***Cross-Sectional associations between Mediterranean diet and body composition in preschool children. CORAL Study.***

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ABSTRACT

Background: Overweight and obesity in children are rising globally, and Mediterranean diet may help reduce obesity and related diseases.

Objective: To assess the association between adherence to the Mediterranean diet and body composition in Spanish preschool children.

Methods: This study included 1,218 children aged 3-6 years from the CORALS cohort. Mediterranean diet adherence was evaluated using the validated MED4CHILD and COME-Kids F&B-FQ questionnaires. Body composition measurements included weight, height, waist circumference, BMI, Fat Mass (FM), Fat-Free Mass Index (FFMI), and Waist-to-Height ratio (WtHR). Multivariate regression and ANCOVA were used to examine associations, adjusting for factors like age, physical activity, and energy intake. We also performed a Cohen's d analysis to assess effect size.

Results: Adherence to the Mediterranean diet was associated with more favourable body composition in children. Specifically, both the MED4CHILD score and the COME-Kids-derived score showed significant associations with BMI, FFMI, and Waist-to-Height ratio, showing differences by sex. Children who adhered to the Mediterranean diet exhibited lower BMI and higher fat-free mass, and a more favourable waist-to-height ratio. Additionally, although some measures showed weaker associations, all analyses highlighted a trend towards improved body composition with higher adherence. Cohen's d analysis showed small to moderate effect sizes.

Conclusion: Adherence to the Mediterranean diet was significantly linked to favourable body composition indices in Spanish children, highlighting the importance of promoting healthy dietary patterns to prevent overweight and obesity.

## 1. INTRODUCTION

Overweight and obesity have become a major epidemic worldwide [1,2] being one of the greatest public health challenges of the 21st century [3]. In children and adolescents, the age-standardised prevalence of obesity in 2022 was higher than 20% in 21 countries in girls (11%), and 35 countries in boys (18%) [4]. In Spain, the prevalence of excess body weight (overweight and obesity) was 40.6% in 2019, being one of the highest in Europe [5]. There is also a future expectation of a continuous rise in obesity prevalence in the youth population in the coming years [6,7].

Healthy dietary habits have been associated with a reduced risk of overweight and obesity development [8]. Mediterranean diet (MD) is the dietary pattern that has shown the highest beneficial effects on obesity, and related diseases in adulthood [9]. Some studies suggest that the main benefits of the MD pattern are linked to its effect on body composition and metabolic syndrome [10,11]. The traditional MD is a heritage that has developed over hundreds of years, thanks to the exchange of cultures, people, and foods from around the Mediterranean basin. It is a universally appreciated lifestyle, which not only involves a dietary pattern, but also includes cultural, historical, social, territorial, and environmental aspects, closely linked to the habits of the people living in the Mediterranean area [12]. MD is a varied diet that promotes the consumption of fresh, local, and seasonal foods [13]. It is mainly characterised by high consumption of vegetables, fruits, and legumes, as the main source of antioxidants and fibre and olive oil, nuts and fish as the main sources of mono and polyunsaturated fatty acids [14–16].

At the opposite, the Western diet, frequently consumed in children, promotes unhealthy body composition and the prevalence of diseases such as overweight and obesity, insulin resistance, dyslipidaemia, dysbiosis, and increased intestinal permeability, among others [17,18]. In European children, it was observed, the MD is scarcely followed even in countries bordering the Mediterranean Sea, being Sweden the European country with the highest adherence to this dietary pattern [19].

In relation to MD, there is scarce information about its association with body composition and obesity development in children and adolescents. In the IDEFICS study, after two years of follow-up, results showed that a high adherence to MD was inversely associated with the development of overweight and obesity in children 2 to 9 years old at baseline [19]. In a Spanish study, it was observed that strong adherence to MD at age 4 was linked to a reduced risk of developing overweight, obesity, and abdominal obesity by age 8 [20]. One systematic review of clinical trials also observed that MD has potential benefits in reducing the risk of cardiovascular diseases and type 2 diabetes; however, these studies have certain limitations as they were conducted over short periods and with small sample sizes [21]. The great majority of studies only assess simple measurements of body composition such as body mass index (BMI) and waist circumference (WC); and there is a lack of information on fat and fat-free mass compartments. For this reason, it is necessary to study whether adherence to MD is associated with body composition in children. Therefore, the aim of this study is to assess the association between the

Mediterranean dietary pattern and body composition, as well as the prevalence of overweight and obesity in preschool children.

## 2. MATERIALS AND METHODS

### 2.1. Study Design

The CORALS (Childhood Obesity Risk Assessment Longitudinal Study) is a multi-centre prospective cohort study of children living in Spain aged 3-6 years initially, with an ongoing annual data collection during a mean follow-up of 10 years. The study was registered under ClinicalTrials.gov ID NCT06317883 (https://corals.es/). This study will assess the incidence of obesity depending on the exposure to different risk factors (adherence to MD, fractionation of meals/meal occasions, body composition, physical activity, and sedentary lifestyle, among others). All these variables are considered fundamental to understand a multifactorial problem such as childhood obesity. CORALS is developed in selected schools across 7 Spanish cities whose tutors agreed to their participation. Parents or caregivers accepted to participate in the study by signing the informed consent form. The protocol of the study has been approved by the Ethics Committee of each recruitment centre (references nos. 051/2019, 4155/2019, 2019/18, 9/162, 19/162, 19/27, and 2019/131) which was conducted following the standards of the Declaration of Helsinki.

### 2.2. Study Sample

The current research included 3- to 6-year-old children from 7 Spanish cities, Barcelona, Córdoba, Pamplona, Reus, Santiago de Compostela, Valencia, and Zaragoza. A total of 1509 participants (51% boys) were recruited between March 2019 and June 2022. For the present study, we conducted a cross-sectional analysis of the 1218 participants (50.5% girls and 49.5% boys) who had completed the MED4CHILD questionnaire on adherence to MD (explain below) and that all body composition and anthropometric data are available to them at baseline (**Figure 1**).

### 2.3. Adherence to the Mediterranean Diet

Adherence to Mediterranean diet was assessed using two indices:

1) The MED4CHILD questionnaire is a validated [22] adaptation of the 14-item PREDIMED questionnaire for children [23] aiming to have a rapid assessment of the adherence to Mediterranean diet in clinical and epidemiological setting. This adapted questionnaire consists of 18 items. Affirmative answers mean higher adherence and are worth +1 point. In contrast, negative answers mean a lower level of adherence and are worth 0 point. The questionnaire was administered to parents or tutors to complete the information related to their children within an interview at baseline

conducted by trained registered nutritionists. The result is the sum of the scores and ranges from 0 to 18 (minimum to maximum adherence). Adherence to the MED4CHILD was classified in two categories: adherent when the score was ≥10 points and non-adherent when the score was ≤9 points. To adapt the PREDIMED questionnaire to preschool children, the MED4CHILD questionnaire included questions about the consumption of whole-grain cereals, fermented dairy products, snacks such as chips and similar foods, and sugary dairy desserts. Additionally, the question about wine has been removed.

2) The COME-Kids Food and Beverage Frequency Questionnaire (COME-Kids F&B-FQ) [24] is a semi-quantitative questionnaire including 125 items previously validated to assess dietary intake in children. From the information obtained in the COME-Kids F&B-FQ, we have computed a score, considering the majority of the items included in the MED4CHILD questionnaire. The MED4CHILD score estimated from COME-Kids F&B-FQ differs from the original MED4CHILD questionnaire as it is calculated using a semi-quantitative approach based on average yearly food consumption data. The computed score is hereinafter referred as MED4CHILD score estimated from COME-Kids F&B-FQ.

### 2.4. Body Composition Assessment

The same trained researcher consistently obtained the measurements. Each measurement was conducted three times non-consecutively, meaning a full set of measurements was completed before being repeated twice more.

The participants wore light clothing for measuring body weight, body fat percentage and muscle mass percentage by a bioelectric impedance (TANITA 780PMA). Fat Mass Index (FMI) and Fat Free Mass Index (FFMI) were calculated through data of bioelectric impedance. FMI provides a standardized measure of fatness that accounts for differences in body size and is particularly useful for assessing adiposity in children and adolescents. While FFMI provides insight into the lean tissue composition of the body, also adjusted for body size [25]. Also, the TANITA calculated the BMI ($kg/m^2$) of the participants. BMI z-score was calculated according to the criteria of Cole et al. (2012)[26].The height of the subjects was measured using a portable height rod with an accuracy of 0.1 cm (SECA 213). The WC was measured at the level of the narrowest point between the lowest rib and the top of the iliac crest at the end of a normal exhalation. WC was measured to the nearest millimetre with an inelastic tape, with the subject standing upright (SECA 201).

### 2.5. Covariates

To adjust the analyses, the following covariates were included: age (except for models with a z-score dependent variable), centre, mother's education level, total energy intake, total minutes of physical activity per week, and total hours of sleep per day. Age was calculated based

on the reported date of birth. The centre variable was provided by each participating city in the database. Mother's education level was classified according to ISCED criteria [27] (International Standard Classification of Education) into low, medium, or high. Total energy intake was obtained through the COME-Kids F&B Frequency Questionnaire, with the data derived from parental responses regarding their child's diet. Physical activity was measured in terms of total minutes per week, based on family reports of time spent engaging in structured sports activities, either at a sports club or as extracurricular activities at school. Finally, total hours of sleep per day were also collected through parental responses in the self-reported questionnaires.

### 2.6. Statistical Analysis

The current analysis was conducted using the CORALS database updated to 20/01/2023. Baseline characteristics of the study population were presented and analysed by sex as frequencies and percentages (%), whereas the continuous variables are presented as means (M) and standard deviations (SD). Linear regression models were fitted to assess associations between the MED4CHILD questionnaire and MED4CHILD score estimated from COME-Kids F&B-FQ and anthropometric measurements and indices. Models were adjusted by the following confounders: age (except for z-score variables), centre, mother's education level, for model 1, and for model 2 additionally adjusted by total energy intake, total minutes of physical activity per week, and total hours of sleep per day.

To examine adherence to the MED4CHILD and the MED4CHILD score estimated from COME-Kids F&B-FQ questionnaires (both classified as adherent or non-adherent), we performed a multivariate analysis of covariance (ANCOVA). The analysis included sex (boys and girls) and the interaction between sex and adherence to the MED4CHILD questionnaires as factors. The dependent variables were body composition indices, incluiding BMI, BMI z-score FMI, FMI z-score, FFMI, FFMI z-score and Waist-to-Height Ratio (WtHR). We considered sex and the scores from the MED4CHILD questionnaires as fixed factors. The models were adjusted for the following confounders: age (except for z-score variables), centre, mother's education level, total energy intake, total minutes of physical activity per week, and total hours of sleep per day. We include the calculation of Cohen's d to measure effect size. An effect size is considered small when d=0.2, medium when d=0.5, and large when d=0.8.

Odds ratios (ORs) were calculated to estimate the likelihood of obesity based on adherence to the MED4CHILD questionnaire and to the MED4CHILD score estimated from COME-Kids F&B-FQ questionnaire. Models were adjusted by confounders: age, centre, mother's education level, total energy intake, total minutes of physical activity a week, and total hours of sleep per day. In this analysis, the category "non-adherent" served as the reference.

The level of statistical significance was fixed as $p<0.05$. All the statistical analyses were carried out using the SPSS statistical package (version 25.0, SPSS Inc., Chicago, IL, USA).

## 3. RESULTS

The main characteristics of the studied population are described in **Table 1**. The mean age of the participants was 4.96±1.06. Girls showed significantly higher fat mass percentage, FMI, and WtHR compared to boys (all $p<0.005$). These descriptive results also show that girls are more likely to suffer overweight and obesity than boys ($p=0.012$). No other significant differences were observed.

The results from linear regressions performed between the MED4CHILD questionnaire and the MED4CHILD score estimated from COME-Kids F&B-FQ, and the different anthropometric measurements and indices segmented by sex are shown in **Table 2**. Only significant differences were obtained in the crude model for FMI z-score for girls ($p<0.005$) and BMI in boys ($p=0.032$) in the MED4CHILD questionnaire. Using the MED4CHILD score estimated from COME-Kids F&B-FQ, more significant associations were found in the crude model for boys in BMI, BMI z-score, and WC (all $p<0.05$), and for girls in BMI, BMI z-score, FMI and FMI z-score (all $p<0.05$). After adjusting by traditional confounders, significant differences were observed in boys for model 1 in WC and WtHR (both $p=0.016$), and for model 2, significant associations were found in WtHR ($p=0.047$) for boys, and in BMI, BMI z-score, weight, FFMI and FFMI z-score (all $p<0.05$) for girls.

**Table 3** presents the results of the ANCOVA analysis comparing adherence to the Mediterranean diet (categorized as adherent or non-adherent), using the MED4CHILD questionnaire and the MED4CHILD score estimated from the COME-Kids F&B-FQ, segmented by sex. Statistically significant differences were observed in BMI, BMI z-score, and WtHR among categories of MD adherence (assessed by the MED4CHILD) in both sexes ($p<0.005$).

For boys, BMI, BMI z-score, and WtHR show statistically significant differences (all $p<0.005$) in the crude model. In the case of the girls, only WtHR showed significance ($p<0.001$). Using the MED4CHILD score estimated from the COME-Kids F&B-FQ, significant differences were also found for BMI, BMI z-score, and WtHR (all $p<0.005$) in both sexes, with additional differences in FMI z-score for girls ($p<0.05$). After adjusting for confounders (Models 1 and 2), all these indices maintained their significance ($p<0.05$) in both sexes. In girls, the Cohen's d analysis showed small effect sizes for the MED4CHILD questionnaire in FMI (Model 1: 0.27), WtHR (Models 1 and 2: 0.20), BMI (Model 2: 0.28), and BMI z-score (Model 2: 0.27). For the MED4CHILD score estimated from the COME-Kids F&B-FQ, moderate effect sizes were observed in FFMI (Model 2: 0.66) and BMI (Model 2: 0.61). Small effect sizes were found in FMI (crude: 0.31, Model 1: 0.30, Model 2: 0.48), FMI z-score (crude: 0.31, Model 1: 0.30, Model 2: 0.47), FFMI (crude: 0.25, Model 1: 0.26), WtHR (Model 2: 0.20), BMI (crude: 0.31, Model 1: 0.31), and BMI z-score (crude: 0.29, Model 1: 0.35, Model 2: 0.24). In boys, no results showed a small effect size when using the MED4CHILD questionnaire. For the MED4CHILD score estimated from the COME-Kids F&B-FQ, moderate effect sizes were observed in WtHR (Model 2: 0.50) and BMI z-score (Model 2: 0.53), with small effect sizes in WtHR (crude: 0.20, Model 1: 0.25), BMI (crude: 0.33, Model 1: 0.30, Model 2: 0.27), and BMI z-score (Model 1: 0.30).

Binary logistic regressions between adherence to the MD using both (MED4CHILD and MED4CHILD score estimated from COME-Kids F&B-FQ questionnaires) (in two categories, adherent or non-adherent) and overweight-obesity compared with normal weight were performed. No significant relationships were observed. The results were consistent across questionnaires and by sex (Table 4).

## 4. DISCUSSION

This study aimed to evaluate the association between adherence to the MD and different body composition measures and indices, such as weight, BMI, WC, FMI, FFMI, and WtHR. Although BMI is the most used, it does not distinguish between fat mass and fat-free mass. Therefore, we included in the analysis the FMI and FFMI indices to provide a more comprehensive assessment. After adjusting for all relevant confounders (age, centre, mother's education level, total energy intake, total minutes of physical activity per week, and total hours of sleep per day), body fat composition indices were lower in those children showing a high adherence to the MD as compared with those with low adherence to MD. In both sexes, boys and girls, more significant results were observed when using the MED4CHILD score estimated from COME-Kids F&B-FQ as compared with the MED4CHILD.

In this study, we used two methods to assess adherence to the MD. One was based on a short questionnaire aiming to assess and monitor the MD in clinical settings (MED4CHILD). The other one was obtained using the same criteria considered to compute the MED4CHILD, but with food intake information obtained with the validated COME-Kids F&B-FQ [24]. The regression analysis results are more consistent for the MED4CHILD score estimated from COME-Kids F&B-FQ as compared with the MED4CHILD. These differences could be due to the different characteristics of both estimates; MED4CHILD assesses the actual adherence to the MD by means of 18 semiquantitative questions about food consumption and some culinary methods; however, MED4CHILD score estimated from COME-Kids F&B-FQ is based on the frequency of food consumption over the last year.

When the associations were analysed considering MED4CHILD, there was only an association with BMI in boys and FMI z-score in girls, but only considering the crude model. For the analysis using the MED4CHILD score estimated from COME-Kids F&B-FQ, we observed significant associations with the BMI z-score in boys and girls and with the FMI z-score, but only in girls, in the crude models; associations remained significant only in girls after adjusting for confounders (model 2). We have compared children adhering, and non-adhering to MD using both MED4CHILD and MED4CHILD score estimated from COME-Kids F&B-FQ; BMI and BMI z-score in both sexes, and FMI z-score in girls were lower in those adhering to the MD. In relation to FFMI, there was only an association with FFMI z-score in model 2 (adjusted by centre, mother's education level, total energy intake, total minutes of physical activity a week, and total hours of

sleep per day). The only study assessing body composition in relation to MD has been conducted in Chinese adolescents; in which similar results for FMI were reported. Those adolescents following a dietary pattern similar to the MD had the lowest FMI compared to participants who followed other dietary patterns, such as the Western diet; however, they didn't compute z-scores but adjusted by age and sex in their models [28].

In this study, we also found a significant association between MD and FFMI z-score, but only in girls; those adhering to MD showed lower FFMI z-score. In Chinese adolescents' adherence to the MD was associated with higher FFMI; analysis was conducted for boys and girls together but adjusted for age and sex. Another difference with our study is that they didn't adjust to physical activity. This could justify the difference with our study, in girls.

One of the best indicators of central adiposity or abdominal obesity is waist circumference. In order to interpret WC it was suggested to use the WtHR [29]. In our study we observed an association between MED4CHILD score estimated from COME-Kids F&B-FQ and WtHR, but only in boys after adjustments for confounders. When we compared WtHR for children adhering and not adhering to MD, we observed lower WtHR in those adhering (MED4CHILD and MED4CHILD score estimated from COME-Kids F&B-FQ), both in boys and girls. In one study conducted in Spanish children, there was an association between MD and age- and height-standardized residuals of waist circumference and with waist-to-height ratio [30]. Several studies have examined the relationship between adherence to the MD and WC in children and adolescents, showing that a higher adherence to the MD is associated with a lower waist circumference [30,31]. In a multicomponent-multilevel school-based educational intervention on the nutritional habits of children, after 6 months of intervention, they observed significant decreases in WC and WHtR; WC decreased as adherence to MD increased [31].

To assess the clinical significance of the observed results, we also computed Cohen's d. We observed meaningful results for BMI in girls and BMI z-score in boys, after adjusting for confounders. In both cases, the effect size assessed using Cohen's d was considered as medium. For FMI z-score effect size can be considered as small, but only in girls because Cohen's d was 0.27 when using MED4CHILD, and 0.47 when using MED4CHILD score estimated from COME-Kids F&B-FQ. For WC, the effect size was medium in boys (COME-Kids F&B-FQ) and small in girls (both questionnaires). To the best of our knowledge, this is the first study in which the effect size of the differences between children adhering and not adhering to the MD and body composition. Future studies assessing the clinical significance are recommended.

In the binary logistic regression, there was no association between adherence to the MD and overweight/obesity, both in boys and in girls. However, in European children 2 to 10 years, adherence to the MD was associated with a low risk of overweight and obesity in the cross-sectional and longitudinal analysis, after two years of follow-up [19]. Another study conducted on Spanish children showed that a high adherence to MD at the age of 4 was associated with a lower risk of developing overweight, obesity, and abdominal obesity at age 8 years [20]. In American children and adolescents 2-19 years old, it was also observed that higher adherence to the MD

was associated with a lower risk of developing overweight and obesity [32]. In a study carried out on Italian adolescents, they found that adherence to the MD was higher in normal-weight adolescents compared to those with overweight and obesity [33]. The lack of association in our cross-sectional study could be due to the short age of our population as in the other studies the age group is larger or based only on adolescents. However, this should be interpreted in the context of the other results showing an association with BMI, FMI, and FFMI, and should be further confirmed when longitudinal data will be available.

The present study has some strengths, such as a large and diverse sample of children from different Spanish cities, making the sample representative of the country. The use of COME-Kids F&B-FQ questionnaire, a validated tool to assess dietary habits [24], and the anthropometric and body composition methods were performed using standardized protocols. Also, both the dietary questionnaires and the anthropometric measurements were carried out by qualified and trained professionals to avoid bias. Despite this, the study has some limitations. One of them is the use of the COME-Kids F&B-FQ which may also lead to an overestimation of food intake as is the case when food frequency questionnaires are used [34]. Another limitation is the cross-sectional design of the study; therefore, we cannot make cause-effect conclusions or discard other associations.

## 5. CONCLUSION

Adherence to the MD was significantly associated with body fat composition indices in Spanish children. These results emphasise the importance of adopting healthy dietary habits to avoid body fat deposition in children. More longitudinal studies are needed to confirm these results in young children. Due to the complexity of inducing lifestyle changes, involving the family and the environment of the school-aged children is highly recommended.

## Data availability statement

The datasets generated and analysed during the current study are not publicly available due to data regulations and for ethical reasons, considering that this information might compromise research participants' acceptance because our participants only gave their consent for the use of their data by the original team of investigators. However, collaborations for data analyses can be requested by sending a letter to the CORALS Steering Committee (estudiocoral@corals.es). The request will then be passed to all the members of the CORALS Steering Committee for deliberation.

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569 Table 1. General characteristics of the CORAL study population, total and by sex (n=1248).

| | TOTAL N=1218 | BOYS N=603 (49.5%) | GIRLS N=615 (50.5%) |
|---|---|---|---|
| **AGE (YEARS)** | 4.96 ± 1.06 | 4.92 ± 1.04 | 5.00 ± 1.07 |
| **BMI (KG/M$^2$)** | 16.33±2.12 | 16.21±1.99 | 16.45±2.24 |
| **BMI ZSCORE [A]** | 0.30±1.35 | 0.23±1.30 | 0.37±1.40 |
| **BMI CATEGORIES** | | | |
| **THINNESS** | 124 (10.2%) | 62 (10.3%) | 62 (10.1%) |
| **NORMAL WEIGHT** | 827 (67.9%) | 433 (71.8%) | 394 (64.1%) |
| **OVERWEIGHT** | 171 (14.0%) | 70 (11.6%) | 101 (16.4%) |
| **OBESITY** | 96 (7.9%) | 38 (6.3%) | 58 (9.4%) |
| **WEIGHT (KG)** | 20.24±4.70 | 20.19±4.40 | 20.29±4.98 |
| **HEIGHT (CM)** | 110.73±8.66 | 111.11±8.49 | 110.35±8.83 |
| **WAIST CIRCUMFERENCE (CM)** | 52.33±7.21 | 52.03±6.52 | 52.63±7.82 |
| **FM (%)** | 23.11±4.43 | 22.01±4.08 | 24.19±4.48 |
| **FMI (KG/M$^2$)** | 3.86±1.27 | 3.64±1.21 | 4.06±1.29 |
| **FMI ZSCORE** | 2.13±1.85 | 2.22±1.97 | 2.05±1.71 |
| **FFMI (KG/M$^2$)** | 11.89±1.14 | 11.94±1.15 | 11.85±1.14 |
| **FFMI ZSCORE** | -0.76±1.13 | -0.49±1.13 | -1.01±1.07 |
| **WTHR** | 0.47±0.05 | 0.46±0.05 | 0.47±0.06 |
| **MED4CHILD (SCORE)** | 10.75±2.72 | 10.75±2.74 | 10.75±2.70 |
| **MED4CHILD (CATEGORIES)** | | | |
| **ADHERENT (>10)** | 803 (65.9%) | 388 (64.3%) | 415 (67.5%) |
| **NON-ADHERENT (≤9)** | 415 (34.1%) | 215 (35.7%) | 200 (32.5%) |
| **MEDITERRANEAN DIET ADHERENCE (SCORE AS OF COME-KIDS F&B-FQ)** | 6.90±1.97 | 6.93±1.93 | 6.87±2.01 |
| **MEDITERRANEAN DIET ADHERENCE (CATEGORIES AS OF COME-KIDS F&B-FQ)** | | | |
| **ADHERENT (≥10)** | 121 (9.9%) | 61 (10.1%) | 60 (9.8%) |
| **NON-ADHERENT (≤9)** | 1097 (90.1%) | 542 (89.9%) | 555 (90.2%) |

570
571
572 Data are shown as N and % for categorical variables and for continuous variables as mean ± Standard
573 Deviation.
574 Abbreviations: FM: Fat Mass; FMI: Fat Mass Index; FFMI: Free Fat Mass Index; WtHR: Waist to Height
575 Ratio; BMI: Body Mass Index; MED4CHILD: Mediterranean Diet Adherence Questionnaire; COME-Kids
576 F&B-FQ: COME-Kids Food and Beverage Frequency Questionnaire
577 [a] According to Cole et al. (2012)

578 Fat Mass Index and Fat-free Mass Index calculated according to Fat Mass (kg) and Fat-free Mass (kg)
579 assessed by bioelectrical impedance.

580

581 Table 2. Linear regressions (β-coefficient & SD) between MED4CHILD and MED-
582 COME-Kids F&B-FQ and anthropometric measurements and indices.

| | Boys n=603 | | Girls n=615 | |
|---|---|---|---|---|
| | B ±SD | P | B ±SD | p |
| MED4CHILD | | | | |
| **BMI (kg/m$^2$)** | | | | |
| Crude model | -0.364±0.169 | **0.032** | -0.353±0.193 | 0.067 |
| Model 1 | -0.296±0.175 | 0.091 | -0.352±0.198 | 0.076 |
| Model 2 | 0.059±0.266 | 0.825 | -0.477±0.261 | 0.068 |
| **BMI z-score** | | | | |
| Crude model | -0.215±0.111 | 0.053 | -0.227±0.121 | 0.061 |
| Model 1 | -0.223±0.114 | 0.051 | -0.223±0.122 | 0.068 |
| Model 2 | 0.098±0.172 | 0.568 | -0.318±0.166 | 0.056 |
| **Weight (kg)** | | | | |
| Crude model | 0.041±0.375 | 0.912 | -0.635±0.429 | 0.139 |
| Model 1 | -0.092±0.322 | 0.774 | -0.509±0.359 | 0.158 |
| Model 2 | 0.484±0.493 | 0.327 | -0.747±0.508 | 0.142 |
| **WC (cm)** | | | | |
| Crude model | 0.329±0.555 | 0.553 | -0.790±0.674 | 0.241 |
| Model 1 | -0.065±0.556 | 0.906 | -0.923±0.668 | 0.168 |
| Model 2 | -0.010±0.852 | 0.991 | -1.247±1.045 | 0.234 |
| **FMI (kg/m$^2$)** | | | | |
| Crude model | -0.200±0.103 | 0.052 | -0.199±0.111 | 0.074 |
| Model 1 | -0.157±0.106 | 0.141 | -0.193±0.114 | 0.092 |
| Model 2 | 0.012±0.147 | 0.937 | -0.250±0.148 | 0.092 |
| **FMI z-score** | | | | |
| Crude model | -0.317±0.168 | 0.059 | -0.290±0.147 | **0.049** |
| Model 1 | -0.317±0.173 | 0.068 | -0.263±0.149 | 0.078 |
| Model 2 | 0.059±0.232 | 0.798 | -0.338±0.192 | 0.079 |
| **FFMI (kg/m$^2$)** | | | | |
| Crude model | -0.153±0.098 | 0.119 | -0.066±0.098 | 0.501 |
| Model 1 | -0.162±0.101 | 0.111 | -0.116±0.099 | 0.239 |
| Model 2 | -0.033±0.136 | 0.812 | -0.187±0.140 | 0.183 |
| **FFMI z-score** | | | | |
| Crude model | 0.020±0.097 | 0.840 | -0.122±0.092 | 0.185 |
| Model 1 | 0.041±0.100 | 0.679 | -0.125±0.94 | 0.182 |
| Model 2 | 0.151±0.136 | 0.268 | -0.171±0.131 | 0.192 |
| **WtHR** | | | | |
| Crude model | -0.003±0.005 | 0.576 | -0.003±0.005 | 0.530 |
| Model 1 | -0.003±0.004 | 0.430 | -0.006±0.005 | 0.237 |
| Model 2 | -0.004±0.007 | 0.562 | -0.009±0.008 | 0.264 |
| MED-COME-Kids F&B-FQ | | | | |
| **BMI (kg/m$^2$)** | | | | |
| Crude model | -0.603±0.269 | **0.025** | -0.627±0.304 | **0.039** |
| Model 1 | -0.368±0.273 | 0.177 | -0.545±0.311 | 0.081 |
| Model 2 | -0.164±0.420 | 0.696 | -1.045±0.429 | **0.016** |
| **BMI zscore** | | | | |
| Crude model | -0.412±0.176 | **0.019** | -0.457±0.190 | **0.017** |
| Model 1 | -0.301±0.178 | 0.091 | -0.343±0.192 | 0.074 |
| Model 2 | -0.150±0.271 | 0.581 | -0.694±0.273 | **0.012** |
| **Weight (kg)** | | | | |
| Crude model | -1.161±0.593 | 0.051 | -1.233±0.676 | 0.069 |
| Model 1 | -0.631±0.501 | 0.209 | -0.757±0.566 | 0.181 |

| | | | | |
|---|---|---|---|---|
| Model 2 | -0.156±0.780 | 0.841 | -1.681±0.838 | **0.046** |
| **WC (cm)** | | | | |
| Crude model | -1.874±0.879 | **0.033** | -0.516±1.064 | 0.628 |
| Model 1 | -2.074±0.862 | **0.016** | -0.885±1.053 | 0.401 |
| Model 2 | -2.135±1.339 | 0.112 | -2.559±1.727 | 0.140 |
| **FMI (kg/m$^2$)** | | | | |
| Crude model | -0.132±0.164 | 0.420 | -0.355±0.175 | **0.044** |
| Model 1 | -0.039±0.166 | 0.813 | -0.267±0.180 | 0.139 |
| Model 2 | 0.102±0.232 | 0.660 | -0.397±0.245 | 0.106 |
| **FMI zscore** | | | | |
| Crude model | -0.189±0.267 | 0.479 | -0.469±0.232 | **0.044** |
| Model 1 | -0.002±0.271 | 0.993 | -0.318±0.235 | 0.177 |
| Model 2 | 0.244±0.365 | 0.505 | -0.518±0.318 | 0.105 |
| **FFMI (kg/m$^2$)** | | | | |
| Crude model | -0.166±0.156 | 0.288 | -0.262±0.155 | 0.091 |
| Model 1 | -0.129±0.158 | 0.415 | -0.270±0.155 | 0.081 |
| Model 2 | -0.376±0.214 | 0.080 | -0.690±0.229 | **0.003** |
| **FFMI zscore** | | | | |
| Crude model | -0.243±0.154 | 0.114 | -0.179±0.146 | 0.220 |
| Model 1 | -0.192±0.156 | 0.219 | -0.180±0.147 | 0.223 |
| Model 2 | -0.196±0.215 | 0.362 | -0.499±0.215 | **0.021** |
| **WtHR** | | | | |
| Crude model | -0.012±0.007 | 0.107 | 0.002±0.008 | 0.821 |
| Model 1 | -0.017±0.007 | **0.016** | -0.006±0.008 | 0.445 |
| Model 2 | -0.021±0.011 | **0.047** | -0.019±0.013 | 0.140 |

Model 1 adjusted by age, center, and mother's educational level, except for z-score variables only adjusted by center and mother's educational level.
Model 2 adjusted additionally by total energy intake, total minutes of physical activity per week, and total hours of sleep per day.

BMI: Body Mass Index; FMI: Fat Mass Index; FFMI: Free Fat Mass Index; WtHR: Waist to Height Ratio; MED4CHILD: Mediterranean Diet Adherence Questionnaire; MED-COME-Kids F&B-FQ: MED4CHILD questionnaire through the validated COME-Kids Food and Beverage Frequency Questionnaire.

Fat Mass Index and Fat-free Mass Index calculated according to Fat Mass (kg) and Fat-free Mass (kg) assessed by bioelectrical impedance.

596 **Table 3. Results of ANCOVA models with independent variable adherence to the**
597 **MED4CHILD and MED-COME-Kids F&B-FQ in 2 categories (adherent or non-adherent)**
598 **segmented by sex.**

599

| | Boys Adherent | Non-adherent | p | Cohen's d | Girls Adherent | Non-adherent | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| **MED4CHILD** | | | | | | | | |
| **BMI (kg/m$^2$) *** | 16.08±1.83 | 16.45±2.24 | **0.030** | 0.19 | 16.33±2.18 | 16.68±2.35 | 0.071 | 0.13 |
| **Model 1** | 16.07±1.82 | 16.40±2.19 | **0.003** | 0.17 | 16.29±2.15 | 16.69±2.36 | **0.003** | 0.18 |
| **Model 2** | 16.13±1.97 | 16.05±2.03 | **0.037** | 0.04 | 16.26±1.91 | 16.82±2.24 | **0.024** | 0.28 |
| **BMI z-score (kg/m$^2$)** | 0.16±1.24 | 0.37±1.40 | **0.041** | 0.16 | 0.30±1.38 | 0.53±1.44 | 0.065 | 0.16 |
| **Model 1** | 0.15±1.23 | 0.34±1.38 | **0.001** | 0.15 | 0.28±1.37 | 0.53±1.45 | **<0.001** | 0.18 |
| **Model 2** | 0.21±1.23 | 0.10±1.40 | **0.012** | 0.09 | 0.30±1.25 | 0.64±1.37 | **0.010** | 0.27 |
| **FMI (kg/m$^2$) *** | 3.57±1.12 | 3.77±1.34 | 0.058 | 0.17 | 4.00±1.25 | 4.20±1.35 | 0.078 | 0.16 |
| **Model 1** | 3.57±1.11 | 3.74±1.32 | **0.003** | 0.14 | 3.97±1.24 | 4.20±1.36 | **0.004** | 0.18 |
| **Model 2** | 3.54±1.13 | 3.52±1.08 | **0.005** | 0.01 | 3.92±1.10 | 4.22±1.23 | **0.024** | 0.27 |
| **FMI z-score (kg/m$^2$)** | 2.10±1.83 | 2.42±2.21 | 0.059 | 0.16 | 1.96±1.65 | 2.25±1.82 | 0.051 | 0.17 |
| **Model 1** | 2.09±1.82 | 2.37±2.16 | **0.002** | 0.14 | 1.92±1.63 | 2.25±1.82 | **0.006** | 0.19 |
| **Model 2** | 2.07±1.81 | 2.00±1.68 | **0.002** | 0.04 | 1.85±1.42 | 2.25±1.61 | **0.039** | 0.27 |
| **FFMI (kg/m$^2$) *** | 11.88±1.19 | 12.04±1.07 | 0.087 | 0.14 | 11.83±1.14 | 11.89±1.13 | 0.528 | 0.05 |
| **Model 1** | 11.88±1.19 | 12.02±1.06 | **<0.001** | 0.12 | 11.81±1.13 | 11.90±1.14 | **<0.001** | 0.08 |
| **Model 2** | 11.98±1.00 | 11.97±1.11 | **0.001** | 0.01 | 11.87±1.13 | 12.02±1.14 | **<0.001** | 0.14 |
| **FFMI z-score** | -0.49±1.16 | -0.51±1.09 | 0.901 | 0.02 | -1.05±1.06 | -0.93±1.10 | 0.193 | 0.11 |
| **Model 1** | -0.50±1.16 | -0.53±1.07 | 0.679 | 0.02 | -1.07±1.05 | -0.94±1.10 | 0.182 | 0.12 |
| **Model 2** | -0.47±1.07 | -0.57±0.95 | 0.268 | 0.10 | -1.07±0.98 | -0.90±1.11 | 0.192 | 0.17 |
| **WtHR*** | 0.47±0.05 | 0.47±0.62 | **<0.001** | 0.00 | 0.47±0.05 | 0.48±0.74 | **<0.001** | 0.02 |
| **Model 1** | 0.47±0.05 | 0.47±0.06 | **<0.001** | 0.00 | 0.47±0.05 | 0.48±0.07 | **<0.001** | 0.20 |
| **Model 2** | 0.46±0.05 | 0.46±0.06 | **<0.001** | 0.00 | 0.47±0.05 | 0.48±0.08 | **0.008** | 0.20 |
| **MED-COME-Kids F&B-FQ** | | | | | | | | |
| **BMI (kg/m$^2$) *** | 15.67±1.69 | 16.27±2.01 | **0.025** | 0.33 | 15.88±1.95 | 16.51±2.26 | **0.050** | 0.31 |
| **Model 1** | 15.66±1.70 | 16.25±1.98 | **0.004** | 0.30 | 15.81±1.89 | 16.49±2.25 | **0.003** | 0.31 |
| **Model 2** | 15.62±1.89 | 16.15±2.00 | **0.036** | 0.27 | 15.36±1.44 | 16.55±2.06 | **0.011** | 0.61 |
| **BMI z-score (kg/m$^2$)** | -0.13±1.18 | 0.28±1.31 | **0.020** | 0.12 | -0.03±1.33 | 0.42±1.40 | **0.024** | 0.29 |
| **Model 1** | -0.13±1.19 | 0.26±1.29 | **0.001** | 0.30 | -0.07±1.31 | 0.41±1.40 | **<0.001** | 0.35 |
| **Model 2** | -0.15±1.35 | 0.21±1.28 | **0.012** | 0.53 | -0.31±1.12 | 0.48±1.30 | **0.004** | 0.24 |
| **FMI (kg/m$^2$) *** | 3.53±1.43 | 3.66±1.18 | 0.413 | 0.10 | 3.74±1.11 | 4.10±1.30 | 0.054 | 0.31 |
| **Model 1** | 3.53±1.44 | 3.64±1.16 | **0.006** | 0.09 | 3.70±1.06 | 4.08±1.30 | **0.005** | 0.30 |
| **Model 2** | 3.40±1.12 | 3.55±1.11 | **0.005** | 0.14 | 3.54±0.78 | 4.07±1.17 | **0.025** | 0.48 |
| **FMI z-score (kg/m$^2$)** | 2.05±2.40 | 2.24±1.92 | 0.479 | 0.08 | 1.63±1.43 | 2.10±1.73 | **0.048** | 0.31 |
| **Model 1** | 2.05±2.42 | 2.21±1.89 | **0.004** | 0.08 | 1.57±1.38 | 2.08±1.73 | **0.009** | 0.30 |
| **Model 2** | 1.90±1.88 | 2.06±1.75 | **0.001** | 0.09 | 1.36±1.05 | 2.04±1.52 | **0.044** | 0.47 |
| **FFMI (kg/m$^2$) *** | 11.79±1.83 | 11.96±1.05 | 0.301 | 0.11 | 11.61±0.96 | 11.87±1.15 | 0.126 | 0.25 |
| **Model 1** | 11.79±1.84 | 11.95±1.04 | **<0.001** | 0.14 | 11.58±0.93 | 11.87±1.15 | **<0.001** | 0.26 |
| **Model 2** | 11.53±0.90 | 12.02±1.05 | **<0.001** | 0.51 | 11.30±0.81 | 11.98±1.15 | **<0.001** | 0.66 |
| **FFMI z-score** | -0.72±1.54 | -0.47±1.08 | 0.118 | 0.19 | -1.17±1.14 | -0.99±1.06 | 0.257 | 0.16 |
| **Model 1** | -0.73±1.55 | -0.49±1.07 | 0.219 | 0.22 | -1.21±1.12 | -1.01±1.06 | 0.223 | 0.19 |
| **Model 2** | -0.82±0.87 | -0.47±1.04 | 0.362 | 0.36 | -1.48±0.87 | -0.97±1.03 | **0.021** | 0.52 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **WtHR *** | 0.46±0.05 | 0.47±0.05 | **<0.001** | 0.20 | 0.48±0.05 | 0.48±0.06 | **<0.001** | 0.00 |
| **Model 1** | 0.46±0.05 | 0.47±0.05 | **<0.001** | 0.25 | 0.48±0.05 | 0.48±0.06 | **<0.001** | 0.00 |
| **Model 2** | 0.44±0.05 | 0.46±0.05 | **<0.001** | 0.50 | 0.46±0.05 | 0.47±0.06 | **0.006** | 0.20 |

Data are shown as mean ± Standard Deviation.
*Adjusted by age
Model 1 adjusted by age, center, and mother's educational level, except for z-score variables only adjusted by center and mother's educational level.
Model 2 adjusted additionally by total energy intake, total minutes of physical activity per week, and total hours of sleep per day.

BMI: Body Mass Index; FMI: Fat Mass Index; FFMI: Free Fat Mass Index; WtHR: Waist to Height Ratio; MED4CHILD: Mediterranean Diet Adherence Questionnaire; MED-COME-Kids F&B-FQ: MED4CHILD questionnaire through the validated COME-Kids Food and Beverage Frequency Questionnaire.

Fat Mass Index and Fat-free Mass Index calculated according to Fat Mass (kg) and Fat-free Mass (kg) assessed by bioelectrical impedance.

**Table 4**. Binary logistic regressions between BMI status (with or without overweight-obesity) and adherence to the MED4CHILD (adherent or non-adherent) segmented by sex.

| | Boys | | | Girls | | |
|---|---|---|---|---|---|---|
| | OR | 95% IC | *p* | OR | 95% IC | *p* |
| **MED4CHILD** | | | | | | |
| Crude model | 1.702 | 0.877-3.302 | 0.116 | 1.464 | 0.840-2.552 | 0.178 |
| Model 1 | 1.586 | 0.741-3.397 | 0.235 | 1.424 | 0.780-2.597 | 0.250 |
| Model 2 | 1.450 | 0.423-4.976 | 0.555 | 1.814 | 0.729-4.510 | 0.200 |
| **MED-COME-Kids F&B-FQ** | | | | | | |
| Crude model | 1.987 | 0.464-8.500 | 0.355 | 2.060 | 0.622-6.827 | 0.237 |
| Model 1 | 1.398 | 0.306-6.389 | 0.666 | 2.491 | 0.570-10.889 | 0.225 |
| Model 2 | 0.586 | 0.060-5.678 | 0.644 | 2.949 | 0.321-27.078 | 0.339 |

Taking as references the non-adherence and adherence to the MED-COME-Kids F&B-FQ: MED4CHILD in 2 categories (adherent or non-adherent), taking as reference the non-adherence Model 1 adjusted by age, center, and mother's educational level.
Model 2 adjusted additionally by total energy intake, total minutes of physical activity per week, and total hours of sleep per day.

BMI: Body Mass Index; MED4CHILD: Mediterranean Diet Adherence Questionnaire; MED-COME-Kids F&B-FQ: MED4CHILD questionnaire through the validated COME-Kids Food and Beverage Frequency Questionnaire.

Table 1. General characteristics of the CORAL study population, total and by sex (n=1248).

Data are shown as N and % for categorical variables and for continuous variables as mean ± Standard Deviation.

Abbreviations: FM: Fat Mass; FMI: Fat Mass Index; FFMI: Free Fat Mass Index; WtHR: Waist to Height Ratio; BMI: Body Mass Index; MED4CHILD: Mediterranean Diet Adherence Questionnaire; COME-Kids F&B-FQ: COME-Kids Food and Beverage Frequency Questionnaire

[a] According to Cole et al. (2012)

633 Fat Mass Index and Fat-free Mass Index calculated according to Fat Mass (kg) and Fat-free Mass
634 (kg) assessed by bioelectrical impedance.

635

636 Table 2. Linear regressions (β-coefficient & SD) between MED4CHILD and MED-COME-Kids F&B-
637 FQ and anthropometric measurements and indices.

638 Model 1 adjusted by age, center, and mother's educational level, except for z-score variables only
639 adjusted by center and mother's educational level.
640 Model 2 adjusted additionally by total energy intake, total minutes of physical activity per week,
641 and total hours of sleep per day.

642 BMI: Body Mass Index; FMI: Fat Mass Index; FFMI: Free Fat Mass Index; WtHR: Waist to Height
643 Ratio; MED4CHILD: Mediterranean Diet Adherence Questionnaire; MED-COME-Kids F&B-FQ: MED4CHILD
644 questionnaire through the validated COME-Kids Food and Beverage Frequency Questionnaire.

645 Fat Mass Index and Fat-free Mass Index calculated according to Fat Mass (kg) and Fat-free Mass
646 (kg) assessed by bioelectrical impedance.

647

648 Table 3. Results of ANCOVA models with independent variable adherence to the MED4CHILD and
649 MED-COME-Kids F&B-FQ in 2 categories (adherent or non-adherent) segmented by sex.

650 Data are shown as mean ± Standard Deviation.
651 *Adjusted by age
652 Model 1 adjusted by age, center, and mother's educational level, except for z-score variables only
653 adjusted by center and mother's educational level.
654 Model 2 adjusted additionally by total energy intake, total minutes of physical activity per week,
655 and total hours of sleep per day.

656 BMI: Body Mass Index; FMI: Fat Mass Index; FFMI: Free Fat Mass Index; WtHR: Waist to Height
657 Ratio; MED4CHILD: Mediterranean Diet Adherence Questionnaire; MED-COME-Kids F&B-FQ: MED4CHILD
658 questionnaire through the validated COME-Kids Food and Beverage Frequency Questionnaire.

659 Fat Mass Index and Fat-free Mass Index calculated according to Fat Mass (kg) and Fat-free Mass
660 (kg) assessed by bioelectrical impedance.

661

662 Table 4. Binary logistic regressions between BMI status (with or without overweight-obesity) and
663 adherence to the MED4CHILD (adherent or non-adherent) segmented by sex.

Taking as references the non-adherence and adherence to the MED-COME-Kids F&B-FQ: MED4CHILD in 2 categories (adherent or non-adherent), taking as reference the non-adherence Model 1 adjusted by age, center, and mother's educational level.

Model 2 adjusted additionally by total energy intake, total minutes of physical activity per week, and total hours of sleep per day.

BMI: Body Mass Index; MED4CHILD: Mediterranean Diet Adherence Questionnaire; MED-COME-Kids F&B-FQ: MED4CHILD questionnaire through the validated COME-Kids Food and Beverage Frequency Questionnaire.

*Figure 1. Flowchart of the CORAL Study*