

Underweight in 14 to 16 year-old girls and boys: prevalence and associations with physical activity and sedentary activities

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Abstract

Introduction and objectives. Underweight is associated with increased mortality of adults when compared to normal weight or overweight individuals. Studies of associations between underweight and physical activity levels in adolescents are sparse. The aim of this study was to determine the prevalence of underweight amongst 14 to 16 year-old girls and boys in tandem with the levels of physical activity and time spent in sedentary activities. The results were compared to those observed in normal weight and overweight adolescents.

Material and methods. This study included 1702 girls and 1547 boys aged from 14 to 16 years from twelve gymnasium schools in Poznan (Poland). Based on BMI values, the participants were assigned to the following categories: a) underweight, b) normal weight, and c) overweight. The levels of physical activity, participation rates in physical education classes and the time spent in sedentary activities were determined by means of questionnaire survey.

Results. The fraction of underweight girls amounted to 11.6% and was similar to the percentage of obese girls (14.6%). The fraction of underweight boys was 7.0%, and was markedly lower than the percentage of overweight boys (17.0%). Underweight and overweight boys were characterized by significantly lower levels of physical activity compared to normal weight participants ($p \leq .001$). Both in girls and in boys, the prevalence of underweight and overweight was not significantly associated with the time spent in various sedentary activities.

Conclusions. Underweight occurs in relatively high fraction of girls and boys. Underweight is associated with lower levels of physical activity in boys. The prevalence of underweight among adolescents is not associated with time spent in sedentary activities.

Key words

underweight, physical activity, sedentary activities, adolescents

INTRODUCTION

Issues related to overweight and obesity and their associations with physical activity (PA) and sedentary activities have been studied especially frequently. However, little attention has been paid to nearly equally frequent problem of underweight in children and adolescents. Moreover, in many studies overweight individuals were compared to those with normal weight, while potential differences between normal weight and underweight subjects were not taken into consideration. Underweight in turn is associated with increased mortality of adults and elderly people when compared to normal weight or overweight individuals [1]. In their study of 15 year-old girls and boys, Pu and Chou [2] revealed that underweight individuals perceive their health status as satisfactory less frequently than normal weight or overweight adolescents.

As frequently reported in literature, supervised PA programs should be involved in the reduction of excessive fat tissue. In Poland this approach is additionally supported by sufficient number of physical education (PE) hours in school, which is one of the highest in Europe [3]. However, the issue of underweight is still frequently overlooked, and not included as a component of health programs. Therefore,

optimal levels of PA for underweight children and adolescents have not been defined thus far, same holds true for frequency and most desirable forms of training.

Studies of associations between underweight and PA levels are sparse [4], similar to research on relationships between underweight and the levels of sedentary activities or participation rates in PE classes. This lack of studies in underweight children and adolescents, and incomplete understanding of health consequences of underweight in many countries have been previously reported by Fishman et al. [5].

Objective. The aim of this study was to determine the prevalence of underweight amongst 14 to 16 year-old girls and boys. Moreover, we searched for potential associations between the occurrence of underweight and PA level, participation rates in PE classes or time spent in sedentary activities. These relationships were further analyzed against analogous associations observed in normal weight and overweight adolescents.

MATERIAL AND METHODS

Participants. The cross-sectional sample for the study included data from 1702 girls (including 520 girls aged 14-years old, 572 aged 15-years old and 610 aged 16-years) and 1547 boys (including 459 aged 14-years old, 501 aged

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15-years old and 587 aged 16-years). The participants were recruited from 12 junior high schools in Poznan (a major city in Poland with approximately 550,000 inhabitants). The schools were selected randomly.

Body height and body weight were determined in all participants and the values of body mass index (BMI) were calculated. Based on BMI values, the participants were assigned to the following categories: a) underweight, b) normal weight, and c) overweight (including individuals recognized as obese based on BMI values). Classification into particular categories was based on age- and gender-adjusted cut off values of BMI for children and adolescents as determined by Cole et al. [6, 7]. This enabled the determination of gender- and age-adjusted percentages of girls and boys with overweight and obesity. According to Malina et al. [4], criteria used in our study accurately determine the frequency of underweight, overweight and obesity in subjects of various ages.

Final numbers of participants stratified by gender, age and the frequency of underweight, normal weight and overweight are presented in Table 1. Noticeably, the fraction of underweight participants was relatively high. In girls, this fraction ranged between 11.1% and 12.0% and therefore was similar to the percentages of overweight girls (14.3% to 15.0%). The fractions of underweight boys were lower, from 5.9% to 8.7% (compared to 15.5–18.1% of overweight individuals). The study protocol was approved by the Local Bioethical Committee of the Karol Marcinkowski University of Medical Sciences in Poznan (decision no. 1068/07).

Table 1. Number of girls and boys in particular age categories stratified by the occurrence of underweight, normal weight and overweight

	Underweight participants N (%)	Normal weight participants N (%)	Overweight participants N (%)	Total number of participants N (%)
Girls				
14 years of age	58 (11.1)	384 (73.8)	78 (15.0)	520 (100)
15 years of age	66 (11.5)	423 (73.9)	83 (14.5)	572 (100)
16 years of age	73 (12.0)	450 (73.8)	87 (14.3)	610 (100)
Total girls	197 (11.6)	1257 (73.8)	248 (14.6)	1702 (100)
Boys				
14 years of age	27 (5.9)	349 (76.0)	83 (18.1)	459 (100)
15 years of age	30 (6.0)	382 (76.2)	89 (17.8)	501 (100)
16 years of age	51 (8.7)	445 (75.8)	91 (15.5)	587 (100)
Total boys	108 (7.0)	1176 (76.0)	263 (17.0)	1547 (100)
Total girls and boys	305 (9.4)	2433 (74.9)	511 (15.7)	3249 (100)

Questionnaire. The questionnaire was comprised of three parts. The first one pertained to the levels of PA, the second – to participation rates in PE classes, and the third – to time spent in selected sedentary activities.

The level of PA was determined with Physical Activity Screening Measure [8]. The MVPA (Moderate-to-Vigorous Physical Activity) index was calculated based on the questionnaire answers. This measure corresponds to average number of days per week with at least 60 minutes spent in various forms of PA, during which, in participants' subjective opinion, their heart rates accelerated, and they experienced a feeling of the shortness of breath (higher breath rate). MVPA index was calculated based on the following formula:

$$MVPA = (P1 + P2)/2$$

where: MVPA – PA index; P1 – number of physically active days during last 7 days; P2 – number of physically active days during typical (usual) week.

Participation rates in PE classes were determined based on the answers to question: "How often have you participated in PE classes at school during recent several months?" The possible answers ranged from "I have participated in every or nearly every PE class" to "I have not participated in PE classes at all". Therefore this question pertained to active participation in PE classes.

Time spent in sedentary activities was determined based on answers to three questions obtained from the Health Behavior in School-aged Children Study questionnaire [9]. These questions concerned time spent watching television/video/DVD, doing homework, and using computer (playing computer games, sending text messages and using communicators, chatting, visiting websites, watching videos) or game console. Possible answer categories ranged from "none at all" (0 hours) to "at least 7 hours per day" (with possibility of filling in the number of hours if higher than 7), and school days and weekends were treated separately.

Statistical analysis. Significance of differences between variables studied in girls and boys was determined with the Mann-Whitney U test, while differences between underweight, normal weight and overweight individuals were analyzed using the Kruskal-Wallis test and multiple comparison test. The differences were considered significant by $p \leq 0.05$. Statistical calculations were made with the Statistica 8.0 package (StatSoft).

RESULTS

As shown in Table 2, 25.9% of underweight girls, 25.3% of normal weight girls and 15.3% of overweight girls spent at least one hour daily in moderate/intense PA for 5.5 to 7 days per week. Correspondingly, percentages of underweight, normal weight and overweight boys were 26.9%, 38.4% and 28.1%, respectively. Underweight and overweight boys were characterized by lower levels of PA when compared to normal weight individuals ($p \leq 0.001$). The fraction of overweight girls who were physically active for more than five days of week (15.3%) was lower than amongst their underweight (25.9%) and normal weight peers (25.3%).

Table 2. Differences in physical activity levels between underweight, normal weight and overweight girls and boys, determined by means of the Kruskal-Wallis test and multiple comparison test

MVPA [no. of days/ week]	Girls			Boys		
	Under- weight N (%)	Normal weight N (%)	Over- weight N (%)	Under- weight N (%)	Normal weight N (%)	Over- weight N (%)
0-2	36 (18.3)	177 (14.1)	41 (16.5)	21 (19.4)	130 (11.1)	51 (19.4)
2.5-5	110 (55.8)	762 (60.6)	169 (68.1)	58 (53.7)	594 (50.5)	138 (52.5)
5.5-7	51 (25.9)	318 (25.3)	38 (15.3)	29 (26.9)	452 (38.4)	74 (28.1)

***a, b

*** $p \leq 0.001$, a – significant difference between underweight and normal weight individuals, b – significant difference between normal weight and overweight individuals

Data presented in Table 3 suggests that normal weight and underweight girls were characterized by similar participation rates in PE classes. Slightly more than 70% of girls from both of these groups participated in every or nearly every PE lesson. The participation rates were significantly lower amongst overweight girls ($p \leq 0.001$). Only 54.8% of girls from this group systematically participated in PE classes. Only 66.2% of overweight boys systematically participated in PE classes, while 2.7% did not participate at all. The fraction of systematic participants was significantly lower ($p \leq 0.001$) compared to normal weight boys. However, even in this latter group the fraction of systematically participating individuals (79.9%) was also not adequate. Underweight boys did not differ from their normal weight peers in terms of participation rates in PE classes.

Table 3. Differences in participation rates in PE classes between underweight, normal weight and overweight girls and boys, determined by means of the Kruskal-Wallis test and multiple comparison test

	Girls			Boys		
	Under-weight N (%)	Normal weight N (%)	Over-weight N (%)	Under-weight N (%)	Normal weight N (%)	Over-weight N (%)
I have participated in every or nearly every PE class	138 (70.1)	890 (70.8)	136 (54.8)	80 (74.1)	940 (79.9)	174 (66.2)
I have participated in half or more of all PE classes	36 (18.3)	230 (18.3)	64 (25.8)	13 (12.0)	161 (13.7)	58 (22.0)
I have participated in less than half of all PE classes	13 (6.6)	70 (5.6)	25 (10.1)	9 (8.3)	30 (2.5)	15 (5.7)
I have not participated in nearly all PE classes	4 (2.0)	37 (2.9)	16 (6.5)	5 (4.6)	26 (2.2)	9 (3.4)
I have not participated in PE classes at all	6 (3.0)	30 (2.4)	7 (2.8)	1 (0.9)	19 (1.6)	7 (2.7)
	***b, c			***b		

*** $p \leq 0.001$, b – significant difference between normal weight and overweight individuals, c – significant difference between underweight and overweight individuals

Table 4 summarizes number of hours spent in various sedentary activities by underweight, normal weight and overweight participants. Both in girls and in boys, number of hours spent watching TV was not significantly associated with the prevalence of underweight or overweight. It should be noted, however, that during weekends two-thirds of boys and girls spent more than two hours per day watching TV, and in one-fourth of participants daily time spent watching TV on weekends was longer than four hours.

Generally, 14% to a little over 22% of boys spent more than two hours per day doing their homework. Time spent doing homework was the shortest amongst normal weight boys, and differed significantly compared to overweight individuals ($p \leq 0.01$ for school days and weekends; $p \leq 0.001$ for overall number of weekly hours). Girls spent more time doing their homework when compared to boys; approximately 30% of girls spent more than two hours daily on this type of activity.

Table 4. Differences in time spent in various sedentary activities between underweight, normal weight and overweight girls and boys, determined by means of the Kruskal-Wallis test and multiple comparison test

Number of hours	Girls			Boys		
	Under-weight N (%)	Normal weight N (%)	Over-weight N (%)	Under-weight N (%)	Normal weight N (%)	Over-weight N (%)
WATCHING TV						
School days						
0-2	120 (60.9)	758 (60.3)	141 (56.9)	59 (54.6)	724 (61.6)	168 (63.9)
2.1-4	60 (30.5)	380 (30.2)	88 (35.5)	40 (37.0)	333 (28.3)	65 (24.7)
>4	17 (8.6)	119 (9.5)	19 (7.7)	9 (8.3)	118 (10.0)	30 (11.4)
Weekends						
0-2	65 (33.0)	460 (36.6)	87 (35.1)	35 (32.4)	473 (40.2)	98 (37.3)
2.1-4	83 (42.1)	478 (38.0)	86 (34.7)	40 (37.0)	388 (33.0)	82 (31.2)
>4	49 (24.9)	319 (25.4)	75 (30.2)	33 (30.5)	315 (26.8)	83 (31.6)
Overall						
0-2	105 (53.3)	656 (52.2)	110 (44.4)	55 (50.9)	641 (54.5)	138 (52.5)
2.1-4	60 (30.5)	394 (31.3)	87 (35.1)	28 (25.9)	337 (28.7)	74 (28.1)
>4	32 (16.2)	207 (16.5)	51 (20.6)	25 (23.1)	198 (16.8)	51 (19.4)
DOING HOMEWORK						
School days						
0-2	127 (64.5)	896 (71.3)	163 (65.7)	84 (77.8)	1003 (85.3)	215 (81.7)
2.1-4	63 (32.0)	319 (25.4)	76 (30.6)	21 (19.4)	144 (12.2)	36 (13.7)
>4	7 (3.5)	42 (3.3)	9 (3.6)	3 (2.8)	29 (2.5)	12 (4.6)
***b						
Weekends						
0-2	131 (66.5)	840 (66.8)	155 (62.5)	81 (75.0)	981 (83.4)	200 (76.0)
2.1-4	55 (27.9)	322 (25.6)	63 (25.4)	20 (18.5)	149 (12.7)	47 (17.9)
>4	11 (5.6)	95 (7.6)	30 (12.1)	7 (6.5)	46 (3.9)	16 (6.1)
***b						
Overall						
0-2	138 (70.1)	894 (71.1)	170 (68.5)	85 (78.7)	1011 (86.0)	214 (81.4)
2.1-4	48 (24.4)	296 (23.5)	55 (22.2)	19 (17.6)	132 (11.2)	36 (13.7)
>4	11 (5.6)	67 (5.3)	23 (9.3)	4 (3.7)	33 (2.8)	13 (4.9)
***b						
USING COMPUTER/GAME CONSOLE						
School days						
0-2	126 (64.0)	731 (58.1)	146 (58.9)	43 (39.8)	586 (49.8)	139 (52.8)
2.1-4	53 (26.9)	410 (32.6)	76 (30.6)	43 (39.8)	356 (30.3)	78 (29.7)
>4	18 (9.1)	116 (9.2)	26 (10.5)	22 (20.4)	234 (19.9)	46 (17.5)
Weekends						
0-2	72 (36.5)	439 (34.9)	101 (40.7)	15 (13.9)	328 (27.9)	67 (25.5)
2.1-4	69 (35.0)	473 (37.6)	66 (26.6)	41 (38.0)	396 (33.7)	91 (34.6)
>4	56 (28.4)	345 (27.4)	81 (32.7)	52 (48.1)	452 (38.4)	105 (39.9)
*a						
Overall						
0-2	117 (59.4)	625 (49.7)	130 (52.4)	34 (31.5)	461 (39.2)	108 (41.1)
2.1-4	47 (23.9)	414 (32.9)	70 (28.2)	44 (40.7)	380 (32.3)	85 (32.3)
>4	33 (16.8)	218 (17.3)	48 (19.4)	30 (27.8)	335 (28.5)	70 (26.6)

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$, a – significant difference between underweight and normal weight individuals, b – significant difference between normal weight and overweight individuals

Weekend days were characterized by higher amounts of time spent doing homework.

Time spent using computer/game console was longer in boys than in girls. Between 26.6% and 28.5% of boys spent more than four hours daily engaging in this type of activity. During weekends, time spent using computer/game console was the longest in underweight boys (48.1%), and significant difference was observed compared to the time spent by normal weight individuals (38.4%, $p \leq 0.05$). On weekends, fraction of participants spending more than four hours daily using computer/game console was two to three fold higher than on school days.

Noticeably, the fraction of participants spending more than four hours daily in three analyzed types of sedentary activities was the highest amongst overweight girls. In boys, the highest fractions were observed in underweight and overweight individuals.

DISCUSSION

There are a number of reasons that cause the examination of issues connected with underweight to be particularly important for health professionals. Low muscle mass markedly affects the ability to perform physical exercise [4]. Excessively low content of fat tissue may in turn cause significant health problems and diminish the general physical condition since adipocytes are responsible for secretion of various vital substances [10]. Underweight is frequently associated with malnutrition, and may co-exist with immune system impairment, higher susceptibility to infections and improper functioning of muscular, cardiovascular and alimentary systems [11, 12]. In adolescents, the deficiency of body mass may be linked to various health problems, e.g. asthma, scoliosis, delayed puberty, emotional problems, and negative self-perception of body image [13].

In this study, underweight was observed in 7% of boys and 11.6% of girls. Some authors; however, have claimed a higher prevalence of underweight. In a Turkish study of 12 to 17 year-old adolescents (approximately 1000 participants) underweight was observed in 11.1% and 14.4% girls and boys, respectively [14], while the prevalence of underweight in German boys and girls was 12.6% and 19.1%, correspondingly [15]. Results comparable to those of our study were recorded in Hungary where out of roughly two thousand participants 5.1% of boys and 6.8% of girls were found to be underweight [16]. Similarly, in Tuscany underweight was observed in 8.7% of approximately one and a half thousand 15 years-old girls and boys [17]. Therefore, despite decreasing trend in the occurrence of underweight adolescents observed in various countries worldwide [18], the results of previous European studies and our findings suggest that underweight is still not a marginal finding in this age category. It should be noted; however, that differences in percentage of underweight individuals usually corresponded to several percent, and that various criteria were used to determine the frequency of underweight.

According to national recommendations published in European Union countries, young people should be physically active (moderate to intense PA) for at least one hour daily [19]. However, these recommendations seem difficult to attain as confirmed by the results of our study among others. Only between 15.3% and 38.4% of girls and boys participating in

this study declared at least one hour of PA per day for more than five days per week. Boys with normal weight were more active compared to their over- and underweight peers. Consequently, lower levels of PA in boys seem to be associated either with excessive or too low (underweight) body weight. Associations between PA and the occurrence of underweight were rarely a subject of any studies. Amongst sparse studies dealing with this problem, Levin et al. [20], Elinder et al. [21], and Kumar et al. [22] observed that underweight co-exists with lower levels of PA in boys, which is consistent with the results of this study. Moreover, Malina et al. [4] observed reduced levels of PA and lower interest in this form of activity in underweight children.

Differences in PA levels between overweight and normal weight boys, in favor of the latter, have also been revealed by a representative study of Polish pupils from gymnasium schools. In this study, 800 randomly selected boys and 1106 girls were qualified as obese (including overweight individuals) or non-obese [23]. In contrast to boys, significant differences in PA levels were not observed between girls. De Bourdeaudhuij et al. [24] studied large group of individuals ($n = 6078$) aged from 11 to 19 years, who were classified as overweight (including obesity) or normal weight based on BMI values. Individuals with normal weight were significantly more frequently involved in sport activities, devoting more time to moderate or intense PA. Unfavorable profile of PA was also observed in overweight girls in whom the levels of PA were determined using accelerometer [25].

Undesirable profile of PA in participants of this study was also confirmed by their low participation rates in PE classes. Both underweight girls and boys rarely participated actively in PE classes. Similar findings have been observed by previously mentioned study of Polish gymnasium pupils [23]. This study revealed that non-obese boys and girls participated in all or nearly all PE classes more frequently (75.5% and 68.9% participation rates in boys and girls, respectively) compared to their obese peers (66.8% and 61.6%, respectively). To the best of our knowledge, relationship between participation rates in PE classes and the prevalence of underweight amongst adolescents have been studied only by Levin et al. [20] thus far. According to these authors, underweight girls participate in PE classes rarer than their normal weight peers. This finding; however, was not confirmed by our study.

Additionally, lower levels of PA and lower participation rates of under-/overweight individuals in PE classes can be associated with lower levels of physical fitness in these adolescents. Poorer physical fitness profile limits exercise and PA performance. Additionally, lower fitness levels hamper participation in PE classes as a result of criticism expressed by other pupils. The role of overweight or underweight in determining the levels of health-related fitness was revealed by Artero et al. [26] and Castro-Pinero et al. [27] amongst others.

Noticeably, normal weight and underweight girls were found to be characterized by similar levels of PA and similar participation rates in PE classes, both being markedly higher than in overweight girls. In turn, boys with normal weight were characterized by markedly higher levels of PA and higher participation rates in PE classes when compared to other groups, while underweight and overweight boys were less physically active.

According to American Academy of Pediatrics recommendations [28], time spent watching TV should not

exceed two hours per day. This criterion was only met by 44.4% to 54.5% of adolescents participating in our study. In view of Dennison et al. [29] findings, who observed that each additional hour daily spent watching TV is associated with an additional 2% risk of obesity, it might postulated that this could be one of the reasons behind alarming increase in the prevalence of obesity amongst adolescents. However, our study did not reveal an association between the duration of sedentary activities and the prevalence of under- or overweight. Also Carvalhal et al. [30] did not observe association between BMI values and the time spent using computer by girls and boys, and watching TV by girls. De Bourdeaudhuij et al. [24] have found no significant differences between normal weight and overweight adolescents in time spent watching TV, video or playing computer games.

Obese girls spent significantly higher amounts of time watching TV (36.3 hours weekly) when compared to their non-obese peers (28.9 hours weekly). Unfortunately, underweight participants were not distinguished in any of these aforementioned studies, and therefore assessment of their results in view of our findings is hindered. Nonetheless, the only significant difference observed between underweight individuals and other participants of our study pertained to higher amounts of time spent by underweight boys using computer during weekends.

However, the results of this study should be interpreted with care due to at least three reasons. Firstly, data on PA, participation rates in PE classes and sedentary behavior was based on declarations of participating adolescents, and as such may deviate from factual state. Secondly, the true fractions of underweight, normal weight and overweight participants in general population might differ from our results because of 83.5% questionnaire participation rate. Thirdly, our study used criteria defined by Cole et al. [6, 7] to determine the prevalence of underweight, normal weight and overweight amongst our participants. In view of the fact that other authors have used various other national and international criteria comparative and interpretative possibilities are limited.

The noteworthy aspect of our study is an issue of underweight amongst adolescents which has been rarely studied thus far, but nonetheless should not be marginalized due to serious health consequences. Additionally, this study has determined the prevalence of underweight which was revealed to be comparable to the frequencies of overweight and obesity. Most health-related programs in developed countries are oriented towards obesity prevention and control while the problem of underweight is usually not addressed in these programs. As has been observed in our study, PA levels and the duration of sedentary activities has been found to be unfavorable or even alarming. No significant associations were observed between prevalence of underweight or overweight and the time spent in sedentary activities. Prevalence of underweight and overweight in boys was inversely correlated with PA levels. Therefore, it can be assumed that proper body weight is determined by the time spent engaging in PA at sufficient level rather than by the duration of various sedentary activities.

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