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ORIGINAL ARTICLE

Prevalence, trends and risk factors of thinness among Greek children and adolescents

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Keywords

Thinness • Trends • Risk factors • Children • Adolescents

Summary

Introduction. *Thinness affects more children and adolescents than obesity. Thus, the aim of the study is to examine the recent estimates of thinness and associated risk factors, and to identify trends in thinness, among Greek schoolchildren.*
Methods. *Epidemiological study. Population data from the recent estimates are derived from a school-based health survey polled in 2015 on 336,014 participants aged 4- to 17-years-old. To assess trends of thinness (1996-2015) we included a total of 300,104 children aged 8- to 9-years-old. Physical activity, dietary habits and sedentary activities were assessed through self-completed questionnaires. The gender and age-specific body mass index cut-off points proposed by International Obesity Task Force were used in order to define weight groups.*
Results. *Percent 8.4% of girls and 6.5% of boys were thin (all grades included). The prevalence of thinness decreased with age more in boys (from 13.8% at 4-years-old to 5.1% at 17-years-old, $p < 0.001$), than in girls (from 10.9% at 4-years-old to 8.7% at 17-years-old, $p < 0.001$). Sufficient dietary habits (OR: 0.87, 95% CI: 0.77-0.97) and adequate physical activity levels (OR: 0.92, 95% CI: 0.85-0.99) were associated with decreased risk of thinness. Thin schoolchildren performed better in aerobic fitness test than normalweight ones. Between 1996 and 2015, thinness rates decreased from 8.0% to 6.5% in boys ($p = 0.046$) and from 10.6% to 8.4% in girls ($p = 0.036$).*
Conclusions. *Our results suggest that thinness is a significant overlooked phenomenon. Although the prevalence of thinness has decreased the last two decades among Greek schoolchildren, actions need to be taken from public policy makers in order to establish and maintain a healthy body weight.*

Introduction

Thinness among children and adolescents can be described clinically as the low body mass index (BMI)-for-age [1]. In 2016, 192 million children worldwide were moderate and severe thin, while, in the same year, 124 million children worldwide were obese [2]. Thinness has a considerable impact on the health, development and well-being of children and adolescents which can also extend into adulthood [1]. Specifically, thinness is associated with stunting, menstrual irregularity, delayed maturation, nutritional deficiencies, and reduced cognitive capacity [3, 4].In addition, it is connected to frailty in muscular strength and work capacity, and lessens bone density into later life [1]. The problem of thinness concerns countries with different levels of socioeconomic status and is attributed to medical, social, and economic issues [5]. Especially in European countries, thinness is more prevalent among young females, potentially due to their desire to attain a dreamlike beauty of thinness displayed by fashion industry [6, 7]. Moderate or/and severe thinness could be a sign of malnutrition attributed to unhealthy eating behaviors. The factors that make susceptible a child/adolescent to undernutrition or malnutrition are complicated [8]. Thinness could be an indicator of malnutrition even though thin children and adolescents are not inevitably undernourished [9].

There is even less data accessible in the scientific literature on the prevalence of thinness among children and adolescents in Greece [10], while in developed countries trends in children's thinness have been scarcely documented [2, 7, 11, 12]. In addition, due to the lack of up to date data in the literature, research on the issues of factors associated with thinness in schoolchildren deserves further attention. Moreover, we hypothesized that thinness would have a negative impact on physical fitness measurements as compared to normalweight.
The aims of the present study were to: (i) describe the prevalence of graded thinness in Greek children and adolescents aged 4- to 17-years-old, using the three cut-off points proposed by Cole et al. [13]; (ii) investigate whether there is an association between lifestyle factors and thinness; (iii) identify trends in the prevalence of 3 grades of thinness in the last two decades in nationally representative samples of 8- to 9-years-old children; and (iv) explore association between thinness and physical fitness performances.

Methods

Main study (participants)

Data were derived from a nation-wide, school-based health survey under the auspices of the Ministry of Education. Anthropometric, physical activity, sedentary

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habits, nutrition, and physical fitness data along with information on age and sex were collected from March 2015 to May 2015. In total, 336,014 (51% boys) children aged 4- to 17-years-old from pre-elementary (4- to 5-years-old), elementary (6- to 11-years-old) and middle (12- to 17-years-old) public and private schools agreed to participate in the study (participation rate was almost 40% of the total population). The working sample was representative of the entire Greek population(chi-square p-value as compared to the current sample with the age-sex distribution of all Greek areas = 0.93).

Assessment of demographic and anthropometric measurements

Demographic information of students (e.g., school, class, gender and date of birth) was obtained from each school headmaster. Children's height and weight were measured in the morning, using a standardized procedure. The exact ages of the participants were calculated from birth and examination dates. Weight was measured in the standing upright position with electronic scales with a precision of 100 g. Standing height was determined to the nearest 0.5 cm with the child's weight being equally distributed on the two feet, head back and buttocks on the vertical land of the height gauge. BMI was calculated as the ratio of body weight to the square of height (kg/m^2). Thinness (3 grades) and normal weight children were classified using the International Obesity Task Force (IOTF) age- and gender-specific BMI cut-off criteria as the most proper for epidemiologic studies [14]. We used the term thinness, instead of the term underweight in children, which the World Health Organization (WHO) uses to mean low BMI for age in children and adolescents. The WHO graded definition of thinness (adult cut-off points of 16, 17 and 18.5 kg/m^2 at age 18 years) corresponds to the three cut offs of thinness in IOTF criteria [1]. Specifically, using the IOTF age- and sex-specific criteria, the three categories of thinness were determined, coding grades I, II and III as cut-offs of 17 < BMI < 18.5 kg/m^2, 16 < BMI < 17 kg/m^2 and BMI < 16 kg/m^2, respectively. In each school, two teachers of physical education (PE) performed all anthropometric measurements. PE teachers followed a specific detailed protocol taught in corresponding seminars held by the Greek General Secretariat of Sports and followed a standardized procedure of measurements in order to minimize the inter-rate variability among schools.

Assessment of physical fitness levels

The Euro-fit physical fitness (PF) test battery was used to evaluate children's PF levels [15]. The battery consists of five tests: (a) a multi-stage 20 m shuttle run test (20 m SRT), to estimate aerobic performance; (b) a maximum 10 × 5 m shuttle run test (10 × 5 m SRT) to evaluate speed and agility; (c) a sit-ups test in 30 seconds (SUs), to measure the endurance of the abdominal and hip-flexor muscles; (d) a standing long jump (SLJ), to evaluate lower body explosive power; and (e) a sit and reach (SR) test to measure flexibility. All five PF tests were administered during the PE class by trained physical education professionals.

Assessment of dietary habits

Participating children's dietary, physical activity and sedentary habits were recorded via the use of an electronic questionnaire. It was completed at school with the presence and assistance of their teachers and/or information technology professors. Students' dietary habits were assessed through the KIDMED (Mediterranean Diet Quality Index for children and adolescents), developed by Serra-Majem et al. [16]. The total KIDMED score ranges from 0 to 12 and is classified into three levels: ≥8, suggesting an optimal adherence to the Mediterranean diet (MD); 4-7, suggesting an average adherence to the MD and an improvement needed to adjust dietary intake to guidelines; and ≤ 3, suggesting a low adherence to the MD and generally a low diet quality.

Assessment of self-reported physical activity and sedentary time

Physical activity (PA) patterns were also self-reported. The questionnaire has been previously used in children in other large-scale epidemiological studies [17] and included simple closed-type questions regarding children's frequency, time and intensity of participation in (i) school-related PA; (ii) organized sports activities; and (iii) PA during leisure time. The frequency of all reported PA was multiplied by the minutes of moderate to vigorous physical activities (MVPA) and then divided by seven to obtain the mean daily time children engaged in MVPA. Children who participated in MVPA at least for 60 minutes per day were considered as meeting the recommendation for PA [18].

Daily time (in hours) spent in sedentary activities (e.g. television viewing, use of Internet for non-study reasons, playing with computer or/and console games) was also calculated for each student. Students were classified as sedentary or not, i.e., exceeding (> 2 hours per day) or not (≤ 2 hours per day) the recommended daily time spent in sedentary activities [19, 20].

Based on the Consensus Statement of the American Academy of Sleep Medicine, we classified as meeting the recommendations of sufficient sleep those children who were sleeping at least nine hours daily and those adolescents who were sleeping at least eight hours per day. Children and adolescents that were sleeping daily fewer than the number of recommended hours were classified as having insufficient sleep [21].

Trends (1996-2015) of thinness

Population data derived from five waves of a nation-wide school-based health survey, carried out by the auspices of the Ministry of Education in 1996, 2001, 2006, 2010 and 2015.Specifically, anthropometric data and information on age, gender, city and area were collected yearly, between March 1 and June 15, in almost all schools of Primary Education (roughly 85%); schools that did not participate were from borderland areas, with small numbers of children. There were not differences in the survey methodology as well as measurement methods across time. Analytical presentation of anthropometric measurements is described above. The response rates of

participation were similar and the characteristics of the responders remained consistent, across time. Thus, from 1996 to 2015, a total of 300,104 children 8- to 9-years-old (51% boys and 49% girls, over 95% of the total student population) participated in the present study.

Ethical approval

Ethical approval for all health surveys was graded by the Ethical Review Board of the Ministry of Education and the Ethical Committee of Harokopio University. As the measurements were included in an obligatory school curriculum, verbal informed consent by the students was considered sufficient.

Data analysis

Normality was verified through the Shapiro-Wilk test. Descriptive statistics were expressed as means ± standard deviations. Prevalence of thinness and normal weight was calculated as the ratio of those children belonging in the corresponding class, based on the proposed cut-off points for BMI by IOTF and divided by the total number of children. Comparisons of the prevalence between genders were performed using the Pearson's chi-square test. Furthermore, simple regression analysis was used to evaluate the trends of each grade of thinness and in total (with lag 0). The independent variable was the year of birth. Serial dependency was evaluated using the partial autocorrelation function; no autocorrelation was observed for various lags tested. Results are presented as b-coefficient ± standard error (SE). In order to assess the potential effect of several lifestyle factors on thinness, binary logistic regression analysis was implemented and odds ratios (OR) with the corresponding 95% confidence intervals (CI) were calculated. The Hosmer and Lemeshow's goodness-of-fit test was calculated in order to evaluate the model's goodness-of-fit and residual analysis was implicated using the dbeta, the leverage, and Cook's distance D statistics in order to identify outliers and influential observations. Z-scores were calculated for each fitness test, by gender. All statistical analyses were performed using the SPSS version 23.0 software for Windows (SPSS Inc., Chicago, Il, USA). Statistical significance level from two-sided hypotheses was set at $p < 0.05$.

Results

Thinness in 2015 in children and adolescents

Prevalence of thinness (three grades and total) by age and gender is incorporated in Table I. More girls than boys aged 4- to 17-years-old were thin (8.4% vs. 6.5%, $p < 0.001$). In the whole population, proportions of thin-

Tab. I. Prevalence of thinness grades according to IOTF definitions, by gender and age, in 4- to 17- years-old Greek children.

	Boys				Girls			
Age†	Grade III (%)	Grade II (%)	Grade I (%)	Total (%)	Grade III (%)	Grade II (%)	Grade I (%)	Total (%)
Children								
4	2.3*	2.4*	9.1*	13.8*	1.1	2.3	9.0	10.9
5	1.1*	2.2*	9.3*	12.6*	1.3	2.4	7.2	10.9
6	0.7	1.8*	7.4*	9.9	0.8	2.0	7.0	9.8
7	0.7*	1.4*	6.3*	8.4*	0.9	1.6	6.8	9.3
8	0.4*	1.0*	5.5*	7.0*	0.6	1.4	6.4	8.4
9	0.4	0.8*	4.9*	6.1*	0.5	1.2	5.8	7.6
10	0.3*	0.7*	4.4*	5.4*	0.5	1.2	6.1	7.8
11	0.2*	0.6*	4.7*	5.5*	0.5	1.3	6.2	8.0
B ± SE per year change	-0.24 ± 0.06	-0.28 ± 0.03	-0.76 ± 0.10	-1.3 ± 0.15	-0.11 ± 0.02	-0.19 ± 0.03	-0.35 ± 0.09	-0.52 ± 0.08
P for trend = 0.008		< 0.001	< 0.001	< 0.001	= 0.003	= 0.001	= 0.008	= 0.014
Adolescents								
12	0.2*	0.7*	4.5*	5.3*	0.5	1.3	6.6	8.4
13	0.2*	0.8*	4.6*	5.6*	0.5	1.3	6.5	8.4
14	0.2*	0.7*	4.1*	5.0*	0.6	0.9	5.2	6.7
15	0.3*	0.6*	3.6*	4.4*	0.3	1.2	5.9	7.4
16	0.2*	0.7*	3.9*	4.8*	0.3	1.1	6.1	7.5
17	0.3*	0.5*	4.3*	5.1*	0.5	1.4	6.8	8.7
B ± SE per year change	0.02 ± 0.01	-0.04 ± 0.02	-0.10 ± 0.09	-0.11 ± 0.09	-0.02 ± 0.03	0.01 ± 0.05	0.01 ± 0.16	-0.01 ± 0.20
P for trend	= 0.188	= 0.104	= 0.302	= 0.293	= 0.414	= 0.910	= 0.931	= 0.979
All								
B ± SE per year change	-0.10 ± 0.03	-0.13 ± 0.2	-0.39 ± 0.06	-0.62 ± 0.11	-0.06 ± 0.01	-0.08 ± 0.02	-0.13 ± 0.05	-0.23 ± 0.06
P for trend	= 0.004	< 0.001	< 0.001	< 0.001	< 0.001	= 0.001	= 0.02	< 0.001

B: beta; SE: standard error; IOTF: International Obesity Task Force; Thinness Grade III (BMI < 16.0); Thinness Grade II (BMI = 16.0-16.9); Thinness Grade I (BMI = 17.0-18.49); †Age: completed age, e.g., 4 years = 4.00-4.99 years; * p-value < 0.05 for differences between boys and girls from the same thinness grade.

ness decreased with age, in both genders (all p-values for trend < 0.05).The findings regarding the trend of thinness by gender during childhood and adolescence are presenting in Table I. In childhood, thinness (three grades and total) rates were decreasing with age, in both genders (all p-values for trend < 0.05). In adolescence, no significant differences were observed in thinness rates.

Health behaviors of children/adolescents on thinness

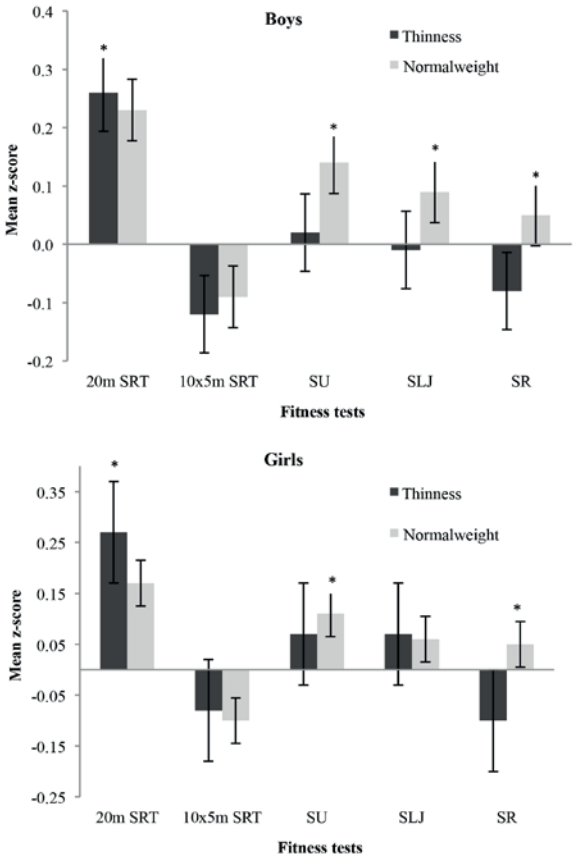
Data were analyzed only for those children who filled their questionnaire (177,091 children) from a whole sample of 232,401 schoolchildren 8- to 17-years-old.In unadjusted binary logistic regression (normalweight vs. thinness), adherence to the Mediterranean diet was associated with lower odds of thinness in both genders (Tab. II, Model 1). After adjusting for potential covariates (e.g. sleeping hours and screen time), the food habits index, previously reported remained significantly associated with thinness, in both genders (Tab. II, Model 2). Additional further adjustment for PA levels holds onto the same results regarding nutrition habits, while it appears that adequate PA level was associated with lower odds of being thin, in both genders. (Tab. II, Model 3). Finally, when PF measurements were added in the analysis (Tab. II, Model 4), the influence of previous factors did not changed significantly, while improved performances in aerobic fitness (20 m SRT) measurements were related to lower probabilities of being thin, in both genders (all p-values < 0.05). In opposite, better performances in SLJ, SR and SUs among boys and SR, SUs among girls were connected to higher odds of being thin (all p-values < 0.05). Specifically, performances of thin boys was significantly poorer than normalweight ones on SR

Tab. II. Associations between health behaviors and odds of normalweight vs. thinness, by gender.

Predictors	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)
Boys				
Adherence to the Mediterranean diet (low vs. moderate/high)	0.875 (0.871-0.880)	0.816 (0.741-0.898)	0.823 (0.747-0.906)	0.857 (0.760-0.967)
Sleeping hours (insufficient vs. sufficient)		0.964 (0.963-1.028)	0.963 (0.902-1.067)	0.931 (0.862-1.006)
Screen time (increased vs. acceptable time)		1.018 (0.949-1.092)	1.025 (0.955-1.100)	1.004 (0.922-1.094)
Physical activity levels (inadequate vs. adequate)			0.902 (0.846-0.961)	0.919 (0.850-0.993)
Sit and reach test (per 1cm)				0.924 (0.979-0.989)
20 meters shuttle run test (per 1 stage)				1.006 (1.004-1.008)
10x5 meters shuttle run test (per 1 sec)				0.991 (0.979-1.004)
Sit-ups in 30 seconds (per 1 sit-up)				0.973 (0.966-0.981)
Standing long jump (per 1 cm)				0.999 (0.989-0.999)
Girls				
Adherence to the Mediterranean diet (low vs. moderate/high)	0.911 (0.844-0.978)	0.908 (0.831-0.993)	0.909 (0.831-0.994)	0.890 (0.792-0.999)
Sleeping hours (insufficient vs. sufficient)		0.949 (0.897-1.004)	0.949 (0.896-1.003)	0.945 (0.880-1.014)
Screen time (increased vs. acceptable time)		0.979 (0.916-1.046)	0.979 (0.916-1.047)	0.963 (0.885-1.048)
Physical activity levels (inadequate vs. adequate)			0.912 (0.875-0.960)	0.924 (0.862-0.990)
Sit and reach test (per 1 cm)				0.981 (0.977-0.985)
20 meters shuttle run test (per 1 stage)				1.009 (1.007-1.012)
10x5 meters shuttle run test (per 1 sec)				1.003 (0.992-1.014)
Sit-ups in 30 seconds (per 1 sit up)				0.982 (0.986-0.999)
Standing long jump (per 1 cm)				1.000 (0.999-1.001)

OR: odds ratio; CI: confidence interval;; Model 1: KIDMED index; Model 2: Model 1 + Sleeping status and screen time; Model 3: Model 2 + Physical activity levels; Model 4: Model 3 + Physical fitness measurements

Fig. 1. The differences between the physical fitness tests measurements of normalweight boys and girls aged 6- to 17-years-old as compared to thin ones (IOTF criteria); SR: sit-and-reach; SLJ: standing long jump; SU: sit up; 10 x 5 m SRT: 10 X 5 m shuttle run test; 20 m SRT: 20 m shuttle run test. *p < 0.05 for differences between normalweight and thin.



(p < 0.001), SLJ (p < 0.001) and SUs (p < 0.001), while thin boys outperformed on 20mSRT in comparison to normalweight (p < 0.05) (Fig. 1). Thin girls presented better performances in 20 m SRT(p < 0.001), but poorer in SR and SUs(p < 0.001) than normalweight ones (Fig. 1).There were no significant differences between thin and normalweight ones in 10 × 5 m SRT test, for both genders.

Trends of thinness (1996-2015)

The trends of thinness (1996-2015) by grades and in total are presented in Table III. Rates of thinness as total in boys decreased, from 8.0% in 1996 to 6.5% in 2015 (p = 0.036), while a significant decreasing trend per 0.03 ± 0.01% (p < 0.001) per year was observed only in thinness grade II, the same time period. For girls, a decrease in thinness rates of grade II and in total from 2.2% to 1.4% (p = 0.01) and from 10.6% to 8.4% (p = 0.046), was evident between 1996 and 2015.

Discussion

The main findings of our study, indicate that: (a) thinness rates seems to decrease in the transitioning from childhood to adolescence, (b) compliance with recommendations in Mediterranean diet and adequate physical activity levels decreased the odds of thinness, in both genders, (c) thin schoolchildren performed better in aerobic fitness test than normalweight ones, and (d) the trends of thinness the last two decades presented a significant decrease in both genders.

The current results indicated that the overall prevalence of thinness was higher in girls than in boys. In general, the prevalence of thinness among Greek schoolchildren is similar to countries such as Brazil and Russia, higher to that in the USA, and lesser than in developing areas such as south Asia, southeast Asia, China and Africa, on the basis of the same definitions of thinness (IOTF criteria) [10, 22]. In similar, the mean prevalence of thinness in girls and boys aged 2-18 years from The Netherlands in 2009 were 10.1% and 9.5%, respectively [11]. Also, the presented findings are in line with those of study among ten European countries (thinness rates equal to 7.2% and 5.4%, in boys and girls, respectively) [23] and with those of Spanish and United Kingdom children aged 9- to 10-year-old that refereed percentages 9.0% among boys and 9.5% among girls (IOTF criteria) [12, 24].Potentially, dieting with advanced age, particularly in adolescent girls, might be an explanation for the higher prevalence of thinness among girls.

Thinness rates in the transitioning from childhood to adolescence seem to significantly decreased, in both genders. The finding that thinness in schoolchildren

Tab. III. Trends (1996-2015) of thinness (3 Grades) among boys and girls 8- to 9-years-old.

	1996 (n = 61995)	2001 (n = 65332)	2006 (n = 71227)	2011 (n = 60251)	2015 (n = 41299)	B±SE per year change	P for trend
Boys							
Grade III (%)	0.7	0.8	0.7	0.5	0.4	-0.01 ± 0.01	0.379
Grade II (%)	1.5	1.4	1.3	1.1	0.9	-0.03 ± 0.01	0.010
Grade I (%)	5.7	5.7	5.9	5.5	5.2	-0.02 ± 0.02	0.249
Total (%)	8.0	7.9	7.9	7.1	6.5	-0.08 ± 0.02	0.036
Girls							
Grade III (%)	1.0	1.5	1.1	0.9	0.6	-0.03 ± 0.02	0.181
Grade II (%)	2.2	2.3	1.9	1.7	1.4	-0.05 ± 0.01	0.010
Grade I (%)	7.4	6.8	6.7	6.5	6.4	-0.05 ± 0.01	0.032
Total (%)	10.6	10.6	10.7	9.1	8.4	-0.13 ± 0.04	0.046

is declining across age has been reported and elsewhere [12, 25, 26]. Furthermore, results in schoolchildren from 10 European countries and the USA refereed increased prevalence of thinness in younger schoolchildren compared to older ones [7].

To our knowledge, this study is the first to examine the association of thinness with several modifiable lifestyle factors simultaneously. Adequate dietary habits and PA levels related to decreased risk of being thin among Greek children and adolescents. Thin children are more prone to poor dietary habits (e.g. dislike of fish, vegetables, legumes etc.) compared to normalweight counterparts [27]. An unbalanced diet could be a reason of malnutrition, which is related to holdup in somatic growth and development among children [28]. Thin children may consume fewer dietary nutrients such as minerals and vitamins that are required for optimal health [29]. Moreover, increase in PA levels with the adequate energy and protein intake can promote children's healthy body composition [30].

The relationships between thinness and physical fitness are less well investigated. Our results indicated that thin children performed poorer than normalweight ones on SU, SLJ and SR tests, but better on 20 m SRT. Previous study of our laboratory in 8- to 9-years-old children revealed that underweight children (IOTF criteria) had better performances on 20 m SRT as compared to normalweight ones [31]. In accordance, study among 10,285 children shown that underweight children performed better on 20 m SRT than normalweight ones ($p = 0.017$) but poorer on SU and SLJ tests [32]. Also, thin children aged 6- to 18-years-old from Mozambique performed worse in absolute strength tests, better in endurance tests, and equally in agility test, as compared to normalweight group [33]. In contrast, Malina et al., did not found significant differences between stunted (z-score below -2.00) and normalweight children aged 6- to 13-years-old in the distance covered in 8 to 12 min runs [34]. Potentially, the lower weight of thin children could be an advantageous parameter for aerobic fitness performance, especially for weight-bearing physical activities like running.

In our study thinness rates were decreasing steadily between 1996 and 2015. Globally, the prevalence of moderate and severe thinness decreased from 9.2% to 8.4% between 1975 and 2016 in girls and from 14.8% to 12.4% in boys, the same time period [2]. In line, data regarding the trends of thinness during childhood has been shown a decline in the USA, Brazil, China and The Netherlands [11, 22]. Furthermore, study included adolescents from ten European countries and the USA, indicated that the prevalence of thinness has declined in almost all countries from 1998 to 2006 [7].

Our study has several strengths. It was conducted in a wide age-range group and examined several anthropometric and lifestyle factors. Furthermore, primary and secondary education is compulsory in Greece and, therefore, we were able to study a great proportion of 4- to 17-years-old children and adolescents.

Limitations of the present study include methodological issues and the fact that potential confounding factors (e.g. genetic factors, socioeconomic status, sexual maturation, etc.) have not been evaluated. In addition, information on the health status of the schoolchildren (e.g. infectious disease) has not been assessed. Dietary habits, physical activity and sedentary time status are based on self-reported data that could be subject to socially desirable reporting bias.

Conclusions

Despite the previously mentioned limitations, our results revealed that almost 7.5% of schoolchildren population was thin, while thinness rates in both genders were transitioning at more favorable levels from childhood to adolescence. Poor dietary habits and inadequate PA levels were associated with increased risk of thinness. Thin schoolchildren presented better performances in aerobic fitness test than normalweight ones. The trends of thinness the last two decades showed a significant decrease. This study suggests that health actions should be adopted for the treatment of thinness, with emphasis in primary caregivers of children who can support and establish behaviors to achieve and maintain a healthy weight for the child.

Supplementary Table (Tab. SI).

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Conflict of interest statement

The authors declare no conflict of interest.

Authors' contributions

KDT designed the study, performed the data collection and analysis and wrote the paper. DBP and GP participated in the design of the study and critically reviewed the paper. LSS was involved in the study design, manuscript writing and in overall supervision of the study.

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Tab. SI. Anthropometric indices (means ± SE) of population by gender and age.

	Boys				Girls			
Age†	N	Height (cm)	Weight (kg)	BMI (kg/m²)	N	Height (cm)	Weight (kg)	BMI (kg/m²)
4	3157	107.9 (5.0)*	18.7 (2.8)*	16.0 (1.9)	3091	106.6 (5.1)	18.3 (2.8)	16.0 (1.9)
5	4550	113.1 (5.4)*	20.8 (3.8)*	16.3 (2.1)*	4477	111.8 (5.3)	20.2 (3.7)	16.1 (2.2)
6	11361	120.0 (5.6)*	24.0 (3.7)*	16.4 (2.4)*	11139	118.8 (5.5)	23.3 (4.6)	16.4 (2.4)
7	21034	125.1 (5.8)*	26.6 (5.5)*	16.9 (2.6)*	21165	124.1 (5.8)	26.0 (5.3)	16.8 (2.6)
8	21159	131.4 (6.0)*	30.4 (6.7)*	17.6 (3.0)*	20140	130.0 (6.1)	29.7 (6.5)	17.4 (3.0)
9	21387	136.9 (6.4)*	34.5 (8.0)*	18.3 (3.3)*	20524	135.6 (6.5)	33.7 (7.7)	18.1 (3.2)
10	21162	142.1 (6.8)*	38.5 (9.0)*	18.9 (3.5)*	20424	141.8 (7.7)	38.0 (8.9)	18.7 (3.4)
11	19875	147.3 (7.1)*	43.2 (10.2)*	19.6 (3.6)*	18910	148.4 (7.6)	43.0 (9.9)	19.3 (3.6)
12	16349	153.7 (7.9)*	47.5 (11.3)*	20.1 (3.8)*	15465	154.8 (7.4)	47.9 (10.6)	19.9 (3.6)
13	8515	160.5 (8.7)*	54.0 (12.9)*	20.7 (3.9)*	7819	159.2 (6.7)	52.1 (10.8)	20.5 (3.7)
14	7635	167.4 (8.5)*	60.5 (13.6)*	21.4 (3.9)*	6734	162.0 (6.2)	55.6 (10.5)	21.2 (3.6)
15	6273	172.5 (7.5)*	65.2 (13.1)*	21.8 (3.8)*	5425	163.2 (6.1)	57.5 (10.2)	21.6 (3.5)
16	3695	175.5 (7.0)*	69.3 (13.0)*	22.5 (3.8)*	3413	164.2 (6.3)	58.9 (10.4)	21.8 (3.5)
17	2358	177.0 (7.1)*	72.0 (13.2)*	22.9 (3.7)*	2228	164.7 (6.3)	60.1 (10.8)	22.1 (3.6)
P for trend		< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001

† Age: completed age, e.g., 4 years = 4.00-4.99 years; * p-value < 0.01 between boys and girls; BMI: Body Mass Index.

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