BA, Santos TR, Araujo PA, Resende RA, Ocarino JM. Influence of reducing anterior pelvic tilt on shoulder posture and the electromyographic activity of scapular upward rotators. Braz J Phys Ther. 2019. https://doi.org/10.1016/j.bjpt.2019.02.002
24. Thigpen CA, Padua DA, Michener LA, Guskiewicz K, Giuliani C, Keener JD, Stergiou N. Head and shoulder posture affect scapular mechanics and muscle activity in overhead tasks. J Electromyogr Kinesiol. 2010;20(4):701-9.https://doi.org/10.1016/j.jelekin.2009.12.003
25. Fon GT, Pitt MJ, Thies Jr AC. Thoracic kyphosis: range in normal subjects. American Journal of Roentgenology. 1980 May 1;134(5):979-83. https://doi.org/10.2214/ajr.134.5.979
26. Dockrell S, Bennett K, Culleton-Quinn E. Computer use and musculoskeletal symptoms among undergraduate university students. Comput Educ. 2015;85:102-9. https://doi.org/10.1016/j.compedu.2015.02.001
27. Faul F, Erdfelder E, Lang AG, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175-91. https://link.springer.com/article/10.3758/BF03193146
28. Grande-Alonso M, Saiz BM, Zuazo AM, Lara SL, La Touche R. Biobehavioural analysis of the vestibular system and posture control in patients with cervicogenic dizziness. A cross-sectional study. Neurología (English Edition). 2018;33(2):98-106. https://doi.org/10.1016/j.nrleng.2016.06.006
29. Ruivo RM, Pezarat-Correia P, Carita AI. Intrarater and interrater reliability of photographic measurement of upper-body standing posture of adolescents. J Manipulative Physiol Ther. 2015;38(1):74-80. https://doi.org/10.1016/j.jmpt.2014.10.009
30. Barrett E, McCreesh K, Lewis J. Reliability and validity of non-radiographic methods of thoracic kyphosis measurement: a systematic review. Man Ther. 2014;19(1):10-7. https://doi.org/10.1016/j.math.2013.09.003
31. de Oliveira TS, Candotti CT, La Torre M, Pelinson PP, Furlanetto TS, Kutchak FM, Loss JF. Validity and reproducibility of the measurements obtained using the flexicurve instrument to evaluate the angles of thoracic and lumbar curvatures of the spine in the sagittal plane. Rehabil Res Pract. 2012;2012.
32. Youdas JW, Suman VJ, Garrett TR. Reliability of measurements of lumbar spine sagittal mobility obtained with the flexible curve. J Orthop Sports Phys Ther. 1995;21(1):13-20.
33. Lundon KM, Li AM, Bibershtein S. Interrater and intrarater reliability in the measurement of kyphosis in postmenopausal women with osteoporosis. J Spine. 1998;23(18):1978-85.
34. Teixeira F, & Carvalho G. Reliability and validity of thoracic kyphosis measurements using flexicurve method. 2007; Braz J Phys Ther,11(3), 199e204.
35. Bijur PE, Silver W, Gallagher EJ. Reliability of the visual analog scale for measurement of acute pain. Acad Emerg Med. 2001;8(12):1153-7. https://doi.org/10.1111/j.1553-2712.2001.tb01132.x

36. Cohen J. (1988). Statistical Power Analysis for the Behavioral Sciences. New York, NY: Routledge Academic.
37. Neira SR, Marques AP, Pérez IP, Cervantes RF, Costa JV. Effectiveness of aquatic therapy vs land-based therapy for balance and pain in women with fibromyalgia: a study protocol for a randomised controlled trial. BMC Musculoskelet Disord. 2017;18(1):22. https://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-016-1364-5
38. Prentice W E, & Kaminski T W. Rehabilitation techniques for sports medicine and athletic training, Fifth Edition. New York: McGraw-Hill. 2011:32-110.
39. Kamioka H, Tsutani K, Okuizumi H, Mutoh Y, Ohta M, Handa S, Okada S, Kitayuguchi J, Kamada M, Shiozawa N, Honda T. Effectiveness of aquatic exercise and balneotherapy: a summary of systematic reviews based on randomized controlled trials of water immersion therapies. J Epidemiol. 2010;20(1):2-12.
40. Beardsley C, Škarabot J. Effects of self-myofascial release: a systematic review. J Bodyw Mov Ther. 2015;19(4):747-58. https://doi.org/10.1016/j.jbmt.2015.08.007
41. Koren Y, Kalichman L. Deep tissue massage: What are we talking about? J Bodyw Mov Ther. 2018;22(2):247-51. https://doi.org/10.1016/j.jbmt.2017.05.006
42. Clark M, Lucett S, editors. NASM essentials of corrective exercise training. Lippincott Williams & Wilkins. 2010: 45-119.
43. Gu SY, Hwangbo G, Lee JH. Relationship between position sense and reposition errors according to the degree of upper crossed syndrome. J Phys Ther Sci. 2016;28(2):438-41. https://doi.org/10.1589/jpts.28.438
44. Lau KT, Cheung KY, Chan MH, Lo KY, Chiu TT. Relationships between sagittal postures of thoracic and cervical spine, presence of neck pain, neck pain severity and disability. Man Ther. 2010;15(5):457-62. https://doi.org/10.1016/j.math.2010.03.009
45. Lluch E, Arguisuelas MD, Quesada OC, Noguera EM, Puchades MP, Rodríguez JA, Falla D. Immediate effects of active versus passive scapular correction on pain and pressure pain threshold in patients with chronic neck pain. J Manipulative Physiol Ther. 2014;37(9):660-6. https://doi.org/10.1016/j.jmpt.2014.08.007

Tables

Table 1. demographic characteristics of subjects

RSP¥ (°)	FHP® (°)	HK (°)	Use of laptop and phone per week (h)	Activity mean (h)	Age (year)	BMI€ (kg/m^2)	height (cm)	weight (kg)	Groups
55.1±1.7	49±1.07	49.6±2.9	6.2±1.4	6.1±2.1	22.4±1.3	23.9±0.7	172.9±1.1	71.9±2.6	Exercises group (n=14)
55.0±2.0	49.08±2.08	49±1.9	6.03±0.5	5.6±3.1	23.5±0.8	23.2±0.4	170.1±1.3	70.6±1.8	Control (n=16)
0.95	1.00	0.56	0.34	0.53	0.48	0.39	0.41	0.68	P-value

¥ FSH Rounded Shoulder Posture, ® FHP: Forward Head Posture, HK: Hyper Kyphosis € BMI: Body Mass Index.

 Between-group comparison in pretest (all P>0.05)

Table 2. Summary of results for all tests performed

	Group	Pre-test M±SD	Post-test M±SD	P-value	ES©
Kyphosis(°)†	EX.	49.61±2.9	39.8±1.9*	0.001	0.97
	CON.	49.08±2.4	48.8±1.7	0.64	0.03
FHP(°)†	EX.	55±1.7	47.6±1.3*	0.001	0.98
	CON.	55±1.9	54±2.5	0.21	0.09
RSP(°)†	EX.	49.6±1.7	40.07±1.8*	0.001	0.98
	CON.	49.66±1.9	49.18±1.4	0.34	0.06
VAS(cm) †	EX.	5.6±0.7	2.4±0.6*	0.001	0.96
	CON.	5.7±1.2	5.8±1.6	0.56	0.04

* Significant difference between pre-test and post-test (P<0.05).

©ES: Effect Size.

† Significant group-by-time interaction (P<0.05).

Figures

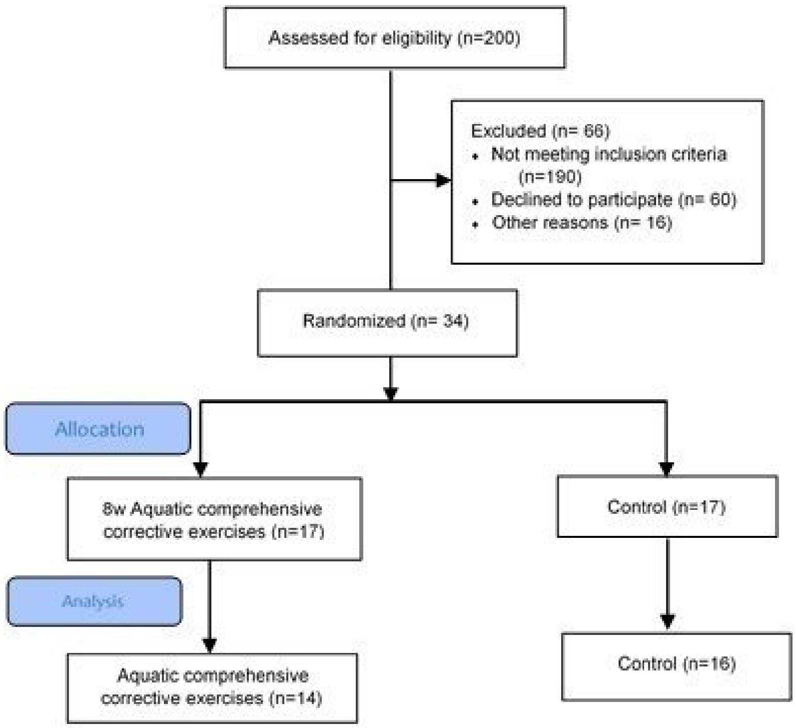

Figure 1

CONSORT flow diagram

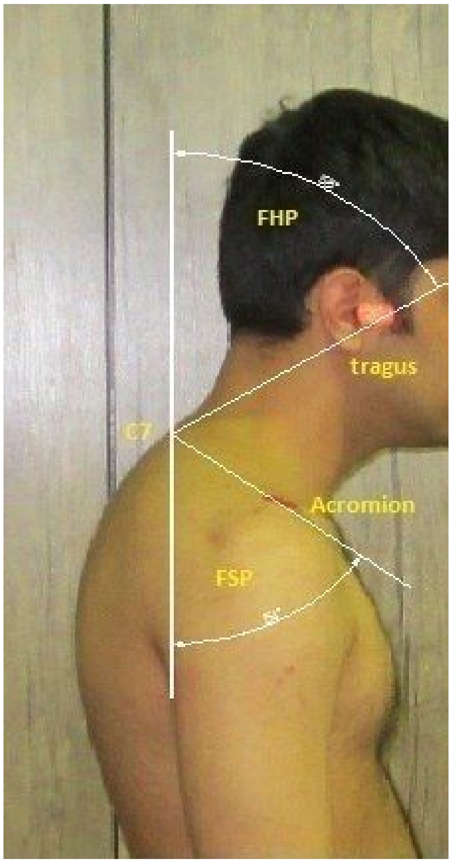

Figure 2

Calculation of FHP and RSP angles using AutoCAD software

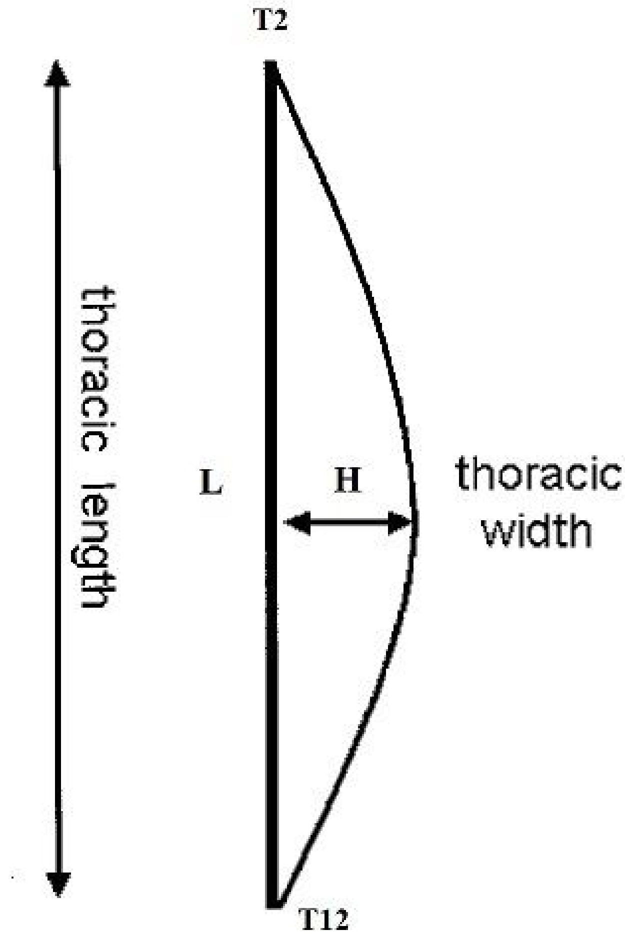

Figure 3

Measurement of kyphosis angle using flexible ruler

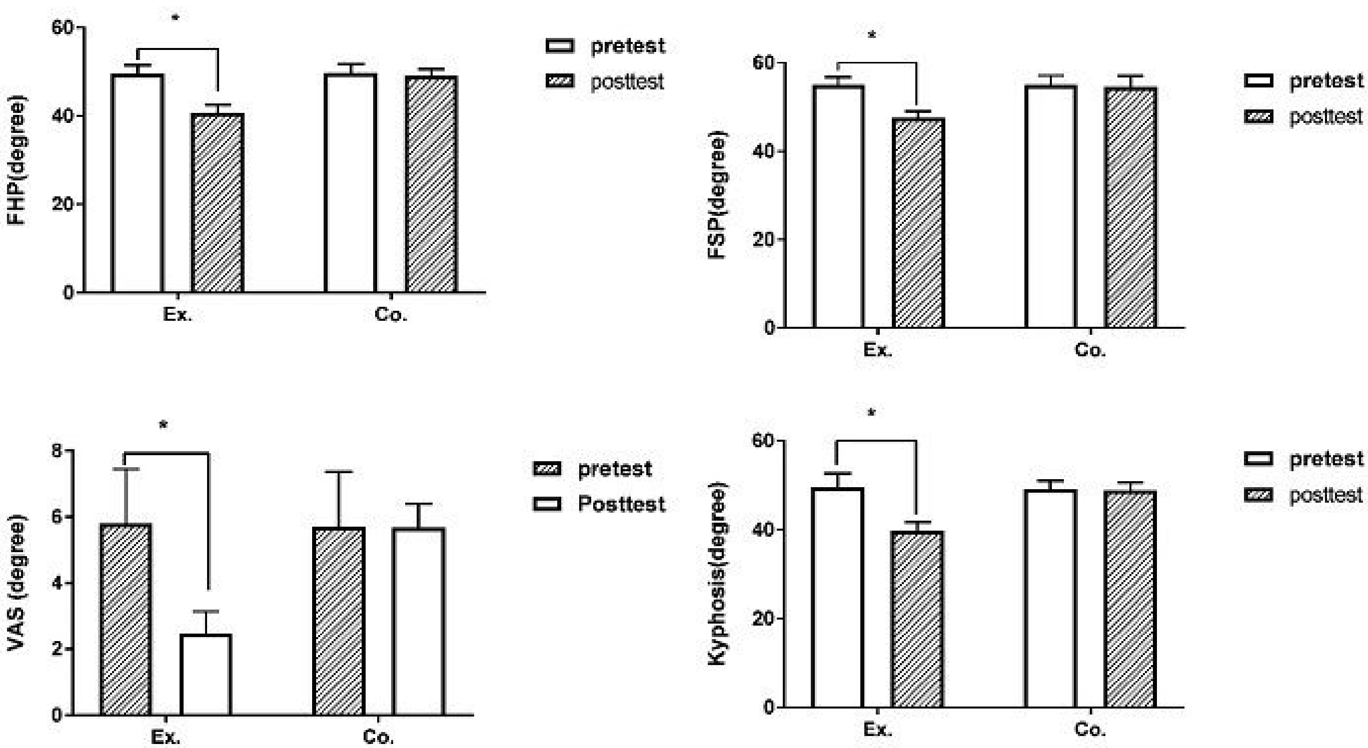

Figure 4

Mean FHP, RSP, HK, and pain in the post-test compared with values derived in the pre-test

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Appendix1.docx
- Methodsformula.docx