

Relationship between body mass index and postural balance and flexibility in adolescent girls

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ABSTRACT

Adolescence is a transition period from childhood to adulthood which is marked by many changes. Adolescents generally have a sedentary lifestyle which causes an increase in body mass index. An increase in body mass index has a negative impact on postural balance and flexibility. Excessive fat in the body tends to change the location of the body's center of gravity and limit joint movement. This study aimed to determine the relationship between body mass index and postural balance and flexibility in adolescent girls. This research was a correlation study and used a cross sectional research design with a total of 35 young women. The parameters used to measure postural balance are the Y-balance test and flexibility is the sit-and-reach test. The data analysis used in this research is Pearson correlation analysis. The results showed that there was a significant relationship between body mass index and postural balance ($p=0.001$) and flexibility ($p=0.001$) and the level of closeness of the relationship between each variable was very strong ($r=0.825$). The higher the BMI, the lower the postural balance and flexibility.

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INTRODUCTION

Adolescence is a transition period from childhood to adulthood characterized by changes such as: biological changes, psychological changes, and social changes. Adolescence in general lasts from age 10-13 years and ends at the age of 18-22 years. The World Health Organization (WHO) defines adolescence as occurring between the ages of 10 and 19 years (WHO, 2019). Teenagers are generally prone to unhealthy behavior. One of the important components of adolescent health is physical activity. Insufficient physical activity generally occurs among teenagers because teenagers have sedentary lifestyle habits. Sedentary lifestyle has detrimental impacts on physical, mental and social health (Bann et al., 2019). Adverse impact on health including increased risk of heart disease, cancer, diabetes mellitus, hypertension, dyslipidemia, and disease musculoskeletal (Park et al., 2020). Teenager which has high physical activity tends to have a lower body mass index (BMI) normal and conversely, low physical activity in adolescents has an important role

in the development of obesity (Putra & Rizqi, 2018). The United States and China report an increase in the incidence of obesity in children and adolescents due to low physical activity (Agung & Jatmiko, 2022).

Body mass index is known as an indicator of body composition. Several studies have shown that BMI is related to body fat measurements. BMI is often used to determine the amount of fat in the body so that individuals with a high BMI are thought to have a high amount of total fat in the body (Mujtahidin et al., 2015). It is important to maintain a normal BMI to make it easier to carry out daily activities and avoid the occurrence of various types of diseases (Dharmawan et al., 2022). The average BMI and prevalence of obesity from 1975 to 2016 continued to increase throughout the world, especially for the categories of children and adolescents. The average BMI value increased rapidly in East Asia, South Asia and Southeast Asia (Bentham et al., 2017). In Indonesia, the increasing trend and prevalence of BMI in the overweight and obese categories has increased in all age groups in the last two decades. Boys have a higher prevalence rate than adults, but the prevalence is still less high than girls in the adolescent and adult age group (Rachmi et al., 2017). Based on the United Nations Children's Fund (UNICEF), Indonesia is the second country with the largest number of obese teenagers at 12.2% (Sugiatmi & Handayani, 2018). Obesity is a serious problem in adolescents that can continue into adulthood (Telisa et al., 2020). Body weight is related to aspects of postural stability. Being overweight has a negative impact on postural balance. Balance is the ability of an individual to remain in a state of balance and adapt to gravity, the ground surface and objects in the environment when carrying out daily life activities (Dharmawan et al., 2022). Excess weight causes a difference in the position of the body's center of gravity, thus affecting postural balance and increasing the risk of falls (Utami et al., 2022). Increasing BMI is also synonymous with the body's stretching or stretching ability.

The ability of muscle tissue to stretch maximally is defined as body flexibility. Flexibility allows the body to move with a full range of motion without pain or resistance, thereby reducing the risk of injury during activities (Rahman & Islam, 2020). Good flexibility means the muscles can contract concentrically or eccentrically with maximum Range of Motion (ROM). Low flexibility will alter posture control (Kalichman & Ben David, 2017). One factor that reduces flexibility is body fat. Excessive fat deposits in the body can hinder stretching or stretching of the body. The components of postural balance and flexibility are very important components for overall physical fitness which is related to health, especially in adolescence, which is a crisis period that determines life as an adult.

RESEARCH METHOD

This research is a correlation research and uses a cross sectional research design. The sampling technique was purposive sampling of 35 teenagers. All samples in this study were female, aged 13-15 years, healthy and had not experienced a musculoskeletal injury in the last 6 months. The research was conducted at MTS Assalam Manado, which is a boarding school for women only. All respondents in this study have been provided with information regarding their consent and have signed informed consent. The data source used is a primary data source that directly measures research respondents.

Body mass index

Body mass index is one method that is widely used to determine the level of overweight and obesity because it is an easy, cheap and non-invasive method.⁽⁶⁾ BMI data is collected using weight and height data. Body weight was measured using a body scale and height was measured using a microtoise. Body mass index (kg/m²) is assessed as body weight in kilograms (kg) divided by the square of body height in meters (m). WHO classifies BMI into several categories, namely underweight: BMI < 18.50, normal weight: BMI 18.50-24.99, overweight: BMI 25.00-29.99, and obese BMI ≥ 30.00 kg/m² (Garraza et al., 2023).

Postural Balance

Y-balance test is a modification of the Star Excursion Balance Test (SEBT) which is often used to assess dynamic balance or postural balance (Garraza et al., 2023)(Clagg et al., 2015). The Y-balance test measures postural balance using 3 directions, namely anterior, posteromedial and posterolateral. The respondent stands with one leg at the midpoint of the Y-shaped track with the other leg hanging (non-weight-bearing) and hands on the waist. Respondents were instructed to reach in each direction (anterior, posteromedial and posterolateral) with 3 attempts.

Sit-and-Reach Test

Sit-and-reach test is used generally to assess or measure the flexibility of the lower back and hip joints (Jamnick et al., 2016). Flexibility means a person's effectiveness in adapting to all activities by stretching the body in large joint areas (Baltaci et al., 2003). The procedure to perform the test is to first place the measuring stick on the floor, stick the tape across at the 15th inch. Respondents sat upright and the measuring tape was between their legs. Place the heel on the cross band. Respondents were asked to move their backs forward with their arms parallel to their feet and their fingertips touching the meter⁽¹⁹⁾. Flexibility in girls aged 11-15 years is classified into several categories, namely poor: 18.9 cm, moderate: 28.9 cm, good: 35.3 cm and excellent: 42 cm.

Data Analysis

The data analysis used in this research is univariate and bivariate analysis. Hypothesis testing was carried out using parametric tests using Pearson to analyze the relationship between BMI and postural balance and flexibility.

RESULTS AND DISCUSSIONS

The research results can be seen in Table 1, showing that based on age characteristics, the most numerous subjects were 13 years old, 17 people. Based on BMI, the most numerous subjects were subjects with a normal BMI category, 25 people. Based on flexibility, the most numerous subjects were subjects who had low flexibility (poor) as many as 23 people.

Table 1. Subject characteristics

Variable	n	%
Age		
13 years old	17	48.6
14 years	7	20.0
15 years	11	31.4
Body mass index		
Underweight	5	14.3
Normal	25	71.4
Overweight	5	14.3
Flexibility		
Poor	23	65.7
Moderate	12	34.3
Good	0	0
Total	35	100

Table 2 shows that the average body mass index for female adolescents is 21.5 kg/m². The Y-balance test measured in different directions shows an average value, namely anterior 72.1 cm, posteromedial 90.5 cm and posterolateral 94.7 cm. Flexibility was measured using the sit-and-reach test with an average score of 23.1 cm.

Table 2. Average value of variables

Variable	Mean	Elementary School
BMI	21.5	2,4
Anterior	72.1	3.7

Variable	Mean	Elementary School
Posteromedial	90.5	2,3
Posterolateral	94.7	5.3
Flexibility	23.1	4.8

Table 3 shows that there is a significant relationship between BMI and postural balance measured in three different directions, namely anterior ($p=0.001$) with an inverse relationship and a very strong level of relationship ($r=0.814$), posteromedial ($p=0.001$) with an inversely proportional relationship and a very strong level of closeness ($r=0.791$), as well as a posterolateral direction ($p=0.001$) with an inversely proportional relationship and a very strong level of closeness ($r=0.718$). From the data it can be concluded that the higher the BMI, the lower the postural balance, and vice versa.

Table 3. Relationship between BMI and postural balance

Variable	pa)	rb)
Anterior	0.001*	-0.814
Posteromedial	0.001*	-0.791
Posterolateral	0.001*	-0.718

^{a)}The p value of the Pearson test results

^{b)}R value of test results *Pearson*

*Significant at <0.05

Table 4 shows that there is a significant relationship between BMI and flexibility ($p=0.001$) with an inverse relationship and a very strong level of relationship ($r=0.825$). From the data it can be concluded that the higher the BMI, the lower the subject's flexibility, and vice versa.

Table 4. Relationship between BMI and flexibility

Variable	pa)	rb)
Flexibility	0.001*	-0.825

^{a)}The p value of the Pearson test results

^{b)}R value of test results *Pearson*

*Significant at <0.05

Discussion

Subject Characteristics

This study consisted of subjects aged 13-15 years with the highest number of subjects aged 13 years and the highest number of subjects having a normal BMI category. The majority of teenagers in the study showed a normal BMI but weight control must still be considered. According to WHO, 340 million teenagers and children aged 5-19 years are obese (Ataey et al., 2020). According to Riskesdas, in Indonesia there are 16.0% of teenagers aged 13-15 years who are overweight and obese (Badan Penelitian Dan Pengembangan Kesehatan Republik Indonesia, 2018). According to Riskesdas, the highest prevalence of obesity in Indonesia occurs in women at 32.9% compared to the lower prevalence of obesity in men, namely 19.7%. This can happen because women's metabolism tends to be slower than men. Women have a 10% lower Basal Metabolic Rate (BMR), so women convert more food into fat than muscle and men convert more food into muscle and energy reserves (Lubis et al., 2020).

The results showed that the majority of subjects had poor flexibility. Previous research shows similar results in adolescent girls having limited category flexibility. Teenagers generally have a relaxed lifestyle which causes teenagers to tend to be less flexible and have the habit of sitting for a long time at school. The habit of sitting for a long time causes the workload on the back muscles to become heavier. An increase in the workload of the back muscles results in an imbalance in body posture so that the muscles will experience overuse. If this situation lasts long enough, it will reduce the ROM of the spinal joints, especially in the lumbar region. Decreased lumbar movement ability will reduce body flexibility (Kurnia & Suptiani, 2022).

Relationship between BMI and Postural Balance

The research results found a significant relationship between BMI and postural balance and a very strong level of relationship closeness. This is in line with previous research which shows a significant relationship between BMI and dynamic balance in adolescents (Azi, 2021). Other research also mentions the influence of BMI on dynamic balance in the elderly (Yuliadarwati et al., 2021). The higher the BMI, the lower the static and dynamic balance values. The results of this study indicate a relationship between BMI and postural balance (Madhuri Gaur, 2015). Teenagers generally prefer indoor activities such as playing games and watching TV, which can cause postural control disorders which in turn have an impact on decreased balance (Azzeh et al., 2017). Obesity can impair adaptability and mobility by limiting an individual's ability to plan motor skills. Poor motor skills interfere with the body's ability to respond to existing stimuli and the inability to adjust motor planning can lead to imbalance. Balance is a person's ability to maintain body position when carrying out a movement. In individuals who are overweight, there will be fat accumulation and loss of soft tissue tone. In addition, excess body weight can change the body's center of gravity according to body alignment and the amount of load borne by joints and muscle pull. Excessive fat accumulation, which is indicated by a higher BMI, will cause balance disorders (Azzeh et al., 2017). The high level of adipose tissue in the abdominal area affects postural balance (Corbeil et al., 2001). This is related to the resulting ankle torque, which is related to the distance between the ankle joint and the center of mass (COM). This distance correlates with the ankle torque generated to achieve balance (Azzeh et al., 2017). Good balance will produce effective and efficient movement.

Postural balance is regulated by the central nervous system. The main sensory systems involved in postural control and balance are the visual, vestibular, and somatosensory systems. Good and proper body postural balance is reflected when an individual is able to perform various static and dynamic activities, such as sitting, standing, walking and running with the ability to contract the appropriate muscles required for a controlled midline body posture. The ability to make adjustments when responding to changes in position or movement without using compensatory movements as well included as an indicator that the individual has adequate postural balance (Alcock et al., 2018).

The results of this study are not in line with Alhusaini's (2020) research which shows that there is no positive correlation between BMI and postural balance (Alhusaini et al., 2020).

Relationship between BMI and Flexibility

The results of previous research in the higher BMI category showed a low score for the flexibility test, which shows that the lower the BMI, the higher the level of flexibility (Agung & Jatmiko, 2022). Excessive body fat in obese people has been shown to reduce flexibility and motor performance (Benetti et al., 2016). The amount of fat in the body is thought to limit the movement of the joints, through the mechanism that the presence of fat around the joints and bones blocks a person from maximizing the movement of the joints and bones (Mujtahidin et al., 2015). Flexibility is the physiological range of motion of a joint and plays an important role in the performance of simple or complex movements involved in daily life activities. Flexibility is the maximum range of motion in a joint. Decreased flexibility can result in musculoskeletal damage (Agung & Jatmiko, 2022). Previous studies have shown that the higher the BMI, the worse the hamstring muscle flexibility. This occurs due to limited movement caused by excessive muscle mass (Gite et al., 2021). Increased adiposity in the adolescent group caused by decreased physical activity can have an effect that can interfere with muscle flexibility (Kansra et al., 2021). Other research shows a positive correlation between fat and flexibility, but the level of this relationship is still relatively weak (Gite et al., 2021). Individuals who have a high BMI are indicated to be overweight, so individuals who have a high BMI are likely to have a high amount of fat in their body. The presence of excess fat will likely hinder flexibility (Mujtahidin et al., 2015).

Flexibility is related to body weight, skin thickness, and body surface area. Body size influences the accumulation of body fat in the abdomen and muscle fibers, which affects muscle flexibility. High BMI tends to have a limited range of motion than normal BMI. Flexibility is significantly correlated with body mass (Primasoni, 2022). There is a relationship between BMI and lumbar flexibility, although the relationship is weak (Mašlanko et al., 2020). Problems with the motor system are one of the consequences that will occur due to increasing body mass in adolescents (Purnama, 2007). Adolescents who are overweight or have a BMI in the overweight or obese category usually show poor coordination and achieve lower motor ability test scores when compared to adolescents who tend to have a normal BMI category (Agung & Jatmiko, 2022). Flexibility is needed to maintain body flexibility in carrying out daily activities.

Other research revealed that there was no positive relationship between BMI and flexibility (Kansra et al., 2021). There was no significant relationship between BMI variables and hamstring muscle flexibility (Gite et al., 2021). Other research also shows that there is no significant relationship between BMI and flexibility (Mujtahidin et al., 2015). Research on productive age also found that there was no correlation between flexibility in performing lumbar flexion movements and BMI (Ward, 2013).

CONCLUSION

Increasing BMI can cause a decrease in balance ability in reaching 3 directions (anterior, posteromedial and posterolateral) and can reduce flexibility ability. Individuals who are in the obese category have a greater risk of falling than individuals in the ideal weight category. The correlation results concluded that there was a strong correlation between the BMI variable and postural balance and flexibility. It is recommended for further research to conduct research on a larger sample of men so that we can see the relationship between body mass index and postural balance and flexibility in terms of gender factors.

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