# Sex Differences in Body Mass Index, Mediterranean Diet Adherence, and Physical Activity Level among Italian Adolescents

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**Objective:** Unhealthy lifestyle habits during adolescence are linked to a higher risk of chronic degenerative disease during adulthood. The aim of this study was to assess the lifestyle habits among Italian adolescents, considering the potential influence of sex. **Methods:** Data were collected from 1707 eligible students. Demographic, dietary, and lifestyle data were collected, by using KIDMED and PAQ-C instruments. **Results:** The overall population had a medium adherence to a Mediterranean diet (58%, KIDMED score: 2.11 ± 0.64). There was no statistically significant difference in adherence by sex. We found boys to be more physically active than girls ($p < .001$). Considering ponderal index status, boys had turned out to be more overweight and obese respectively (13% and 4% respect to 10% and 2% in female population, $p < .05$, respectively), due to the presence of only one risk factor (medium or low both in diet and in physical activity score). **Conclusions:** Our results showed that our population stands at average levels both for its adherence to the Mediterranean diet and for physical activity, with males having a higher percentage of overweight and obesity. Importantly, in contrast to girls, boys have a higher risk of obesity, also in the presence of a single risk factor.

**Key words:** Mediterranean diet; KIDMED; PAQ-C; adolescents; body mass index
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Chronic degenerative diseases represent a serious health problem, destined to grow with the aging of the population. Increasing evidence shows that the prevention of these diseases, including cancer, neurodegenerative diseases, and in particular cardiovascular diseases (CV), must be carried out from childhood and adolescence with the adoption of preventive lifestyle behaviors.[1]

It is commonly accepted, in fact, that unhealthy lifestyle habits during these sensitive windows are linked to a higher risk of disease during adulthood, with important consequences for the psychological dimension of health as well.[2,3] In childhood and adolescence, many health determinants are believed to be mandatory components of ideal cardiovascular health (iCVH), according to which, cardiovascular health is linked to certain health behaviors and their sequelae (smoking status, body mass index [BMI], physical activity and diet) and 3 traditional cardiovascular risk factors (high cholesterol,

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**Table 1**
**Background Characteristics of the Study Population – Total and by Sex**

| | Total (N = 1711) | Boys (N = 954) | Girls (N = 978) | p-value |
|---|---|---|---|---|
| **Age, (years)** | 12.5±1.1 | 12.5±1.1 | 12.5±1.1 | ns |
| **BMI (kg/m²)** | 18.5±3.2 | 18.6±3.1 | 18.4±3.2 | ns |
| **Physical activity (PAQ-C), N (%)** | | | | < .001 |
| **Low** | 673 (40) | 260 (31) | 413 (47) | |
| **Medium** | 844 (49) | 446 (54) | 398 (45) | |
| **High** | 190 (11) | 122 (15) | 68 (8) | |
| **KIDMED score, mean±SD** | 2.11±0.64 | 2.11±0.62 | 2.12±0.66 | ns |
| **KIDMED score adherence groups, N (%)** | | | | |
| Low | 263 (15) | 120 (14) | 143 (16) | |
| Medium | 985 (58) | 496 (60) | 489 (56) | |
| High | 459 (27) | 212 (26) | 247 (28) | |

**Note.**
**Data are expressed as mean ± standard deviation (SD) or number (%).**
**BMI: body mass index**
**ns: not significant**
**P-values are for $\chi^2$ tests.**

high blood pressure, and high serum glucose). In this field, longitudinal studies have determined the importance of obtaining iCVH early in life, underlying that high iCVH during adolescence, is connected with a more positive cardiac structure and function, as well as a lower risk of hypertension and metabolic syndrome in adulthood.[4] However, epidemiological, pathological, and risk factor data show that up to 57% of boys and 50% of girls are overweight and up to 31% of boys and 21% of girls are obese.[5]

Therefore, risk factors must be measured in children and adolescents, and clinical care guidelines must encourage the inclusion of this population in early identification and treatment to mitigate risk, because it is likely that risk-taking behavior may be maintained or even worsened over time. Given the role of the school as a critical factor in the preventive perspective, because of its educational role and ability to reach practically all younger age groups, we launched this study within the Italian schools as part of the AVATAR project, with the aim of assessing lifestyle habits of currently healthy adolescents.

## METHODS

### Participants and Procedure

Data in the AVATAR study were collected between 2017 and 2018. Ten junior high schools participated in the AVATAR project, acronym for "*A* new purpose for promotion and e*VA*luation of heal*T*h and well-being *A*mong healthy teenage*R*s."[6] Overall, 1932 boys and girls were included. Adolescents were enrolled according to the following inclusion criteria: age 10-14 years, absence of neuropsychiatric or other diseases, informed consent signed, and completion of the questionnaires in their entirety. Of these 1932 potential participants, 37 were excluded for diagnosed neuropsychiatric or other diseases, 45 for not signing the informed consent, and 143 for not completing all the questionnaires. Therefore, the final population consisted of 1707 adolescents (mean age 12.5±1, boys 828). Questionnaire completion occurred in classes

**Table 2**
**Adherence to Mediterranean Diet (KIDMED) and Physical Activity Level (PAQ-C) according to BMI Classification in the Overall Population**

| BMI classification | KIDMED High | KIDMED Medium | KIDMED Low | p-value |
|---|---|---|---|---|
| **Normal weight** | 351 (27) | 762 (58) | 196 (15) | ns |
| **Obese** | 12 (24) | 27 (53) | 12 (24) | |
| **Overweight** | 57 (29) | 110 (57) | 27 (14) | |
| **Underweight** | 40 (26) | 84 (55) | 28 (18) | |
| | **PAQ-C High** | **PAQ-C Medium** | **PAQ-C Low** | **p-value** |
| **Normal weight** | 149 (11) | 666 (51) | 494 (38) | < .05 |
| **Obese** | 2 (4) | 21 (41) | 28 (55) | |
| **Overweight** | 17 (9) | 85 (44) | 92 (47) | |
| **Under weight** | 23 (15) | 70 (46) | 59 (39) | |

**Note.**
**Data are expressed as n (%).**
**ns: not significant**

at school during participants' computer lesson. No incentive was provided to adolescents or parents. A research assistant was available to provide information and technical support to aid questionnaire completion.

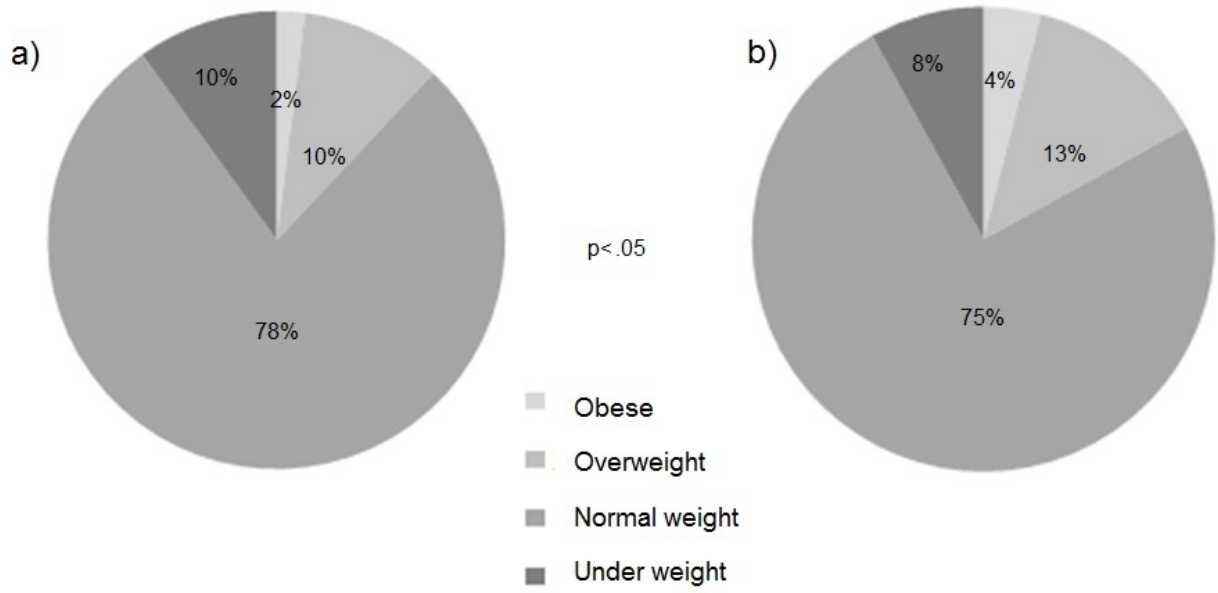
## Measures

Data were collected by means of the AVATAR Web-tool;[6] height and weight were measured previously by trained school staff, and according to World Health Organization (WHO) age groups.[7] Body mass index (BMI) was calculated as weight (kg)/height$^2$ (m$^2$) and clustered into categories: underweight, normal weight, overweight, and obese.[8] BMI is widely used to screen children and adolescents for overweight and obesity and is an easy metric to calculate. In this case, percentiles based on age and sex from standardized population guideline were used similar to those used to monitor growth and development.[9]

Dietary habits were evaluated using the Mediterranean Diet Quality Index for children and adolescents (KIDMED), developed in persons aged 2-24 years, and focused on specific food habits of the Mediterranean tradition.[10] The KIDMED index was based on principles sustaining Mediterranean dietary patterns as well as those contrary to it. The KIDMED score is calculated from 16 yes/no questions. Most of them concern the consumption of different food groups. For each "yes" response one point is given to answers representing positive food habits (items 1-5, 7-11, 13, 15), and one point is subtracted for those representing negative food habits (items 6, 12, 14, 16). Three categories of adherence (good, average, and poor) were defined according to a score ≥ 8, between 4 and 7, and ≤ 3, respectively.

Physical activity levels were assessed using the Physical Activity Questionnaire for Older Children (PAQ-C). The questionnaire provides a general measure of physical activity for 8-to-20-year-olds. The PAQ-C is a self-administrated questionnaire consisting of 9 items rated on a 5-point scale in regard to a child's level of physical activity during his/her leisure time, at school, during recess, lunch, and physical education classes, after school, in the evenings, and the weekend. The mean of these 9 items results in the final PAQ-C activity summary score. A score of "1" indicates low physical activity, whereas a score of "5" indicates high physical activity.[11]

**Figure 1**
**BMI Classification by Sex Expressed as Percentage of Adolescents (Girls – a; Boys – b)**




### Data Analysis

We used Student's t test and the $\chi^2$ test for continuous and categorical variables, respectively. Data are expressed as mean ± SD. Analyses were performed using StatView software. A p-value ≤ .05 was considered statistically significant.

## RESULTS

Table 1 shows demographic characteristics, BMI, dietary patterns (KIDMED), and physical activity levels (PAQ-C) of the population. In the overall study population, the average KIDMED score was 2.11 ± 0.64, indicating a medium level of adherence (58%) (Table 1). There were no statistically significant differences between boys and girls in the different categories of adherence to the Mediterranean diet (low, medium, high). In particular, the highest percentage for the population as a whole (modal response) was for medium adherence; just 27% of the respondents fell into the high adherence category. When the relationship between KIDMED score and BMI classification was analyzed for all participants and by sex, we did not find statistically significant associations (Table 2).

The PAQ-C test revealed that our study participants had medium and low levels of physical activity; only 11% exhibited a high score. Boys showed higher activity levels compared to their female counterparts ($p < .001$, Table 1). We found a statistically significant association between physical activity level and BMI classification both in the overall population ($p < .05$) and in boys ($p < .01$) (Table 2).

When we considered ponderal index status, expressed as the percentage of boys and girls in underweight and normal weight, overweight, or obese categories (Figure 1), a greater proportion of boys were overweight and obese respectively (*Boys:* N = 124, 13% and N = 38, 4%, vs *Girls:* N = 98, 10% and N = 20, 2% in girls, ($p < .05$). Moreover, when we clustered boys and girls according to lifestyle habits (Table 3), putting together the different stratifications of dietary habits and physical activity levels (for example High KIDMED/High PAQ-C), among boys, the presence of one of the 2 variables in the lower category was enough to determine a predisposition toward obesity ($p < .005$, Table 3). Furthermore, in the high adherence/high physical activity category there were no youth who exhibited obesity.

**Table 3**
**BMI Classification (Obese vs Non-obese) as a Function of KIDMED and Physical Activity Levels by Sex**

| PAQ-C/KIDMED | Non-Obese Girls | ObeseGirls | p-value | Non-Obese Boys | Obese Boys | p-value |
|---|---|---|---|---|---|---|
| **High/High** | 26 (100) | 0 (0) | | 35 (100) | 0 (0) | |
| **Medium/Medium, Medium/ High** | 367 (99) | 5 (1) | | 452 (97) | 12 (3) | |
| **High/Low** | 105 (99) | 1 (1) | | 67 (93) | 5 (7) | |
| **Medium/Low or Low/Low** | 363 (97) | 12 (3) | ns | 241 (94) | 16 (6) | < .005 |

**Note.**
**Data are expressed as n (%).**
**PAQ-C: Physical Activity Questionnaire for Older Children**
**ns: not significant**
**P-values are for $\chi 2$ tests.**

## DISCUSSION

In this study, we showed that in a sample of healthy adolescent students, adherence to a Mediterranean diet, body-mass index and physical activity or sedentary behavior, as parameters referable to iCVH, among adolescents in Italy, considering potential gender differences. Our results also showed that for this sample of Italian adolescents, the proportion adhering to a Mediterranean diet was modest – only 27% had a high KIDMED score. Importantly, there were no statistically significant differences between boys and girls, when considering the different categories of adherence (high, low, and medium); moreover, adherence to a Mediterranean diet was not associated with changes in BMI. These data align with previous results from European multi-center studies in which pre-school and school-aged children showed no gender-related differences, and Mediterranean diet adherence varied considerably, according to age, country, and parent education.[12] Furthermore, our data align with evidence indicating a gradual abandonment of the traditional Mediterranean diet patterns by Mediterranean populations, younger persons in particular, who appear to be shifting towards a Western dietary pattern.[13]

Fortunately, in our population, the percentage of low adherence was limited to 15%; therefore, hypothesizing that in the Italian sample, diet still represents a health-promoting factor with possible positive effects on academic performance, on health-related quality of life perception, and on physical activity behaviors.[14-16]

Regarding physical activity status, both boys and girls scored in the high and medium ranges. Unlike a previous study, we did not find a higher level of physical activity being related to greater adherence to the Mediterranean diet.[17] Most likely, healthy lifestyle, represented by higher levels of physical activity, lower levels of sedentary time, and greater adherence to the Mediterranean diet, tend to combine in a "Mediterranean lifestyle," with documented positive effects on health-related quality of life.[17,18] As noted though, we did not see this physical activity-diet adherence relationship.

When we considered BMI z-score, divided into categories of underweight, normal weight, risk of overweight, and obesity, boys exhibited a higher percentage of overweight and obesity compared to girls, although they performed higher physical activity.[8] This apparent inconsistency is aligns with several results of studies investigating associations between physical activity and body mass index in adolescents. In fact, some evidence suggests that increasing levels of physical activity are associated with a higher BMI in children and adolescents, while others emphasized, alongside physical activity, the role of sedentary levels in modifying BMI index.[19,20] In particular, in girls, sedentary behavior seems to have a greater impact on BMI than does physical activity.[20] In addition, other factors are involved in overweight and obesity such as high-

levels of screen time and alteration in sleep quality, which we did not evaluate in this study. Our results align with evidence that more than 30% of adolescents present as overweight or obese, according to US Centers for Disease Control and Prevention (CDC) growth charts.[21] In Italy, the Health Behaviour in School-aged Children (HBSC) survey revealed a picture comparable to our results, in which boys exhibited a higher prevalence of overweight/obese than girls.[22] In particular, some types of behavior associated with obesity (eg, low physical activity and high television/screen time) obtained poorer results in southern regions of the country than in central or northern regions.[23] Nonetheless, in the last years encouraging data came out of Tuscany, where there has been a statistically significant decrease in the prevalence of overweight/obesity in children (32% vs 26%, $p < .001$).[24] The authors hypothesized that this difference is probably related to a series of regional and local actions that have taken place in many sectors of society, demonstrating the importance of public health initiatives, and official nutrition recommendations and dietary guidelines, as well as school programs.

Another important point to note from our study is that the prevalence and trends of overweight and obesity in boys was not linked to the co-presence of the 2 risk factors – low adherence to the Mediterranean Diet and low physical activity; rather, the presence of just one of them is sufficient to have an independent effect. This greater presence of obesity in boys concurs with previous studies and could have a greater long-term impact on cardiovascular risk factors.[25] In fact, previous studies show that adolescent girls, unlike boys, might be more likely to change their dietary habits to attain weight control.[26]

### Limitations

We used self-report questionnaires to assess both adherence to Mediterranean diet and physical activity level. In addition, dietary habits were collected without regard to the exact quantity of food consumed. Finally, although BMI was highly correlated with adiposity, the use of BMI as a measure of weight status has been criticized, especially in children and adolescents, because BMI may be affected by skeletal structure and muscle mass.[27]

### Conclusion

We showed that our population stands at average levels both for its adherence to the Mediterranean diet and for physical activity, with boys having a higher percentage of overweight and obesity. Importantly, boys have a higher risk of obesity in the presence of a single risk factor (low Mediterranean diet adherence or low physical activity), a relationship we did not find for girls in our sample. Screening and characterizing children and adolescents at higher risk should be considered as a global priority, requiring the cooperation between multiple institutions, including families, schools, healthcare entities, and researchers. In particular, given the role of school as "context for health," it is conceivable that the development of school-based platforms, employing a "user-friendly language" specifically targeted for user age, to educate children and adolescents about assessing their health status, encouraging adoption of healthy behaviors, and evaluating the efficacy of adopted interventions could be valuable. In this perspective, the AVATAR project, in which KIDMED and PAQ-C questionnaires are included, is helpful because it is performed at school and can provide information directly to teachers that can foster interventions responsive to the needs of students.

## IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

The school health program is a key to promoting a healthy lifestyle. Our results highlight important potential lifestyle disparities in adolescents, which may contribute to larger health issues during adulthood. The noted difference between boys and girls linked to the presence of a single risk factor emphasizes the need for gender-specific and personalized strategies. School initiatives can assist health professionals during this sensitive "time window" of adolescence.

School, already defined by the World Health Organization as " a healthy social setting," must identify as a primary setting for the early recognition of symptoms in adolescents, and have the opportunity to incorporate preventive strategies into the educational curriculum in a nonthreatening environment. This must be a priority for policymakers and practitioners to reduce the burden of disease, and to define a strategy that integrates education

and health actions with the aim of contributing to the integral and interdisciplinary education of students through prevention, promotion, and healthcare actions. This action is aimed not only to reduce weight-related disease during adolescence, but also to decrease the burden of disease later in adulthood.

Achieving this end represents a major challenge for researchers, practitioners, and policymakers in terms of definition, funding, development, and implementation of prevention programs targeting adolescents' health behaviors at individual, peer, family, school, community, and societal levels.

Future studies in health and well-being in adolescents, should focus on school-based efforts to improve lifestyle, and involve the different social settings for a more comprehensive, multidimensional, and personalized perspective.

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**Human Subject Approval Statement**

The study was approved by the internal ethics committee of each participating school, in accordance with Italian law. In addition, all parents or legal guardians gave informed consent, and authorized researchers to use their data in accordance with Italian law. All procedures performed in the study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Conflict of Interest Disclosure Statement**

The authors declare no conflicts of interest.

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