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Original Article

Effects of a Physical Activity Educational Intervention on Upper-Body Abnormalities, BMI and Quality of Life among Female Obese Middle-School Students

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Abstract

Background: Finding educational program for correcting skeletal abnormalities and improving quality of life among obese adolescents is of great importance. Therefore, the present study employed a protocol centered on physical activity and exercise to assess its effectiveness in rectifying upper body abnormalities (forward head posture and kyphosis), BMI, and the quality of life of female obese middle-school students.

Methods: This was a quasi-experimental investigation. The study participants were 42 female obese middle-school students in Tehran, Iran, during the 2023-2024 academic year, aged between 12 and 15 years, who were randomly assigned into the experimental or control groups. The intervention consisted of a 60 minutes program over a period of 12 weeks, including a structured corrective exercise regimen followed by a Pilates training. Upper-body abnormalities (forward head and kyphosis), BMI, and quality of life were measured using standard tools. Data were analyzed using ANCOVA.

Results: In the baseline, the results showed no significant differences between the groups concerning forward head posture (51.57 vs. 51.09, P=0.623), kyphosis (51.33 vs. 51.42, P=0.920), BMI (32.46 vs. 32.87, P=0.559), and quality of life (47.47 vs. 48.28, P=0.854). However, the results showed that the intervention had a significant impact on forward head posture (39.80 vs. 51.28, P<0.001), kyphosis (38.42 vs. 51.52, P<0.001), BMI (29.57 vs. 32.95, P<0.001), and quality of life (57.14 vs. 48.71, P<0.001).

Conclusions: Given the favorable impacts of corrective and Pilates exercise modality on physical well-being and life quality, it is plausible that such exercises could serve as a viable intervention for ameliorating obesity-related deformities in affected individuals.

Keywords: Obesity, Exercise, Quality of Life, Adolescents, Abnormality

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1. Introduction

Obesity, a globally prevalent nutritional disorder, is linked to a multitude of health issues, including: type 2 diabetes, metabolic irregularities, glucose intolerance, insulin resistance, elevated insulin levels, orthopedic and skeletal complications, neurological conditions, respiratory issues, endocrine disorders, heightened triglycerides and cholesterol levels, liver diseases, hypertension, cardiovascular ailments, pseudotumor, headaches, bladder disorders, various cancers, and ovarian cysts (1-3). The World Health Organization defines overweight and obesity as the abnormal and excessive accumulation of body fat that adversely affects an individual's health (3). This condition not only leads to physical and personal repercussions but also incurs economic costs and engenders psychological and social challenges, such as anxiety, diminished self-esteem, and experiences of stigma and discrimination related to obesity (2, 3). The extent of social stigma faced by individuals is a predictor of the psychological effects they endure (4, 5). Furthermore, obesity significantly influences the emotional development of children and adolescents who encounter discrimination and stigma. Young individuals with obesity are particularly vulnerable to adverse psychosocial outcomes, including bullying, discrimination, and low self-worth (4). Generally, the psychosocial ramifications of obesity can diminish individuals' quality of life and exacerbate the overall disease burden (5).

Statistics reveal that the rise in global obesity rates is largely attributable to shifts in lifestyle, with projections indicating that this number may reach 537 million individuals by the year 2030 (6). Previous studies demonstrated a correlation between the prevalence of obesity and unhealthy lifestyle choices (1, 2, 5). The forces of globalization and the consumption of cultural products significantly influence lifestyle alterations. Key contributors to the rise in snack consumption and the subsequent obesity epidemic among children and adolescents include the growing prevalence of urban living, pervasive television advertising, the appeal of product packaging, and a general lack of nutritional knowledge among parents (7-10). The recent surge in obesity rates among younger populations underscores the urgent need for further research in this area. Consequently, examining the factors linked to obesity and identifying effective treatment strategies is of paramount importance.

A review of literature revealed that obesity, as one of the mind-body interactions, is not only a cause of physical problems, but also a factor in the emergence of behavioral problems (2, 4, 5, 8, 9). Obesity has a two-way relationship with psychological disorders and the psychiatric status of the individual. In other words, many psychological problems can be the primary and permanent cause of obesity, and obesity itself can also lead to many adverse psychological consequences and dissatisfaction with life. In the recent years, researchers and clinical experts showed a growing interest in exploring the relationship between health-related quality of life and chronic diseases, such as obesity and overweight (10-14). In this regard, the new strategies of the World Health Organization state that the focus and concentration of research should take a health perspective, and focus on increasing the quality of life related to the health of individuals (14). However, in today's world, with the development of urbanization, industrialization of societies, increased economic growth and globalization of the market, rapid changes have been created in people's dietary patterns and lifestyles (5, 6). These changes are not necessarily beneficial to the health and well-being of the society and have often led to the widespread prevalence of obesity and diet-related chronic diseases in adults and the young population (3, 4). Therefore, it is becoming increasingly clear that the problems and issues associated with obesity are not limited to medical and physical conditions; rather, obesity has a significant impact on the functional capacity and quality of life of individuals. Therefore, the quality of life is a significant factor to consider when discussing the issue of obesity. Different structural abnormalities, including asymmetrical shoulders, lumbar curvature, kyphosis, flat feet, bowed knees, and forward head tilt, manifest during childhood and adolescence, often attributed to insufficient muscle strength at these developmental stages (15-19). Additionally, excess weight and obesity are significant contributors to the emergence of these structural issues. The prevalence of such abnormalities among children has become increasingly concerning. The body mass index (BMI) serves as a robust indicator of prevalent chronic musculoskeletal conditions and associated pains, such as back, knee, and leg pain, which are frequently linked to structural irregularities in overweight and obese children (15, 17, 20-22). The functional and structural impairments resulting from excess weight on the locomotor system in children are widely acknowledged. Musculoskeletal health is crucial for individuals' mobility, skill execution, work performance, and daily activities (17, 18). In recent years, there has been a notable rise in the prevalence and impact of musculoskeletal disorders (16). These disorders are identified as significant contributors to disability and premature mortality globally (19, 20). Research indicated that musculoskeletal pain and injuries are common during childhood and adolescence, potentially influencing the onset of musculoskeletal disorders in later life (19, 21, 22). Consequently, it is imperative to identify these abnormalities early and implement effective preventive strategies to mitigate chronic pain in adulthood.

Posture results from the intricate coordination and collaboration among various body components, particularly muscles and bones (17, 19). Bones serve as the structural foundation of the body, while muscles facilitate movement within this framework. Consequently, the strength and weakness of these elements significantly influence the configuration and mobility of the limbs (17, 20). To enhance this system, it is essential to engage in exercises and sports activities that promote both mobility and strength, thereby maintaining the optimal positioning of the limbs. Currently, numerous approaches exist to address postural

abnormalities, including surgical interventions, various types of braces, lumbar-pelvic supports, and corrective exercises (23-27). To mitigate musculoskeletal disorders, a range of treatment protocols has been proposed, with corrective exercises being particularly effective in addressing specific physical irregularities such as lumbar lordosis, dorsal kyphosis, and scoliosis (24, 25). The efficacy of exercise therapy in alleviating and potentially resolving these conditions underscores its critical importance; for instance, the benefits of relaxation techniques and stretching exercises in reducing musculoskeletal issues are noteworthy. Overall, physical activity and exercise are recognized as fundamental strategies in the primary management of chronic musculoskeletal pain (27-30). Nevertheless, the investigation into the impact of corrective exercise techniques on skeletal abnormalities in obese adolescents has been relatively limited. Therefore, this study employed a protocol centered on physical activity and exercise to assess its effectiveness in rectifying upper body abnormalities in this demographic. Additionally, the study examined the influence of this corrective exercise protocol on body mass index and the quality of life of female obese middle-school students.

2. Methods

2.1. Design

The current investigation is classified as the quasi-experimental study, characterized by the implementation of an intervention variable and deliberate selection of samples in accordance with established inclusion and exclusion criteria.

2.2. Participants

The participants were 42 female middle-school students, aged between 12 and 15 years. The study participants were selected using the convenience sampling method. Subsequently, the participants were divided into experimental and control groups using a simple random method, each comprising 21 students (Figure 1). A comprehensive overview of the study was provided to all participants and their guardians, and those who agreed to participate in the study were given the information collection and consent forms, which they signed after reviewing the content. The inclusion criteria were: between 12 and 15 years of age, body mass index (BMI) exceeding 30, forward head angle greater than 46 degrees, and kyphosis angle surpassing 45 degrees. The exclusion criteria were: having physical disabilities, balance and neuromuscular disorders, spinal fractures, a prior history of bone and joint diseases affecting the shoulder girdle and neck region.

2.3. Sample Size Determination

The sample size was determined using G*Power software, with a significance level set at 0.05 and a power of 0.95. The mean scores for upper-body abnormalities (i.e., forward head) at the pretest and the posttest were 48.37±1.71 and 46.75±1.94, and 47.82±1.47 and 48.00±1.69 in the experimental and the control group, respectively (30).

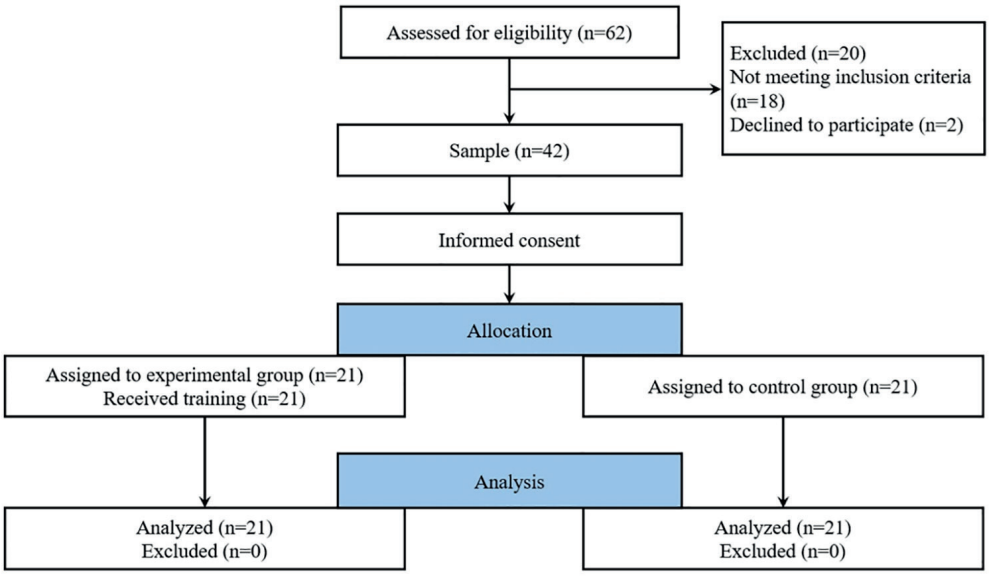

Figure 1: The figure shows the CONSORT flow diagram of the study.

2.4. Data Collection and Measurements

2.4.1. Upper-body Abnormalities: To evaluate the head-forward posture, a lateral imaging technique was employed. Initially, the 7C and tragus landmarks were identified, and the participant was positioned in an upright stance. A camera was then set up at a distance of 256 cm, aligned with the participant's shoulder height. The participant was instructed to bend and straighten their posture three times before sitting comfortably and gazing straight ahead. After a two-minute interval, three sequential photographs of the subject were captured. These images were subsequently imported into the J Image software, where the angle formed between the perpendicular line through the 7C point and the line connecting the tragus to the 7C point was computed, thereby determining the head-forward angle for further analysis.

In addition, the Spinal Mouse device (MED PRO model, manufactured in Switzerland) was used to assess the conditions of kyphosis. This sophisticated non-invasive instrument evaluates spinal health across multiple planes. To determine the extent of kyphosis, participants were instructed to position their feet shoulder-width apart, maintain straight knees, gaze forward, and adopt a neutral standing posture. The examiner then positioned themselves behind the participant, locating and marking the C7 spinous process (the seventh cervical vertebra) through palpation as a reference point. Subsequently, the Spinal Mouse was activated, and its rollers were placed above and below the C7 vertebra. The device was then drawn down the spine to approximately the S3 vertebra (the third sacral vertebra). This procedure was also conducted while the participant was in both flexed and extended trunk positions. As the device traversed the spine, it recorded the trajectory of movement, spinal curvature, the angles of individual vertebrae, and the degree of back curvature (from T1T2 to T12L1 levels) on a monitor in degrees. The software associated with the device was then employed to extract the kyphosis degree from the T1 to T12 levels (the first to the twelfth thoracic vertebrae). Each measurement was repeated three times for every participant, and the average values were documented and analyzed to determine the degree of kyphosis for each individual.

2.4.2. BMI: The calculation of the body mass index (BMI) for adolescents was conducted using the formula weight (in kilograms) divided by the square of height (in meters). In this study, the participants' height and weight were meticulously measured, after which BMI was calculated through the specified formula.

2.4.3. Quality of Life: Health-related quality of life was evaluated using the Pediatric Quality of Life Inventory Version 4.0 Generic Core Scales (PedsQL) (31), which comprises 23 items rated on a 5-point Likert scale ranging from 0 (never) to 4 (almost always). The scoring for certain items is reversed, and all responses are linearly converted to a scale from 0 to 100, with the following transformations: 0 corresponds to 100, 1 to 75, 2 to 50, 3 to 25, and 4 to 0. The highest possible score is 100, while the lowest is 0. In this study, the reliability of the PedsQL was assessed, yielding a Cronbach's alpha of $\alpha=0.92$.

2.5. Procedure

After obtaining approval from the ethics committee, coordination with the education department was established to secure the necessary permissions. Subsequently, visits were made to the targeted schools to identify students eligible to participate in the study. An initial coordination meeting was held with the parents of these students, during which the research objectives and the implementation protocol were explained. During this meeting, parents completed written consent forms for their children's participation in the study. Following this, a pre-test was administered to all participants under uniform conditions. The experimental group then engaged in the research protocol, while the control group did not undergo the experimental protocol. Finally, after the research protocol was executed, all participants took part in a post-test under the same conditions.

2.6. Intervention

The intervention implemented in this study comprised two distinct components. The initial component focused on corrective exercises, while the subsequent component involved Pilates exercises. The primary objective of the corrective exercises was to address and ameliorate the participants' specific abnormalities, while the Pilates exercises aimed to enhance the strength of core muscles, refining body composition, and

augmenting balance and flexibility. Following the completion of the pre-test, participants in the experimental group engaged in a structured corrective exercise regimen over a period of 12 weeks, attending three sessions per week, each lasting 30 minutes, conducted in a gym setting. This exercise program was facilitated by two trainers specialized in corrective exercise, and was meticulously designed in accordance with established exercise science principles, including: intensity, duration, and the overload principle. The intensity of the exercises was tailored to each participant's level of tolerance, with the progression from simpler to more complex movements. In the initial sessions, exercises were characterized by lower intensity, fewer repetitions, and shorter duration, gradually increasing in difficulty as participants adapted. The corrective exercise program encompassed four categories: primarily featuring isometric exercises targeting the neck; strengthening exercises for the abdominal and back muscles; flexion exercises for the neck and lumbar regions; and specialized shoulder exercises aimed at enhancing both strength and flexibility of the associated musculature. Following the corrective exercises, participants in the experimental group engaged in 30 minutes of Pilates activities, specifically Zumba group sessions, led by a qualified Pilates instructor. The post-test was administered one week following the conclusion of the intervention. Participants in the control group did not engage in any corrective or Pilates exercises during this period.

2.7. Data Analysis

The data were analyzed using descriptive statistics, which included the calculation of the mean and standard deviation. In addition, The Kolmogorov-Smirnov test was also applied to evaluate the normality of the data distribution. An independent t-test was conducted to compare the baseline data (i.e., pretest) across groups. In addition, a paired t-test was employed to examine the effects of physical activity educational intervention on upper-body abnormalities, BMI and quality of life. All statistical analyses were performed using SPSS version 27, with a significance threshold established at 0.05.

3. Results

The study comprised a total of 42 participants. The average age for the intervention group was 13.93±0.25 years, while the control group had an average age of 13.90±0.21 years. Table 1 outlines the demographic characteristics, including age, height, and weight, of the sample divided into intervention and control groups. An independent t-test indicated no significant age differences between the two groups (t=0.21, P>0.05). In terms of height, the intervention group averaged 160.33±3.64 cm, compared with 161.49±2.93 cm for the control group. Again, the independent t-test revealed no significant differences in height (t=0.36, P>0.05). Lastly, the average weight for the intervention group was 83.36±4.49 kg, while the control group averaged 85.50±5.06 kg. The independent t-test confirmed no significant differences in weight between the groups (t=0.25, P>0.05).

Table 1: Demographic characteristics of the participants

Variables	Mean±SD
Age (years)	
Intervention (n=21)	13.93±0.25
Control (n=21)	13.90±0.21
Total (n=42)	13.92±0.22
Height(cm)	
Intervention (n=21)	160.33±3.64
Control (n=21)	161.49±2.93
Total (n=42)	160.88±3.21
Weight(kg)	
Intervention (n=21)	83.36±4.49
Control (n=21)	85.50±5.06
Total (n=42)	84.40±4.69

SD: Standard Deviation

Table 2 shows the mean values and standard deviations for the variables of the study at both the pre-test and post-test stages, along with the results of group comparisons. Notably, all the variables demonstrated a normal distribution. The descriptive statistics indicated no significant differences between the groups concerning forward head posture (51.57 vs. 51.09, P=0.623), kyphosis (51.33 vs. 51.42, P=0.920), BMI (32.46 vs. 32.87, P=0.559), and quality of life (47.47 vs. 48.28, P=0.854). These findings suggested that the groups were similar across all the variables prior to the intervention. Furthermore, the analysis of post-test scores revealed significant differences between the intervention and control groups in terms of forward head posture (39.80 vs. 51.28, P<0.001), kyphosis (38.42 vs. 51.52, P<0.001), BMI (29.57 vs. 32.95, P<0.001), and quality of life (57.14 vs. 48.71, P<0.001). These results indicated that engaging in a therapeutic physical activity intervention effectively mitigated upper-body postural problems, decreased BMI, and enhanced the quality of life for female adolescents with obesity.

Table 2: Pretest and posttest scores across groups

Variables	Phase	Group		Between-group Comparison
		Intervention	Control	
		M±SD	M±SD	
Forward Head	Pretest	51.57±2.90	51.09±3.30	t=0.496 P=0.623
	Posttest	39.80±3.02	51.28±2.77	t=- 12.802 P<0.001
	Within-group Comparison	t=14.955 P<0.001	t=- 1.073 P=0.296	
Kyphosis	Pretest	51.33±3.11	51.42±2.95	t=- 0.101 P=0.920
	Posttest	38.42±2.94	51.52±3.05	t=- 14.137 P<0.001
	Within-group Comparison	t=14.100 P<0.001	t=- 0.623 P=0.540	
BMI	Pretest	32.46±1.92	32.87±2.53	t=- 0.589 P=0.559
	Posttest	29.57±1.85	32.95±2.55	t=- 5.155 P<0.001
	Within-group Comparison	t=8.455 P<0.001	t=- 1.576 P=0.131	
Quality of Life	Pretest	47.47±14.22	48.28±14.10	t=- 0.185 P=0.854
	Posttest	57.14±11.76	48.71±13.75	t=2.134 P=0.039
	Within-group Comparison	t=- 5.661 P<0.001	t=- 0.750 P=0.462	

SD: Standard Deviation; BMI: Body Mass Index

4. Discussion

The impact of physical activity exercise techniques based on corrective and Pilates exercises on skeletal abnormalities and quality of life in obese adolescents has been rarely studied. Therefore, this study employed a protocol centered on physical activity and exercise to assess its effectiveness in rectifying upper body abnormalities (forward head posture and kyphosis), BMI, and the quality of life of obese adolescents.

The findings indicated that the intervention had a significant impact on forward head posture, kyphosis, BMI, and quality of life. These outcomes imply that participation in a therapeutic physical activity intervention effectively addressed upper-body postural issues, reduced BMI, and improved the quality of life for female adolescents with obesity. The findings regarding to the upper-body abnormalities were in line with those of previous studies (24, 25, 27-30). To interpret these findings, it can be stated that the forward head posture and kyphosis can be addressed through the development of a corrective program that incorporates stretching exercises targeting shortened muscles and strengthening exercises aimed at weakened muscles in specific areas. This approach is effective in mitigating the forward head angle in individuals affected by this condition (25, 26). While all muscles contribute to movement control and spinal stabilization, the deep muscles are particularly crucial for regulating intervertebral movements, as they also provide stability to the spine during dynamic activities (25, 28). Corrective exercises based on strength training appears to influence the length of muscle tendons, alter various skeletal components, and enhance ligament stability. Conversely, corrective exercises based on stretching exercises serve to coordinate muscle function (24, 25). These stretching activities contribute to elongating the muscles on the concave side while simultaneously strengthening those on the convex side, ultimately leading to a reduction in kyphosis abnormalities. Consequently, it can be concluded that the enhancement of spinal rectus muscle strength is crucial for the maintenance of body structure and posture (27, 29). In addition, Pilates training has resulted in additive benefits for upper-limb abnormalities, because Pilates exercises bolster the musculature of the upper arms, upper body, core, as well as the abdominal

and lower back regions (30). Regular engagement in this form of exercise appears to contribute to improved strength and endurance in both the limbs and various bodily organs, while also serving to mitigate the advancement of muscle degradation and deterioration (28, 29).

The results concerning obesity suggested that engagement in a therapeutic physical activity program significantly lowered the BMI of female adolescents suffering from obesity. These results corroborated earlier research, which indicated that involvement in physical exercise contributes to effective weight management (32-35). To interpret these findings, it can be sated that the participants in the intervention group engaged in strength training aimed at enhancing upper body musculature, along with Pilates exercises that primarily emphasized breathing techniques (24, 25, 33, 35). Research indicated that deep and diaphragmatic breathing elevates energy expenditure during physical activity, as it not only activates the primary muscles but also engages the respiratory muscles, which in turn consume additional energy. Furthermore, this form of breathing facilitates improved oxygen delivery to the working muscles (24, 34, 35). Additional studies suggested that enhanced oxygenation through deep breathing can lead to increased insulin sensitivity, thereby reducing the necessity for excessive insulin production, which subsequently promotes fat oxidation within the body (33, 34). Given that deep and diaphragmatic breathing is a fundamental aspect of Pilates, it is anticipated that participation in these exercises will contribute to a reduction in body fat percentage and overall fat mass.

Finally, the findings indicated that the intervention had a significant impact on quality of life. These results corroborated earlier research, implying that participation in a therapeutic physical activity intervention effectively improved the quality of life for female adolescents with obesity (36-40). Quality of life serves as a critical indicator of the efficacy of various exercise methodologies. Individuals consistently seek to enhance their quality of life, and any efforts made in this pursuit are beneficial (36, 37). Engaging in physical exercise constitutes a fundamental aspect of daily human existence. However, individuals with obesity often face limitations in their ability to participate in such activities due to insufficient physical fitness, which can foster a negative perception of exercise (38). Consequently, these individuals frequently adopt a sedentary lifestyle, resulting in diminished physical fitness and a lower quality of life compared with their counterparts. Pilates exercises offer a range of benefits, including the release of essential hormones that promote well-being, such as serotonin, as well as inducing bodily relaxation, lowering cortisol levels (the stress hormone), alleviating fatigue, and enhancing self-esteem (39, 40). The advantages of exercise extend beyond physical health; they also play a significant role in mental well-being. The mental health benefits associated with physical activity include a reduction in mental health disorders, as well as decreased anxiety, depression, and irritability in response to stressors. For many, engaging in physical activities, like Pilates, serves as a valuable means of relaxation (32, 35, 37, 39). Obese individuals often experience a diminished sense of self-worth due to their inability to engage in preferred physical activities, which adversely impacts their self-esteem. This decline in self-confidence can lead to heightened levels of anxiety, depression, and feelings of sadness, further influencing their social interactions and contributing to social isolation. Consequently, obesity has a profound effect on multiple dimensions of an individual's life, restricting their physical, mental, and social engagements, ultimately resulting in a decreased quality of life. Engaging in breathing exercises, along with addressing musculoskeletal issues and reducing obesity, has likely enhanced the functional capacity of obese adolescents, thereby improving their overall quality of life (35, 37, 39, 40). Enhancing an individual's physical and physiological state contributes to greater efficacy in managing personal affairs, subsequently bolstering self-confidence. This improvement fosters a more profound understanding of one's existence, ultimately leading to an elevated quality of life (36, 37).

4.1. Limitations

This study exhibited both advantages and limitations. A notable strength was the focus on obese adolescents as participants, a demographic that has received insufficient attention in prior investigations. Additionally, the implementation of a 12-week intervention period facilitated the assessment of the long-term impacts of the training program on the variables of interest. Conversely, the study did not assess the nutritional status of the participants, a potential determinant of their obesity. Furthermore, the socio-economic factors

of the subjects were not analyzed, which may also influence the research outcomes. Future research should incorporate controls for both socio-economic and nutritional status to enhance the validity of the findings.

5. Conclusions

The present study integrated physical activities, such as strength training, aimed at enhancing upper body musculature and Pilates designed to bolster respiratory function and balance. Our results demonstrated that this exercise program effectively addresses upper body deformities (including forward head kyphosis), obesity, and overall quality of life in adolescents with obesity. The study results suggested that the observed benefits stem from both muscle enhancement and weight reduction among obese adolescents. Consequently, given the favorable impacts of this exercise modality on physical well-being and life quality, it is plausible that such exercises could serve as a viable intervention for ameliorating obesity-related deformities in affected individuals.

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Authors' Contribution

Sara Bagheri: Substantial contributions to the conception, design of the work, acquisition of data for the work, drafting the work and reviewing it critically for important intellectual content. Abdollah HemayatTalab: Design of the work and drafting the work. Amineh Sahranavard: Substantial contributions to the conception, design of the work; drafting the work and reviewing it critically for important intellectual content. Saeed Ghorbani: Design of the work, acquisition, analysis, and interpretation of data for the work; drafting the work and reviewing it critically for important intellectual content. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, such as the questions related to the accuracy or integrity of any part of the work.

Conflict of interests: None declared.

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Ethical Approval

The Ethics Review Board of Islamic Azad University of Aliabad Katoul, Golestan Province, Iran approved the present study with the code of IR.IAU.AK.REC.1398.003. Also, written informed consent was obtained from parents of children.

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