Original Article :

Does Increasing Body Weight Negatively Impact Children's Muscular Flexibility in Saudi Arabia?

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Abstract

Background and Aims:

The incidence of overweight and obesity among children and adolescents is rising. The rise in weight and obesity impairs Saudi children's physical activity and muscular flexibility, especially during the pandemic. However, few studies focus on the relationship between weight and physical fitness in Saudi. Aims: Therefore, this study aims to perform among Saudi Arabian children to assess the relationship between muscular flexibility and weight.

Methods:

A cross-sectional study of 195 children aged 6 to 13 was performed in Saudi Arabia. Children who had not previously experienced musculoskeletal pain, neurological disorders, or congenital or acquired spinal deformities were included. For this study, weight and height measurements were taken to calculate body mass index (BMI) in kg/m2, and a sit-and-reach (STR) test was measured to determine muscular flexibility in centimeters.

Results:

The Pearson correlation between STR and weight was negative (-0.26), with a 95% CI of -0.39 to -0.13, indicating a weak but statistically significant relationship between STR and weight. While controlling for other variables in the model, the regression analysis revealed that for every unit (kg/m2) increase in BMI, muscular flexibility decreased by 0.147 units on average (Beta =-0.147; [95 percent CI: -2.07- (-0.039)]. Gender and muscular flexibility were found to have a negative relationship (Beta =-0.078; [95 percent CI: (-2.98) to (0.86)].

Conclusions:
Being overweight and obese were inversely related to muscular flexibility as measured by STR, with no meaningful distinctions between boys and girls.

Keywords:
Obesity; muscular flexibility; children; Saudi Arabia.

Introduction

Overweight and obesity in children are becoming more common all over the world [1] with a decline in physical fitness [2] and especially during the pandemic [3]. Children's pandemic limitations and sedentary lifestyles lead to physical and nutritional changes [4-6]. Children's lower physical fitness may persist into adulthood with several physical and psychological problems [7]. Pediatric obesity has serious short-term and long-term adverse consequences [8,9]. Due to the excess adipose tissue, children may demonstrate early signs of several chronic diseases [8,9]. For example, previous research shows that overweight and obese children are more likely to develop risk factors for cardiovascular diseases [9], asthma [10], lower self-esteem, and other psychological problems [11]. However, few studies focus on the relationship between weight and physical fitness, defined as a group of characteristics or attributes associated with a child's ability to perform physical activities [12].

The influence of being overweight on physical fitness has been assessed using different fitness components, and the effect varies by the type of fitness component being evaluated. For example, it has been found that overweight adolescents typically have poor muscular endurance as determined by sit-ups [13] and cardiovascular health as assessed by endurance runs [14,15]. Nevertheless, an improvement in isometric strength as evaluated by the handgrip test [16,17] and similar flexibility as measured by the sit-and-reach (STR) test were noticed in adolescents [17,18]. Further, the literature highlights that children with a higher body mass index (BMI) tend to perform poorly in weight-bearing activities, such as the activities that require moving body weight [19-25]. However, there is inconsistent data on the association between children's weight and muscular strength [21,23-27].

Furthermore, these studies are conducted in western populations where the prevalence of underweight is lower than in overweight children [28,29]. On the other hand, most resource-constrained settings, such as Saudi Arabia, have the dual burden of being overweight and underweight [30,31]. Hence, investigating different weight

categories and physical fitness is essential in resource-poor settings. Therefore, we aimed to conduct this study among Saudi Arabian children to assess the relationship between muscular flexibility and weight. Further, we aimed to study muscular flexibility using sit-and-reach (STR) by gender to examine gender differences.

Materials and Methods

Study Design:

A cross-sectional study was conducted to examine the relationship between muscular flexibility (Sit to Reach test) and weight groups (underweight, normal, overweight, and obese).

Study participants:

One hundred ninety-five children aged 6 to 13 years were enrolled in the study after taking their assent from their parents. Children were only participating who had not previously experienced musculoskeletal pain, neurological disorders, or congenital or acquired spinal deformities. The over 13-years-old were not enrolled due to inhibition of physical flexibility. The early onset of puberty alters aerobic fitness by increasing the body size and dimension of the heart, lungs, muscles, and circulatory system [32-34]. Therefore, after enrolling eligible children, data were collected on essential variables such as age in years, weight in kilograms, and height in cm. The Majmaah University for Research Ethics committee approved this study under project # (MUREC) (HA-01-R-008).

Outcomes Measures:

Sociodemographic Data: Data was collected on the gender of the child and categorized them into girls/females or boys/males. Weight and height data were measured using standardized and calibrated measurement scales, and these data were recorded to calculate body mass index (BMI) in kg/m^2. The BMI variable was further calculated to categorize children into underweight (less than the 5th percentile), normal weight (5th percentile to less than the 85th percentile), overweight (85th to less than the 95th percentile), and obese children using the World Health Organization (WHO) cut-offs for children (95th percentile or greater) [35]. The main exposure variable was BMI for this study, whereas the outcome variable was muscular flexibility as evaluated by hip and low back flexibility. Regarding the Sit-and-reach test (STR), the dependent or outcome variable was assessed in cm using an STR test [36].

Procedures:

The STR scores were collected using a standard sit-and-reach wooden box by positioning each participant for the test, and the numbered tape was placed on the top of the box to acquire the STR scores. The

lowest point was 0, and the highest point was 40 cm. The participants were then asked to sit on the floor with their knees completely extended and their ankles in neutral dorsiflexion against the box. Next, the participant was guided to place their hands on top of the box's surface and slowly reach forward as far as possible while extending their knees. The hands were kept evenly aligned as the participant extended forward along the box's surface. Each participant rehearsed the movement twice, and the third repetition of the STR score (in centimeters) was recorded.

Statistical Anaylsis:The mean with standard deviations (SD) were reported along with frequencies and proportions to describe the characteristics of the study population. More specifically, for categorical variables such as gender and BMI status, frequencies and proportions to describe the characteristics of the study population were reported. Histograms superimposed were measured on the normal curve to test the normality assumption for continuous variables. The mean and standard deviation for continuous variables such as age, weight, height, and BMI were described. A Pearson correlation was performed with the respective parameters and their respective 95% confidence intervals to assess the correlation between STR and other demographic and anthropometric variables. The relationship between children's BMI status and muscular flexibility in Saudi Arabia was determined using linear regression analysis. For significant results, a p-value of less than 0.05 was set. The regression analysis results were presented as standardized and unstandardized beta coefficients with 95% Confidence Intervals (CIs). The SPSS 23.0 was used to analyze the data.

Results

Descriptive characteristics of study participants

An analysis of 195 children in Saudi Arabia was conducted. Table 1 shows the demographic and anthropometric characteristics of study participants. The mean age of the children was 9.21 years, with a standard deviation of 2.04. Whereas mean±SD for the weight (kg), height (cm), and BMI (kg/m2) were 33.94±12.71, 128.91±16.21, and 20.04±5.07, respectively. The findings indicated that more than half of the study participants (54%) were boys, and 46% were girls, as shown in Table 1. Moreover, 5% of the children were underweight, 47% had normal weight; however, 19% were overweight, and 29% were obese (Table 1).

Table 1: Demographics and anthropometric characteristics of study participants (n=195)

Variable	Mean	SD	n	%
Age	9.21	2.04		NA
Weight	33.94	12.71		NA
Height	128.91	16.21		NA
BMI (Kg/m2)	20.04	5.07		NA
STR (cm)	21.75	6.78		
BMI status (%)	NA			
Underweight			10	5%
Healthy weight			91	47%
Overweight			37	19%
Obese			57	29%
Gender (%)	NA			
Girls			90	46%
Boys			105	54%

Muscular flexibility by gender and BMI status:

One of the primary purposes of the research was to assess muscular flexibility by gender and BMI status. The box plots in figures 1 and 2 show the muscular flexibility by BMI status and gender, respectively. The data revealed that underweight and normal-weight children had relatively higher STR (cm) values than overweight and obese children. More precisely, the mean (SD) STR for underweight and normal-weight children was 20.5 (6.20) and 23.66 (5.6). In contrast, overweight and obese children had lower mean STR of 18.69 (6.47) and 20.96 (7.92), respectively. Similarly, while assessing the STR by gender, we found that the mean STR for girls was 22.44 with an SD of 6.63. In contrast, boys had a slightly lower STR of 21.17 with an SD of 6.89, as shown in figure 2.

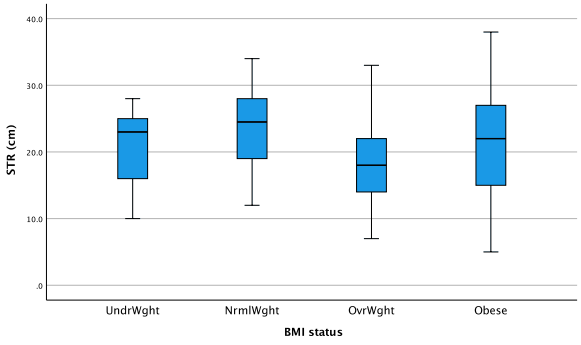


Figure 1: Muscular flexibility by BMI status

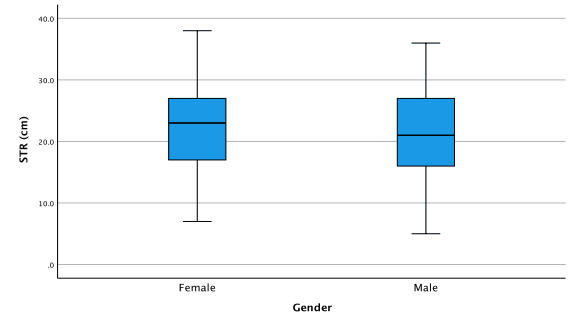


Figure 2: Muscular flexibility by gender

Correlation between muscular flexibility and demographic and anthropometric variables

Table 2 shows the correlation between muscular flexibility and demographic and anthropometric variables. Overall, there

was a negative correlation between muscular flexibility (STR) and demographic and anthropometric variables. The Pearson correlation between STR and age was negative (-0.21) with a 95% CI of -0.34 and -0.07, suggesting a weak but statistically significant correlation between STR and age. This indicates that as a child's age increases, the muscular flexibility decreases. Likewise, the Pearson correlation between STR score and weight was negative (-0.26) with 95% CI of -0.39 and -0.13, suggesting a weak but statistically significant correlation between STR and weight, which implies that as the weight of a child increases, muscular flexibility starts to decline. Similarly, the Pearson correlation between STR and BMI (kg/m2) was negative (-0.18) with 95% CI of -0.31 and -0.04, suggesting the weak but statistically significant correlation between STR and BMI as shown in Table 2.

Table 2: Correlation between STR and demographic and anthropometric variables (n=195)

		Age	Weight (kg)	Height (cm)	BMI (kg/m2)	BMI status	STR (cm)
Age	Pearson Correlation	1	.735**	.637**	.458**	.245**	-.209**
	P-value		<.001	<.001	<.001	<.001	0.004
Weight (kg)	Pearson Correlation	.735**	1	.749**	.660**	.521**	-.264**
	P-value	<.001		<.001	<.001	<.001	<.001
Height (cm)	Pearson Correlation	.637**	.749**	1	0.026	-0.079	-.204**
	P-value	<.001	<.001		0.721	0.272	0.004
BMI (kg/m2)	Pearson Correlation	.458**	.660**	0.026	1	.881**	-.179*
	P-value	<.001	<.001	0.721		<.001	0.012
BMI status	Pearson Correlation	.245**	.521**	-0.079	.881**	1	-.155*
	Sig. (2-tailed)	<.001	<.001	0.272	<.001		0.031
STR (cm)	Pearson Correlation	-.209**	-.264**	-.204**	-.179*	-.155*	1
	P-value	0.004	<.001	0.004	0.012	0.031	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

While looking at other variables, we found that BMI was positively correlated with age, indicating that as the age of a child increases, the child tends to gain weight. More precisely, the Pearson correlation between age and BMI was strong (0.46) and statistically significant (P-value: <0.05).

Association between BMI status and muscular flexibility of children in Saudi Arabia

A linear regression model was estimated to

assess the relationship between children's BMI status and muscular flexibility in Saudi Arabia. The results demonstrated a statistically significant negative relationship between BMI status and muscular flexibility, as shown in Table 3. More specifically, with one unit (kg/m2) increase in BMI, on average, the muscular flexibility decreased by 0.147 units with statistically significant results (Beta = -0.147; [95% CI: -2.07-(-0.039)]) while adjusting for other variables in the model. These results confirmed our main hypothesis that increasing weight leads to a decrease in muscular flexibility. A negative relationship was found between gender and muscular flexibility (Beta = -0.078; [95% CI: (-2.98) - (0.86)]). However, because the null value in the 95 percent CI was zero, the results were not statistically significant (Table 3).

Table 3: Association between BMI status and muscular flexibility of children in Saudi Arabia (n=195)

Final Model	Unstandardized Coefficients		Standardized Coefficients	t	P-value	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
BMI status	-1.053	0.514	-0.147	-2.048	0.042	-2.067	-0.039
Gender	-1.061	0.973	-0.078	-1.09	0.277	-2.98	0.859
Dependent Variable: STR (cm)							

Discussion

This study was undertaken to assess the relationship between muscular flexibility and weight in children aged 6 to 13 years in Saudi Arabia. Overall, the data revealed an inverse and negative relationship between muscular flexibility, measured by using STR, and the children's weight. The main findings of the final regression model demonstrated that muscular flexibility was negatively associated with body mass index, confirming the study's primary hypothesis. These findings suggest that an increase in weight may adversely affect muscular flexibility. In addition, study results illustrated that muscular flexibility was lower for boys as compared to girls, with statistically insignificant results. Further, the findings demonstrated a negative relationship between the child's age and muscular flexibility, suggesting that muscular flexibility decreases with a child's age.

Our main findings regarding the negative relationship between muscular flexibility and weight are analogous to the existing literature. For example, Bataweel and Ibrahim conducted a cross-sectional study among elementary school children in Saudi Arabia on 150 children in 2020 [37]. The authors found that children with obesity or increased weight showed impaired postur-

al balance and musculoskeletal flexibility [37]. Further, the authors found that calf muscles were less flexible in obese children than in normal-weight children [37]. Similarly, a study conducted in Taiwan found that children with obesity have poor muscular strength [38]. Also, Chen et al. (2002) found that increased weight was associated with low muscular flexibility, as revealed by poor sit and reach performance among the children [17].

These consistent findings can be collectively explained by the fact that obese or overweight children may have reduced sensitivity to the mechanoreceptors, delays in motor signal transmission, and neuromuscular fatigue [39-42]. In addition, the possible explanation for these findings could be na excess of body fat that creates an extra load that may affect their movement and flexibility [43]. Besides, obese and overweight children tend to perform limited weight-bearing activities as they require more energy than normal-weight children, limiting their flexibility [38,44]. This is because overweight and obese children don't have as much confidence in their performance in physical activities [32].

However, Pongprapai et al., (1994); Deforche et al., (2003); Kim et al., (2005); and Fogelholm et al., (2007) did not find any differences in the muscular flexibility between normal weight and obese boys in their respective studies [13,14,45]. While Fogelholm et al., (2007) found the inverse relationship between overweight and muscular flexibility, the magnitude of the effect size was smaller with a lower strength of the relationship [46]. These discrepancies in the findings could be attributed to the variations in study settings, sample size, and differences in exposure measurement. For example, height and weight were self-reported in the study by Fogelholm et al., (2007), which may result in misclassification of exposure. Such misclassification may explain the differences in the findings of these results.

Strengths and limitations

This is the first study to examine the relationship between weight and muscular flexibility in Saudi children. The findings provide valuable insights into an important public health issue of obesity and its effects on children's flexibility. This unique strength of the study may guide researchers to be mindful of the effects of obesity on children. Another strength of the current study is that the children's weight and height were objectively measured rather than relying on self-reported data from parents. This would minimize the potential for misclassification bias in na exposure. Similarly, the outcome variable (muscular flexibility measured by the sit-to-reach test)

was kept as a continuous variable and did not dichotomize the outcome into poor versus good muscular flexibility, which also prevented the misclassification bias in the outcome and gave us the confidence to have enough power for the outcome variable. However, some potential limitations to this study must be acknowledged. One of the limitations of this study was the focus on sit-to-reach tests only, as we did not consider physical fitness holistically. Comprehensive physical fitness requires other tests such as endurance running, agility, handgrip strength, squat jump, standing long jump, and static balance. Therefore, future studies are warranted to assess a child's comprehensive physical fitness and its relationship with the child's weight with a larger sample size and a more representative sample. Another limitation of this study is the study design, as it was a cross-sectional study; therefore, the temporal relationship between being overweight and muscular flexibility could not be established. Children may have poor muscular flexibility, which may prevent them from being physically active, affecting their weight and increasing their tendency to become obese. In addition, our sample size was relatively smaller than other similar studies, which may have prevented us from studying the gender differences.

Conclusion

This study demonstrates that being overweight or obese was inversely associated with a decrease in muscular flexibility as measured by a sit-to-reach test, with no differences between boys and girls.

The findings regarding the relationship between weight and muscular flexibility are not consistent in the literature, therefore, warranting more studies in the future on larger sample sizes with more representation of all Saudi children to confirm these findings. In addition, Saudi children may show poor flexibility as their weight increases. Therefore, to reduce the burden of obesity and its associated negative consequences on physical fitness and other health parameters, the Saudi government must collaborate with education and health representatives to develop school programs to help children remain physically active. However, based on the current study findings, we recommend designing and executing schools' programs to create an environment that is not obesogenic.

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