

Research Paper

Effectiveness of the Alexander Technique on Quality of Life in Young Men With Upper Crossed Syndrome



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ABSTRACT

Purpose: Studies show that upper-crossed syndrome causes a decrease in health and quality of life (QoL) in affected people due to various physiological and psychological complications. Considering the high prevalence of upper crossed syndrome, this study investigates the effectiveness of the Alexander technique on physical and mental dimensions of QoL in young men with upper crossed syndrome.

Methods: We assigned 24 male participants (aged between 19-25 years) into two groups (experimental and control) using a convenience sampling method. We used the short form of health survey-36 to evaluate the physical and mental aspects of their health. After measuring the desired variables of all participants in the pre-test stage, the participants of the experimental condition completed 12 training sessions of the Alexander technique over six weeks. We used analysis of covariance and correlated t-test to analyze the results.

Results: There was a significant difference between the physical dimension of QoL in the experimental condition after applying the Alexander technique intervention compared to the control condition ($P < 0.001$). Similarly, there was a significant difference between the mental dimension of QoL in the experimental condition compared to the control condition ($P < 0.001$).

Conclusion: Considering the significant effect of the Alexander technique as an educational intervention on participants' physical and mental health in the current study, we suggest that health and rehabilitation experts use the Alexander technique as a psychophysical re-education method to practically improve health and QoL in individuals with upper-crossed syndrome.

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Highlights

- Upper-crossed syndrome exhibits a high prevalence in society, causing poor posture and various physiological and psychological complications.
- The Alexander technique, as a method of posture re-education, has not been studied sufficiently, and further investigation is required to determine its effectiveness on the quality of life (QoL).
- A total of 12 training sessions of the Alexander technique can enhance both the mental and physical dimensions of the QoL in individuals with upper crossed syndrome.

Plain Language Summary

Due to the advancements in technology in modern life and changes in the lifestyle of people in society, the phenomenon of sedentary life has emerged. Inactivity, prolonged poor posture, and repetitive movement habits have contributed to the prevalence of poor posture in society. Upper-crossed syndrome, characterized by improper body posture, is highly prevalent among different individuals. Studies indicate that upper crossed syndrome, with its adverse effects on the body and mind of affected individuals, leads to various complications, including decreased quality of life (QoL). Several treatments and methods have been employed to correct upper-crossed syndrome, with postural re-education garnering attention from experts in recent years. The Alexander technique, as a method of posture re-education, has been less studied compared to other methods. This study investigates the effectiveness of this technique in improving the QoL in people with upper-crossed syndrome. The results of the study revealed that training in the Alexander technique by qualified professionals can correct inappropriate movement habits by enhancing body awareness. This, in turn, leads to improvements in both physical and mental health for affected individuals. Therefore, it is recommended that rehabilitation and health experts consider the Alexander technique as a practical postural re-education method for treating and enhancing the health of people with upper-crossed syndrome.

Introduction

In modern life, a vast majority of people are suffering from disorders caused by inappropriate use of muscles and improper daily postures, which consequently lead to deformities in the human body's posture [1]. Upper-crossed syndrome is currently one of the physical abnormalities that has a high prevalence [2]. The prevalence of upper-crossed syndrome has been reported in 32.4% of employees, 24.3% of drivers, and 27% of housewives [3]. In this deformity, thoracic kyphosis increases because of the decrease in the endurance and strength of the spinal extensor muscles [4]. Moreover, it may generate undesirable consequences in the body, such as reduced physical performance [5], pulmonary dysfunction [6], balance disorder [7], difficulty in doing daily life activities [8], and decrease in health and quality of life (QoL) [9, 10]. The upper crossed syndrome due to poor posture and inappropriate appearance (from an aesthetic point of view) accompanied by the presence of physical complications may lead to anxiety and reduced self-esteem [11]. A combination of these

issues negatively affects patients' physical and mental health and eventually decreases their QoL [10]. Given the high prevalence and various physiological and psychological complications of upper-crossed syndrome, the importance of correcting this deformity is crucial.

A variety of corrective methods have been used for people with upper-crossed syndrome, including manual therapy, exercise, the use of tapes, assistive devices, and posture re-education [12]. In recent years, the attention of health professionals has been focused on posture training as a method to prevent and correct musculoskeletal system disorders, especially head, neck, and trunk abnormalities. One of the relatively common methods of body posture re-education is the Alexander technique [13]. Although the Alexander technique was initially utilized by artists, researchers in the field of health and rehabilitation have recently become interested in the application of this technique in various health-related cases [14]. Despite the current application of the Alexander technique by researchers, it is still under investigation compared to the other methods and interventions.

The purpose of the Alexander technique is to help a person increase body awareness and use this information to achieve a more efficient performance. Alexander technique training sessions include posture exercises from lying down and sitting to more dynamic positions, such as standing up and walking, and special activities like working at a desk, studying, and playing the guitar [15]. This technique uses the teacher-student paradigm instead of the therapist-patient paradigm and its main focus is on education and not treatment [16]. Alexander technique enables people to become aware of their posture in a sensorimotor way and to change their faulty habitual movement patterns [13]. In this method, the person learns to identify the sources causing the tension response in the body, to prevent faulty habitual movement patterns, and to replace it with an efficient movement pattern according to the timing, direction, and stress reduction with an emphasis on the head, neck, and trunk [15]. Frederick Mathias Alexander, the inventor of this method, believed that movement is created not only by the body but also by the mind, and he called the division of the human organism into mental and physical parts a mistake [17]. The Alexander technique has a low degree of commonality with other corrective methods using stretching or muscle-strengthening exercises. In this method, the conscious use of the individual as an active method of psychophysical re-education is desired [18]. The effectiveness of the Alexander technique on various cases, such as back pain [19], neck pain [20], problems of the elderly [21], and Parkinson disease [22] has been investigated so far. Despite the reported findings related to the benefits of the Alexander technique, there is still insufficient scientific evidence to confirm the effectiveness of this technique in most health-related fields and a demand for more comprehensive and controlled studies is evident [14].

Nowadays, QoL is considered a basic index for evaluating various dimensions of people's health in human societies, and its investigation is of special importance. QoL refers to the concept of how well people consider their daily life in different physical, psychological, and social dimensions to be good and desirable and follow social and universal standards [23]. One of the fields in which the most research on QoL has been conducted is health-care [24]. The musculoskeletal condition of the spine is one of the main causes of pain that ultimately reduces one's QoL [25]. The findings of existing research show the relationship between postural defects and QoL and state that correct body posture is one of the most effective indicators of health and QoL [26]; therefore, interventions and methods that help to improve posture will probably enhance the QoL. Furthermore, the Alexander technique can boost the functional quality of movement and amplify the QoL by increasing body awareness [14].

In a study that investigated the effectiveness of the Alexander technique, massage therapy, and exercise therapy on chronic back pain, the researchers concluded that Alexander technique training by trained instructors has created long-term benefits in patients with chronic back pain and improved their QoL significantly [19]. Also, in a review study titled "Alexander technique for chronic asthma," the authors stated conclusively that clinical studies consisting of controlled and strong methodologies are needed to delve into the effect of the Alexander technique on various aspects of human health and the QoL among those who are exposed to different disorders [27].

A limited number of studies have been conducted on the Alexander technique in the country [22, 28]. We found that the existing studies used the Alexander technique as an exercise or a treatment (this technique is only training). Most importantly, lacking supervision by an Alexander technique expert in the design and implementation of the protocol in these studies attenuated the quality of their research. Therefore, it is necessary to conduct research containing a more efficient methodology by applying the correct training protocol under the supervision of a certified Alexander technique specialist. The majority of the studies in connection with the effect of the Alexander technique consist of diseases, such as back pain [19] and Parkinson [22, 28]. Considering the high prevalence of upper crossed syndrome [2, 3] and the negative effects of this abnormality on various aspects of one's life, their QoL in particular [9, 10], the necessity of conducting research comprising the Alexander technique, QoL, and upper crossed syndrome was evident; therefore, this study investigated the effect of the Alexander technique on the physical and mental dimensions of QoL in young men with upper crossed syndrome.

Materials and Methods

Study participants

Using the convenience sampling method, we selected 24 male university students aged 19-25 years for the current study and randomly divided them into an experimental (n=12) and a control group (n=12). We distributed the invitations to absorb volunteer male students at the [University of Tehran](#) to participate in the first phase of the study. After an initial screening by posture grid, the students with upper crossed syndrome were diagnosed and selected as samples. The criteria for sample size (n=24) were based on the variable of QoL and using the G*Power software [29] with the assumptions of the confidence coefficient of 95% ($\alpha=0.05$), statistical power 80% ($\beta=0.2$), and the effect size ($d=0.6$) (Appendix 1).

In addition to the age and gender, the other inclusion criteria were normal body mass index between 18.5 to 24.9 kg/m², forward head deformity greater than 46 degrees, kyphosis greater than 42 degrees, and forward shoulder greater than 52 degrees [30]. Those volunteers who had a history of fractures, surgery, or problems in the spine, shoulder girdle, and pelvis, visual or hearing impairment, and depression, anxiety, or mental disorders were excluded from the study.

Study design

The current research design was semi-experimental containing two conditions: a) An experimental condition, and b) A control condition. A total of 12 participants were allocated in each condition. A pre-test and post-test was conducted before and after interventions. The study was conducted blindly and the information that could cause the deviation of the study results was not presented to the participants till the completion of the study.

Before starting the study, we debriefed the participants about the intervention, the confidentiality of the results, and the right to withdraw at any stage of the research. Subsequently, written consent was obtained from them to participate in the study and participants' information was collected using demographic questionnaires, a digital scale, and a digital meter (to accurately measure their height and weight and calculate their body mass index). To evaluate the posture of the subjects, the forward head and forward shoulder angles were measured by photogrammetric method and the kyphosis angle was accurately measured using a flexible ruler. The measurements were carried out by the main researcher at the health center of [University of Tehran](#). During the intervention, the participants of the experimental condition received the educational intervention of the Alexander technique according to the predetermined protocol for six weeks. Alexander technique training sessions were held in a classroom with adequate space, ventilation, and light. The control condition was not subjected to any special education and training and the participants of the control condition were only evaluated in the pre-test and post-test.

The goal of the Alexander technique training protocol was to increase body awareness, correct inappropriate movement habits, and help participants function correctly in daily activities. During the experimental condition, the participants were taught the Alexander technique using manual guidance, and verbal, visual, and proprioception feedback. In the first two sessions, we concentrated on the participants' familiarity with the Alexander technique, explaining goals, and identifying

their weak physical habits and inefficient movement patterns. In the following sessions, we instructed the participants about the following items: a) The correct way to hold the head, neck, and spine while sitting, standing, and walking; b) The correct way to sit and stand up; c) The correct way to sit and lift objects; d) The correct way to work in a bent position; e) The correct way to carry bags and equipment; f) The correct posture when writing and reading; g) The correct expressions of the face and eyes; and h) The correct way of breathing [28]. During these sessions, the participants tried to familiarize themselves with the basic concepts of Alexander's technique, including inhibition, primary control, and direction, in addition to correcting wrong body habits and improving movement patterns. They were also asked to apply the acquired knowledge in their daily activities.

To obtain sufficient expertise for instructing the Alexander technique to the participants, the first author completed the necessary training (24 training sessions within 3 months) under the supervision of an Alexander technique expert¹ and familiarized himself with the core principles of the technique. The training protocol for the current study was then designed by seeking advice from the certified expert. The Alexander technique protocol was applied by the participants under the direct supervision of the first author throughout the study (Figure 1).

According to the designed Alexander technique protocol, the participants of the experimental condition completed 12 training sessions within 6 weeks (two sessions weekly). Individualized training sessions were conducted during the first four weeks for each participant. The participants attended group sessions instead of individualized sessions during the last two weeks of the interventions. Each individualized session of the Alexander technique was 40 min consisting of the following items: a) Examining body habits and patterns during various activities (5 min); b) Teaching and applying the basic principles of Alexander technique, including inhibition, primary control, and direction in various activities, such as sitting, standing, walking, studying, and lifting objects using tactile and verbal feedback (30 min); and c) Question and answer by the participants and teaching how to use the Alexander technique in daily activities (5 min). After completing eight individualized sessions within four weeks, the participants finalized their intervention phase by completing four 60-min group sessions within the remaining two weeks. The emphasis of the group sessions was on repeating and reminding the basic principles of the Alexander technique using minimal

1. Dr. Azin Movahed, certified teacher in the Alexander technique from the American Society for the Alexander Technique (AmSAT).



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Figure 1. Applying the training intervention of the Alexander technique (individual and group sessions)

contact and verbal feedback to increase the participants' independence for the practical use of the Alexander technique in daily activities. A total of 104 training sessions of the Alexander technique composed of 96 individualized training sessions and eight group training sessions were conducted throughout the experimental condition. All participants attended the sessions following the schedule and only one participant missed one of his individualized and one of his group sessions (total attendance rate=0.98). In the group phase of the intervention, the participants were divided into two separate groups (six participants in each group) to comply with the existing health protocols.

The emphasis of the Alexander technique training sessions was on the benefits of increasing self-awareness during the activity. The participants were encouraged to self-evaluate while performing their usual daily activities, such as standing, sitting, working with the computer, personal tasks, and housework, and most importantly, to apply the learned principles of the Alexander technique to improve physical and movement habits. We used tactile feedback to teach the subjects how to maintain a coherent connection of different parts of the body during the activities. We also asked them to communicate any problems in understanding and implementing the movements so that the training could be completed correctly and accurately.

The short form (SF-36) health survey was used to assess the participants' QoL. This self-report questionnaire is a 36-item scale which is designed by Ware and Sherburne [31]. The SF-36 questionnaire evaluates two general dimensions of QoL, which include the physical health dimension (physical function, physical role limitations, bodily pain, and general health perception) and the mental health dimension (energy/vitality, social functioning, emotional role limitations, and mental health). The outcome is evaluated through the score of the physical dimension and the score of the mental dimension, respectively [32]. A Likert scale from 1 (very bad) to 5 (very good) for scoring is used in this questionnaire [33]. The evaluations performed on the dimensions of SF-36 show that this questionnaire is a reliable scale with content validity. In a study by Brazier et al., the validity of the original version of this questionnaire for all subscales was more than 0.85 and the validity of this tool was confirmed concerning the Nottingham health profile [32]. The questionnaire had good validity, reliability, and internal consistency and this has also been confirmed in the Iranian population [33]. In the present study, the reliability of this questionnaire was reported as 0.83 using the Cronbach α coefficient. Descriptive statistics, including Mean \pm SD were used to describe the research variables. Also, after assessing the normality of data distribution by the Shapiro-Wilk test, the analysis of covariance (ANCOVA) and Correlated t-test was conducted using the SPSS software, version 26, to evaluate

research hypotheses. The significance level for all statistical tests was considered equal to 0.05. Furthermore, to evaluate the effectiveness of the Alexander technique intervention on the physical and mental dimensions of QoL, the effect size was also calculated and reported.

Results

In this section, we discuss the collected data, analyses, and results related to 24 young male participants with upper-crossed syndrome. The descriptive findings of the participants are presented in Table 1. The results of the independent t-test showed no significant difference between the mean demographic variables of height, weight, body mass index, and age of the research participants in the control and experimental conditions ($P > 0.05$).

The Shapiro-Wilk test was used to check the normality of data distribution. Based on the results of the Shapiro-Wilk test, the variables had a normal distribution in the control and experimental conditions ($P > 0.05$). The results related to the mean score of the physical and mental dimensions and the total score of the QoL in the pre-test and post-test stages of the experimental and control conditions are illustrated in Table 2.

We used the ANCOVA test to compare the effect of the Alexander technique on the physical dimension of QoL in participants with crossed syndrome between the control and experimental conditions. The results of the ANCOVA test, presented in Table 3, indicated that after controlling for the effect of the pre-test, there is a significant difference between the mean scores of the physical dimension of the QoL of the control and experimental conditions. Therefore, the Alexander technique has significantly increased the physical dimension of the QoL in young men with upper-crossed syndrome ($F_{(1, 21)} = 82.303, P < 0.001, \eta^2 = 0.79$).

This study used the correlated t-test to compare the intra-group variable of the physical dimension of the QoL. According to the results of the correlated t-test, the mean scores of the physical dimension of the QoL in the experimental condition from the pre-test (Mean±SD 67.68±10.779) to the post-test (Mean±SD 86.70±9.606) significantly increased ($T [11] = -12.151, P < 0.001$).

Similarly, we used the analysis of the covariance test to compare the effect of the Alexander technique on the mental dimension of the QoL in participants with upper-crossed syndrome. The results of the ANCOVA test, presented in Table 4, indicated that after controlling for the effect of the pre-test, there is a significant difference be-

Table 1. Description of the height, weight, body mass index, and age of the research participants

Variables	Mean±SD		Sig.
	Control Group	Experimental Group	
Height (cm)	175.916±6.761	176.91±4.1000	0.192
Weight (kg)	70.91±8.151	71.75±4.392	0.312
Body mass index (kg/m ²)	22.83±1.992	22.91±2.065	0.438
Age (y)	22.96±1.574	22.85±1.392	0.101

Table 2. Description of the variables of physical and mental dimensions and the total score of the subjects in the conditions and stages of the research

Conditions	Stages	Mean±SE		
		Physical Component Score	Mental Component Score	Total Health Score
Experimental condition	Pre-test	67.68±3.111	51.88±3.442	59.78±3.263
	Post-test	86.70±2.773	78.00±3.209	86.70±2.847
Control condition	Pre-test	71.24±2.805	55.41±327.3	63.32±2.915
	Post-test	70.93±2.597	51.32±2.802	61.12±2.673

Table 3. Results of the analysis of covariance test for inter-group comparison of mean score of the physical dimension of QoL in research conditions

Dimensions	Source	Sum of Squares	df	Mean Squares	F	Sig.	Effect Size
Physical dimension of QoL (score)	Pre-test	1396.256	1	256.1396	57.564	0.001	0.733
	Group	1996.342	1	342.1996	82.303	0.001	0.797
	Error	509.374	21	256.24			

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Table 4. Results of analysis of covariance test for inter-group comparison of mean scores of the mental dimension of QoL in research conditions

Dimensions	Source	Sum of Squares	df	Mean Squares	F	Sig.	Effect Size
Mental dimension of QoL (score)	Pre-test	1440.746	1	1440.746	31.665	0.001	0.601
	Group	4965.731	1	4965.731	138.109	0.001	0.839
	Error	955.490	21	45.500			

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tween the mean scores of the mental dimension of the QoL of the control and the experimental conditions. Therefore, the Alexander technique has significantly increased the mental dimension of the QoL in young men with upper-crossed syndrome ($F_{(1,21)}=109.138, P<0.001, \eta^2=0.83$).

This study also used the correlated t-test to compare the intra-group variable of the mental dimension of the QoL. Following the results of the correlated t-test, the mean scores of the mental dimension of the QoL in the experimental condition from the pre-test (Mean±SD 51.88±11.857) to the post-test (Mean±SD 78.00±11.116) significantly increased ($T [11]=-11.235, P<0.001$).

Discussion

This research was conducted to investigate the effectiveness of the Alexander technique on the physical and mental dimensions of the QoL in young men with upper-crossed syndrome. According to the findings of the current study, the Alexander technique significantly increased the physical aspect of the QoL in young men with upper-crossed syndrome in the experimental condition. After participating in the educational intervention of the Alexander technique, the average physical component score of the participants of the experimental condition was 86.70 which shows an average of 19.02 points increase compared to the pre-test, which is a high score in the SF-36 health survey. This is indicative of the improvement of the physical dimension of participants' QoL at the end of intervention in the experimental condition. Considering the reported size effect (0.79),

Alexander technique training has significantly improved the physical dimension of health in the experimental condition. The greatest improvement in the physical dimension of the QoL of the experimental condition was observed in the general health subscale with a 23.75 points increase compared to the pre-test. The findings of the present study were consistent with the findings of the studies by Little et al. [19] and Kim and Baek [34]; however, they were in contrast with the results of the study by Pourkamali et al. [28]. Pourkamali et al. (2016) compared the effectiveness of massage therapy, Alexander and Dosaho technique on happiness, hope, health, and QoL of elderly people with Parkinson disease. The results of their study showed that the Alexander technique had no significant effect on improving the QoL [28]. The difference between the results of the current study and the study by Pourkamali et al. [28] might be due to various factors, such as the difference in the age of the participants, condition of their participants who were suffering from Parkinson disease (which creates limitations and continuous physical and mental problems), and limited number of training sessions of the Alexander technique in their study compared to the current study. Moreover, the lack of supervision of a certified teacher of the Alexander technique in the study by Pourkamali et al. [28] can have a negative impact on the quality of training by the researchers and lead to translation inefficiency and ineffectiveness of the Alexander technique training during the intervention.

Moreover, based on the findings of the current study, the Alexander technique significantly increased the mental aspect of the QoL in young men with upper crossed syndrome in the experimental condition. After participating in the educational intervention of the Alexander technique, the average mental component score of the participants of the experimental condition was 78.00 which shows an average of 26.12 points increase compared to the pre-test, which is a high score in the SF-36 health survey. According to the reported effect size (0.83), the Alexander technique training significantly improved the mental dimension of health in the experimental condition. The greatest improvement in the mental dimension of the QoL of the experimental condition was observed in the social performance subscale with a 26.04 points increase compared to the pre-test.

A limited number of studies have investigated the effectiveness of the Alexander technique on the mental dimension of QoL. The findings of the recent study were consistent with the results of the study by Kim and Beak [34], but contrary to the results of the study by Little et al. [19]. Little et al. investigated the effectiveness of the Alexander technique, massage therapy, and exercise prescription on chronic back pain. They reported no significant difference related to the mental dimension of QoL ($P=0.314$) between the Alexander technique (experimental) condition and the control condition [19]. The participants of their study were suffering from chronic back pain that can negatively impact the mental state and relaxation of the patients and consequently lead to the ineffectiveness of the Alexander technique on their mental dimension. Whereas, the participants of the current study were young and healthy, and the quality of the training was improved by the supervision of an expert in the field.

In addition to the quantitative examination of the participants in connection with the effectiveness of the Alexander technique intervention on health in the current study, we qualitatively collected participants' experiences, attitudes, and feedback regarding the Alexander technique training. This study conducted individual interviews two weeks after the implementation of the protocol. The majority of the participants indicated that they joined the study since they assumed that the Alexander technique training was beneficial. They highlighted other reasons for attending the session, such as the convenience of the training, modest effort, no difficult compared to sports exercises, reasonable cost, attainability, and feasibility (whenever/wherever). They also emphasized that the sessions and training were enjoyable and attractive, and they introduced and highly recommended the Alexander

technique training to their family and friends. Furthermore, they stated that after application of the Alexander technique, they feel improvements and lightness in their body actions and freedom of movement besides feeling a sense of physical and mental relaxation. They suggested the introduction of the Alexander technique not only to a wider range of university students but also to the members of society. These findings were consistent with the results of the studies by Cohen et al. [35], Hanefeld et al. [36] and Tunnicliffe [21].

Finally, the 6-week training protocol of the Alexander technique in the present study was effective in improving the physical and mental dimensions of the participants' QoL. The amount of change in the total score of the QoL in the experimental condition after the intervention was from 59.78 points in the pre-test to 82.35 points in the post-test, which indicated the overall improvement of health and QoL in the experimental condition. The benefits of conducting the Alexander technique intervention were improving the physical condition of the participants, enhancing their body awareness and coordination, and consequently cultivating their health and QoL. Most importantly, based on the scores, the mental dimension of QoL was developed slightly more than the physical dimension of QoL. This might be due to the mental nature of the Alexander technique and more emphasis on the use of the mind while delivering this method.

Conclusion

Based on the results of the present study, the Alexander technique training improves the physical and mental dimensions of QoL in people with upper-crossed syndrome. The Alexander technique can increase individuals' mental and physical energy levels in their daily lives by removing inappropriate physical habits, eliminating faulty movement patterns, replacing them with correct habits, and improving posture that subsequently leads to cultivating general health. Therefore, the application of the Alexander technique as a practical and effective psychophysical re-education method independently or along with other interventions is highly recommended in the field of health and rehabilitation, to enhance the physical and mental dimensions of health and QoL in people with upper crossed syndrome. We suggest that the effectiveness of the Alexander technique on various dimensions of health and QoL in various ranges of age groups and genders who are suffering from different physical or mental issues should be investigated in future studies along with conducting follow-up sessions.

Study limitations

Considering the timeframe of conducting this study, the COVID-19 pandemic impeded the progress. In addition, there were some limitations throughout this research, including difficulties in finding volunteers to attend the experiments, obligations to reduce the sample and number of Alexander technique training sessions due to the existing risk factors, the conundrum of accessing a safe and suitable place to implement the educational intervention, and the absence of research background. We could not carry out the follow-up phase due to the COVID-19 restrictions and obstacles to re-accessing the participants.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of [University of Tehran](#) (Code: IR.UT.SPORT.REC.1400.032 in 1401).

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Authors' contributions

Conceptualization and supervision: Mohammad Hosein Alizadeh and Houman Minoonezhad; Protocol designing and data collection: Hamid Babaei and Azin Movahed; Data analysis: Hamid Babaei and Houman Minoonezhad; Methodology, investigation and preparing the original draft: All authors; Review and final edition: Roy Maher.

Conflict of interest

The authors declared no conflict of interest.

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[1] -- Saturday, June 04, 2022 -- 18:31:29
F tests - ANCOVA: Fixed effects, main effects and interactions
Analysis:  A priori: Compute required sample size
Input:    Effect size f           = 0.6
          α err prob            = 0.05
          Power (1-β err prob)  = 0.8
          Numerator df          = 1
          Number of groups      = 2
          Number of covariates  = 1
Output:   Noncentrality parameter λ = 8.6400000
          Critical F            = 4.3247937
          Denominator df       = 21
          Total sample size     = 24
Actual power = 0.8003240
```

Appendix 1. Calculation of the sample size using the G*Power software

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