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RESEARCH

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Comparison of balance and proprioception of the shoulder joint in girls with and without upper cross syndrome

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Abstract

Introduction.

Upper cross syndrome is one of the most common disorders of the upper part of body, often associated with abnormalities of forward head, forward shoulders, elevated and protracted of scapula, and increased thoracic kyphosis. Conducting research on upper cross syndrome, especially in girls, is of highly significant, considering this issue and lack of examination of complications and consequences of this syndrome; therefore, this study aims to compare the balance and proprioception of the shoulder joint in girls with and without upper cross syndrome.

Method The statistical population included two groups of 10-12-year-old female students, i.e., healthy and those with upper cross syndrome in the city of Khalkhal in Iran in 2022–2023. A total of 60 girl children were included in this study. The subjects were screened using a checker board and after quantitative evaluations of posture, they were assigned into two groups: healthy group (No. 30) and the one suffering from upper cross syndrome (No. 30). Forward head and forward shoulder angle were assessed using photography and kinovea software, kyphosis angle using Goniometer-pro app, static and dynamic balance using BESS and Y tests, also proprioception at angles of 45- and 80-degrees external rotation of the shoulder joint through photography and kinovea software. Data were analyzed through independent t-test in SPSS software version 26 at the significance level of 0.05.

Results Healthy girls were in a better position in all variables of static balance (1.14 95% CI: [0.96, 1.70], $p=0.001$), dynamic balance (0.81, 95% CI: [0.73,1.24], $p=0.001$), proprioception of external rotation of shoulder joint at 45- (0.78, 95% CI: [0.64, 1.14], $p=0.001$) and 80-degrees (0.89, 95% CI: [0.59, 1.34], $p=0.001$) angles than those with upper cross syndrome.

Conclusion It can be concluded that upper cross syndrome causes a decrease in balance and proprioception of the shoulder joint in female students; therefore, along with correcting the abnormalities, special attention should be paid to strengthening and improving these components. It is recommended for rehabilitation professionals to apply exercise training programs to improve the balance and proprioception and correct of the upper cross syndrome: that the strengthening of these components prevents musculoskeletal disorders.

Implications for clinical practice

• It is recommended for rehabilitation professionals to apply exercise training programs to improve the balance and proprioception of individual with upper cross syndrome.

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• It is recommended for rehabilitation professionals to apply exercise training programs to correct of the upper cross syndrome in order to prevents musculoskeletal disorders.

Keywords Balance, Proprioception, Shoulder joint, Syndrome

Introduction

Sustaining a correct posture requires the natural and balanced maintenance of different body parts. In such a state, muscles of the body are at their lowest activity level, and the body is at a minimum level of fatigue and pain, therefore, it will be more efficient [1]. On the other hand, repetitive movements and wrong body postures in the long term can cause motor defects and the occurrence of various syndromes in the body [2]. Meanwhile, upper cross syndrome is one of the most common disorders of the upper part of body, which includes 45–65% of shoulder pain. The incidence of shoulder pain in the general society population has been reported to be about 21%, of which 40% persists for one year, and costs 39 billion per year [3]. Upper cross syndrome is often associated with abnormalities of forward head, forward shoulders, elevated and protracted of scapula, and increased thoracic kyphosis [4, 5]. In this syndrome, the muscles prone to shortness and stiffness include pectoralis minor, pectoralis major, upper trapezius, levator scapulae, latissimus dorsi, teres major, sternocleidomastoid, subscapularis, anterior deltoid, and muscles prone to weakness or inhibition include rhomboid, middle and lower trapezius, teres minor, infraspinatus, serratus anterior and deep neck flexors [6]. This pattern of muscle imbalance causes dysfunction in atlanto-occipital joints and articular processes of cervical and thoracic vertebrae [7].

One of the most important groups subject to upper cross syndrome disorder are young adults [8]. The prevalence of this disorder has been reported in the age range of 7–14 years [9]. The primary and major cause of upper cross syndrome in students is the repetition and maintenance of improper body posture for a prolonged period of time at school and applying chronic pressure to the upper body area [10]. Students usually sit in the classroom for long periods of time with a fixed neck, shoulder and back in a poor posture. Unfavorable postures in students can occur due to factors such as lack of movement, school desks and benches not being appropriate to their height, weight of backpacks, long-term sitting next to television and video entertainments [11]. Moreover, due to the long and incorrect sitting position, and repeated and constant use of the upper extremities in students, there is a possibility of muscle imbalance in upper quarter of the body, and this issue can probably affect the performance of their upper extremities as well [12]. All these cases represent the significance of prevention and correction of this malalignment.

Existence of problems such as vestibular sense disorders or defects in higher brain centers and muscle imbalances cause disturbances in performing balance skills. This is a known factor that proper balance, proper functioning of vestibular system, proprioception and sense of vision and muscle balance are required for a movement [13]. McDaniels et al. (2018) investigated the static balance and compensatory mechanisms in individuals with spine abnormalities, and the obtained results found a significant difference between the group with abnormalities and the healthy one in the placement of the body's center of mass [14].

Another variable that may be impaired due to musculoskeletal abnormalities is proprioception. Proprioception receives sensory inputs from muscle spindle receptors, tendons, joints, and skin receptors, and determines the position, direction, intensity, and speed of joint movements based on these inputs [15]. Therefore, information received from proprioceptive receptors plays a critical role in stability of joint dynamics and motor planning for neuromuscular control, and any factor that reduces the accuracy of this sense can increase the stress on the joint by disrupting joint stability and make it prone to injury [16]. In this regard, Lee et al. (2014) proved that any change in muscle length caused by forward head decreases joint proprioception [17].

In general, weakness and stretching of muscles around the shoulder and neck due to skeletal structure of the body being in a certain position for a long time can play an influential role in the occurrence of body abnormalities such as upper cross syndrome. Also, very few studies have been carried out on the comparison of balance and proprioception in individuals with and without musculoskeletal abnormalities. Conducting research on upper cross syndrome, especially in girls, is of highly significant, which is less observed in previous researches. Considering this issue and lack of examination of complications and consequences of this syndrome, the present study aims to compare the balance and proprioception in girls with and without upper cross syndrome.

Methodology

Descriptive and causal-comparative methods have been used in the current study, which was conducted in the field.

Participants

The statistical population of the study included two groups of 10-12-year-old female students, i.e., healthy and those with upper cross syndrome, in the city of Khalkhal, Iran, in 2022–2023. According to independent t-test using effect size η=0.25, confidence level α=0.05, and expected power of 95%, the total number of required samples was estimated to be 60 (in other words 30 participants in each group). The intended calculations were performed using G*Power version 3.1.9.2. The participants were selected by non-random targeted sampling and assigned into the healthy (No. 30) and upper cross syndrome groups (No. 30). For this purpose, the subjects were screened using standard instruments, and those with upper cross syndrome were separated from the healthy ones. To distinguish affected individuals, quantitative assessments of head, shoulder, and thoracic arch were performed and those with criteria related to upper cross syndrome were included in the abnormal group. Samples with upper cross syndrome were defined as those with back curvature greater than 42 degrees, forward shoulder greater than 52 degrees, and forward slouching greater than 46 degrees.

Implementation procedure

Before starting the research, first by obtaining permission from Education Department of Khalkhal and by visiting the schools during a meeting with school officials, necessary explanations regarding the process of research performance, and the purpose and necessity of the study were provided to the officials. Moreover, the subjects and their parents participated in an explanatory meeting, and before obtaining consent from the parents and students, the researcher provided general explanations regarding the research purpose, methods of conducting it, harmlessness of the intervention, and confidentiality of the information obtained. So, they were given the option to participate in the research with full knowledge and consent. The inclusion criteria for the research consisted of: female students 10–12 years old, the same level of physical activity, having upper cross syndrome (forward shoulder over 52˚, forward head over 46˚, and kyphosis over 42˚) in the group with abnormalities [18], no history of fracture and surgery, non-participation in an intervention or exercise program during the study, and voluntary willingness for participation, measured by the personal information questionnaire and initial screening. The criteria for leaving the research included non-cooperation of the individuals in correctly performing the tests and pain in muscles and joints during the tests. To select the subjects (those with upper cross syndrome and healthy ones), they were screened by making the necessary arrangements and using a checker board [19], and then in the next stages, the group of upper cross syndrome were subjected to quantitative postural assessments.

The measurement of anthropometric characteristics including height, weight, body mass index (BMI) and subsequent assessments were carried out in full compliance with ethical principles in an indoor gym with suitable ambient temperature and sufficient light, and maintaining health protocols with the presence of subjects. To measure forward head, kyphosis, and forward shoulder angles, the subjects were uncovered from the upper lumbar. All assessments were performed in the presence of the subjects' guardians or legal guardians. Also, the participants in this study were assessed only once. Assessments and measurements were completely non-invasive and did not pose any risk to the individual's health and were completely voluntary. All information related to each person was kept confidential and only the collected data and their results were published with no name and relevant characteristics, and after analyzing the data, the corresponding pictures were removed.

Data collection instruments

Measurement of forward head and forward shoulder angle for this purpose, the photographic method was used. This method has optimal reproducibility and has been used in many studies. To measure forward head and forward shoulder angle using this method, first, three anatomical landmarks of ear tragus, the right acromion process, as well as spinous process of C7 vertebra, were specified and marked with landmarks. Then, the subjects were asked to stand in the designated place next to the wall (at a distance of 23 cm) so that their left arm was facing the wall. Then, the photographic tripod, on which the digital camera was positioned, was placed at a distance of 265 cm from the wall and its height adjusted at the subject's right shoulder level. In such conditions, the subjects were asked to bend forward three times and raise their hands above their heads three times, and then stand comfortably and naturally and look at a hypothetical point on the opposite wall (eyes had to be in line with the horizon). Then, after a pause of 5 s, the examiner took a picture of the body profile view. Then, the photo was transferred to computer and using Kinovea software, the angle of the line connecting tragus and C7 with a perpendicular line (forward head angle) and angle of the line connecting C7 and acromion process with a perpendicular line (forward shoulder angle) were measured. Angles over 52° for the forward shoulder and those over 46° for the forward head along with a kyphosis angle of more than 42 degrees were recognized as upper cross syndrome [20]. The inter-rater (ICC=0.997) and validity (ICC=0.998) of this instrument has been confirmed in the studies of Abd Elrahim et al. (2016) and Balsalobre et al. (2014) [21, 22](Fig. 1).

Measurement of kyphosis angle

For this purpose, Goniometer-pro app was used. The subjects were asked to remove their upper body clothes so that the researcher could identify the first and twelfth

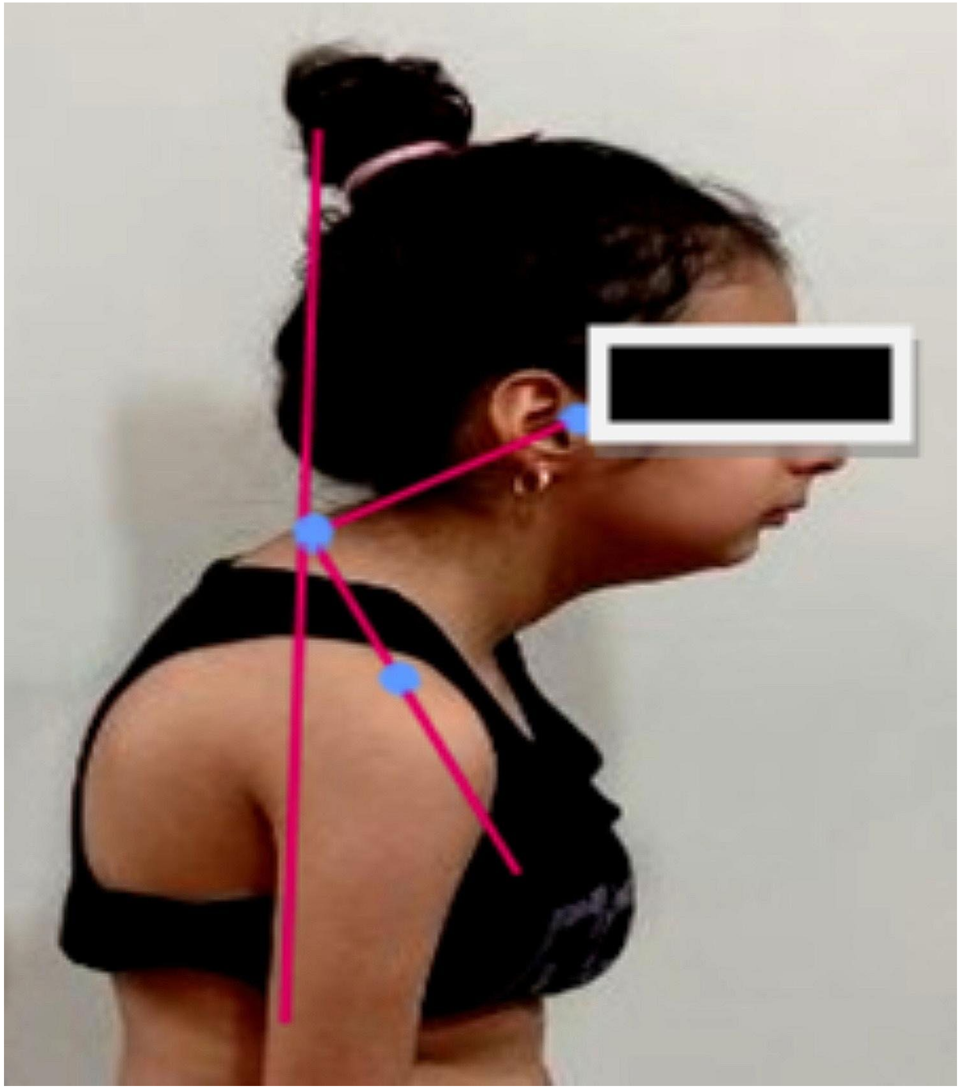

Fig. 1 Assessment of forward head and forward shoulder angles

thoracic vertebra by observing and touching the spine with her fingers. The participants were asked to stand in a normal position, the distance between the two heels should be 15 cm and keep the arms in 90° flexion. These two vertebrae were identified as the initial and final landmarks. After running goniometer program in the smartphone, by placing the central and bottom part of the smartphone, it was held vertically on initial landmark (T1) and the green button was touched in the program; then the central and lower part of the smartphone was kept on the (T12) and the green button was pressed. Finally, two numbers were recorded on the smartphone, the smaller of which indicated angle of the thoracic kyphosis. An angle above 42° is considered as hyper kyphosis [23]. For the goniometer application, an excellent correlation (r=0.81, p=0.000), for intra-rater (ICC=0.88) and inter-rater reliability (ICC=0.915) were obtained in the study of Faramarzi and Ghanizadeh Hesar [24]) Fig. 2

Assessment of static balance

BESS test was used to measure static balance. This test includes 3 standing positions, each of which was performed on stable (Fig. 3) and unstable (Fig. 4) surfaces, for the dominant and non-dominant legs. The stable surface consisted of a hard and thin carpet and unstable surface consisted of a compressed foam pad (foam pad with 30×40 cm dimensions, 10 cm thickness, and 35 kg/m3 density). These 3 positions include double- leg stance (feet together), single-leg stance (standing on the tested leg, while hip is flexed to approximately 30˚ and knee flexed to approximately 45˚), and a tandem stance (non-dominant foot behind the dominant foot, and the heel has touched the toes of the rear foot). In all three conditions, eyes were closed and hands were on the hips.

Fig. 2 Assessment of back kyphosis

Fig. 3 Measuring static balance on a stable surface (BESS test)

Errors include opening eyes, moving the hands off the hips, touching the ground with the foot that is not in contact with the ground, hopping and stepping, any movement of the standing leg, lifting the heel or toe off the ground, abducting the hip by more than 30˚ and staying away from the position more than 5 s. Each position was kept for 20 s and the score was determined by recording number of errors and after a 10 s rest, the next move was performed. The maximum number of errors was considered 10 for each of the positions. Finally, the errors related to each position were recorded and a total score was calculated for the subject's static balance [25]. Sabin (2011) stated the validity of this test to be 0.88–0.92 [26]. Bell et al. (2011) have confirmed the validity and reliability of this test, too [27]. Khanna et al. (2015), have reported that Baseline BESS scores in children aged 10 to 17 years were normally distributed and were not related

Fig. 4 Measuring static balance on an unstable surface (BESS test)

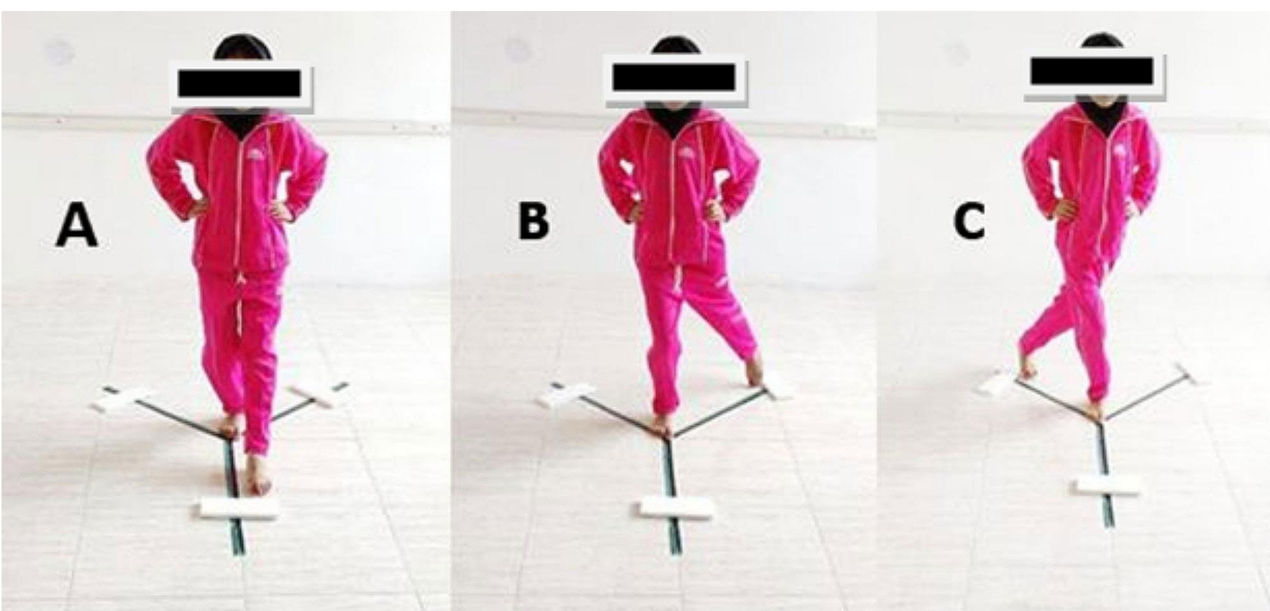

Fig. 5 Y balance test to assess dynamic balance

to age, sex, height, weight, body mass index, or sports participation [25].

Assessment of dynamic balance

Y balance test (Y Balance Test Kit) was used to evaluate dynamic balance. In this test, 3 directions (anterior, posteriomedial, Posteriolateral) were drawn with an angle of 135˚ between the anterior and posterior directions and 90˚ between the posterior directions from each other, while one leg of the subject is placed in center of Y drawn by the researcher. The other leg performs the reaching action. Reaching distance is measured in centimeters in three directions: anterior, posteriomedial, Posteriolateral (Fig. 5). To reduce learning effect, only six practice trials are allowed before the test administration. The act of reaching in each direction is performed three times and its average is recorded for each limb and normalized based on the length of the lower limb. To perform this test and also to normalize the data, actual length of the leg, i.e., from the anterior superior iliac spine (ASIS) to medial malleolus, is measured while the subject is lying on the ground in supine position, and the record was divided by length of the leg, then multiplied by 100 to obtain the reaching distance in terms of leg length:

$$\text{Score of each direction} = \frac{Reaching\ Distance}{\text{Length of the Limb}} * 100$$

If the subject leans on a leg that performs the reaching action, or does a movement in the leg that was in center of the Y test, or if the person is unable to maintain balance, that corresponding reaching action is removed and the subject is asked to repeat the test again. Moreover, before performing the test, the subjects' dominant leg was determined. If right leg was dominant, the test was performed in a counter-clockwise direction, and if the left one was dominant, it was performed in a clockwise direction [28]. Plisky et al. (2009), Scott et al. (2013), reported the validity and reliability of the Y balance test to be optimal [29, 30]. Lee (2012) has reported that Y-Balance Test revealed excellent reliability as a dynamic balance measurement tool to assess the dynamic balance ability among school children. Children with high dynamic balance ability are believed could outperform in sports, games and other related physical activities [31].

Assessment of proprioception

First, the subjects were asked to lie on their backs on the bed (in supine position). Then, the arm of each limb was placed in 90˚ abduction and elbow of the same limb was placed in 90˚ flexion, then the olecranon and styloid process of ulna were marked. In a condition that their eyes were open, they passively rotated their arm externally up to 45 degrees. The subjects were asked to keep this angle in mind and re-create it after 5 s with closed eyes. For the angle of 80˚, all things were carried out in the same order. This situation was measured three times and the mean difference with the original angle was recorded. To assess proprioception, photography method by digital camera and Kinovea software were used to quantify and assess proprioception. The reliability of this test is reported between 0.87 and 0.99 [32] Chu (2017) has reported in the systematic review that proprioception is the subconscious and conscious awareness of the spatial and mechanical status of the musculoskeletal framework revealed excellent method to assess the joint position sense among school children [33] (Fig. 6).

Statistical method

Shapiro-Wilk test was used in this study to check the Normality of data. After confirming normality of the data distribution, the independent t-test was used to compare research variables between the two groups. It is worth noting that all analyses were performed in SPSS version 26 at the level of 0.05 (Fig. 7).

Results

Mean and standard deviation of the demographic variables, including age, height, weight, and body mass index (BMI) of the subjects are presented in Table 1.

Independent t-test was used to evaluate the demographic characteristics of the subjects. No significant difference was found between groups in characteristic information ($p > 0.05$). confounding factors that may have influenced the study findings. For instance, factors such as age, gender, physical activity levels, were controlled. So that these factors do not affect the results of the main research variables. Subjects were placed at the same level in terms of physical activity. All subjects were girls. And the results of the independent t-test did not show a significant difference between the age of the subjects.

Results of independent t-test relating to the variables of balance and proprioception are provided in Table 2. By inferring from this Table and given the t-value obtained, it is concluded that the difference between the mean of the two groups is statistically significant. Therefore, there is a significant difference between balance and proprioception in girls with and without upper cross syndrome ($P < 0.05$). By referring to the mean values of the variables in two groups, it can be concluded that the balance and

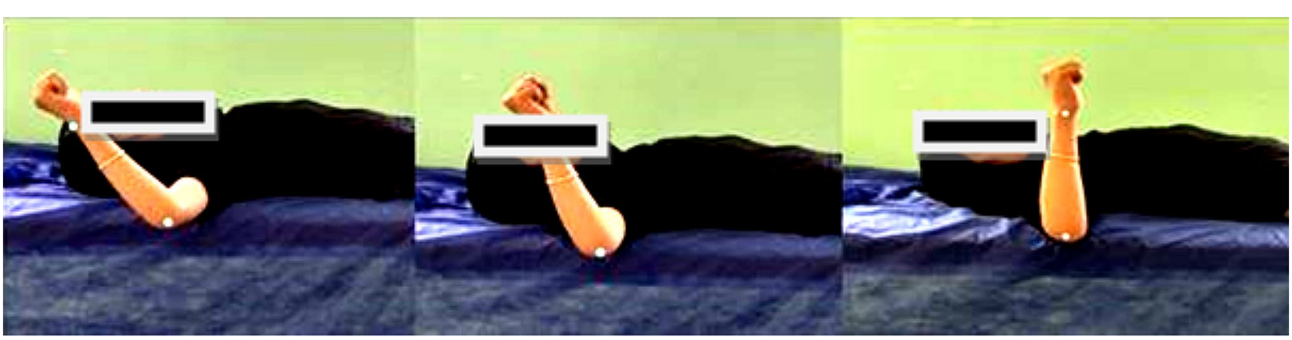

Fig. 6 Measurement of shoulder joint proprioception

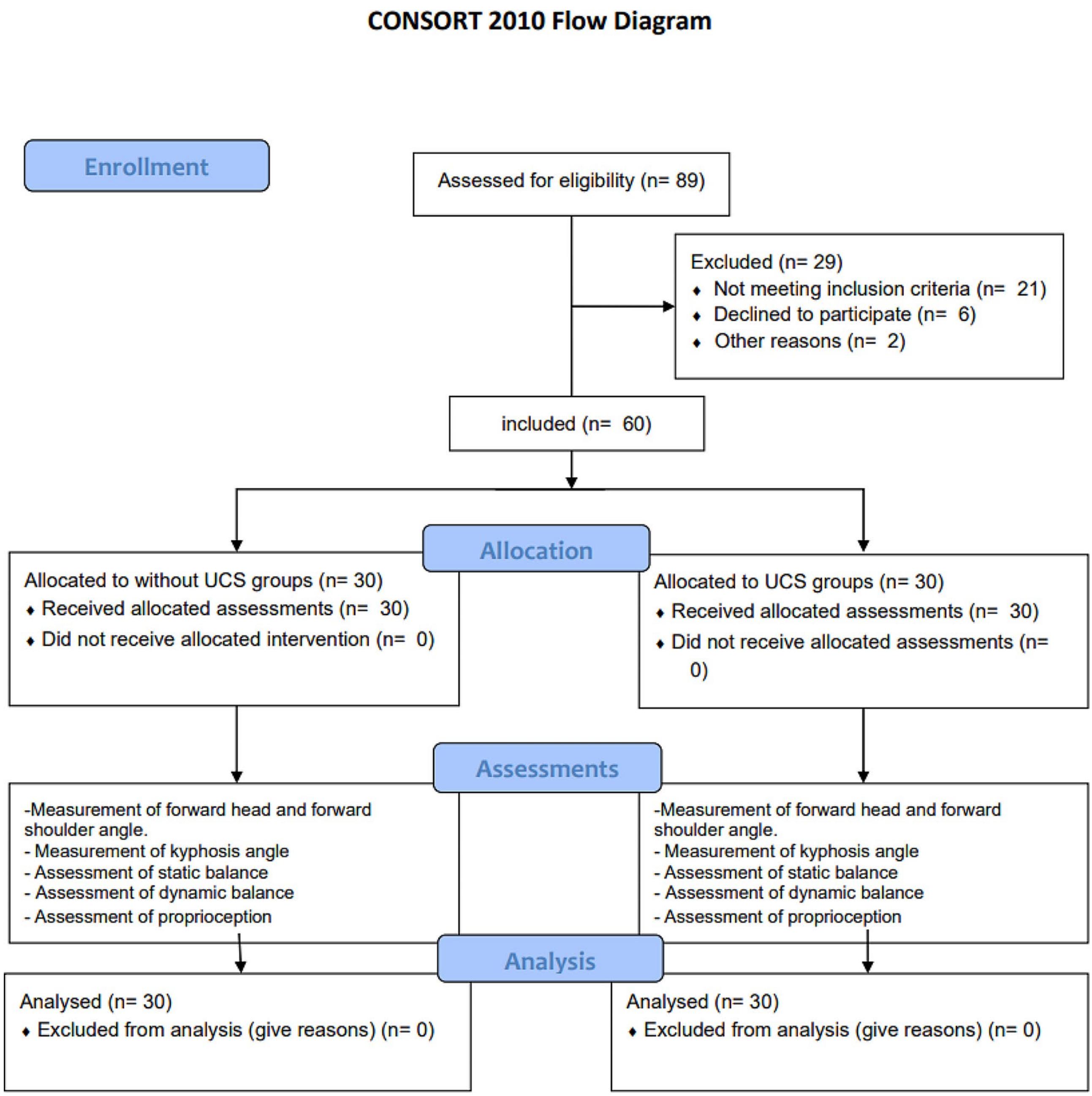

Fig. 7 Flowchart of eligibility, inclusion and exclusion criteria, and analysis. UCS: upper cross syndrome

Table 1 Mean and standard deviation of demographic characteristics of the subjects in research groups

Group	Variables	Age (year)	Height (Cm)	Weight (Kg)	BMI (Kg/M^2)
Healthy	SD ± Mean	11.16 ± 0.80	142.36 ± 4.46	38.33 ± 3.12	19.06 ± 0.83
Upper Cross Syndrome	SD ± Mean	10.55 ± 0.41	140.27 ± 3.52	37.58 ± 2.00	19.17 ± 0.74
p-value		0.42	0.19	0.65	0.98

Table 2 Comparison of variables related to balance and proprioception between the group of Upper Cross Syndrome and healthy ones

Variable	Group	Mean ± SD	T value	Degree of freedom	Effect size (95% CI) and *p*-value	*p*-value
Static balance (no. of error)	Upper Cross Syndrome	4.50 ± 0.82	17.00	58	1.14 (0.96 to 1.70)	0.001*
	Healthy	2.19 ± 0.50				
Overall score of dynamic balance (percentage of leg length)	Upper Cross Syndrome	82.75 ± 6.43	24.13	58	0.81 (0.73to 1.24)	0.001*
	Healthy	91.59 ± 5.77				
Proprioception of 45˚ external Rot. in right shoulder (degrees)	Upper Cross Syndrome	7.10 ± 1.55	8.13	58	0.78 (0.64 to 1.14)	0.001*
	Healthy	3.06 ± 0.65				
Proprioception of 45˚ external Rot. in left shoulder (degrees)	Upper Cross Syndrome	6.57 ± 1.12	14.54	58	0.88 (0.53 to 1.76)	0.001*
	Healthy	2.39 ± 0.78				
Proprioception of 80˚ external Rot. in right shoulder (degrees)	Upper Cross Syndrome	7.44 ± 1.76	23.08	58	0.89 (0.59 to 1.34)	0.001*
	Healthy	4.82 ± 1.30				
Proprioception of 80˚ external Rot. in left shoulder (degrees)	Upper Cross Syndrome	6.16 ± 1.27	15.99	58	0.97 (0.84 to 1.64)	0.001*
	Healthy	3.10 ± 0.55				

*Significant differences compared between groups ($p \leq 0.05$)

proprioception scores in the healthy group are better than the one with upper cross syndrome.

Discussion

Findings of the present study demonstrated that the difference between the mean of static balance in girls with and without upper cross syndrome is significant, such that healthy girls were in a better condition in static balance variable than those with upper cross syndrome. The findings of this section are consistent with the findings of some studies [14, 34, 35] and inconsistent with some other ones [28, 36]. Among the possible causes of incongruity, the difference in types of abnormality, age, and gender of the subjects, as well as severity of the abnormalities could be mentioned. One of the possible reasons for this result can be the neuro-muscular adaptation and recovery of correct posture in healthy individuals compared to those with syndrome. In individuals with upper cross syndrome, reduction of glenohumeral joint stability occurs in upper quarter of the body [37] and the head is placed near or outside the range where the body maintains balance stability, thus affecting the static balance of the person [38]. In this regard, Kang et al. (2012) reported in a study that, the forward head posture causes the center of body mass to fall forward and reduce static balance in individuals who use computers for a long time [39]. Eum et al. (2013) also investigated the relationship between kyphosis and lower limb mobility, balance, and disability among elderlies, and reported that increased kyphosis is associated with decreased balance and disability in individuals [40]. In another study, Lee (2016) investigated the relationship between forward head posture and static and semi-dynamic balance, the results of which suggested that forward head posture affects static balance and semi-dynamic balance [41]. Therefore, it seems that a disorder in the alignment of the upper limb, such as the upper crossed syndrome, can cause a disturbance in static balance. Studies have shown that poor static balance in children can disrupt the learning of other motor skills [42, 43], thus lowering children's motor performance in the long term and reducing the participation of these people in physical and sports activities, which leads to the quality of life of children decreases in the long term [44].

Also, results of the current study indicated that difference between the mean of dynamic balance in girls with and without upper cross syndrome is significant. In this regard, healthy girls were in a better place in dynamic balance variable than those with upper cross syndrome. This finding is consistent with findings of previous studies [28, 34–36]. In explaining the findings of this part of the research, it can be assumed that, from a clinical point of view, stabilizing a posture in the body requires coordinated activity and processing of afferent information from all three senses. One of the key areas of proprioception to maintain posture and balance of the body is the cervical spine, which has been proven to be the feedforward role of muscles in this area before of hand movement [45]. A high density of muscle spindle in the small deep neck muscles causes neck muscles to take on an important role in controlling the posture. Due to the upper cross syndrome, functional disorder occurs in the muscle and joint receptors in neck area, which can lead to an increase in the sensitivity of muscle spindles and stimulation of gamma motor neurons and creation of a negative impact on dynamic balance [46]. It seems that one of the potential reasons for the decrease in dynamic balance with the increase of forward head and forward shoulder and kyphosis is the change in location of the center of body mass forward and down [41]. Therefore, given the relationship between dynamic balance and spinal curvature, it can be said that individuals with upper cross syndrome have less balance and use hip and ankle joints more to maintain their balance. The starting point of this disorder is the adoption of an inappropriate posture, which leads to the creation of sudden simultaneous loads that affect the stable and appropriate posture; thus, improper posture is formed. As a result, the person would have a weak motor mechanism, causing a dynamic imbalance in the body, and the body is placed around a new center of gravity, and this factor can, in turn, cause injury [47].

Furthermore, findings of the present study reported that mean difference of the shoulder proprioception in girls with and without the upper cross syndrome is significant. Healthy girls were in a more favorable situation in proprioception variables of 45- and 80-degrees of shoulder external rotation in both right and left limbs than those with upper cross syndrome. With this respect, Gu et al. (2016) approved that as postural disharmony becomes more severe in upper cross syndrome cases, cervical spine proprioception decreases [48]. Shaghayeghfard et al. (2015) investigated the proprioception of neck in individuals with forward head and compared it with healthy ones, and their results expressed that those individuals with forward head have more errors in reconstructing some neck movements than healthy ones [49]. Also, Lee et al. (2014) investigated the characteristics of the proprioception of the neck in forward head posture, their results exhibited that the change in muscle length caused by forward head reduces joint proprioception [17]. In explanation of this finding, it can be said that deviation of the body from the ideal position in upper cross syndrome can cause sensitivity defect of the muscle spindle, followed by a defect in proprioception. Basically, biomechanical changes resulting from abnormal alignment can affect the force imposed on joint, mechanical efficiency of muscles, and function of proprioception. Because when the center of gravity of a part of the body deviates from its natural alignment, a postural abnormality occurs, hence, affecting the efficiency of the body. Since in upper cross syndrome cases, a group of neck and shoulder muscles, especially the deep flexor, which play a critical role in local stability of the neck area, are weakened, it is possible that in individuals with this syndrome, the proprioception would be disrupted. Proprioception is a specialized development of the sense of palpation, which includes sense of movement and joint position, and in fact, one of the aspects of proprioception includes awareness of the joint position. Muscles of the neck and shoulder areas have a very high density of muscle spindles and receptors of this areas have a reflexive and central connection with the vision and vestibular systems. The high density and special shape of muscle spindles of the neck and shoulder region reflects the significance of proprioceptive information and its key role in posture of the upper limb [50]. It has been reported that the lack of proprioception leads to joint disorders and in the long term it can cause the destruction of joints, especially in the neck area, and as a result, it causes pain in the neck joints. Therefore, it seems that programs should be considered to identify people with muscle imbalances, especially upper cross syndrome, and accordingly, corrective exercises should be done to correct these pastural defects [51, 52] .

Given this research findings, it is proposed that exercise trainers, therapists, and physiotherapists familiarize individuals with upper cross syndrome with corrective exercises to improve their balance and sense of proprioception to prevent further injuries and correct these abnormalities. It is also suggested that screening for upper cross syndrome be conducted in schools so that affected students could be identified and treated as soon as possible.

Limitations and future scope

This study has a few methodological limitations that should be disclosed. First, the findings from this study are specific to 10–12-year-old female children. More research is needed to identify whether our findings can be generalized to male children, in this age range. Second, small sample size which can be done in larger samples as well. Third, there was no blinding in the evaluation of the variables and blinding of valuations; so, it is suggested that future researchers consider this limitation.

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Author contributions

ZKH, MHF EMF., contributed to the conceptualization, data curation, investigation, methodology, project administration, resources, supervision, validation, visualization, and writing (reviewing and editing) of the study.

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Data availability

The datasets generated and analyzed during the current study are not publicly available, as individual privacy could be compromised, but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

We confirm that all experiments were performed in accordance with relevant guidelines and regulations. Authors confirm experiments on humans and the use of human tissue samples confirm that all experiments were performed in accordance with relevant guidelines and regulations. The studies involving human participants were reviewed and approved by ethics committee of Sports Sciences Research Institute of Iran with code of ethics, No: IR.SSRC.REC.1401. 10. Also, all methods were carried out in accordance with relevant guidelines and regulations and the study procedures were explained, and informed consent was obtained from all participants and their parents prior to study initiation.

Consent for publication
Not applicable.

Informed consent
This attesting to informed consent from all subjects and/or their legal guardian(s) for publication of identifying information/images in an online open-access publication.

Competing interests
The authors declare no competing interests.

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