



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

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ABSTRACT

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

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

Setting: France.

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

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

Conclusions: Results of this study show that the prevalence of obesity was stable, while the prevalence of overweight decreased significantly, despite high in French children. Findings suggest also that thinness is becoming becomes an important phenomenon in children. Developing preventive and nutritional programs in order to modify the lifestyle might help to control 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⁽¹⁾. 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⁽²⁾. Paediatric obesity and related consequences on physical,
37 social and psychological parameters have been widely demonstrated⁽³⁾. 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⁽⁴⁾. 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⁽⁵⁻⁷⁾. Underweight in children is also linked to many serious physical,
43 psychological and social consequences on health from childhood to adulthood^(8,9).

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^(1,2).

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[®]" (<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 (kg/m^2). Nutritional status was assessed using the IOTF scale⁽¹⁰⁾.

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 χ^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 α 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 ± 1.6 and 8.6 ± 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⁽²⁾.

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⁽²⁾. 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⁽²⁾. A similar observation was also observed at the
124 international level, especially in high-income countries⁽¹¹⁾. 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^(2,11,12).

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^(5,6,13). 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⁽¹⁴⁻¹⁵⁾. 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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201

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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	0.913
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	0.202
BMI (kg.m ²)	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 ²)	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 ²)	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 ²)	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 χ^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

205 indicated in bold font.

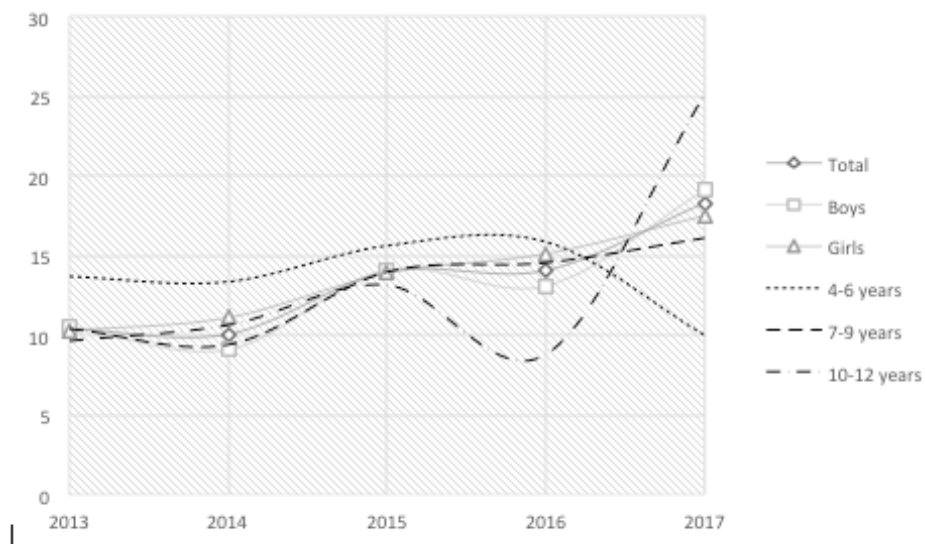
206 Percentages are row percentages for prevalence rates by age group; percentages are column percentages for total prevalence rates by sex.

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 Diagnoform program.

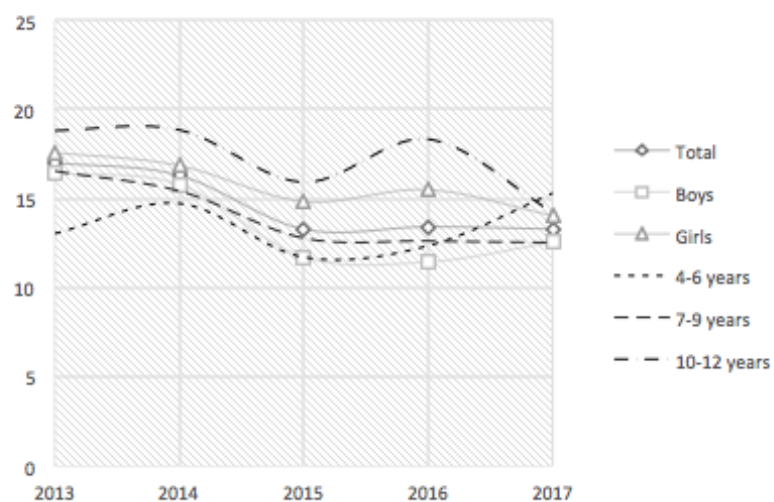
Program:		2013 (n 7211)		2014 (n 3540)		2015 (n 2937)		2016 (n 4256)		2017 (n 1972)		P for trend*
	n	%	n	%	n	%	n	%	n	%		
4-6 years												
Underweight												
Overall	69	13.64	39	13.36	52	15.62	226	15.86	17	10	0.5294	
Boys	38	15.32	15	10.07	32	19.28	117	16.39	10	13.16	0.4994	
Girls	31	12.02	24	16.78	20	11.98	109	15.33	7	7.45	0.8283	
Healthy weight												
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	
Overweight												
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	0.0307	
Girls	32	12.40	16	11.19	21	12.57	103	14.49	18	19.15	0.1111	
Obese												
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	
7-9 years												
Underweight												
Overall	456	10.46	215	9.40	283	13.97	315	14.51	194	16.10	<0.0001	
Boys	238	10.92	109	9.11	146	14.05	144	12.70	109	17.67	<0.0001	
Girls	218	9.99	106	9.71	137	13.88	171	16.49	85	14.46	<0.0001	
Healthy weight												
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	
Overweight												
Overall	719	16.49	353	15.43	259	12.78	274	12.62	151	12.53	<0.0001	
Boys	339	15.56	174	14.55	118	11.36	133	11.73	74	11.99	<0.001	
Girls	380	17.42	179	16.39	141	14.29	141	13.60	77	13.10	<0.001	
Obese												
Overall	276	6.33	132	5.77	79	3.90	135	6.22	52	4.32	0.0153	
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	
10-12 years												
Underweight												
Overall	227	9.68	102	10.63	76	13.15	58	8.79	150	25.13	<0.0001	
Boys	112	8.99	43	8.74	30	11.11	25	7.42	70	23.65	<0.0001	
Girls	115	10.47	59	12.61	46	14.94	33	10.22	80	26.58	<0.0001	
Healthy weight												
Overall	1519	64.80	612	63.75	377	65.22	430	65.15	342	57.29	0.0209	

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

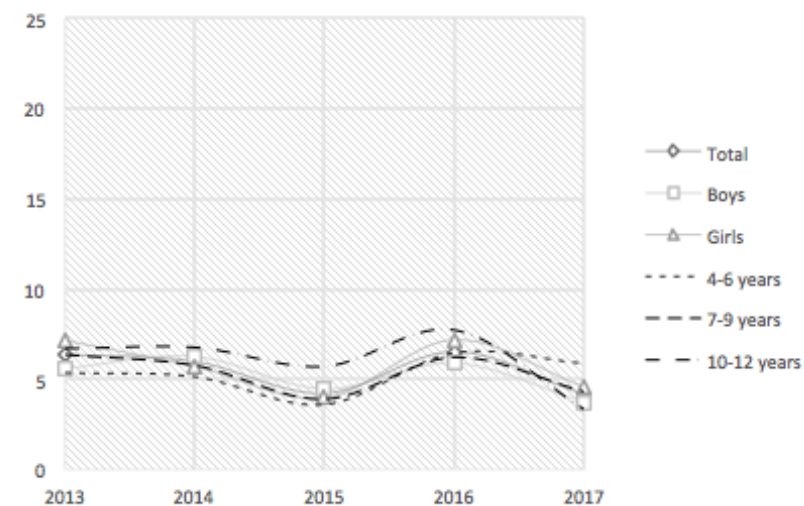
*Cochran–Armitage trend test. Significant P values are indicated in bold font.



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.