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# Trends in the prevalence of overweight, obesity and underweight in French children, aged 4–12 years, from 2013 to 2017

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1 **Title:** Trends in prevalence of overweight, obesity and underweight in French children, age 4-12  
2 years, from 2013 to 2017

3

4 Jérémy Vanhelst<sup>1</sup>, Jean-Benoît Baudelet<sup>2</sup>, David Thivel<sup>3</sup>, Hervé Ovigneur<sup>4</sup>, Thibault Deschamps<sup>4</sup>

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6

## ABSTRACT

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9 **Objective:** To assess the prevalence of underweight, overweight and obesity in French children  
10 from 2013 to 2017.

11 **Design:** Cross-sectional study performed in fourteen regions of France. Physical measures included  
12 weight, height and Body Mass Index (BMI). Underweight, overweight and obesity were defined  
13 according to age- and sex-specific BMI cut-off points from the International Obesity Task Force.

14 **Setting:** France.

15 **Subjects:** Children (10 159 boys, 9 757 girls) from the voluntary, non-representative Diagnoform  
16 program between 2013 and 2017, at the age of 4 to 12 years.

17 **Results:** The prevalence of overweight and obesity were higher in girls compared to boys  
18 ( $P < 0.001$ ). Underweight was also more prevalent in girls ( $P < 0.05$ ). Although there were no  
19 significant changes in the prevalence of obesity in boys or girls from 2013 to 2017, a significant  
20 decrease in overweight among boys and girls was found ( $P < 0.001$ ) during the same time period. In  
21 contrast, prevalence of underweight increased in girls and boys (from 10.0 to 20.0%;  $P < 0.0001$ )  
22 between 2013 and 2017.

23 **Conclusions:** Results of this study show that the prevalence of obesity was stable, while the  
24 prevalence of overweight decreased significantly, despite high in French children. Findings suggest  
25 also that thinness is becoming becomes an important phenomenon in children. Developing  
26 preventive and nutritional programs in order to modify the lifestyle might help to control  
27 underweight and obesity in children.

## 28 **Introduction**

29 Overweight and obesity are pathologies marked by an increase in body fat as a consequence of a  
30 positive energy balance, when the energy intake exceeds energy expenditure over a prolonged  
31 period. Obesity in children is considered the main childhood health problem in European countries.  
32 In 2010, based on International Obesity Task Force (IOTF) definitions and the World Health  
33 Organization's Childhood Obesity Surveillance Initiative, the authors estimated that about 25% of  
34 European children (aged 6 to 9 years) were overweight or obese<sup>(1)</sup>. A recent systematic review and  
35 meta-analysis observed a high prevalence of childhood overweight and obesity with a trend for  
36 stabilization in most European countries<sup>(2)</sup>. Paediatric obesity and related consequences on physical,  
37 social and psychological parameters have been widely demonstrated<sup>(3)</sup>. In addition, the persistence  
38 of paediatric obesity into adulthood can lead to increased morbidity from type 2 diabetes, cardio-  
39 vascular diseases and cancer, and increased early mortality<sup>(4)</sup>. While the prevalence of overweight  
40 and obesity has been studied broadly, data on the prevalence of underweight are scarce and limited.  
41 Nevertheless, some studies suggested that the prevalence of underweight tends to increase in  
42 developed countries<sup>(5-7)</sup>. Underweight in children is also linked to many serious physical,  
43 psychological and social consequences on health from childhood to adulthood<sup>(8,9)</sup>.

44 Monitoring weight status in children across different countries is essential and may help to identify  
45 the target population for primary prevention and be helpful for health promotion policies. To date,  
46 tracking of children about their weight status (underweight, overweight and obesity) in France has  
47 been inconsistent and data are missing since 2010<sup>(1,2)</sup>.

48 The purpose of the present study was first to measure the prevalence of underweight, overweight  
49 and obesity in French children from 2013 to 2017 and to compare the results with findings prior to  
50 2013.

## 51 **Methods**

52 This ancillary study used data from the French health program "Diagnoform<sup>®</sup>" (<https://irfo.fr/>). The  
53 principal objective of this program was to assess the physical fitness of a large, voluntary, non-  
54 representative sample of the French population aged from 5 years to 60 years and older. This  
55 program is divided into four categories: (i) DiagnoKid for children aged 4–10 years; (ii)  
56 DiagnoTonic for adolescents and young adults aged 10–25 years; (iii) DiagnoActif for adults aged  
57 25–60 years; and (iv) DiagnoHealth for people aged 60 years and older. The program was  
58 performed in large settings throughout France, such as school playgrounds or sports club  
59 gymnasiums.

60 All procedures were performed in accordance with the 1975 Helsinki Declaration as revised in 2008  
61 and European Good Clinical Practices. As the research did not involve an intervention and the data  
62 were collected retrospectively using the organizational structure of the study (Institut des  
63 Rencontres de la Forme; <https://irfo.fr/>), this study was considered an epidemiological study. In this  
64 context, written informed consent was not required according to French human research regulations.  
65 All data obtained from the organizer (results of physical fitness tests and anthropometrics data) of  
66 the event were anonymous, declared and approved by the French National Commission of the  
67 Informatics Personal Data (Commission Nationale de l'Informatique et des Libertés, CNIL). The  
68 aims and objectives of the Diagnoform programme were explained carefully to each child and to  
69 their parents. After this explanation, the children and parents could accept or decline to participate  
70 in this event and to record their information technology data anonymously. The data were recorded  
71 into an electronic data system by the organizer. For the present study, the data analyses were  
72 performed using only the children's data.

73 Many schools in France were invited to participate in the study, with each school director deciding  
74 whether to participate or not. From the 356 schools invited, 309 have accepted to participate the  
75 Diagnoform program (*i.e.* 85% of positive response rate). When director accepted the invitation, all  
76 students were invited to participate. However, due to sick or absent children on the day of the  
77 assessment, 11% of students (3 534) could not participated. Each year, a different group of students  
78 was measured. In addition, data were collected from 14 of the 22 regions of France (*i.e.* 64%). From  
79 the Diagnoform program performed between 2010 and 2018 with an age range from 4 to 17 years,  
80 32 132 (16 378 boys and 15 754 girls) volunteered to participate. Because of the small sample size  
81 of participants aged 13–17 years compared with other age–sex classes and the data obtained from  
82 2010 to 2012 and 2018, we restricted the analysis to 19 916 (10 159 boys and 9 757 girls) children  
83 and adolescents aged 4–12 years.

## 84 ***Measurements***

### 85 *Anthropometric measures*

86 Body weight was measured to the nearest 0.1 kg using an electronic scale with the participant  
87 wearing light clothes and without shoes. Height was measured without shoes to the nearest 0.1 cm  
88 using a standard physician's scale. Body mass index (BMI) was calculated as weight/height squared  
89 ( $\text{kg}/\text{m}^2$ ). Nutritional status was assessed using the IOTF scale<sup>(10)</sup>.

90 ***Statistical analysis***

91 The data are presented as percentages for categorical variables and as means and standard  
92 deviations for continuous variables. The normality of the distribution was checked graphically using  
93 the Shapiro–Wilk test.

94 Comparisons of underweight, overweight and obesity between boys and girls were assessed by the  
95  $\chi^2$  test. Changes in underweight, overweight and obesity from 2013 to 2017 were assessed using the  
96 Cochran–Armitage trend test.

97 All statistical tests were performed at the two-tailed  $\alpha$  level of 0.05. Data were analysed using the  
98 statistical software packages IBM SPSS Statistics for Windows (Version 22.0; IBM SPSS, Armonk,  
99 NY, USA) R Project for Statistical Computing (v. 3.6.1) and Excel 2013 (Microsoft, Redmond,  
100 WA, USA).

101 **Results**

102 The mean age for boys and for girls was  $8.7 \pm 1.6$  and  $8.6 \pm 1.6$  years, respectively. Mean height,  
103 weight, BMI and prevalence rates of underweight, overweight and obesity by sex and age group are  
104 presented in Table 1. Overweight and obesity were significantly greater in girls compared with boys  
105 ( $P < 0.001$ ) (Table 1). The prevalence of underweight was also higher in girls than boys ( $P < 0.01$ ).

106 The prevalence rates from 2013 to 2017 for boys and girls combined and by sex are presented in  
107 Table 2 and Figure 1. No significant changes in obese was found for boys and girls, respectively  
108 ( $P > 0.05$ ) (Table 2). The proportion of overweight was lower in 2017 than in 2013 among boys and  
109 girls ( $P < 0.01$ ) (Table 2). Conversely, the prevalence of underweight increased in girls and boys  
110 (from 10.0 to 20.0%,  $P < 0.0001$ ) between 2013 and 2017.

111 **Discussion**

112 Many countries have developed public health initiatives and policies to prevent and treat unhealthy  
113 weight issues in children. Therefore, monitoring underweight, overweight and obesity in youth is  
114 essential for accurate tracking and to evaluate the effectiveness of these public health  
115 recommendations and intervention programs. However, data on tracking in childhood are scarce,  
116 limited and missing among French children and adolescents since 2010<sup>(2)</sup>.

117 Using the IOTF criteria, the results of our present study suggest that the prevalence of overweight  
118 changed significantly, showing a decrease between 2013 and 2017 (17.3 to 13.4%). During the  
119 same period, the obesity prevalence also decreased by 38%, from 6.1% to 3.8%, although not  
120 significantly. These findings concur with the results from a recent meta-analysis performed from  
121 1999 to 2016 in European children<sup>(2)</sup>. The researchers reported that in some European countries

122 during the last two decades, the growing overweight and obesity prevalence trend had reached a  
123 plateau or sometimes showed a slight decline<sup>(2)</sup>. A similar observation was also observed at the  
124 international level, especially in high-income countries<sup>(11)</sup>. Even though our data show encouraging  
125 results, the proportion remains high. Current national public health initiatives in children must be  
126 maintained and strengthened in the future.

127 Another outcome from our study is the difference between boys and girls found in the prevalence of  
128 overweight and obesity. The prevalence rates of overweight and obesity were significantly higher in  
129 girls compared with boys; however, the sex differences were small (14.5% vs 16.4% for overweight  
130 boys and girls; 5.2% vs 5.8% for obese boys and girls). This finding is also consistent with previous  
131 results from other studies<sup>(2,11,12)</sup>.

132 Although the data on overweight and obesity prevalence from this survey are encouraging, another  
133 major concern was highlighted. Our results show the alarming progression of underweight between  
134 2013 and 2017 among both boys and girls. The prevalence of underweight has effectively doubled  
135 in five years (10.0% vs 20.7% and 10.5% vs 20.5% for boys and girls, respectively). Previous  
136 studies have highlighted the maturing of this phenomenon and underlined the need for further  
137 attention<sup>(5,6,13)</sup>. Since underweight is also associated with adverse health consequences (physical,  
138 psychological and social) throughout the life course, there is an urgent need to develop strategies to  
139 reduce this growing prevalence. In addition, when monitoring overweight and obesity is performed,  
140 we recommend also systematically assessing the rate of underweight prevalence.

141 The current study has strengths and limitations. One of the first strengths of the study was the large  
142 sample size of children with age- and gender-specific information across France. The use of  
143 standardized procedures to assess anthropometric measures was another strength. Although the  
144 present data derive from a large sample belonging to 65% of the administrative French regions, this  
145 study did not use a stratified sample design. Therefore, it is not possible to assume that the studied  
146 cohort is fully representative of the child population in France. In addition, our results showing  
147 increasing underweight and decreasing overweight must be used with caution because we cannot  
148 exclude whether there is a general shifting of the bell curve (or spreading out) or just a difference in  
149 our sample between the measurement date (2013 to 2017). Indeed, due to the voluntary programme,  
150 the number of participants across the years studied differs dramatically and may affect our results.  
151 Another potential weakness is the lack of socio-economic information that were not collected,  
152 which could have impacted our findings. A socio-economic gradient in overweight and obesity was  
153 effectively reported in most partly developed countries, with a higher prevalence of overweight and  
154 obesity being observed in more-disadvantaged groups<sup>(14-15)</sup>. Consequently, we recommend studies  
155 that incorporate random subject selection and to assess socio-economic status.

156 In summary, the data from our study suggest a quite stable prevalence of obesity with a declining  
157 prevalence of overweight despite remaining high in French children between 2013 and 2017. Our  
158 results also indicate that underweight increased significantly in both sexes. This concern becomes  
159 an important phenomenon in children and warrant careful monitoring in coming years. Based on the  
160 study results, the authors support the public health policies currently being developed and also  
161 encourage the development of new strategies to prevent and treat underweight issues.



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**Table 1.** Prevalence rates of underweight, overweight and obesity, and mean anthropometric characteristics with standard deviations in French boys and girls, age 4-12 years, during the period 2013-2017 (n = 19916)

	Boys				Girls				P*
	4-6 years	7-9 years	10-12 years	Total	4-6 years	7-9 years	10-12 years	Total	
<i>Underweight</i>									
Prevalence (n%)	212/17.12	746/60.26	280/22.62	1238/12.19	191/15.39	717/57.78	333/26.83	1241/12.72	<0.05
Height (cm)	120.21 ± 5.93	129.68 ± 7.81	138.24 ± 9.02	129.4 ± 9.89	118.66 ± 5.43	127.68 ± 7.65	138.79 ± 8.93	129.36 ± 10.27	<b>0.913</b>
Weight (kg)	22.84 ± 2.60	27.14 ± 4.07	27.11 ± 3.91	22.90 ± 4.10	18.40 ± 1.76	21.76 ± 3.02	27.17 ± 4.05	22.72 ± 4.36	<b>0.202</b>
BMI (kg.m <sup>2</sup> )	15.60 ± 0.97	16.08 ± 1.18	14.11 ± 0.64	13.57 ± 0.72	13.05 ± 0.56	13.29 ± 0.65	14.03 ± 0.81	13.45 ± 0.76	<0.001
<i>Overweight</i>									
Prevalence (n%)	160/11.10	838/58.15	443/30.74	1441/14.18	190/11.98	918/57.88	478/30.14	1586/16.25	<0.001
Height (cm)	123.36 ± 6.7	133.12 ± 35.40	146.41 ± 6.76	135.25 ± 10.47	122.60 ± 6.07	132.18 ± 7.77	147.09 ± 7.93	134.54 ± 11.15	<0.01
Weight (kg)	28.45 ± 3.35	35.40 ± 5.46	47.74 ± 5.64	37.75 ± 8.23	27.92 ± 3.20	34.86 ± 5.40	48.34 ± 22.25	37.31 ± 8.74	0.73
BMI (kg.m <sup>2</sup> )	18.63 ± 0.67	19.85 ± 1.12	22.21 ± 1.35	20.35 ± 1.65	18.52 ± 0.69	19.82 ± 1.19	22.25 ± 1.34	20.28 ± 1.70	0.166
<i>Obese</i>									
Prevalence (n%)	65/11.75	314/56.78	174/31.46	553/5.44	91/15.12	360/59.80	151/25.08	602/6.17	<0.001
Height (cm)	124.29 ± 6.01	134.27 ± 8.52	148.64 ± 8.51	136.28 ± 10.97	122.87 ± 6.04	132.51 ± 7.89	148.70 ± 8.03	134.53 ± 11.20	<0.001
Weight (kg)	34.46 ± 4.46	44.43 ± 8.74	61.60 ± 9.81	47.16 ± 12.01	34.40 ± 5.83	42.23 ± 7.75	61.45 ± 10.43	45.19 ± 12.14	<0.001
BMI (kg.m <sup>2</sup> )	22.26 ± 1.95	24.45 ± 2.79	27.75 ± 2.67	24.97 ± 3.19	22.71 ± 3.11	23.88 ± 2.56	27.64 ± 2.98	24.51 ± 3.19	<0.01
<i>Normal weight</i>									
Prevalence (n%)	916/13.22	4267/61.60	1744/25.18	6927/68.16	901/14.24	3891/61.49	1536/24.27	6328/64.85	<0.001
Height (cm)	120.86 ± 5.37	129.60 ± 7.17	142.64 ± 7.35	131.74 ± 9.82	119.60 ± 5.25	128.95 ± 7.69	143.53 ± 7.78	131.18 ± 10.64	<0.01
Weight (kg)	23.25 ± 4.64	28.49 ± 6.82	35.27 ± 5.17	28.61 ± 5.87	22.13 ± 2.57	26.82 ± 4.36	35.90 ± 5.51	28.36 ± 6.37	<0.05
BMI (kg.m <sup>2</sup> )	16.00 ± 2.41	16.78 ± 2.80	17.26 ± 1.49	16.31 ± 1.36	15.43 ± 1.02	16.03 ± 1.23	17.34 ± 1.53	16.26 ± 1.44	<0.05

204 \* The  $\chi^2$  was performed to assess differences in prevalence rates by sex; Student's t test was performed to assess differences in anthropometric data by sex. Significant P values are indicated in bold font.

206 Percentages are row percentages for prevalence rates by age group; percentages are column percentages for total prevalence rates by sex.

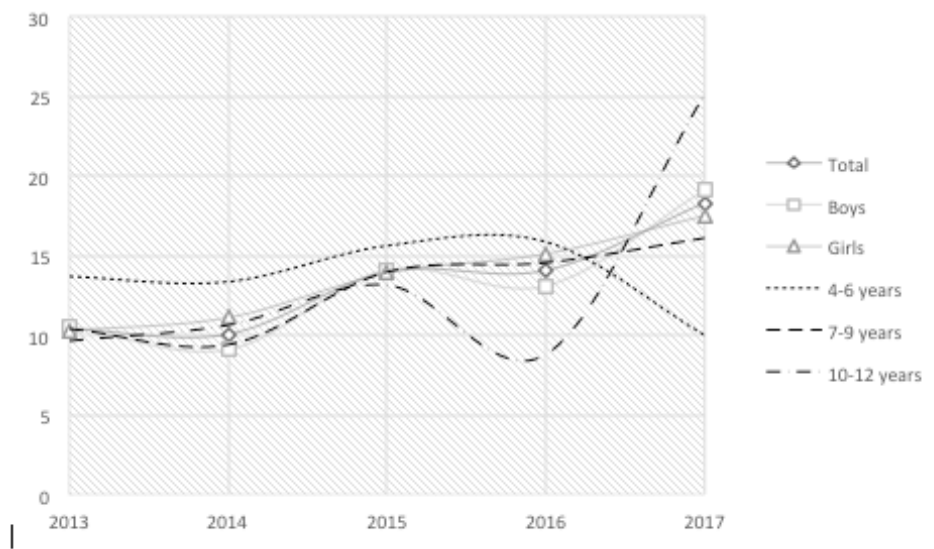
**Table 2.** Overall and sex-specific number, proportions (%) children, age 4-12 years, classified as underweight, healthy weight, overweight and obese in 2013 and 2017 from the Diagonform program.

	2013 (n 7211)		2014 (n 3540)		2015 (n 2937)		2016 (n 4256)		2017 (n 1972)		P for trend*
	n	%	n	%	n	%	n	%	n	%	
<b>4-6 years</b>											
<b>Underweight</b>											
Overall	69	13.64	39	13.36	52	15.62	226	15.86	17	10	0.5294
Boys	38	15.32	15	10.07	32	19.28	117	16.39	10	13.16	0.4994
Girls	31	12.02	24	16.78	20	11.98	109	15.33	7	7.45	0.8283
<b>Healthy weight</b>											
Overall	344	67.98	195	66.78	230	69.07	931	65.33	117	68.82	0.4148
Boys	167	67.34	99	66.44	113	68.07	481	67.37	56	73.68	0.6266
Girls	177	68.60	96	67.13	117	70.06	450	63.29	61	64.89	0.1108
<b>Overweight</b>											
Overall	66	13.04	43	14.73	39	11.71	176	12.35	26	15.29	0.7809
Boys	34	13.71	27	18.12	18	10.84	73	10.22	8	10.53	<b>0.0307</b>
Girls	32	12.40	16	11.19	21	12.57	103	14.49	18	19.15	0.1111
<b>Obese</b>											
Overall	27	5.34	15	5.14	12	3.60	92	6.46	10	5.88	0.2731
Boys	9	3.63	8	5.37	3	1.81	43	6.02	2	2.63	0.2931
Girls	18	6.98	7	4.90	9	5.39	49	6.89	8	8.51	0.5933
<b>7-9 years</b>											
<b>Underweight</b>											
Overall	456	10.46	215	9.40	283	13.97	315	14.51	194	16.10	<b>&lt;0.0001</b>
Boys	238	10.92	109	9.11	146	14.05	144	12.70	109	17.67	<b>&lt;0.0001</b>
Girls	218	9.99	106	9.71	137	13.88	171	16.49	85	14.46	<b>&lt;0.0001</b>
<b>Healthy weight</b>											
Overall	2910	66.73	1588	69.41	1405	69.35	1447	66.65	808	67.05	0.9297
Boys	1483	68.06	838	70.07	734	70.64	803	70.81	409	66.29	0.66
Girls	1427	65.40	750	68.68	671	67.98	644	62.10	399	67.86	0.7065
<b>Overweight</b>											
Overall	719	16.49	353	15.43	259	12.78	274	12.62	151	12.53	<b>&lt;0.0001</b>
Boys	339	15.56	174	14.55	118	11.36	133	11.73	74	11.99	<b>&lt;0.001</b>
Girls	380	17.42	179	16.39	141	14.29	141	13.60	77	13.10	<b>&lt;0.001</b>
<b>Obese</b>											
Overall	276	6.33	132	5.77	79	3.90	135	6.22	52	4.32	<b>0.0153</b>
Boys	119	5.46	75	6.27	41	3.95	54	4.76	25	4.05	0.0510
Girls	157	7.20	57	5.22	38	3.85	81	7.81	27	4.59	0.1466
<b>10-12 years</b>											
<b>Underweight</b>											
Overall	227	9.68	102	10.63	76	13.15	58	8.79	150	25.13	<b>&lt;0.0001</b>
Boys	112	8.99	43	8.74	30	11.11	25	7.42	70	23.65	<b>&lt;0.0001</b>
Girls	115	10.47	59	12.61	46	14.94	33	10.22	80	26.58	<b>&lt;0.0001</b>
<b>Healthy weight</b>											
Overall	1519	64.80	612	63.75	377	65.22	430	65.15	342	57.29	<b>0.0209</b>

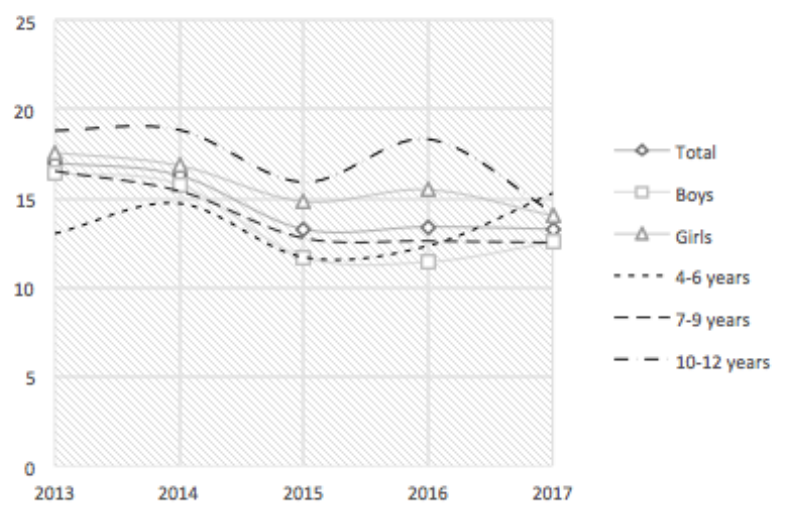
	<i>Boys</i>	825	66.21	328	66.67	181	67.04	236	70.03	174	58.78	0.2866
	<i>Girls</i>	694	63.21	284	60.68	196	63.64	194	60.06	168	55.81	<b>0.0387</b>
<b>Overweight</b>	<i>Overall</i>	442	18.86	181	18.85	92	15.92	121	18.33	85	14.24	0.0170
	<i>Boys</i>	231	18.54	89	18.09	37	13.70	44	13.06	42	14.19	<b>0.0044</b>
	<i>Girls</i>	211	19.22	92	19.66	55	17.86	77	23.84	43	14.29	0.5122
<b>Obese</b>	<i>Overall</i>	156	6.66	65	6.77	33	5.71	51	7.73	20	3.35	0.0661
	<i>Boys</i>	78	6.26	32	6.50	22	8.15	32	9.50	10	3.38	0.9763
	<i>Girls</i>	78	7.10	33	7.05	11	3.57	19	5.88	10	3.32	<b>0.0088</b>
<b>Total</b>												
<b>Underweight</b>	<i>Overall</i>	752	10.43	356	10.06	411	13.99	599	14.07	361	18.31	<b>&lt;0.0001</b>
	<i>Boys</i>	388	10.56	167	9.09	208	14.10	286	13.09	189	19.11	<b>&lt;0.0001</b>
	<i>Girls</i>	364	10.29	189	11.10	203	13.89	313	15.11	172	17.50	<b>&lt;0.0001</b>
<b>Healthy weight</b>	<i>Overall</i>	4773	66.19	2395	67.66	2012	68.51	2808	65.98	1267	64.25	0.238
	<i>Boys</i>	2475	67.38	1265	68.86	1028	69.69	1520	69.57	639	64.61	0.9895
	<i>Girls</i>	2298	64.95	1130	66.35	984	67.31	1288	62.19	628	63.89	0.1031
<b>Overweight</b>	<i>Overall</i>	1227	17.02	577	16.30	390	13.28	571	13.42	262	13.29	<b>&lt;0.0001</b>
	<i>Boys</i>	604	16.44	290	15.79	173	11.73	250	11.44	124	12.54	<b>&lt;0.0001</b>
	<i>Girls</i>	623	17.61	287	16.85	217	14.84	321	15.50	138	14.04	<b>0.0012</b>
<b>Obese</b>	<i>Overall</i>	459	6.37	212	5.99	124	4.22	278	6.53	82	4.16	0.1507
	<i>Boys</i>	206	5.61	115	6.26	66	4.47	129	5.90	37	3.74	0.2738
	<i>Girls</i>	253	7.15	97	5.70	58	3.97	149	7.19	45	4.58	0.3395

\*Cochran–Armitage trend test. Significant P values are indicated in bold font.

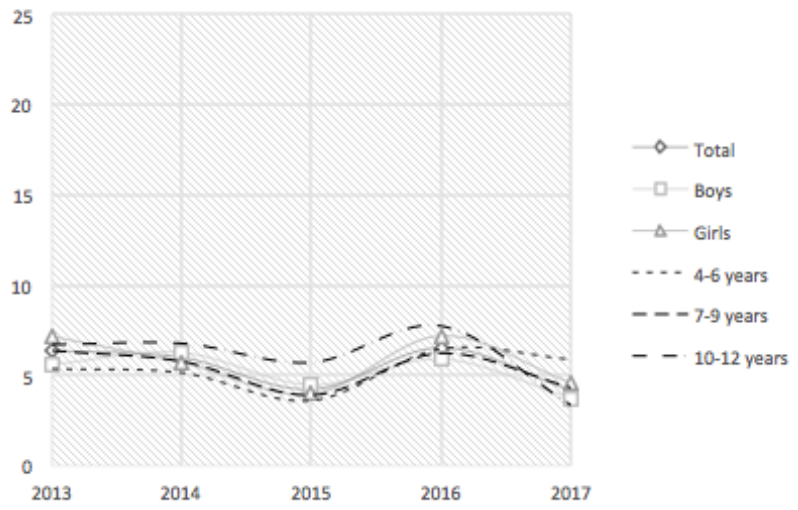




A) Underweight



B) Overweight



C) Obesity

Figure 1. Prevalence rates of underweight, overweight and obesity among French children, age 4-12 years, from 2013 to 2017.