Brief Report
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Comparison of Postural Balance, Muscle Force and Spinal Posture in Obese Children and Adolescents- A Protocol Study

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Abstract

Objective: Obesity is a major public health concern. Since the prevalence of obesity is increasing, exploring the impacts of obesity on the developing musculoskeletal system is important. The aim of this study was to compare postural balance, muscle force, and spinal posture between children and adolescents with and without obesity.
Materials and Methods: This is a case-control study on 90 children and adolescents with and without obesity (N=45 in each group). Outcome measures will be postural balance, muscle force, and spinal posture. These outcome measures will be compared between groups.
Results: Evaluation of HbA1c level based on the presence or absence of anemia showed that in diabetic group with anemia significantly had a lower level 8.4 (± 1.5) than people without anemia 8.6 (± 1.5) (P= 0.045).
Conclusion: The findings can determine the importance of assessing musculoskeletal health in children and adolescents with obesity.
Keywords: Postural balance, Muscle force, Posture, Obesity, Children, Adolescents

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Introduction

Pediatric obesity is one of the most serious public health challenges in 21st century which has multiple negative consequences on individual health (1,2). The prevalence of obesity is increasing worldwide (3). Among non-communicable diseases, obesity is a major concern (4). Obesity is dependent on a combination of multiple factors, including genetic, environmental, social and behavioral (5,6)

Postural balance is the ability to maintain and restore body balance in different positions and activities. Postural balance is required for performing activities of daily living and prevention of injury and develops as the child matures (7,8). Overweight and obesity in children and adolescents may impair postural balance (9). Impaired postural balance can lead to limited physical activity, increased risk of falling, and higher risk of fracture (7,10).

The aim of the study will be to compare the postural balance, muscle force, and spinal posture in children and adolescents with and without obesity

Material and methods

The current study will be conducted at the research center for prevention of non-communicable diseases of Isfahan University of Medical Sciences. The participants of this study will be male children and adolescents with obesity. The normal body mass index control group was matched with age (6-11 years old). Participants will be selected simple randomly from the lists of household information of health centers in Isfahan. Eligible participants will be invited to participate in the current study. Informed consent will be signed by parents. The participants will be divided into obese and normal body mass index (BMI) groups using the references WHO. The normal group have the BMI from the 5th to 84th percentile. Obese group have the BMI greater than 95 percentile (11).

The participants with the following criteria will be excluded; underweight (BMI <5th percentile for age) children, participation in sport exercise or recreational exercise for more than 2 hour per week (excessive physical activity increase force of antigravity muscles), history of neuromuscular disorders (effective on force and balance), history of soft tissue or musculoskeletal injuries in the previous 6 months, history of surgery of the lower extremities, use of assistive devices for ambulation, uncompensated visual disorders, leg length difference greater than 1 cm in the lower extremities, musculoskeletal pain of the lower extremity at rest or during testing, presence of cardiac or respiratory diseases, history of taking medication affecting balance or muscle force in the previous 6 months (anti-spastic, anti-seizure or sedative drugs), presence of any mental disorders, congenital anomalies, inability to perform any of the assessment tests, unwillingness to participate in assessment tests, any type of obvious spinal and limb deformities (e.g.scoliosis, torticoli, kyphosis,...) (12).

Data sources

Body height will be measured in the standing position by a meter attached to the wall. Body weight, BMI, and body composition (trunk and lower extremity fat mass and fat free mass) will be determined using the In Body 270 device. The Balance Error Scoring System and Modified Star Excursion Test will be used to assess static and dynamic postural balance. The muscle force of the lower extremities will be measured by a digital dynamometer (digital force gage, SF-500). The sagittal spinal posture (cranio-vertebral, thoracic kyphosis and lumbar lordosis angles) will be evaluated through photography of the lateral view by a digital camera. Details of the methods of assessment will be explained in the following paragraphs.

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Eligible children and adolescents will be evaluated for inclusion and exclusion criteria. Eligible children and adolescents and their parents will be informed about the aims, methods, and duration of the study. They will be assured that their information and data will be kept private. Volunteers will receive an informed consent form, and in case of agreement, they will sign it and enter the study.

Measurement

Anthropometric indexes

For the measurement of anthropometric indexes, body height (meter), body weight (kilogram), and BMI (kilogram/ meter 2) will be measured. Body height will be measured in the upright standing position by a fixed meter attached to the wall. Body weight, body mass index, and body composition (trunk and lower extremity fat mass and fat free mass) will be determined using an In Body device (In Body 270, In Body co, Seoul, Korea). BMI (kilogram/ meter^2) will be calculated by dividing body weight by squared height (m^2) (12). According to previous studies, this device is reliable for measuring body composition (13).

Measurement of postural balance

Static postural balance

Static postural balance will be measured using the Balance Error Scoring System. Participants are requested to remove their shoes and identify their dominant foot. To determine the dominant foot, they will be asked which foot they preferentially use for kicking a ball. If they cannot determine the dominant foot, they will be asked which hand they write with; in these cases, the ipsilateral foot will be defined as the dominant foot (14). Participants will be requested to maintain 3 standing positions for 20 s, with hands on the iliac crests and eyes closed. The first condition is standing with a narrow base of support and foot close together. The second and third positions are standing on one leg (non-dominant leg) and standing in tandem stance with the leading dominant leg. These positions are repeated on a foam surface. For each error during testing, participants will be given a negative score. Errors include hand lifting off the iliac crest, eye opening, stumbling, stepping, falling, and moving the hip into more than 30 degrees of flexion or abduction, remaining out of position for more than 5 s, and separation of the heel or forefoot from the ground. Before the main test, one test trial in each direction will be performed for familiarization of participants. After the test trial, the main test will be performed in each condition (14). If participants cannot maintain stability in each condition for 5 s, they will be given a maximum score of 10 on that condition. A maximum of 10 scores in each condition is allowed. Total score is the summation of scores on six conditions. Total score will be between 0 and60 (15). It should be mentioned that the reliability of this test will be examined before the main study.

Dynamic postural balance

Dynamic postural balance will be measured using a modified star excursion test. This test will be drawn using adhesive tape on the floor. Each participant will be informed by the examiner through visual instruction and verbal description. Before the main test, each participant will perform each of the three directions six times to minimize the effect of learning. The participant will be requested to stand on one leg, while hands on the hip and the standing leg maintain contact with the floor. The participant should reach in the anterior, posteromedial, and posterolateral directions with their great toe while keeping the entire supporting lower extremity in contact with the ground. In this test, the most distal aspect of the hallux should be placed at the center of the intersection between the lines. The distal point of the great toe will be colored to mark the maximum distance of reaching with washable paint. The test will be performed for dominant and non-dominant lower extremities. Each measurement for dominant and non-dominant lower extremities

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will be recorded three times. If the participant cannot maintain standing on one leg, cannot maintain the heel in full contact with the floor shifts the weight or leans on the reach foot, or cannot return the swing leg to the starting position, the test will be ignored and repeated. The maximum reach distance will be measured by marking a tape measure at the most distal part of the foot reached. Scoring for each direction was performed by dividing the greatest reach distance by limb length (distance between anterior superior iliac crest and medial malleolus) and multiplying by 100. A combined score for each limb will be calculated as the combination of the maximum recorded distance in 3 directions divided by the multiplication of the limb length by 3 times. The result is multiplied by 100 (16,17). It should be mentioned that the reliability of this test will be examined on 15 boys with healthy body mass index before the main study.

Isometric force of the lower extremity muscles

Isometric force of the lower extremity muscles will be measured using a digital dynamometer (digital force gage, SF-500) for the dominant lower extremity (18). Prior to the main study, a pilot study will be conducted on 15 boys with healthy body mass index to determine the intra-rater reliability of the digital dynamometer for measuring the force of lower extremity muscles. The reason for isometric force measurement is that assessment of isometric force is a main factor for postural control and balance in children and adolescents (19). Isometric force measurement for each muscle group will be performed 3 times with a 5-s hold time and 30-s rest interval. Maximum recorded force will be considered for statistical analysis (19). In force tests, the dynamometer will be connected to a fixed bar. Participants will be requested to push against the digital dynamometer. The level of the dynamometer on the fixed bar will be adjusted for each muscle group. Before starting to measure the isometric force of each muscle group, the digital dynamometer will be zeroed.

Hip extensor and abductor muscles

Position of the participant will be standing position. The dynamometer will be placed on the posterior or lateral surface of the leg, proximal to the lateral malleolus for hip extensor and abductor muscles, respectively (20).

Knee flexor and extensor muscles

The participant will sit right into the chair with their back against the backrest, knees flexed 90 degrees. The dynamometer will be placed in the anterior or posterior surface of the distal leg, proximal to the ankle joint for knee extensor and flexor muscles, respectively (21).

Plantar and dorsi-flexor muscles

The position of the participant will be long sitting position on the mat for plantar flexor muscles. The dynamometer will be placed on the palmar surface of the foot, proximal to the metacarpophalangeal joint. For the dorsi-flexor muscles, the participant will be sitting on a chair, knees flexed 90 degrees. they will need to sit right into the chair with their back against the backrest. The dynamometer will be placed on the dorsal surface of the foot, proximal to the metacarpophalangeal joint (21).

Sagittal spinal posture

For measurement of sagittal spinal posture, lateral view photography by digital camera will be used. Photography by digital camera is a simple and objective method for evaluation of body posture. This method has good validity and reliability for the evaluation of spinal posture against a gold-standard method such as X-rays (22,23). For photography, a Sony digital camera (DSC WX80) will be used. The camera will be placed on a tripod, 1.5 m away from the ground, and the location of the camera will be fixed. The height of the camera is adjusted to the shoulder level. The participant will be asked to stand in their

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habitual standing position, looking forward, feet apart shoulder width and moving elbows forward. Photographs will be taken 3 times from the lateral view of the participant (both left and right side). Reflective markers will be used to measure spinal angles, and these markers will be placed on anatomical landmarks. These landmarks are the external ear meatus, spinous process of the seventh cervical vertebra (C7), first and twelfth thoracic vertebra (T1, T12), first and fifth lumbar vertebra (L1, L5), and first sacral vertebra (S1). For measurement of cranio-vertebral angle, thoracic kyphosis, and lumbar lordosis, saved images will be recruited using ImageJ software (USA National Institutes of Health [NIH], Bethesda, MA, USA). The aforementioned angles will be measured on each picture by the angle tool of this software, and the mean of three angles will be calculated.

Cranio-vertebral angle is the angle between a horizontal line and a line connecting the external ear meatus to the spinous process of the seventh cervical vertebra. The thoracic kyphosis angle is the angle formed between the line tangent to the body contour at the level of C7-T1 spinous processes and the line tangent to the body contour at the level of T12-L1 spinous processes. The lumbar lordosis angle is formed between the line tangent to the body contour at the level of the T12-L1 spinous processes and the line tangent to the body contour at the level of the L5-S1 spinous processes (23-25). It should be mentioned that reliability will be examined in 15 boys with healthy body mass index before the main study.

Body composition analysis

Fat mass and fat-free mass of the trunk and lower extremities will be estimated using In Body 270 (inbody270, In Body co, Seoul, Korea). This tool uses bioelectrical impedance analysis (BIA) technology. The handheld electrode will be in contact with the fifth finger and the heel will be in contact with the pedal electrode. Participants will be requested to stand on the device barefoot and not move during the measurement. Resistance of body tissues will be used to estimate fat- free mass. In addition to fat free mass, fat mass and percentage of body fat will be analyzed (26). The reason for the evaluation of body composition in this study is that according to some studies, except body weight, fat percentage is a predictor of postural balance. In addition, because of the effect of body composition on living conditions, health, disease, and death, assessment of body composition in children and adolescents is of high importance (27).

Bias

Since gender and maturity influence muscle strength, in this research, only one gender (boys) between 6 and11 years of age will be included. The reason for selecting this age range is that the mean maturity age is between 11 and13 years in Iranian boys. future additional studie will be plannedfor girls

Study size

The sample size formula is represented below (28). The significance level and power of a hypothesis test are considered to be 0.05 and 0.2, respectively. The sample size was calculated to be 45 in each group (90 total). Calculating the sample size was performed using G.Power software.

Statistical methods

Statistical analysis will be performed using SPSS version 24. In descriptive statistics, the mean and standard deviation will be measured. In analytical statistics, the normal distribution of variables will be determined using the Kolmogorov- Smirnov test. In case of normal distribution of variables, independent T-test and in case of non-normal distribution of variables, Mann-Whitney U test will be used for comparison of postural balance, isometric force of lower extremity muscles, and sagittal spinal posture between the two groups (normal weighted and obese group). For evaluation of the relationship between body composition and postural balance in both groups, the correlation coefficient (Pearson or spearman coefficient according the distribution of variables) will be measured. The level of significance is 0.05.

Ethical considerations

The current study is approved by the ethical committee of Isfahan University of Medical Sciences (IR.MUI.REC.1400.061). Subjects will sign an informed consent form before participation in the study.

Results

Recruitment for this study will begin in fall 2022 and is expected to be completed by the end of summer 2023.

Discussion

The current protocol study is designed to compare balance, muscle force, and spinal posture in children and adolescents with and without obesity. In addition, the relationship between body composition and balance will be evaluated between children and adolescents with and without obesity. Similar studies can be helpful in guiding appropriate therapeutic exercise and practice for obese subjects. The current study will be conducted on obese subjects because obesity may induce biomechanical changes in the lower limbs and spine and negatively affect the health of children. For this reason, musculoskeletal assessment in the evaluation of obese children is recommended (29).

In this study, postural balance will be evaluated because maintaining postural balance is essential for participating in physical activities and sports, and it plays an important role in preventing and managing obesity in children (30). In addition to postural balance, muscle force and spinal posture will be evaluated because muscle weakness and postural malalignment are biomechanical factors affecting postural balance (31). In the current study, body composition will be evaluated because, in addition to biomechanical factors, body composition can also predict postural balance (27).According to the results of this protocol study, if there is a difference between the two groups (obese group and normal weighted group) regarding outcome measures, it can be concluded that assessment of these outcome measures is important to be regarded in the management of obese children. Improving postural balance by improving muscle force and posture can be effective for better management of obesity in children. The findings of the current study can highlight the role of physiotherapists in team work in the prevention and management of obesity and related musculoskeletal complications. Improving the musculoskeletal fitness of children has a vital effect on improving the participation of children and adolescents in daily activities, weight management programs based on physical activity, and improving the quality of life related to health.

Conclusions

The results can increase the knowledge of specialists about the importance of evaluating musculoskeletal health and complications in children and adolescents with obesity.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Authors' contributions

F. R: Collected the data and contributed data or analysis tools.

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F. B: Conceived and designed the analysis, wrote the paper and contributed data or analysis tools.

T. R: Conceived and designed the analysis and performed the analysis.

G. O'M: Conceived and designed the analysis, performed the analysis and wrote the paper.

N. TE: Contributed data or analysis tools and performed the analysis.

M. HB: Contributed data or analysis tools and performed the analysis.

R. K: Conceived and designed the analysis and wrote the paper.

All authors have accepted responsibility for the entire content of this manuscript and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved and approved the version to be published.

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