# RELATIONSHIP BETWEEN WEIGHT STATUS AND BASAL METABOLISM IN SCHOOLCHILDREN: THE MODERATING ROLE OF DIET QUALITY AND PHYSICAL ACTIVITY

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**Abstract:**

There is currently a scientific trend to study the association between energy balance and its impact on health from the earliest stages of life. The aim of this study was to examine whether diet quality and physical activity moderate the association between weight status and basal metabolism in a sample of Murcian primary schoolchildren aged 8-12 years. Basal metabolism was calculated according to height, sex, and weight, with fixed coefficients following validated formulae. Physical activity was measured with the Krece-Plus test; the KIDMED questionnaire was used to quantify diet quality and nutritional status was assessed by body mass index (BMI; kg/m$^2$) adjusted for sex and age. The results obtained indicate that overweight schoolchildren had a higher basal metabolism than their normal-weight peers considering their diet quality and physical activity level ($p<.001$, for both). Also, the effects of weight status on basal metabolism may be moderated by diet quality ($p<.05$) but not by physical activity ($p>.05$). These results may be of particular interest to educational and health personnel since generating strategies to improve schoolchildren's eating habits, especially towards higher diet quality, could be vital as a method to increase basal metabolic energy expenditure and their overall health.

***Key words:*** *Mediterranean diet, obesity, physical activity, health, schoolchildren*

## Introduction

The energy required for the regulation of physiological functions depends on the balance between energy intake and expenditure. An imbalance between these conditions, where consumption is favoured over expenditure, leads to an increase in the reserve, which, in turn, favours hypertrophy and hyperplasia of adipose tissue; in chronic conditions, this energy reserve leads to obesity (Sánchez, Polanco, & Rosero, 2020). This study points out that childhood obesity is a pressing challenge and a public health priority in the 21st century, with more than one third of schoolchildren worldwide experiencing overweight or obesity by the end of primary school. In this regard, teachers should be aware of the importance of the main factors influencing an increase in obesity, as paediatric obesity is associated with increased disease risk, including impaired glycaemic and lipid control that can lead to the development of chronic and potentially disabling pathologies, such as type 2 diabetes mellitus and adverse cardiovascular events in adulthood (Martínez-González, Sánchez-Villegas, Toledo-Atucha, & Faulín-Fajardo, 2022; Sánchez, Llussà, & Bautista, 2021).

Basal metabolic rate (BMR) represents the major component of energy expenditure in humans and is therefore of great relevance in obesity treatment. BMR is defined as the minimum energy requirement to maintain vital functions such as cardiovascular and respiratory system function, organ synthesis, cell membrane ion pumps and body temperature programmes (Hulbert & Else, 2004). It is influenced by factors such as age, sex, body composition, physiological state (Mussoi & Rech, 2019), and genetics (Lee, Lee, Kang, Shin, & Sorn, 2021). BMR comprises 50-80 % of daily energy expenditure and is highly variable between subjects, even after adjusting for sex, body weight and body composition (Bi, Forde, Goh, & Henry, 2019; Ravussin, 1995). Determined by indirect calorimetry or with predictive equations, BMR can be a useful predictor of cancer risk independently of body fat (Kliemann, et al., 2020).

At the environmental level, the therapeutic strategy against obesity initially starts with interventions that aim to change lifestyle; increased physical activity (PA) (caloric expenditure) as it can influence the modification of certain structural and functional patterns related to energy metabolism and weight status (Rosa-Guillamón, 2015) and feeding behaviour (caloric intake) as an influence of the gut-brain axis on obesity and BMR has been reported (Ravussin, 1995; Zawada, et al., 2021). Both constructs are key to prevent, manage and potentially reverse metabolic disorders and weight status (calorie balance) (Bai, Goudie, Børsheim, & Weber, 2021; Calcaterra, et al., 2021).

Following a review of the literature (St-Onge & Gallagher, 2010), it has been proposed that reduced BMR and fat oxidation may lead to changes in body composition and that lower BMR at age of 10 years predicts greater change in the BMI z-score of schoolchildren. These aspects indicate that the effects of a relatively low metabolic rate on future weight gain in this population may begin in late childhood (Hohenadel, et al., 2021). In this sense, this study has identified evidence that schoolchildren at risk of obesity are generally not predisposed to higher body weight due to higher metabolic efficiency. Therefore, it is necessary to put more emphasis on defining different subgroups of overweight and normal-weight subjects in studies investigating BMR (Wurmser, et al., 1998) and to observe the influence of weight status on BMR at paediatric age in order to carry out appropriate nutritional approaches. In other words, obesity can modify BMR by several mechanisms with consequent implications for medical, educational and nutritional decisions; it can act in opposite directions (Doros, Delcea, Mardare, & Petcu, 2015; Itagi, Kalaskar, Dukpa, Chandi, & Yunus, 2022).

Based on these precedents, the aim of this study was to examine whether diet quality and physical activity moderate the association between weight status and basal metabolism in a sample of primary school children aged 8-12 years. The alternative hypothesis ($H_1$) was that normal-weight schoolchildren had a lower metabolism than their overweight peers and that diet quality and physical activity would moderate this association.

## Method

### Type of study and participants

Prior to conducting this research, the sample size was calculated in order to ensure robust results (Quispe, Pinto, Huamán, Bueno, & Valle-Campos, 2020). After jointly estimating the *u* (in reference to the number of variables) and $f^2$ (effect size in linear regression models) statistics, it was obtained that the minimum sample had to be of a total of 211 subjects to be able to carry out the linear regression technique, something that is fulfilled since we had a total sample of 281 students.

In this regard, a total of 281 schoolchildren (43.6% boys and 53.7% girls) from Murcia (Spain), aged between 8 and 12 years (M ± SD: 9.63 ± 1.81 years), participated in this descriptive and cross-sectional *ex post facto* study. The sampling was non-probabilistic, chosen non-randomly and by convenience (access to the sample). Four public schools were selected from rural (97 schoolchildren) and urban (184 schoolchildren) environments. These schools had a medium socio-economic level according to the annual general programme of each school. In previous meetings held with the school principals and legal guardians of the schoolchildren, they were informed of the study protocol and informed consent was requested so that the schoolchildren could participate. Inclusion criteria were: children must be between 8-12 years of age (since this is where healthy lifestyle habits begin to be created in the early stages of life) and must not suffer from previous pathologies. The exclusion criterion was the failure to present informed consent to participate in the research.

### Procedure and instruments

The work was carried out during the months of March and April of the 2019/2020 academic year, and each headmaster of the school and the representatives of the parents' associations were informed of the purpose and protocol of the research at a meeting. The working team consisted of a principal researcher and four collaborating colleagues—teachers specialising in primary education and physical education (PE). A theoretical session was held prior to the completion of the *KIDMED* and *Krece-Plus* questionnaire with each study group in order to ensure that all participants understood the items of the questionnaires in this study. The research team administered the test in the natural groups of PE classes. All questionnaires were administered during the first session of the day in order to avoid possible fatigue induced by the school day and to interrupt the school dynamics as little as possible.

The research was carried out in accordance with the ethical standards recognised by the Declaration of Helsinki (2013 revision), following the recommendations of Good Clinical Practice of the EEC (document 111/3976/88 of July 1990) and the current Spanish legal regulations governing clinical research on humans (Royal Decree 561/1993 on clinical trials).

The independent variables were:

I) Diet quality determined using the *KIDMED* questionnaire (Serra, et al., 2004). This instrument is composed of 16 items representing standards of the traditional Mediterranean diet. Four of them are assessed with a negative score (-1 point) if answered positively (items 6, 12, 14 and 16), while the remaining twelve items are assessed with a positive score (+ 1) if answered positively. After summation, an overall score between 4 and 12 is obtained, which describes a better or worse quality of the diet. The value of the *KIDMED* index is: score ≤ 3 indicating a very low quality diet; score between 4 and 7 indicating the need to improve the dietary pattern to conform to the Mediterranean model; and, finally, score ≥ 8 showing an optimal Mediterranean diet. Participants were categorised into two groups: DQ improvable (≤ 7) and optimal DQ (≥ 8).

II) Participants' body weight and height were determined using an electronic scale (TANITA TBF 300A, USA) and measuring rod (SECAA800, USA) with an accuracy of 100 g and 1 mm, respectively, following the protocol of the International Society for the Advancement of Kynanthropometry (ISAK) with level I certified personnel. From these anthropometric variables, the body mass index (BMI; kg/m$^2$) was calculated. From this index, age- and sex-adjusted nutritional status was classified (Cole & Lobstein, 2012). Participants were categorised into two groups: normal weight and overweight (*overweight + obesity*).

III) Physical activity was measured with the short *Krece-Plus test*, part of the enKid study (Román-Viñas, Serra-Majem, Ribas-Barba, Pérez-Rodrigo, & Aranceta-Bartrina, 2003). This test measures the level of habitual PA (0-10) of schoolchildren based on the average daily hours spent watching television or playing video games, and the hours of out-of-school PA per week. Schoolchildren were categorised into two groups according to PA level: insufficient, X < P70 and adequate, X ≥ P70. Cronbach's alpha for this study was 0.70, which is considered adequate and valid.

The dependent variables

Basal metabolism wass considered as a dependent variable in this study:

Basal metabolism (calories), defined as the caloric quota necessary to maintain the organism and its physiological functions alive, in a state of absolute rest, fasting and at constant temperature (Neri & Bargosi, 2000), was calculated according to height, sex and weight, with fixed coefficients following these formulae:

Basal metabolism (male):
655 + (9.6 x weight) + (1.8 x height) - (4.7 x age).

Basal metabolism (female):
66 + (13.7 x weight) + (5 x height) - (6.8 x age).

### Statistical analysis

Normality and homogeneity of variances were obtained using the Kolmogorov-Smirnov and Levene statistics, respectively. As a normal distribution of the values recorded was observed, a parametric analysis was chosen. A differential analysis was then carried out. To indicate the characteristics of this sample, frequency distribution was used for categorical variables and descriptive analyses using the mean ± standard deviation for continuous variables. Student's t-test was used to test for significant differences between the groups (sex [*males vs. females*]; weight status [*normal weight vs. overweight*]; diet quality [*improvable vs. optimal*], and level of physical activity [*improvable vs. optimal*]) and the chi-squared test for categorical variables.

Subsequently, the PROCESS macro tool (version 3.5) of the SPSS software (IBM Corp, Armonk, New York, USA) was applied (version 23). This tool allows for moderation analysis (Hayes, 2017). The initial analysis indicated no significant differences between sexes; consequently, all analyses were conducted with males and females together to achieve greater statistical power. Moderation analysis was used to analyse whether weight status (independent variable) was linked to basal metabolism (dependent variable) by looking at the moderating effect of diet quality and physical activity (moderator variable). Before interpreting the coefficients, goodness-of-fit and model assumptions were assessed. To analyse the goodness-of-fit, the F-test was used, which indicates whether the linear relationship being analysed is statistically significant. It should be noted that this statistic was significant, thus confirming the relevance of the regression technique (Martínez-González, Sánchez-Villegas, Toledo-Atucha, & Faulín-Fajardo, 2020). With respect to the assumptions, as indicated by Pardo and San Martín (2010), the assumption of non-collinearity, linearity, independence of the errors and the Breusch-Pagan test to check the homogeneity of the residuals were checked as indicated by Pardo and San Martín (2010). These assumptions were met in all models. The influence of outliers was also tested using Cook's distance. As the value obtained was less than one (1), it was concluded that there was no influential case. Ordinary least squares (OLS) regression analysis was performed to predict the continuous variables (*basal metabolism* and *KIDMED*). To visualise the effect of the moderator, a simple slope plot was used. Johnson Neyman's method was used to test the point at which diet quality moderated the relationship between weight status and basal metabolism. In turn, since determining the contribution of the predictor is critical when conducting a regression model, the $R^2$ statistic was used (Raschka & Mirjalili, 2019). For the calculation of the sample size, the programme R, version 4.1.2 (pwr package)

(Champely et al., 2018) was used with the significance level set at 5% (p≤.05).

## Results

Table 1 shows that there were 130 males and 151 females in the study. Age and anthropometric markers defined the main characteristics of the sample analysed, where no statistically significant differences were observed (p>.05). Regarding the results of diet quality (calculated from the KIDMED score) and basal metabolism, no significant differences were observed for either males or females. Furthermore, no statistically significant differences were shown for diet quality and physical activity.

Figure 1 shows the differences obtained in the basal metabolism of schoolchildren according to their weight status (*normal weight vs. overweight*) and considering their diet quality (*improvable vs. optimal*) as well as the level of physical activity (*improvable vs. optimal*). It is observed that overweight schoolchildren had a higher basal metabolism than their normal-weight peers, independently of their diet quality (p<.001, for both) and physical activity (p<.001, for both).

Table 2 indicates a positive association between weight status and basal metabolism of schoolchildren (adjusted model) according to ordinary least squares regression. This pathway is identified as a direct effect [*B* = 49.53, 95% CI (confidence intervals) = -224.60 (125.53)], and was moderated by diet quality but not by physical activity. The effect of weight status on basal metabolism was moderated by diet quality [B = 24.51, 95% CI = 16.29 (-2.74)]. That is, for each point increase in the quality of the students' diet, basal metabolism will increase by 24.51 calories. Regarding goodness-of-fit, this model explains approximately 22% of the variance of basal metabolism, which refers to a medium effect

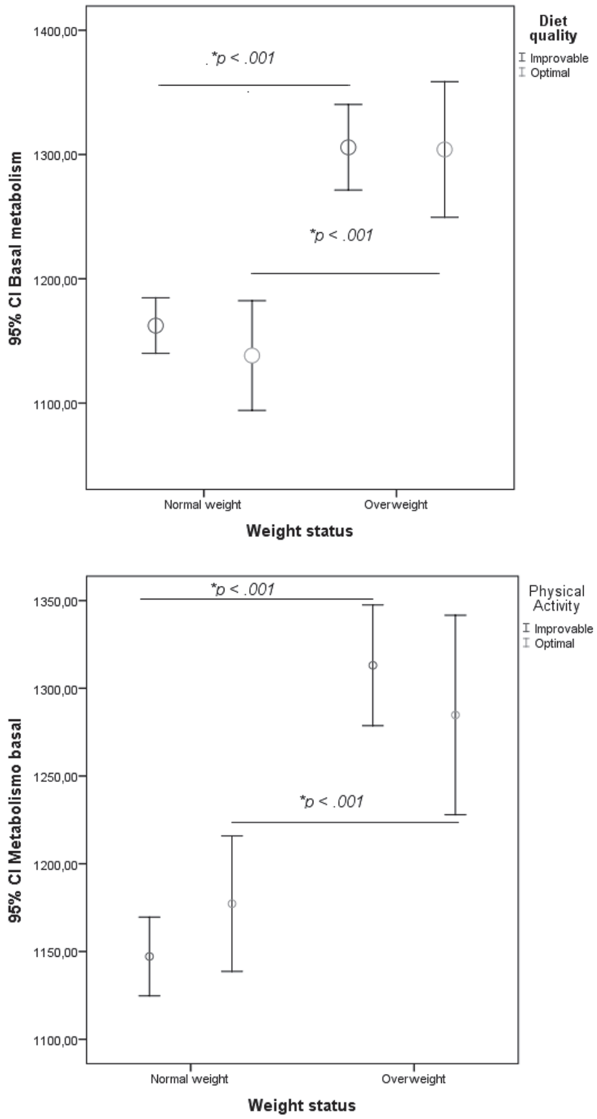


*Figure 1. Differences in the basal metabolism of schoolchildren according to their weight status (normal weight vs. overweight) and considering their diet quality (improvable vs. optimal) and level of physical activity (improvable vs. optimal).*

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

| | Males M ± SD (n = 130) | Females M ± SD (n = 151) | F | *p* | *d* |
|---|---|---|---|---|---|
| Age (years) | 9.59 ± 1.33 | 9.67 ± 1.26 | 1.665 | .623 | 0.05 |
| Height (cm) | 139.36 ± 11.17 | 138.30 ± 11.54 | 1.141 | .274 | 0.09 |
| Weight (kg) | 38.43 ± 10.52 | 37.05 ± 10.54 | 1.294 | .438 | 0.08 |
| BMI $(kg/m^2)$ [c] | 19.43 ± 3.48 | 19.10 ± 3.70 | 3.196 | .457 | 0.08 |
| Normal weight (n = 174) | 27.8% | 18.5% | - | .311 | - |
| Overweight (n = 107) | 34.2% | 19.6% | | .151 | |
| Diet quality[d] | 11.65 ± 2.37 | 11.72 ± 2.20 | 2.451 | .126 | 0.10 |
| Improvable DQ[d] (n=227) | 37.4% | 43.4% | - | .641 | - |
| Optimal DQ[d] (n=54) | 8.9% | 10.3% | | .877 | |
| Physical activity (PA) (0-10) | 5.73 ± 1.88 | 5.64 ± 2.05 | 1.984 | .344 | 0.09 |
| Improvable PA (n=189) | 32.4% | 38.4% | - | .149 | - |
| Optimal PA (n=92) | 13.9% | 15.3% | | .753 | |
| Basal metabolism | 1229,66 ± 113,27 | 1200,83 ± 186,44 | 7.958 | .697 | 0.06 |

*Table 2. Regression model estimating effects on basal metabolism*

| | Basal metabolism (score) (*Y*) | | |
|---|---|---|---|
| Predictors | B (SE) | 95% CI | *p* |
| Weight status (*X*) | 49,53 (88,93) | -224.60 (125.53) | .0481* |
| KIDMED (score) *(W)* | 24,51 (11,06) | 16.29 (-2.74) | .0298* |
| Physical activity (score) *(Z)* | 21,68 (13,34) | 4.5876 (7.96) | .1058 |
| Constant | 1.296,86 (131,33) | 1.038.32 (1.555.41) | .0001** |
| Intercept *(X x W)* | 16,82 (7,45) | 2.15 (31.50) | .0201* |
| Intercept *(X x Z)* | -12,48 (8,82) | 2.86 (4.89) | .1585 |

Note. Data are expressed as unstandardised coefficients (standard error; SE) and 95% confidence intervals (CI). * p≤.050; ** p≤.001.

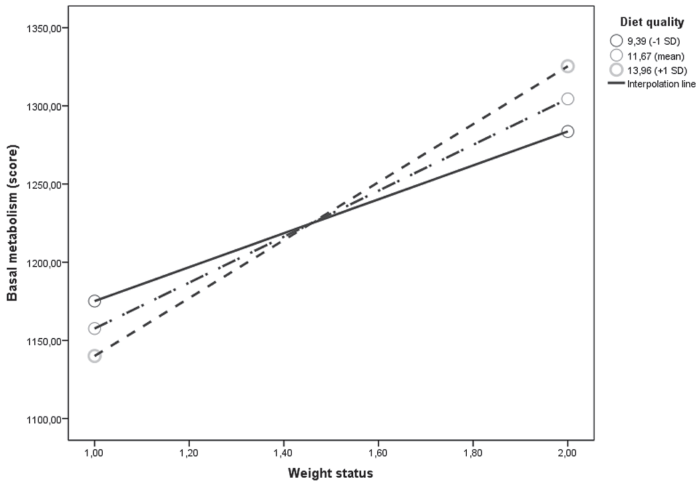


*Figure 2. Moderating effect of weight status on basal metabolism through diet quality in schoolchildren. The estimated mean represents the values of different conditional effects (+1 SD, mean and -1 SD) on diet quality, after adjusting for sex and age.*

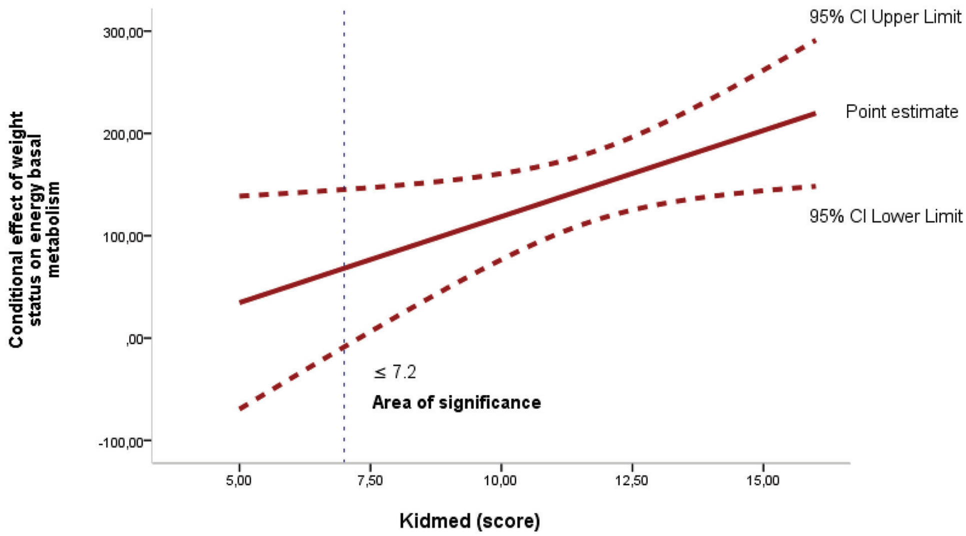


*Figure 3. Estimation of regression slope and 95% confidence intervals for the association between moderator variable (diet quality) and the effect of weight status on basal metabolism, according to the Johnson-Neyman's method. The area of statistical significance at the moderator value (KIDMED score of ≤ 7.2) is shown by the red line.*

size (Cohen, 1988). As for the RMSE, its value is low, indicating a low prediction error (1.645), with a statistical power of 90%.

Figure 2 shows the moderating effect of diet quality on the association between weight status and basal metabolism for different conditional effects (+1 SD, mean and -1 SD) after adjusting for age and sex. Thus, we observed that higher diet quality exerted a positive moderating effect on basal metabolism in overweight schoolchildren, with the largest effect in the category of higher adherence to DM (+1 SD) [(ß = .042, 95% CI = (.001, .069)].

To clarify an estimation point at which the value of the moderator could have an effect, the Johnson-Neyman method was used. Figure 3 shows the result. The moderator value (diet quality expressed as KIDMED score) is shown by the slope and the area of significance, the latter being ≤7.2, indicating that the determination of weight status on basal metabolic expenditure might be stronger for schoolchildren in this area. From this point estimate, a positive area is shown, expressing that the determination of weight status on basal metabolism might be lower for those above this point estimate on diet quality.

## Discussion and conclusions

The aim of this study was to examine whether diet quality and physical activity moderate the association between weight status and basal metabolism in a sample of primary school children aged 8-12 years. The initial hypothesis was that normal-weight schoolchildren would have a lower metabolism than their overweight peers and that diet quality and physical activity would moderate this association. In this sense, it was found that: I) overweight schoolchildren had a higher basal metabolism than their normal-weight peers but II) only diet quality moderated this association between weight status and basal metabolism in schoolchildren.

Given that no studies have been found in the scientific literature in paediatric age groups that analyse the association between these variables by observing the moderating role of diet quality and physical activity, this prevents us from making direct comparisons. In this sense, studies analysing the relationship between weight status and basal metabolism are limited, hence the original focus of our study. These results take on greater importance given the age of the sample, since these are transcendental stages of life in which a healthy lifestyle, such as the quality of the diet, can have an impact on the individual's metabolic expenditure and, consequently, on a higher state of health.

The results found regarding the moderating role of diet quality may be due to physiological (Mohammadpour, et al., 2021; Zapata, et al., 2021) and genetic processes such as thyroxine and adrenaline hormones that can increase basal metabolic expenditure (Lee, et al., 2021; Ravussin, 1995; Rosa-Guillamón, 2015; Zawada, et al., 2021), derived from the assimilation of certain macronutrients in the diet. In other words, several studies have shown an influence of macronutrient intake on the metabolic profile, finding positive effects of the Mediterranean diet on BMR and on the abundance of microbial species associated with better macronutrient metabolism compared to those subjects with a different dietary pattern (Daniele, Scarfò, & Ceccarelli, 2021; Nadimi, Djazayery, & Hosseini, 2013). Methodologically similar research, which aimed to examine the relationship between BMR and dietary intake of micronutrients such as zinc, vitamin C and riboflavin in overweight and obese women, found a significant association between riboflavin intake and BMR, but no significant association between vitamin C, zinc and BMR (Sajjadi, Mirzababaei, Abdollahi, & Shiraseb, 2020). This study noted that zinc has different roles in energy metabolism and functions as a component of several enzymes crucial for the metabolism of carbohydrates, proteins and lipids, and the metabolism of hormones involved in the progression of obesity, especially insulin. Sajjadi et al. (2020) also point out that it appears to be related to the insulin resistance mechanisms generally present in people with obesity. They also show that these subjects with impaired glucose tolerance have higher BMR levels than those with obesity and normal glucose tolerance. Ambra, Canali, Pastore, and Natella (2021) add that an explanatory mechanism for this could be due to the role of ascorbic acid (antioxidants) in the expression of genes involved in adipogenesis, glucocorticoid metabolism and the inflammatory response. In other words, it has been shown, for example, that dietary supplementation with vitamin C does not affect daily energy expenditure or BMR. This finding underlines that the antioxidant effects of the vitamin are not being compensated by modulations in the rate of oxidative metabolism, which could affect the total rates of reactive oxygen species products.

However, Calcaterra et al. (2021) have highlighted that the underlying mechanisms regulating energy homeostasis and food intake are not fully understood, with little research on the relationship of body composition to habitual macronutrient intake among healthy populations (Bi, et al., 2019); therefore, more research is needed. As indicated at the beginning of the discussion, another finding is that overweight schoolchildren have a higher basal metabolism than their normal-weight peers, irrespective of their diet quality and level of physical activity. In this regard, Pannemans and Westerterp (1995) pointed out that energy expenditure, and therefore energy needs, tends to decrease with age due to a decrease in BMR and the level of physical activity. In this study they point out that the effect of physical activity level is twofold: firstly, it has a positive effect on BMR, and secondly, it has a positive effect on fat-free mass. Both effects imply an increase in total energy expenditure, which increases with a higher level of physical activity. In energy balance, this will lead to an increase in energy and nutrient intake. In this vein, Valenzuela, Sobarzo, Basoalto, Sillero-Quintana, and Basoalto

(2019) found a weak correlation between basal metabolism and C-reactive protein; however, they did find a moderate association between BMR and lean mass percentage, reaffirming the importance of this tissue as an active metabolic organ.

Likewise, another study showed that the difference between the weight of obese and normal-weight schoolchildren is partly due to low BMR; the lower BMR in obese schoolchildren could be due to their low cardiorespiratory capacity (Saleh, Afroundeh, Siahkouhian, & Asadi, 2021). In this regard, Diaz et al. (2021) found that BMR increased with increasing maximal oxygen volume regardless of adiposity level (normal weight and overweight). However, Yu, Lee, Arslanian, Tamim, and Kuk (2021) after conducting an intervention study did not detect significant changes in BMR among the physically active groups. However, visceral fat decreased in all subjects compared to those who were not physically active. In this sense, they point out that the change in fat mass but not in visceral fat or skeletal muscle mass was a significant determinant of changes in BMR, regardless of the mode of physical exercise in overweight or obese adolescents.

At the genetic level, the study by Martin-Hadmaș, Martin, Romonți, and Mărginean (2021) reported that by BMR measurements, maximal carbohydrate metabolism changed significantly as a function of proinflammatory cytokine values such as the IL-6 gene, which correlated significantly with respiratory quotient values. Similarly, on the basis of BMR, an increase in the IL-8 gene coefficient was related to the respiratory quotient value. BMR explained about 15% of the variation in biological drivers of feeding rate differences that was considered metabolically significant (Henry, Ponnalagu, Bi, & Forde, 2018). However, Westphal et al. (2021) found no significant differences between BMR per unit mass (BMR/kg) or per unit lean mass (BMR/MM) and weight status. This variability in results may be explained by discrepancies in the way to report the BMR and the fact that BMR is believed to be genetically determined (Ravussin, 1995); further research is needed.

In this sense, Sánchez et al. (2021) indicate that it would be necessary for teachers to be aware of the importance of most of the factors that influence an increase in obesity, not only lifestyle and a healthy diet, but also other indicators such as exposure to endocrine disruptors, genetics, chronodisruption or intestinal microbiota. In this sense, the authors points out that from the classroom, this problem is considered only as the increase in energy consumption, through foods rich in sugars and fats, giving it a simplistic approach. It is therefore necessary to approach the treatment of obesity from a holistic and multifactorial viewpoint. Meanwhile, health promotion professionals in the school environment should consider the positive role that an optimal weight status can play in the overall development of students and initiate programmes to promote a degree of adherence to healthy lifestyles such as healthy eating and physical activity among schoolchildren (Carrillo-López, 2022).

However, the results presented in this study should be interpreted with caution due to the fact that this study was cross-sectional, based on self-reported data, with unknown quality and quantity of physical activity and food consumed daily by schoolchildren. In addition, the low sample size is undoubtedly another limitation. Similarly, it is difficult to infer a cause and effect relationship between weight status and basal metabolism, since, as we have seen, there are confounding factors that are likely to influence these relationships and have not been considered in this study (such as psychological or genetic variables). Therefore, these effects could be related to environmental aspects and deserve to be further investigated in future studies. However, this study is valid and reliable by applying the use of internationally recognised formulae (Cole & Lobstein, 2012; Sanchez, et al., 2020). In addition, further limitations are recognized, such as the use of estimating equations to calculate BMR. It would also be interesting to include in future studies the use of accelerometers to calculate physical activity of the participants, and also compare the data provided by the KIDMED to any similar questionnaire completed by parents or legal guardians, as well as maturation measures to control for this important factor at this age. On a practical level, it is suggested that future studies assume the role of calculating the basal metabolic rate to consider the optimal energy intake and, therefore, individualisation in the prescription of nutritional strategies in healthy patients and those with chronic non-communicable diseases. In this respect, further research is needed.

## Implications for practice

In line with the aim of the study, it has been observed that overweight schoolchildren have a higher basal metabolic rate than their normal-weight peers and how the effects of weight status on basal metabolic rate can be moderated by diet quality among primary schoolchildren. These results may be of particular interest to educational and health care personnel since generating strategies to improve schoolchildren's eating habits, especially towards higher diet quality, could be vital as a method to increase basal metabolic energy expenditure and their overall health. In addition, these interventions should not only target schoolchildren, but also parents and legal guardians as the main responsible persons for their children's diet in order to generate a fuller awareness of the degree of maintenance of a healthy lifestyle that will undoubtedly have an impact on their future health. Undoubtedly, it would be interesting for health professionals and primary care teams to give courses to families in the school environment to provide information on healthy eating by age, on the food wheel, among other aspects.

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