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## Review article

## Mediterranean diet adherence in children and adolescents in southern European countries

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## ABSTRACT

**Background:** Over the last decades, a progressive shifting away from traditional healthy dietary patterns, such as the Mediterranean diet, has been observed. The aim of this review was to evaluate evidence on extent and determinants of adherence to the Mediterranean diet among children and adolescents living in southern European countries.

**Methods:** A review of scientific articles published over the last 15 years conducted on dietary habits and determinants of adherence to the Mediterranean diet in the target population was performed. Cross-sectional surveys conducted in Spain, Greece, and Italy were selected.

**Results:** Irrespectively of the tool used, adherence to the Mediterranean diet was mainly poor in roughly half of the populations investigated. Major determinants of adherence were social and demographic factors. Among the former, high socioeconomic and cultural status of participants' parents (especially mothers) were associated with higher adherence. In most of countries, also living in rural areas was a determinant of high adherence. There was no consistent association with metabolic status, as most of the associations with health-related outcomes were mediated by other key variables, such as sedentary behaviors and engagement in physical activities.

**Conclusions:** There is a need for nutrition education programs to establish healthy eating habits at a young age. Targets for such intervention should not be limited to children and adolescents but also include parents, teachers, and physicians.

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## 1. Introduction

Modern strategies in research on nutrition not just focus on the role of individual nutrients or foods but also aim to measure the relationship between whole diets and health [1–3]. Over the last 20 years, a large body of literature explored and demonstrated the beneficial effects of the Mediterranean dietary pattern over a number of health outcomes [4]. This dietary pattern refers to the traditional eating habits adopted by individuals living in the regions of the Mediterranean basin during the 1960s [5]. Despite with differences across countries, the key features of the Mediterranean diet were the following: (i) high consumption of fruits, vegetables, legumes, and cereals, as main source of fiber and antioxidant compounds; (ii) moderate consumption of fish, nuts, and olive oil as main sources of fats (primarily monounsaturated and polyunsaturated fatty acids [MUFA and PUFA]); (iii) low consumption of red meat and sweets, as sources of trans- and saturated fatty acids; (iv) moderate consumption of wine (mainly red), which contain moderate amount of alcohol and rich in polyphenols. The Mediterranean diet has demonstrated mainly benefits against cardiovascular disease (CVD) [6], which may depend on the benefits toward metabolic diseases [7,8]. Besides a decreased risk of cardiovascular risk factors, several components of the diet may exert direct effects also on cancer prevention [9,10]. The overall result of current research on this topic is that higher adherence to Mediterranean diet may affect chronic disease morbidity and increase life expectancy [11].

It is surprising that individuals living in countries supposed to adopt a traditional Mediterranean dietary pattern are those mostly affected by high prevalence of overweight and obesity. Globalization and urbanization have been considered, at least in part, responsible for the phenomenon of nutrition transition [12]. This process, which is generally referred as “Westernization” of the diet, is particularly evident among the younger generations. Modernization of the society implies a number of unhealthy lifestyle habits, not just limited to modification of food preferences toward “junk” foods, but also relative to sedentary activities (computer and television use), leading to an overall imbalance between energy intake and expenditure [13]. The aim of this narrative review is (i) to examine existing evidence reporting the level of adherence to the Mediterranean diet among children and adolescents living in southern European countries, (ii) to explore potential determinants of adherence, and (iii) to evaluate whether an association with metabolic-related health outcomes exist.

## 2. Search methods

A review of scientific articles published over the last 15 years conducted on dietary habits and determinant of adherence to the Mediterranean diet in children and adolescents living in southern European countries was performed. Key terms, such as “Mediterranean diet,” “adolescents,” “children,” “Spain,” “Greece,” “Italy,” and “Europe,” were used to identify representative cross-sectional surveys conducted in the main countries of interest. Studies were reviewed only whether they reported a measure of level of adherence to the Mediterranean diet (irrespectively of the tool used). Potential determinants and association with body mass index (BMI) status or any other metabolic-related outcomes were also discussed, whether reported.

## 3. Mediterranean diet in Spain

### 3.1. Level of adherence to the Mediterranean diet

Several surveys have been conducted in Spain over the last 15 years, involving the whole country as well as localized specific areas. Among the most important, the EnKid study was the first [14]. Conducted in the 2000, authors developed and tested the Mediterranean Diet Quality Index for children and adolescents (KIDMED), a tool to evaluate the level of adherence to the Mediterranean diet in young populations [15]. The rationale behind the KIDMED index relied on the principles characterizing the Mediterranean dietary pattern. The index ranged from 0 to 12 points based on a 16-question test. Questions indicating food components not in line with the Mediterranean diet (fastfood, skip breakfast, sweets, baked goods) were assigned a value of  $-1$ , those indicating foods that characterize this dietary pattern (fruit and vegetable, fish, pulses, pasta, cereals, nuts, olive oil, and dairy products) were assigned  $+1$ . The sums of the values obtained were classified into three levels: (1)  $>7$ , optimal Mediterranean diet; (2)  $4-7$ , improvement needed to adjust intake to Mediterranean patterns; and (3)  $<4$ , very low diet quality. The findings derived from EnKid study showed for the first time the changes in dietary habits and nutritional status that have occurred in Spain over the last decades, especially among children and adolescents. Very low KIDMED score was found for 4.2% of the sample, 49.4% demonstrated intermediate adherence, and 46.4% had high index results. Among other dietary information, energy consumption was more than 2000 kcal in males and roughly 1700 kcal in females, total fat as a percentage of total energy intakes was 39.8% and 13.4% for saturated fat [14]. The KIDMED score demonstrated to capture the high nutritional quality of the Mediterranean Diet, including an enhanced nutritional adequacy for calcium, iron, magnesium, vitamin B6, vitamin C, and A [16]. Pastries and sausages represented the strongest contributors to the dietary energy density while fruits and vegetables were the lowest.

In two surveys conducted on 8- to 16-year-old population living in Granada (southern Spain) from 2002 to 2005 [17] and from 2005 to 2006 [18], the authors found that the mean energy intake of the study population was higher than the mean theoretical energy expenditure calculated using equations proposed for these ages by the FAO/WHO, with protein, and lipid intake more than double than expected while mineral salts intake was inadequate [17]. The mean KIDMED index score of this population was classified as average-good by the authors. Compared with the EnKid study population, children, and adolescents of Granada consumed similar amount of pasta, rice, breakfast milk products, yoghurt, and cheeses, but higher of fruit, cereals, cereal products, and vegetables, while the percentage consuming adequate amounts of fish was almost half. However, a majority of individuals was consuming olive oil, consistent with other findings in southern Spain, where it is strongly embedded in sociocultural traditions [17].

Another group of studies have been conducted in 1231 adolescents living in the Balearic Islands, western Mediterranean Sea. [19]. Less than 25% of participants met the 2010 nutritional objectives for the Spanish population for dietary fiber, folate, iodine, total fat, SFA, PUFA, total carbohydrates, and fruits and vegetables. However, females showed better compliance with the recommendations for PUFA, cholesterol, and vegetables than did males, but the former also showed lower

compliance to achieve the recommended intakes of micronutrients, total fat, and MUFA than the latter [20]. These findings reflected somehow the attitude to adhere to the Mediterranean dietary pattern. Most of participants reached an average adherence to the Mediterranean diet assessed by a score developed by Trichopoulou et al. [21]. Girls were more likely to be adherent than boys, with an increasing trend of adherence with age more pronounced in males than in females, for which the percentage of adherence was similar in all age-groups [22]. Intakes of functional dietary components like vitamin E, vitamin C, carotene, and dietary fiber were significantly higher among adolescents with high adherence to the Mediterranean diet [22]. The consumption of fruit juice, fiber-rich bread/cookies, cereal bars, fish, and soya milk was higher among adolescents with high Mediterranean diet adherence, while the consumption of milk, probiotics, breakfast cereals, and infusions was higher among adolescents lower adherent. Daily intakes of functional dietary components from plant foods (dietary fiber, vitamins C and E, carotene, and folic acid) were higher among adolescents with high Mediterranean diet adherence [22]. More active boys and girls consumed frequently breakfast cereals and fresh fruit and yogurt. Sedentary behaviors were associated to age and time spent on media screen and homework, and inversely related to adherence to Mediterranean diet [23].

### 3.2. Determinants of adherence to the Mediterranean diet

Significant predictors of adherence to the Mediterranean diet found in the EnKid study were socioeconomic level and mother's education. Interestingly, differences were also observed for adherence by resident population size, with participants living in large cities showing higher adherence to the Mediterranean diet than others [15]. Level of adherence to the Mediterranean diet in adolescents living in the Balearic Islands was influenced by mother's education, especially among those with lower healthy dietary habits. Among other determinants of adherence to the Mediterranean diet, engagement in physical activities or, conversely, spending more than 4 h per day on media screen time seemed to be the most important [24].

### 3.3. Relation of the Mediterranean diet to health outcomes

In the EnKid study, dietary energy density was associated with waist circumferences and waist-to-height ratio while the KIDMED score was inversely related with all the previous parameters [25]. General physical inactivity was high among adolescents living in the Balearic Islands [26]. As well, half of the adolescents had at least one metabolic syndrome component but none had all five risk factors. The metabolic syndrome prevalence in Balearic Islands' adolescents was 5.8% according to the ATP III criteria, despite with significant differences between boys and girls (10.5% vs. 2.7%, respectively). No association was observed between sociodemographic factors and metabolic syndrome prevalence. High triglyceride level, hypertension, low HDL cholesterol level, and central obesity were the most common conditions and were significantly related with lower adherence to the Mediterranean diet [26].

## 4. Mediterranean diet in Greece

### 4.1. Level of adherence to the Mediterranean diet

In an important study evaluating the adherence to the Mediterranean dietary pattern in a national representative sample of pediatric population conducted in Greece in 2007, only 10% out of the 1305 children and adolescents reported eating habits following the principles of the Mediterranean diet [27]. Lately in 2009, another study conducted at national level [the Greek Childhood Obesity (GRECO) study] examining the level of adherence to the Mediterranean diet showed even lower rates, with only 4.3% of children having an optimal KIDMED score while nearly half were classified as low adherers to the Mediterranean

diet [28]. Children with higher KIDMED score were more likely to consume more frequently cereals, fruits, fruit juice, vegetables, dairy products, legumes, nuts, red meat, poultry, eggs, fish, and seafood [28]. In the PANACEA study, another investigation conducted in the greater Athens area on 700 schoolchildren, overall adherence to the Mediterranean diet was poor [29]. Another study comparing anthropometric, demographic, socioeconomic, and lifestyle characteristics (such as sedentary and physical activities, dietary habits) of 525 adolescents resident of Athens ( $n = 275$ ) and Heraklion, Crete ( $n = 250$ ), found that only 21% of the total sample had good adherence to the Mediterranean diet [30].

### 4.2. Determinants of adherence to the Mediterranean diet

Among the most important determinants of adherence to the Mediterranean diet, time spent in sedentary activities and parents' education were found negatively and positively associated, respectively [27]. Moreover, within the age range among adolescents, increased age was negatively associated with the KIDMED score. Finally, children from semi-urban areas of the country had higher KIDMED score compared with those from large urban areas [28]. In the PANACEA study, the high consumption of salty snacks was associated with more TV/video game viewing weekly and with poor dietary habits, including lower adherence to the Mediterranean diet [31]. Among other determinants, higher adherence to the Mediterranean diet was positively associated with parents' education and living with both parents, whereas negatively associated with older age, increased time spent on computer, and low physical activity [30]. Adolescents from Heraklion had a higher adherence than those from a big capital such as Athens, suggesting that urban environment may play a negative role in food choices [30].

### 4.3. Relation of the Mediterranean diet to health outcomes

In the GRECO study, almost one third of children were overweight, while prevalence of obesity was about 10%, higher in boys than in girls. No differences were observed between normal weight and overweight/obese children [28]. Similar null association was found in another study conducted in Athens and Heraklion, Crete [30].

In the PANACEA study, approximately 4 out of 10 schoolchildren were overweight or obese and had, on average, scarce adherence to the Mediterranean diet. Adherence to the Mediterranean diet was inversely associated with children's obesity status only in families in which at least one parent was of higher educational level, but not those in which both parents were of low educational level, suggesting that parental education may play a mediating role in the beneficial effect of Mediterranean diet on children's obesity status [32].

## 5. Mediterranean diet in Cyprus

### 5.1. Level of adherence to the Mediterranean diet

Cyprus (Republic of) is an island country in the Eastern Mediterranean Sea that shares with Greece the traditional Greek-Cypriot cuisine. A nationwide cross-sectional survey [the Cyprus Kids (CYKIDS) study] was conducted during the school year 2004–2005 in 1140 children (9–13 years old) [33]. The percentage of high adherers was less than 10%, whereas more than one third of the children followed a poor-quality diet. The study provided evidence of the association between level of adherence to the principles of Mediterranean diet and diet quality in children. In particular, the consumption of healthy foods, such as fruits, vegetables, seafood, legumes, nuts, and olives, was higher in children who had higher KIDMED score [34]. A more recent study (the Leontio Lyceum ALbuminuria [LLAL] Study) examined dietary habits of 498 students (12–17 years old) finding even worse outcomes, with only 6% of participants high adherent to the Mediterranean diet while 41.9% were classified as having very low diet quality [35].

## 5.2. Determinants of adherence to the Mediterranean diet

Cypriot children living in rural areas did not differ from their counterparts in urban areas regarding their physical activity and sedentary patterns [36]. By contrast, the former consumed more traditional Cypriot food than the latter, being characterized by healthier eating habits, such as having more meals with the family, not eating alone, and eating less fast food. However, the magnitude of the differences reported in frequency of the consumption of all major food was attenuated after adjustment for possible confounders, including socioeconomic status [36].

## 5.3. Relation of the Mediterranean diet to health outcomes

In the CYKIDS study, roughly 1 out of 10 children had elevated BP levels [37]. Moreover, BMI and high frequency of eating while watching TV were positively associated with BP levels, whereas an inverse relationship was shown with the degree of adherence to the Mediterranean diet [37]. Besides blood pressure, higher adherence to this dietary pattern was also associated with lower BMI, despite such relations were mediated by socioeconomic status and physical activity levels, respectively [37,38].

In the LLAL study, the KIDMED score was related to BMI, waist circumference, and systolic blood pressure (BP), but negatively with albumin-to-creatinine ratio, suggesting a close link of accelerated vascular damage with low adherence to this favorable diet of the Mediterranean basin [39].

## 6. Mediterranean diet in Italy

### 6.1. Level of adherence to the Mediterranean diet

A number of surveys have studied both Northern and Southern Italian juvenile dietary habits in relation to adherence to traditional dietary patterns. A survey was conducted in 2009 as part of the ZOOM8 study involving three areas of low (North Italy), medium (Center) and high (South) prevalence of overweight and obesity [40]. Cluster sampling led to 1740 children involved with only 5% of the sample high adherent to the Mediterranean diet, while 62% and 32% had an average and a poor score respectively with a slight North–South trend. Regarding the characterization of the diet, the scarce consumption of fruits, vegetables, and legumes were the main reasons for low adherence to the diet [40].

Another study was conducted on a convenience sample of students attending middle/high schools in similar areas (North, Center, and South Italy) and used a modified version of the method outlined by Trichopoulou et al. [21] by including also fish consumption to evaluate the adherence to the Mediterranean diet [41]. A value of 1 was assigned to beneficial (vegetables, legumes, fruits and nuts, cereal, and fish) and detrimental components (meat, poultry, and dairy products) whether consumption was above and below the median value (according to the Italian National Food Consumption Survey 2005–06 Report), respectively. A high adherence to the Mediterranean diet was found in 14% and moderate in nearly half of the respondents. Adolescents with higher adherence assumed higher median values of carbohydrates, fiber, vitamin B6, vitamin C, folic acid, vitamin A, vitamin D, and MUFA. Respondents from Southern Italy were found to be more adherent to the Mediterranean diet (moderate or high adherence) in comparison to those from the other two areas.

Some studies have been also conducted in specific areas of the country. An individual study conducted in 2012 on a sample of 1127 adolescents recruited in high schools in Northern Italy showed that more than half participants had average adherence to the Mediterranean diet [42]. A cross-sectional study was based on 1135 adolescents of 13–16 years living in Sicily, one of the main Italian islands, reporting that about 10% resulted high adherent to the Mediterranean diet, more than half scored average adherence, and one fourth showed scarce adherence [43]. Regarding nutrient adequacy, those more adherent to the

Mediterranean diet had significantly lower intake of saturated fats, sugars, and more fibers. Besides fruits and vegetables, food groups strongly related with adherence to the diet were pasta and fish, while sweets, fast foods, snacks, and sugary drinks were the less consumed among the most adherent adolescents.

### 6.2. Determinants of adherence to the Mediterranean diet

Level of adherence to the Mediterranean diet was significantly associated with living in areas with more than 50,000 inhabitants and with maternal lower cultural levels [40]. Among students in northern Italy, those with lower physical activity levels and more frequent sedentary behaviors had lower adherence to the Mediterranean diet [42]. The major predictors of high adherence to a Mediterranean dietary pattern in southern Italy were high socioeconomic status and living in a rural area [43].

### 6.3. Relation of the Mediterranean diet to health outcomes

Considering the investigations conducted in the various geographical areas of Italy, 24% and 10% of children were overweight and obese, respectively. Poor adherence to the dietary pattern was not significantly related with BMI or gender [40]. Participants living in southern Italy reported generally higher mean BMI values, despite more adherent to a Mediterranean dietary pattern. A possible reason has been reported to be the scarce time dedicated in physical activities [41]. In investigations held in northern Italy, only being underweight was associated with lower adherence, while being normal or overweighted/obese was not related with dietary habits [42]. In southern Italy, nearly half of participants were overweight or obese, especially boys [43]. Adolescents less adherent to the Mediterranean diet were also more likely to be overweight and obese, as well as begin less involved in physical activities.

## 7. Mediterranean diet in Europe

The identification and prevention of dietary- and lifestyle-induced health effects in children and infants (IDEFICS) study was a population-based cohort of 16,228 children (response proportion 53.4%) aged 2–9 years conducted in eight European countries (Sweden, Germany, Hungary, Italy, Cyprus, Spain, Belgium, and Estonia) in 2007–2008 [44]. During two examinations, parents completed a self-administered questionnaire to assess behavioral and sociodemographic factors and a computer-based 24 h dietary recall, namely, Self-Administered Children and Infant Nutrition Assessment (SACINA). Anthropometric measures were taken at both examinations. Adherence to the Mediterranean diet was evaluated by considering median intakes for six food groups [(1) vegetables and legumes, (2) fruit and nuts, (3) cereal grains and potatoes, (4) fish products, (5) meat products, (6) dairy products, and (7) a ratio of unsaturated to saturated fats] as cutoff to assign one point whether lying above or below those foods supposed to be high or low consumed in the Mediterranean diet, respectively. The highest adherence to a Mediterranean-like dietary pattern was found in Italy (nearly half of participants) followed by central and northern European countries. By contrast, Spain and Cyprus reported the lowest level of adherence. It was found a low prevalence of high consumers of vegetables and legumes among Italian children, while Sweden was characterized by a very low prevalence of high consumers of both dairy and meat products. Italy and Cyprus were also characterized by a high prevalence of children consuming high unsaturated:saturated fat ratio, whereas the high consumption of cereal grains and potatoes characterized both the Swedish and the Estonian diets. Generally, higher adherence to the Mediterranean diet was associated with higher parents' education and income, but not consistently across countries (income was not determinant in Sweden and education was not determinant in Italy) [45]. Similarly, the study group found that a Mediterranean-like dietary pattern was inversely



associated with baseline obesity and percent fat mass and with a 2-year change in BMI, BMI z-scores, waist circumference, and waist-to-hip ratio. However, when looking at national-level analyses, the baseline inverse association between high adherence to the Mediterranean diet and overweight was statistically significant only among Hungarian children and the prospective change only in Belgium. After adjustment for potential confounding factors, all measures remained significant with the exception of fat mass, suggesting that this dietary pattern may be inversely related to overweight and obesity, but not clearly associated with fat distribution *per se*.

## 8. Discussion

This overview of studies conducted on children and adolescents living in the southern European countries showed that, on average, most of the investigations concluded that roughly half of surveys' participants have an average adherence to the Mediterranean dietary pattern (measured by the KIDMED or any other score), while nearly half may have scarce adherence, with a trend toward poorer adherence over time. Adherence to the Mediterranean diet was not always associated with better metabolic and weight status, but it was consistently related with demographic and social characteristics of the study participants and their parents. The situation does not look particularly different across southern European countries. Only one study [45] reported higher levels of adherence to the Mediterranean dietary pattern in Italian children compared with other countries, as well as with other individual studies conducted in Italy. However, depending on the regional (north versus south) and environmental (urban versus rural) areas of investigation, results may vary with a great extent and the general trend is a shifting away from traditional dietary patterns.

Societal changes have led to this progressive change due to the substantial socioeconomic changes throughout all Europe over the past years. Despite general improvements in health status of inhabitants of eastern European countries are suggesting improvements in dietary habits of such populations, epidemiological studies are also showing that dietary patterns in southern European countries are changing toward unhealthy food choices. Modern dietary habits of individuals living the Mediterranean area include an increase in energy intake, a higher consumption of meat products and foods with low nutrient density (i.e., soft drinks and sweets), and a total reduction in fruits and vegetables leading to decreased intake of antioxidant compounds and fiber. The level of adherence to the Mediterranean diet has been also explored in a number of studies involving the adult population, showing similar findings to those observed in children and adolescents, especially regarding the role of socioeconomic status [46–49]. Nevertheless, the health benefits among the higher adherent are remarkable [50–54]. However, the situation is in line with findings showed in this review, describing demographic and social circumstances as the main determinants of adherence to the Mediterranean diet among young populations. Engagement in unhealthy behaviors, such as scarce physical activity and overall poor diet quality, seem to be associated with loss of adherence to traditional dietary patterns in Mediterranean countries and the adoption of new dietary habits especially among the youngest generations.

Several factors related with the demographic change have contributed to this nutrition transition. For instance, the improved socioeconomic conditions in Europe have led to an increased commercial availability of food. However, several reports emphasized on the dramatic changing in food supply and availability in both Mediterranean and non-Mediterranean countries with opposite consequences [55]. Over the last 40 years, the increase in total energy availability (with increase from lipids and fall from carbohydrates) among Mediterranean European countries was accompanied with a high availability of non-Mediterranean food groups (animal fats, vegetable oils, sugar, and meat), whereas the availability of alcoholic beverages, including wine, and legumes decreased substantially [56,57]. By contrast, despite olive

oil, vegetables, fruits, and fish are still more available than other areas, non-Mediterranean countries are acquiring a significant increased availability of such Mediterranean goods, contributing to their consumption [57]. Non-Mediterranean countries are experiencing similar moving away from traditional food habits, more likely to be settled in older individuals. On the other hand, young people may have increased awareness of international dietary patterns that combine pleasant taste with positive health effects, such as the Mediterranean one. The socioeconomic transition affecting also Eastern European countries is determining significant changes in food consumption and dietary habits, and positive trends on health status, with decreased mortality and increased lifespan associated with higher adherence to Mediterranean-like dietary patterns. Education may play an important role on these positive trends, as it has been documented in several studies that individuals with higher education have healthier food choices (i.e., more adherent to the Mediterranean diet) probably due to increased nutrition knowledge and increased motivation to follow healthy lifestyles<sup>(41, 42)</sup>. By contrast, the urbanization of life, together with the improvement in services and networking, may lead also to a more stressful lifestyle, less time spent on cooking, and more time out of home, which may lead with a loss of family values and less control over the youngest generations, which in turn has been demonstrated to be a determinant of diet quality also among younger generations living in the Mediterranean countries [58,59].

Information reported in the present review has to be taken into account in light of some limitations. First, cross-sectional studies reviewed in this paper have limited ability to establish causal relationships between diet and health outcomes (i.e., results affected by reverse causality). Second, several studies have been conducted over 10 years ago, thus dietary habits may have changed over time and not reflect current eating patterns. Third, this was a narrative review, thus it lacked of systematic methods to search and find the evidence presented.

## 9. Conclusions

Major determinants of adherence to a traditional Mediterranean dietary pattern in southern European countries rely on social e demographic factors. Children and adolescents may be the age-groups with the most deteriorated Mediterranean diet profile and high diet quality is associated with overall better physical health. It is plausible that family environment may have a better social background and may be more supportive and caring as well as may encourage healthy eating habits and behaviors. There is a need for nutrition education programs to establish healthy eating habits at a young age that will have beneficial effects in later life. However, the main targets for such intervention should not be limited to children and adolescents but also include parents, teachers, and physicians.

## Conflict of interest

The authors declare that they have no conflict of interest.

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