

## Article

# Influence of Adiposity on Physical Activity in Schoolchildren: The Moderator Role of Adherence to the Mediterranean Diet

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**Abstract:** Background: Studies were performed in order to determine the existing relationship between body composition and both physical activity (PA) levels and food habits. Nevertheless, no study has yet examined if the association between adiposity and PA in children is moderated by adherence to the Mediterranean diet (MD). Methods: the cross-sectional and associative analysis involved a total of 370 children (55.1% boys) aged 6–13, from six different schools from the Murcia region of Spain. Results: The different values of moderator [adherence to the MD expressed as a Mediterranean Diet Quality Index (KIDMED) score] are shown by the slope and the different areas of significance. The first area was shown below  $\leq 3.8$ , indicating that the unfavorable influence of excess of adiposity on PA could be intensified for children in this area. The second area was a significant positive area was shown above  $\geq 9.3$ , expressing that the unfavorable influence of adiposity could be reduced for those who were above this estimation point. Conclusion: Our findings reveal that the adverse effects of excess adiposity on PA can be moderated by adherence to the MD among schoolchildren.

**Keywords:** healthy diet; obesity; feeding patterns; lifestyle; children

## 1. Introduction

Overweight and obesity are known globally as the most severe public health problems due to their worrying increase over time [1]. Although existing knowledge of the serious consequences of overweight and obesity is primarily founded on studies in adults, growing evidence suggests that childhood obesity has a number of immediate, intermediate, and long-term health consequences [2]. Some of these consequences could be linked to the negative relationship between several behaviors associated with physical activity (PA) and adiposity as shown in the scientific literature [3], since insufficient levels of PA are the fourth-leading risk factor for premature mortality in adulthood [4]. In this sense, it is widely thought that childhood adiposity is caused by physical inactivity [5–7] due to

a strong inverse dose–response association with body mass index (BMI) [8]. However, confounding or reverse causation (i.e., that adiposity influences physical inactivity, rather than vice versa) may partially explain this relationship [9]. In this sense, the causal contributions of adiposity to activity levels in children were highlighted [10], which may justify why PA interventions are often unsuccessful in preventing excess weight increase in children [11].

The typical eating habits of the people who live in the regions around the Mediterranean Sea [8], known as the Mediterranean diet (MD), are recognized worldwide as one of the healthiest and most beneficial ways of eating due to the ability to help prevent several chronic, non-communicable diseases [8]. Unfortunately, adherence to the principles of the MD have greatly diminished in the Mediterranean region, principally among young populations [7–11].

Regarding Spain, some studies were conducted to estimate the relationship between body composition and both PA levels and food habits [12–14]. To the best of our knowledge, no study has yet researched if the association between adiposity and PA in children is moderated by adherence to the MD. In this sense, moderation analysis is an adequate analytical strategy to examine when or under what circumstances the independent variable affects the dependent variable [15]. Thus, although multi-component, behavior-changing intervention programs including healthy diet, PA, and behavioral changes may be beneficial for obtaining small, short-term reductions in BMI, BMI z-score, and weight in children [16], we hypothesized that adiposity could diminish the PA level of children and that adherence to the MD could attenuate this negative association. Hence, we aimed to examine whether adherence to the MD moderates the association between adiposity and PA in a sample of Spanish schoolchildren aged 6–13.

## 2. Materials and Methods

### 2.1. Sample Population and Study Design

In this study, the cross-sectional and associative analysis involved 370 children (44.9% girls) aged 6–13 from six different schools from the Murcia region of Spain. Data were collected during the 2017–2018 academic year. The children were categorized by type of schooling: (a) public or (b) private with public funds, as well as area of residence: (a) urban (>5000 inhabitants) or (b) rural ( $\leq 5000$  inhabitants) [17]. The Bioethics Committee of the University of Murcia approved this study protocol (Approval number 2218/2018). The ethical principles of the Declaration of Helsinki were respected. We informed all participants (both parents/legal guardians and their children) about the study's objectives. To participate, written informed consent was required from children and their parents or legal guardians. Those who were exempt from physical education classes were excluded from the study. All of the questionnaires were filled out by the schoolchildren during physical education classes.

### 2.2. Procedures

#### 2.2.1. Anthropometric and Body Composition Measures

Protocols outlined by the International Society for the Advancement of Kinanthropometry (ISAK) were respected during the measurements. All the measurements were obtained by a single qualified Level II (certified by ISAK) evaluator. Skinfolds were measured at the triceps, biceps, subscapular, and iliac crest, using a skinfold caliper (Holtain Ltd., Crosswell, United Kingdom). Body density was estimated by the summary of skinfolds [18]. To obtain body fat from body density, the Siri formula was applied [19], and the difference between full body mass and fat mass was computed as a fat-free mass. On the same day, all participants were assessed according to all the measures related to body composition during the physical education lesson of the school period.

### 2.2.2. Physical Activity

Participants fulfilled the Physical Activity Questionnaire for Older Children (PAQ-C). The PAQ-C is a self-administered, 7-day recall questionnaire, comprising nine items, that assesses the regularity of the physical activities performed at home, at school, and during spare time [20]. It includes nine questions that are classified on a Likert scale and was adapted to and validated for Spanish youths [21]. The suggestions of Bervoets et al. [22] about the fulfilment of PAQ-C for children aged 6–7 were followed, since this questionnaire was validated for children aged 8–14. Thus, we recommended parents to aid their children by reading and completing the items, without providing any guidelines for responding to the different items.

### 2.2.3. Adherence to the Mediterranean Diet

To determine the adherence to the MD, the Mediterranean Diet Quality Index (KIDMED) questionnaire was used [23]. This questionnaire comprises 16 items that are related to Mediterranean dietary patterns. Those items that indicate negative MD meanings score a −1, whereas those with positive meanings (e.g., do you use olive oil for cooking at home?) score a +1. The sum of the 16 items were used to create a global score. According to the global score obtained, children's adherence to the MD was classified as low ( $\leq 3$ ), medium (4–7), or high ( $\geq 8$ ). The questionnaires were supervised and administered by trained staff to help all participants understand the questionnaires.

### 2.3. Statistical Analyses

Frequency distribution for categorical variables and descriptive analyses using mean  $\pm$  standard deviation for the continuous variables were used to indicate the characteristics of this sample. The normality of data was analyzed by the Kolmogorov–Smirnov test. Body fat percentages, PAQ-C scores, and KIDMED scores had skewed distributions and were transformed prior to analyses. To help the understanding of the analyses, we used a two-step technique for changing non-normally distributed variables to normally distributed variables [24]. Student's *t*-test was used to test significant differences between sexes. The PROCESS macro (version 3.4) in SPSS software (IBM Corp, Armonk, New York, USA) for Windows (version 24.0), was applied to perform an analysis of moderation. Initial analysis did not indicate significant interactions between sex and adiposity according to PA level ( $p = 0.277$ ); consequently, all analyses were performed with both boys and girls together. Moderation analysis was used to analyze if adiposity (independent variable) was linked to a lower level of PA (dependent variable), and to determine if this adverse influence was moderated by adherence to the MD (moderator variable). Ordinary least squares (OLS) regression analysis was performed to predict continuous variables (adiposity and PA). To visualize the effect of the moderator, a simple slope plot was used. We used the Johnson–Neyman method to check the point at which the adherence to the MD value moderated the relationship between adiposity and PA level [25]. Sex, age, type of schooling, and area of residence were adjusted for all the tests performed.

## 3. Results

Table 1 shows that there were 370 study participants, of whom 55.1% were boys and 44.9% girls. Age and anthropometric markers defined the main characteristics of the analyzed sample. The differences between sex for height and sum of skinfolds were statistically significant ( $p < 0.050$ ). Regarding PA outcomes (computed from PAQ-C score), boys showed a significantly higher score than girls. Additionally, no statistically significant differences were shown for adherence to the MD.

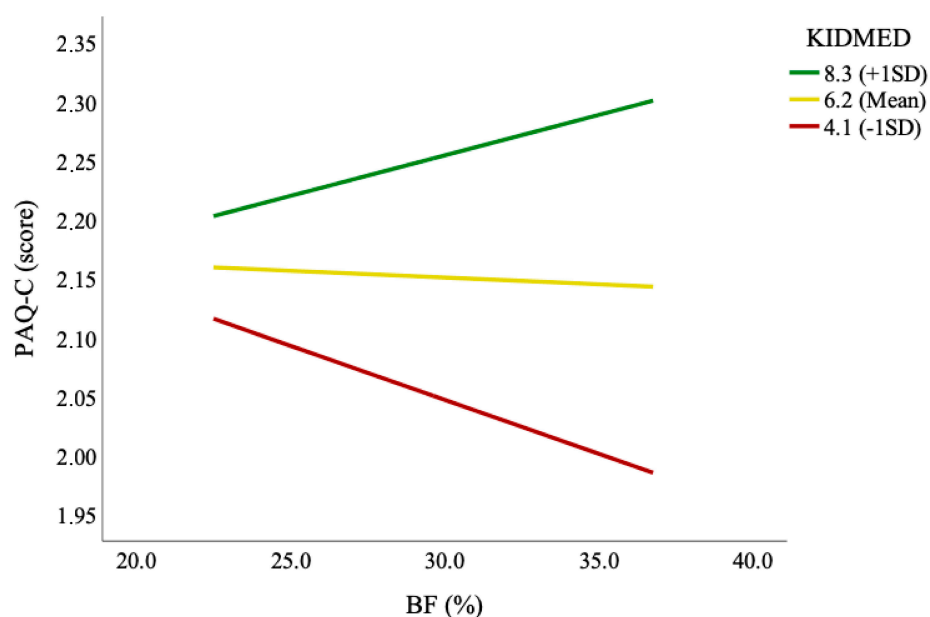
**Table 1.** Main characteristics of the analyzed sample according to sex.

Variables	Boys ( <i>n</i> = 204)		Girls ( <i>n</i> = 166)		<i>p</i>
Age (years)	8.8	1.8	8.5	1.8	0.084
Type of schooling					
Urban	158	77.5	124	74.7	0.310
Rural	46	22.5	42	25.3	
Area of residence					
Public	139	68.1	108	31.9	0.303
Private *	65	31.9	58	34.9	
Weight (kg)	36.41	10.75	34.9	11.10	0.178
Height (cm)	1.37	0.11	1.34	0.12	0.020
BMI (kg/m <sup>2</sup> )	19.08	3.54	19.02	3.93	0.888
Summary of skinfolds (mm)	56.70	24.52	61.98	24.82	0.041
BF (kg)	11.08	5.79	11.28	6.10	0.745
BF (%)	25.94	9.27	27.66	7.67	0.051
PAQ-C (score)	2.21	0.49	2.08	0.42	0.005
KIDMED (score)	6.1	2.1	6.3	2.0	0.476

Data indicated as mean and standard deviation (continuous variables) or numbers and frequencies (categorical variables). BMI: Body mass index; BF: Body fat; WC: waist circumference. \* Private with public funds.

Table 2 indicates a negative association between adiposity (measured via skinfolds) and PA in schoolchildren (adjusted model) according to OLS regression. This path is identified as the direct effect [ $B = -0.025$ ; 95% CI (confident intervals) =  $(-0.443, -0.006)$ ], and was moderated by adherence to the MD. The unfavorable effect of adiposity on PA was moderated by adherence to the MD [ $B = 0.004$ ; 95% CI =  $(0.001, 0.007)$ ].

Figure 1 shows the moderating effect of MD adherence in the association between adiposity on physical activity for different conditional effects (+1 SD, mean, and −1 SD) after adjustment for age, sex, type of schooling, and area of residence. Thus, we observed that higher MD adherence exerted a positive moderation in the PA level of those children with higher adiposity, which was the greatest effect within the category of higher MD adherence (+1 SD) [ $(\beta = 0.010$ ; 95% CI =  $(0.001, 0.019)$ ].



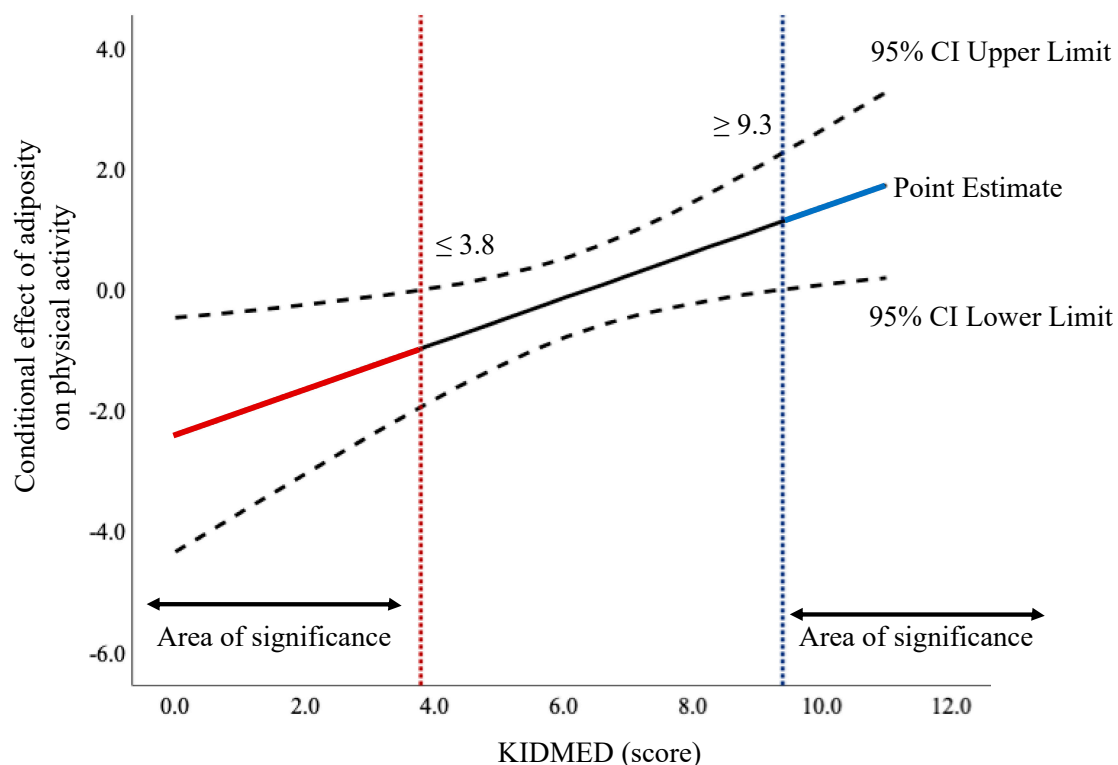
**Figure 1.** Moderating effect of adiposity on physical activity through adherence to the Mediterranean diet in schoolchildren. Estimated mean (colored lines) represent values for different conditional effects (+1 SD, mean, and −1 SD) in adherence to the Mediterranean diet, after adjustment for sex, age, type of schooling, and area of residence.

**Table 2.** Various regression models estimating effects for physical activity.

Predictors		PAQ-C (Score) (Y)											
		Model 1			Model 2			Model 3			Model 4		
		B (SE)	95% CI	$\beta$	B (SE)	95% CI	$\beta$	B (SE)	95% CI	$\beta$	B (SE)	95% CI	$\beta$
BF (%) (X)	$b_1 \rightarrow$	0.002 (0.003)	−0.005, 0.009	0.030	-	-	-	−0.021 * (0.010)	−0.443, −0.006	0.030	−0.024 * (0.010)	−0.043, −0.005	−0.011
KIDMED (score) (W)	$b_2 \rightarrow$	-	-	-	0.045 ** (0.011)	0.023, 0.068	0.205	−0.066 (0.048)	−0.161, 0.029	0.195	−0.059 (0.046)	−0.150, 0.032	0.228
Interaction (X × W)	$b_3 \rightarrow$	-	-	-	-	-	-	0.004 * (0.002)	0.001, 0.007	0.119	0.004 * (0.002)	0.001, 0.007	0.122
Sex	$u_1 \rightarrow$	-	-	-	-	-	-	-	-	-	−0.137 * (0.046)	−0.227, −0.047	−0.148
Age	$u_2 \rightarrow$	-	-	-	-	-	-	-	-	-	0.056 ** (0.013)	0.030, 0.082	0.215
Type of schooling	$u_3 \rightarrow$										0.063 (0.052)	−0.040, 0.167	0.065
Area of residence	$u_4 \rightarrow$										0.159 * (0.058)	0.046, 0.273	0.147
Constant	$i_Y \rightarrow$	2.094 ** (0.103)	1.892, 2.295	-	1.870 ** (0.074)	1.725, 2.015	-	2.505 ** (0.317)	1.881, 3.128	-	1.974 ** (0.356)	1.273, 2.674	-

Data expressed as unstandardized coefficients (standard error—SE), 95% confidence intervals (CIs), and standardized coefficients. Models 1, 2 and 3 are unadjusted; Model 4 is adjusted by sex, age type of schooling, and area of residence. BF: body fat. \*  $p \leq 0.050$ ; \*\*  $p \leq 0.001$ .

To clarify an estimation point from which the moderator value could have a moderative effect, the Johnson–Neyman method was performed. Figure 2 shows the result. The different values of moderator (adherence to the MD expressed as a KIDMED score) are shown by the slope and the different areas of significance. The first area is shown at  $\leq 3.8$ , indicating that the unfavorable influence of excess of adiposity on PA could be stronger for children in this area. In the second area, a significant positive area is shown at  $\geq 9.3$ , expressing that the unfavorable influence of adiposity could be lower for those who were above this estimation point. Finally, a neutral area was perceived, which showed that the negative effect did not increase or decrease in children with a KIDMED score between the lower and upper threshold.



**Figure 2.** Regression slope estimation and 95% confidence intervals for the association between moderator variable (adherence to the Mediterranean diet) and the negative effect of adiposity on physical activity, according to the Johnson–Neyman method. The negative area of statistical significance at moderator value (KIDMED score of  $\leq 3.8$ ) is shown by the red line. The positive area of statistical significance at moderator value (KIDMED score of  $\geq 9.3$ ) is shown by the blue line. The neutral area of statistical significance is shown by the black line.

#### 4. Discussion

The purpose of this study was to examine the moderating role of MD adherence on the negative influence of adiposity on PA in Spanish schoolchildren. Our results presented a negative relationship between adiposity and PA. This finding is in agreement with the results obtained in other countries, where lower levels of PA are found in children who are overweight or obese [26]. Likewise, our findings agree with those obtained by previous studies [5,12], which found that increased adiposity leads to a decrease in PA, suggesting that the association between adiposity and PA is led by the impact of adiposity on PA, rather than vice versa. This could be due to the low level of motor competence in overweight/obese children, which indicates that it is crucial to focus on improving their motor skills to promote regular participation in PA, principally if they do not play sports in a club environment [27].

A positive association between adherence to the MD and PA levels was found. This could be justified because adhering to the MD, apart from its nutritional benefits, produces an active lifestyle [28].

Following this, a recent systematic review found a positive association between MD adherence and high levels of PA [29]. This is related to previous findings [30] that showed that children who eat healthy food are less sedentary and more likely to be physically active compared to children who consume less healthy foods. MD adherence could also stimulate PA by allowing those children who adopt healthier eating habits to be more physically active, if only by supplying them with essential nutrients such as amino acids,  $\omega$ -6 and  $\omega$ -3 fatty acids, vitamins, and certain minerals [29]. Therefore, the higher caloric expenditure of active youths implies a greater intake of essential nutrients [31,32], which necessitates a greater intake of high-quality proteins, glucides, essential fats, and vitamins provided by suitable Mediterranean patterns.

Regarding the association between the MD and adiposity, results from studies performed on youths about the prevention of obesity by the MD indicated a lack of consistency with regards to the findings, showing a negative relationship between MD adherence and excess weight in less than half of studies [4]. This finding could be explained at least partially because the evaluation of the relationship between the MD and excess weight could be biased by the methodology through which the anthropometric values are collected [28]. Another explanation could be that the KIDMED questionnaire measures the quality of the diet and not the quantity. In this sense, increasing calorie consumption (even if based on the MD) will result in weight gain, as dictated by the first law of thermodynamics [6].

The optimization of Mediterranean eating patterns could raise the level of PA and, consequently, children's cardiorespiratory fitness, since, among other factors, regular PA and especially that of vigorous intensity seems to be the most efficient at acting as a successful instrument to mitigate the negative effects of obesity on health [32]. For the overweight and obese pediatric population, PA is a valuable method to control or enhance body composition, metabolic profiles, and states of inflammation [25]. Furthermore, a healthy diet combined with a physically active lifestyle has many health benefits beyond simply promoting a healthy weight [33]. Thus, behavioral strategies aimed at decreasing sedentary behavior, decreasing overall caloric intake, and increasing PA are the keystones of pediatric weight management [34]. Similarly, the efficacy of school interventions that merge diet and PA components seems to be promising for the prevention of childhood obesity worldwide [35].

The main strength of this study is that, to the best of our knowledge, it was the first to analyze whether the relationship between adiposity and PA in children can be moderated by the MD. Another strength is that our findings contribute to the increase in knowledge of children, a population that is often understudied. Our study also had some limitations. We did not determine that the observed associations reveal causal relationships. Due to the cross-sectional study design, we were not able to conclude that increased adherence to the MD (with or without excess adiposity) causes a higher PA level or, conversely, that a lower PA level causes decreased adherence to the MD (i.e., the reverse causality). For this reason, although we argued for a specific direction of the dependence between variables, other directions of the effects are also feasible. Additionally, the calculation of PA patterns would have been more precise if we had used accelerometer devices in our standardized questionnaires. Lastly, we did not measure adiposity using a four-compartment model (4C). This model is the gold standard for evaluating body composition, although it is expensive and requires specialized tools to separately quantify the total bone mineral content, body water, and body volume [36].

## 5. Conclusions

Our findings revealed that the adverse effects of excess adiposity on PA can be moderated by adherence to the MD among schoolchildren. Consequently, strategies designed to improve the eating habits of schoolchildren, especially toward greater adherence to the MD, could be vital as a method to promote their PA and preserve their overall health. Likewise, such interventions should not only be directed toward children but also toward parents and legal guardians as the main individuals responsible for feeding their children.



Future research with representative samples as well as longitudinal monitoring are needed to explore the possible beneficial effects of the MD on the negative relationship between adiposity and PA in schoolchildren.

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