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Differences in Anthropometric Parameters of Children in Six European Countries

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Abstract: Background: The databases of children’s anthropometric parameters are often outdated, rarely representative and are not always available at an international level. Objectives: To present children’s anthropometric parameters in six European countries that contributed to the Feel4Diabetes project and find country-specific differences. Design/Setting: The Feel4Diabetes study was performed between 2016 and 2018, targeting children in Belgium, Bulgaria, Finland, Greece, Hungary and Spain. The current study presents data from the baseline and the yearly follow-up anthropometric measurements. Subjects: In total, 20,832 measurements of children (48.7% boys) between 6 and 10 years of age were conducted. Main outcome measure: weight, height, BMI. Results: Belgian boys had the lowest body weight and height, while Greek boys had the highest body weight, and Finnish had the highest body height. The highest proportion of overweight (percentile above 85%) and obese boys (percentile above 95%) was in Greece, followed by Hungarian, Spanish, Bulgarian and Finnish boys. In contrast, Belgian boys had the lowest ratio in both categories. Among girls, Greece had the highest; Belgium had the lowest body weight; Finland was the highest in all age categories. The ratio in the overweight range was the highest in Greece, followed by Spanish, Bulgarian and Hungarian girls, who were second in the obese category. Finnish girls had lower and Belgian girls

had the lowest ratio in both BMI categories. All the detailed data are presented in tables, and the trends are figures. Conclusions: Our study presents fresh and comparable anthropometric data of children between 6 and 10 years of age in six European countries, supporting the need for appropriate obesity prevention.

Keywords: body weight; body height; BMI of children; child growth; Belgium; Bulgaria; Finland; Greece; Hungary; Spain; Feel4Diabetes

1. Background

Childhood obesity represents one of the most important and challenging public health problems in developed and even less developed countries. Its metabolic and health-related consequences in this age period and later in adulthood are well known [1,2]. The home environment is important, particularly for young children, and can be improved by educating and empowering families, supported by school- and community-based intervention [3,4].

Anthropometric measurements are part of regular children's care and are usually performed by pediatricians, midwives or other staff members of school health services. Registered data could help providers determine if a child is growing properly and can indicate when the child's health and well-being are at risk. To evaluate the individual, registered data can serve as a comparison to (national) databases, which are generated from national(wide) surveys and measurements of the same cohorts regarding gender and age. These data are usually presented in tables or in age-growth charts.

Two of the most important health indicators for children that are regularly measured include their individual growth patterns (weight and height) together with BMI (Body Mass Index). It is a simple weight-for-height index that provides the most useful population-level measure of overweight and obesity worldwide, as it is the same for both sexes and for all ages, including children [5–7].

According to a professional consensus, children two years of age or older with a BMI between the 85th and 94th percentile on age-growth charts are considered overweight, while children with a BMI higher than the 95th percentile are considered obese [8–10]. The BMI z-score is a quantitative measure of the deviation of a specific BMI percentile from the mean of that population. A positive z-score indicates that a child is heavier, while in the case of a negative z-score, a child is lighter than the mean. Thus, a z-score can compare the BMI of a given child to the BMI distribution for a population of children of the same age and sex [4,11].

Available national databases of the child populations are often outdated or do not always provide appropriate representatives. In recent decades there was a shift in the anthropometric parameters of children, which was caused by the “acceleration” of their growth, which closely depended on their changes in living conditions, improved nutrition and other socio-economic circumstances. One of the most used databases was published 20 years ago, based on data from six different countries [12].

The *Feel4Diabetes Project* was a large school- and community-based study that aimed to promote a healthy lifestyle, including healthy eating and increased physical activity, in order to alleviate obesity and obesity-related metabolic risk factors in families at risk for Type-2 Diabetes (T2D) in Europe. The project ran between 2014 and 2019, and the actual program implementation had a total duration of two years (2016–2018) [13]. The *Feel4Diabetes Project*, founded by the European Commission, offered an excellent option to register anthropometric parameters: firstly, to measure a high number of children and, secondly, to make a comparison between populations measured in the six participating countries (Belgium, Bulgaria, Greece, Finland, Hungary and Spain) [14,15].

2. Aim

The current study aimed to present data of the anthropometric parameters of children in the six participating countries over a period of two years and compare national trends.

3. Method

3.1. Study Population

Feel4Diabetes was a European community-based study that included an intervention component at the family, school and community levels [16]. Recruitment was based on a standardized, multi-stage sampling procedure and was conducted within selected provinces in the participating countries, targeting vulnerable population groups at high risk of developing T2D. In *Low- and Middle-Income Countries (LMICs)*, including Bulgaria (BG) and Hungary (HU), all municipalities within the participating regions were eligible for recruitment, while in *High-Income Countries (HICs)* such as Belgium (BE), Finland (FI), families within low socioeconomic status (SES) municipalities were recruited. In Greece (GR) and Spain (ES), low SES municipalities were defined as those with the lowest educational level and/or the highest unemployment rates, as retrieved from official resources and local authorities within each country [15]. Measurements were taken at the baseline of the project, such as the start of the academic year, in the first three grades of obligatory (primary level) education, while intervention and follow-up occurred in the upcoming 2 years. The same method and selection procedures were used in every participating country as has been already described [14,15].

For this study, 20,832 children were included (48.7% boys), and their distribution for age, gender and country are detailed in the tables.

3.2. Measurements

The anthropometric indices of children were measured by trained researchers using standardized protocols and equipment that were calibrated before the start of the measurements (in each time period). Participants were asked to remove heavy clothing and shoes and to stand still in an erect position during the measurements. Portable equipment was used (digital scales for weight, telescopic stadiometers for height, and non-elastic waist tape for waist circumference) [14,16]. Children were first measured at the start of the project when they were 6, 7 or 8 years old. The measurements were repeated every year, and the data of each child were considered at their respective year of age. (i.e., a child entering into the project at 6 years of age was allotted to the group of 6-year-old children. One year later, he/she already belonged to the group of 7 years old children, together with those who started at 7 years of age. (In the text, the exact age groups are abbreviated, i.e., 6–6.99 as 6 year). After calculating the BMI, the 85th percentile was the cut-off for overweight, while above the 95th percentile was considered obesity.

3.3. Statical Analysis

Descriptive statistics were performed on the merged data of 20,832 measurements in the period between 2016 and 2018, focusing on children aged 6–9.99 years. Proportions and 95% confidence intervals were calculated. These cases were considered significant, where the 95% confidence intervals did not overlap. Comparisons were not always made between all groups and categories.

3.4. Ethical Permission

Feel4Diabetes-study adhered to the Declaration of Helsinki and the conventions of the Council of Europe on human rights and biomedicine. Prior to initiating the intervention, all participating countries obtained ethical clearance from the relevant national ethical committees and local authorities (in Hungary, by the National Committee for Scientific Research in Medicine; the approval number is 20095-1/2016/EKU (469/15)). All parents/caregivers provided a signed consent form before being enrolled in the study [14,15].

4. Results

The data and their comparisons are presented in 2 tables and 8 figures.

BOYS. Weight. At the age of 6 y, Hungarian boys had the highest body weight, but from 7 to 9 y of age, Greek boys had the highest body weight. Belgian boys had a significantly lower body weight in each cohort, as presented in Table 1.

Height. At the age of 6 y, Belgian boys had the lowest *body height*. In the age group of 8 y, the Hungarian boys had the smallest height than other countries; this was significant compared to the data of Greek and Finnish boys. In the age group 9 y, Finnish boys were the tallest and significantly higher than Hungarians.

BMI. In the age group 6 y, Bulgarian boys had the lowest value, followed by the Belgian, without significant differences. In the older categories (7–9 y), Belgian boys always had the lowest BMI; however, boys in Greece had the highest.

Table 1. Anthropometric data of boys in each age group of 6 European countries. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary, ES = Spain).

Prevalence					
BOYS	Age-Group [Year]	n	Weight [kg]	Height [cm]	BMI [kg/m ²]
BE	6–6.99	139	23.67 [23.04–24.29]	121.83 [120.90–122.76]	15.87 [15.62–16.13]
	7–7.99	378	26.00 [25.56–26.44]	127.32 [126.76–127.88]	15.97 [15.79–16.15]
	8–8.99	610	29.15 [28.73–29.57]	133.09 [132.62–133.56]	16.38 [16.22–16.54]
	9–9.99	578	32.12 [31.63–32.61]	138.04 [137.54–138.54]	16.77 [16.59–16.96]
BG	6–6.99	37	24.51 [23.24–25.78]	124.35 [123.01–125.68]	15.79 [15.15–16.43]
	7–7.99	331	28.18 [27.55–28.81]	128.39 [127.79–129.00]	16.99 [16.70–17.28]
	8–8.99	593	31.33 [30.80–31.86]	133.49 [133.01–133.96]	17.48 [17.25–17.71]
	9–9.99	673	34.93 [34.34–35.52]	138.20 [137.73–138.68]	18.16 [17.92–18.41]
FI	6–6.99	13	25.73 [23.84–27.62]	124.30 [121.80–126.81]	16.60 [15.74–17.47]
	7–7.99	179	27.66 [27.01–28.30]	128.38 [127.66–129.10]	16.72 [16.43–17.01]
	8–8.99	414	30.91 [30.34–31.48]	133.69 [133.13–134.25]	17.20 [16.97–17.44]
	9–9.99	605	34.70 [34.12–35.27]	139.25 [138.75–139.74]	17.76 [17.54–17.98]
GR	6–6.99	237	25.34 [24.73–25.95]	122.33 [121.68–122.98]	16.84 [16.54–17.14]
	7–7.99	544	29.25 [28.73–29.77]	128.11 [127.65–128.57]	17.69 [17.45–17.92]
	8–8.99	875	33.04 [32.56–33.52]	133.57 [133.19–133.94]	18.38 [18.18–18.59]
	9–9.99	719	36.77 [36.17–37.38]	138.49 [138.05–138.93]	19.02 [18.78–19.25]
HU	6–6.99	34	26.24 [23.99–28.48]	124.32 [121.94–126.71]	16.74 [15.82–17.66]
	7–7.99	242	27.72 [26.86–28.58]	127.35 [126.54–128.16]	16.93 [16.54–17.32]
	8–8.99	490	31.18 [30.49–31.87]	132.47 [131.87–133.07]	17.60 [17.31–17.90]
	9–9.99	705	34.91 [34.24–35.58]	137.79 [137.26–138.32]	18.21 [17.94–18.47]
ES	6–6.99	164	24.74 [24.08–25.40]	121.85 [121.07–122.63]	16.54 [16.25–16.84]
	7–7.99	383	27.63 [27.09–28.18]	127.37 [126.83–127.91]	16.92 [16.68–17.17]
	8–8.99	626	30.98 [30.47–31.48]	133.01 [132.56–133.47]	17.39 [17.18–17.61]
	9–9.99	580	34.03 [33.42–34.63]	137.69 [137.19–138.20]	17.82 [17.58–18.06]

The means of weight-, height- and BMI values, 95%CI of boys separately in 4 age categories during the project period.

GIRLS. Weight. Greek girls had the highest weight; the Belgian girls had the lowest body weight, which was significantly lower than their Hungarian counterparts. This was found for all age cohorts (see Table 2).

Height. The Finnish girls were the highest in all age categories. Compared to the Hungarians, at 6 years of age, the Belgian, Greek and Spanish girls were significantly smaller, while at 7 y, the Finnish and, at 8 y, the Bulgarians were significantly taller.

BMI. In the age group of 6 y, there was no significant difference between the countries. In the later age groups, Greek girls always had the highest values, though this was only significant at 9 y. Greek girls had the significantly highest BMI values. In age groups from 7 to 9 y, Belgian girls had the lowest BMI values compared to others.

These differences and trends are also presented in Figures 1–3.

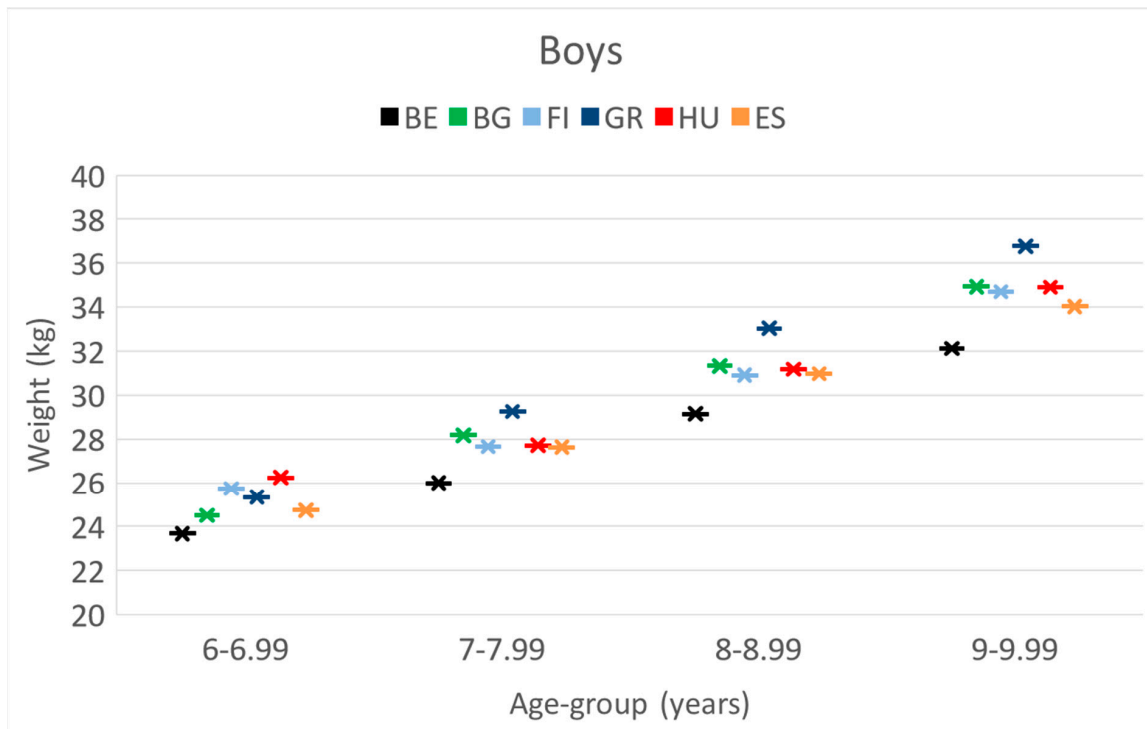


Figure 1. The increase in the mean values of weight [kg] and boys by their age [years] in the 6 countries. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES = Spain).

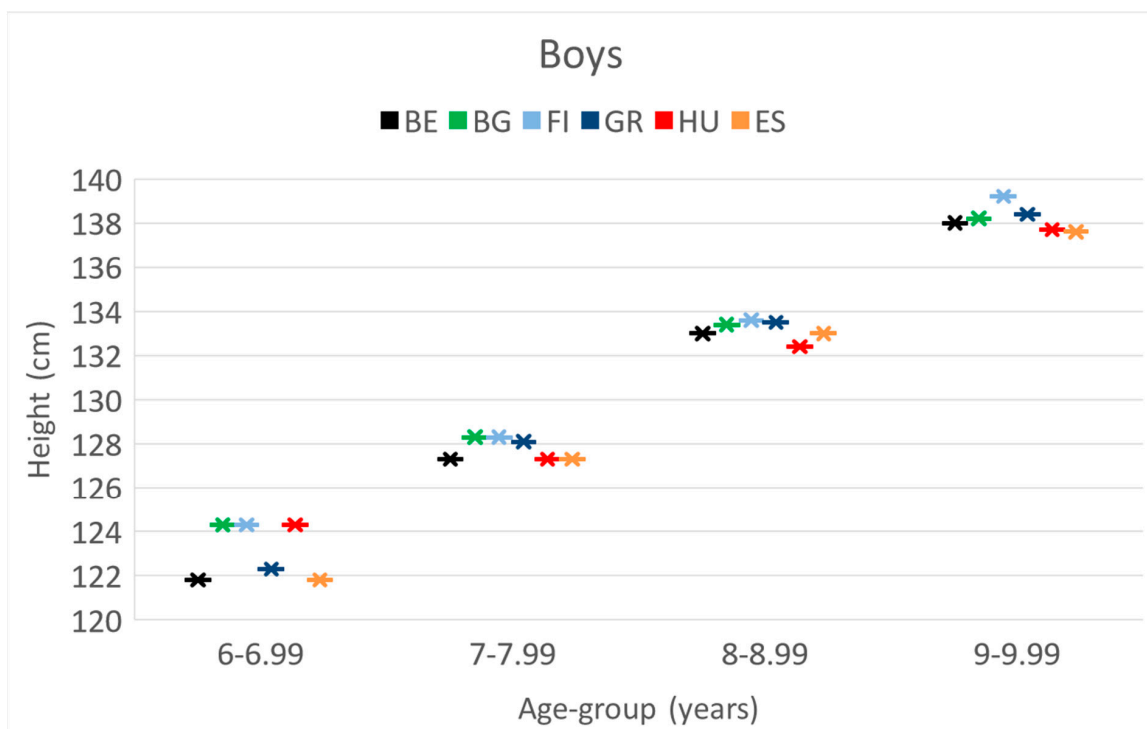


Figure 2. The increase in the mean values of the height [cm] of boys by their age [years] in the 6 countries. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES = Spain).

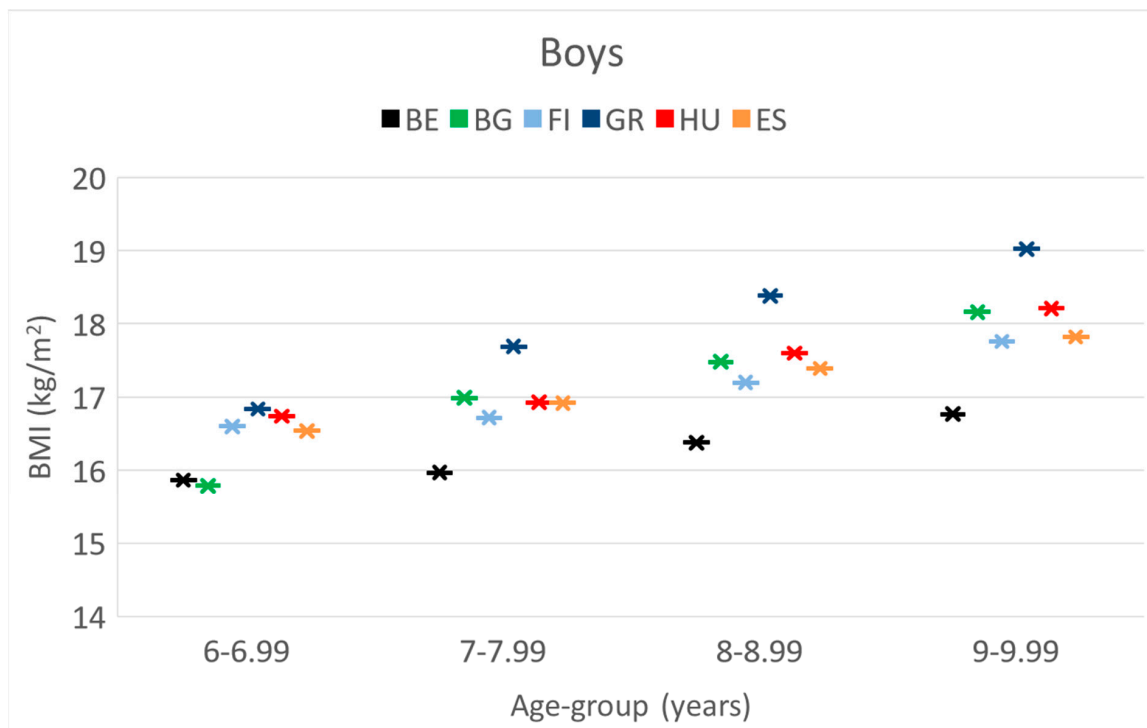


Figure 3. The increase in the mean values of BMI [kg/m²] of boys by their age [years] in the 6 countries. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES = Spain).

Table 2. Anthropometric data of girls in each age group of 6 European countries. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES = Spain).

Prevalence						
GIRLS	Age-Group [year]	n	Weight [kg]	Height [cm]	BMI [kg/m ²]	
BE	6–6.99	129	23.23 [22.70–23.76]	121.03 [120.09–121.97]	15.81 [15.57–16.04]	
	7–7.99	374	25.42 [25.02–25.82]	125.83 [125.26–126.40]	16.00 [15.82–16.18]	
	8–8.99	606	28.99 [28.57–29.41]	132.06 [131.59–132.54]	16.54 [16.36–16.72]	
	9–9.99	580	32.43 [31.88–32.98]	137.21 [136.70–137.72]	17.13 [16.91–17.35]	
BG	6–6.99	41	25.65 [24.30–26.99]	122.10 [120.51–123.70]	17.15 [16.38–17.92]	
	7–7.99	382	27.17 [26.62–27.72]	126.86 [126.31–127.42]	16.78 [16.52–17.04]	
	8–8.99	721	30.79 [30.33–31.25]	132.42 [132.01–132.84]	17.46 [17.25–17.66]	
	9–9.99	783	34.46 [33.94–34.99]	137.77 [137.34–138.20]	18.06 [17.84–18.27]	
FI	6–6.99	8	27.16 [23.41–30.92]	125.66 [124.33–127.00]	17.18 [14.93–19.42]	
	7–7.99	204	27.70 [26.95–28.46]	127.59 [126.85–128.33]	16.87 [16.53–17.22]	
	8–8.99	423	30.17 [29.60–30.74]	132.33 [131.77–132.90]	17.14 [16.89–17.39]	
	9–9.99	612	33.61 [33.07–34.16]	137.97 [137.47–138.46]	17.56 [17.34–17.78]	
GR	6–6.99	232	25.23 [24.57–25.89]	121.41 [120.72–122.09]	17.01 [16.68–17.34]	
	7–7.99	593	28.24 [27.77–28.72]	126.65 [126.19–127.10]	17.48 [17.26–17.70]	
	8–8.99	931	31.76 [31.33–32.20]	132.12 [131.74–132.51]	18.07 [17.88–18.26]	
	9–9.99	783	35.34 [34.80–35.88]	137.45 [137.01–137.90]	18.57 [18.36–18.79]	
HU	6–6.99	34	25.68 [23.97–27.39]	124.33 [122.30–126.36]	16.51 [15.74–17.28]	
	7–7.99	274	27.01 [26.15–27.88]	125.86 [125.07–126.65]	16.88 [16.47–17.28]	
	8–8.99	526	30.70 [29.98–31.41]	131.33 [130.73–131.92]	17.52 [17.30–17.90]	
	9–9.99	778	34.52 [33.83–35.22]	137.42 [136.89–137.94]	18.05 [17.78–18.32]	
ES	6–6.99	160	24.59 [23.92–25.25]	121.20 [120.43–121.98]	16.65 [16.33–16.98]	
	7–7.99	385	27.20 [26.65–27.76]	126.11 [125.55–126.66]	16.99 [16.74–17.24]	
	8–8.99	603	30.63 [30.10–31.16]	131.72 [131.25–132.19]	17.52 [17.30–17.74]	
	9–9.99	521	34.02 [33.33–34.70]	136.85 [136.31–137.40]	18.01 [17.74–18.28]	

The means of weight-, height- and BMI values of girls separately in 4 age categories during the project period.

These differences and trends are more visible in Figures 4–6 as well.

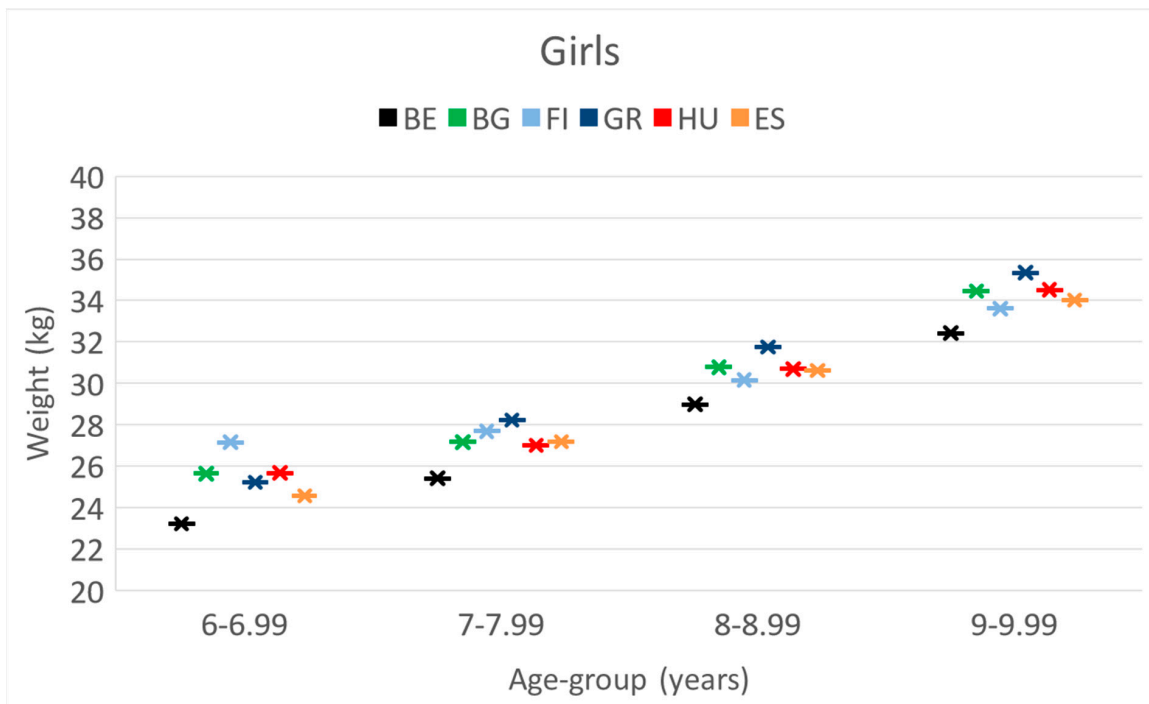


Figure 4. The increase in the mean weight [kg] of girls by their age [years] in the 6 countries. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES = Spain).

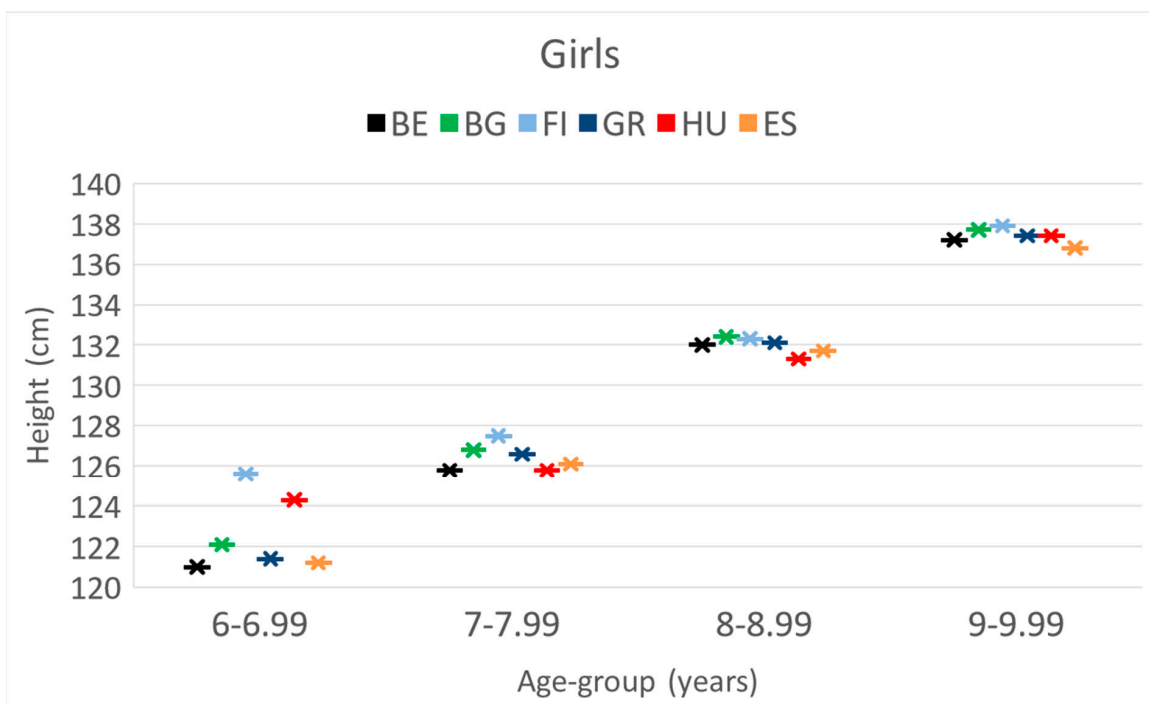


Figure 5. The increase in the mean height [cm] of girls by their age [years] in the 6 countries. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES = Spain).

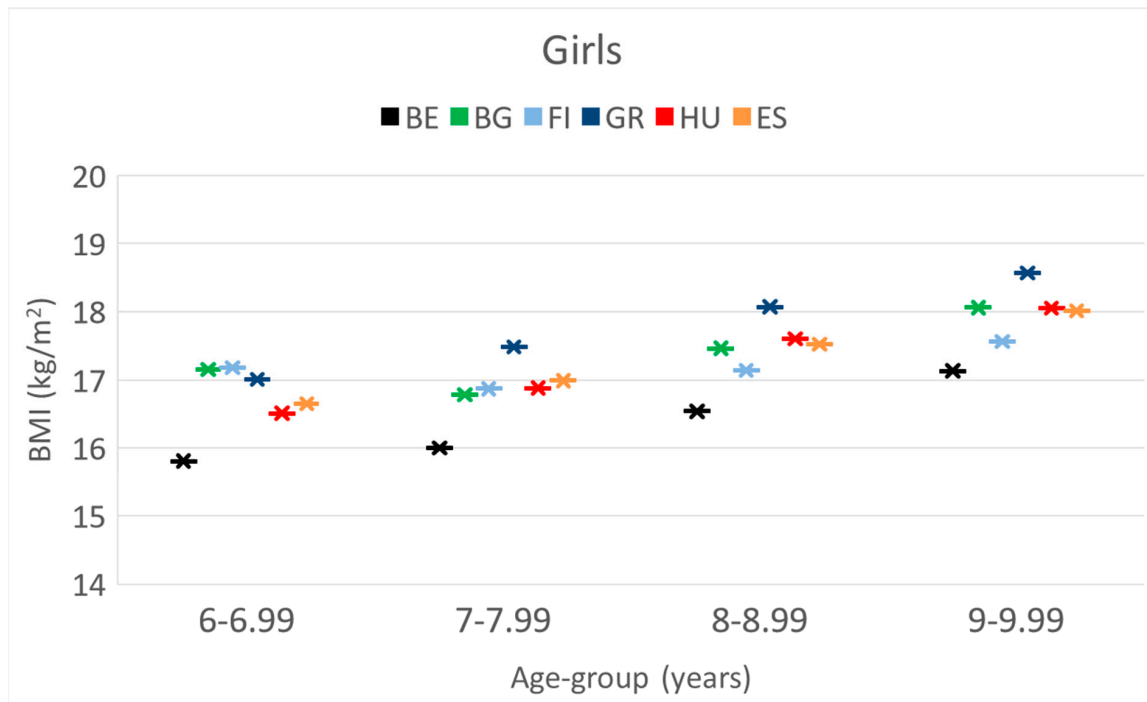


Figure 6. The changes in the mean BMI [kg/m²] by age [years] of girls in the 6 countries. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES= Spain).

The distribution of overweight and obese children was different in the six countries examined. Greek boys represented the greatest proportion among overweight boys for all age cohorts (45–53%), followed by the Hungarians (34–38%), Spanish boys (36–37%) were the third, Bulgarians (30–36%) were the fourth, Finnish had the fifth position (31–34%), while Belgian boys (17–19%) had the lowest proportion above percentiles of 85.

The distributions of obese boys above the 95 percentile were the same. The ranking list was led by the Greeks (29–35%), followed by the Hungarians (25–27%), thereafter, the Spanish (21%) and Bulgarian (18–20%). The last two groups were the Finnish (17–19%) and the Belgian boys (7–9%). The graphs are presented in Figure 7.

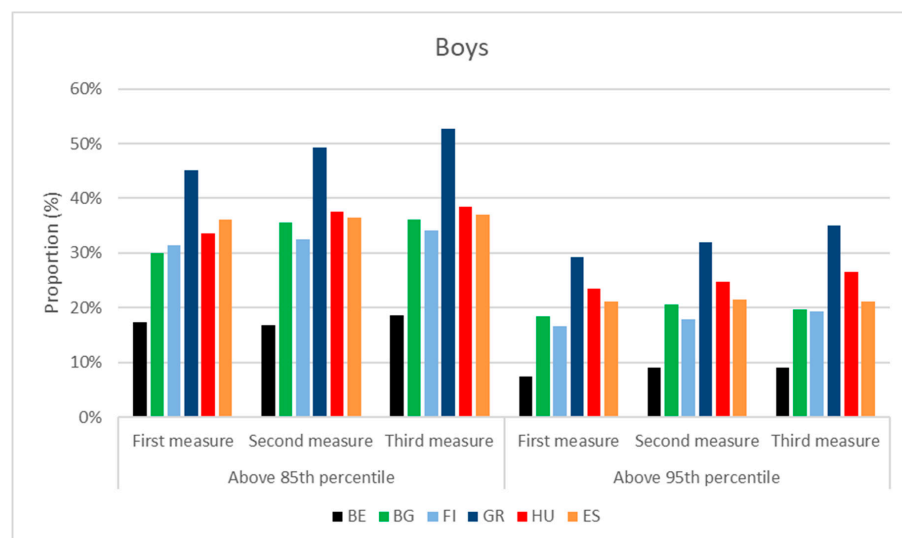


Figure 7. BMI distribution of boys at the time of 3 consecutive anthropometric measurements, performed during the project. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES = Spain).

Among the population of girls, the Greeks represented the greatest proportion in the overweight range, depending on the time of measurements; in total, 41–44% of them were above the percentile of 85. The Spanish were in the second position (32–34%), followed by the Bulgarian (31–33%) and Hungarian girls (29–31%), and thereafter Finnish (27–28%) and Belgian girls (20–21%).

The trend in the distributions of obese girls above the 95 percentile was similar. Greek girls (23–25%) were followed by the Hungarians (19%), Spanish (17–18%) and Bulgarians (16–17%). Fifteen percent of Finnish and 9% of Belgian girls were considered obese. Their distributions are presented in Figure 8.

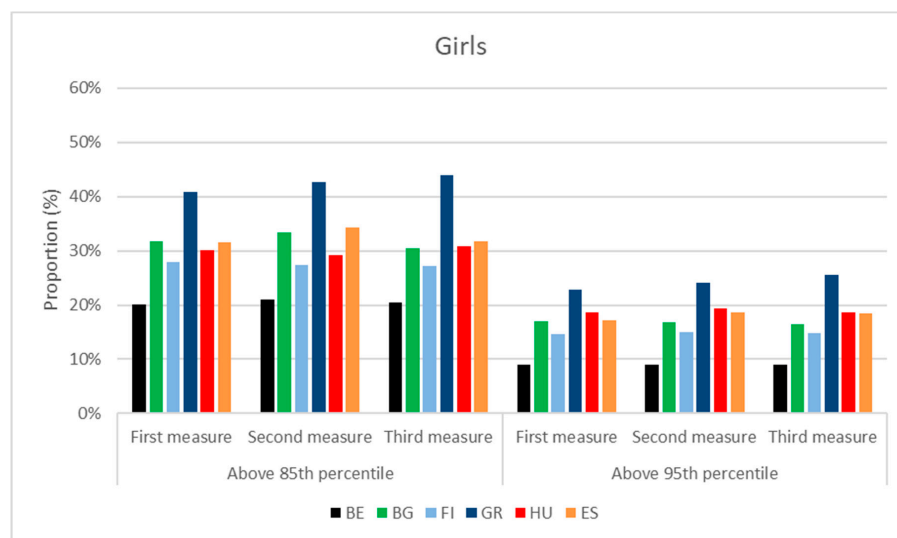


Figure 8. BMI distribution of girls at the time of 3 consecutive anthropometric measurements, performed during the project. (BE = Belgium; BG = Bulgaria; FI = Finland; GR = Greece; HU = Hungary; ES = Spain).

5. Discussion

5.1. Main Findings

The presented figures provide recent and professionally measured, reliable anthropometric data of a large populations of children from six European countries.

Some of them can be emphasized: Belgian boys had the lowest body weight and height, Greek boys had the highest body weight, and Finnish had the highest body height in almost all age cohorts. The highest proportion of overweight and obese boys was in Greece, followed by Hungarian, Spanish, Bulgarian and Finnish boys. Belgian boys had the lowest ratio in both categories.

Among girls, the Greeks had the highest, the Belgians had the lowest body weight, and the Finnish were the highest in all age categories. The ratio in the overweight range was the highest in Greece, followed by Spanish, Bulgarian and Hungarian girls, who were second in the obese category. Finnish girls had lower and Belgian girls had the lowest ratio in both BMI categories.

These small differences found between countries could be explained by the genetic background and environmental differences between these nations, similar to the anthropometric data of their adult populations [17]. Within these six countries, native populations are dominant, and a higher ratio of immigrants is present only in Belgium and Spain without unknown genetic influences.

5.2. Comparison to Previous Research

There have been many studies with anthropometric measurements of children. Almost all similar anthropometric data were recorded from eight different European countries by the *IDEFIC Study* [18]. The *WHO Child Growth Standards* described data between

5- and 19-year aged children [19]. Most of our data correspond to these and to the Finnish survey [20]. None of these studies compared national data, while only a small overlap was observed between the countries involved. Most of them had much fewer participants.

Some of the follow-up projects have proved the importance of school environment and individual lifestyle on children. In the COSI studies (*European Childhood Obesity Surveillance Initiative*), higher scores corresponded to higher support for a healthy school nutrition environment. Bulgaria, Greece and Hungary were among the low-score countries [21].

Anthropometric data recorded in the consecutive COSI studies (children aged 7–9 years) showed differences between countries. The order of overweight boys was: Greece and Spain (43%), Bulgaria (30%), Finland and Hungary (28%). These figures for obesity were from Greece (20%), Spain (18%), Bulgaria (16%), Hungary (14%) and Finland (12%). Among the pupils of the other gender, 41% of the Spanish, 37% of Greeks, and 28% of the Bulgarian and Hungarian girls were overweight, while only 26% were found in Finland. The measured ratio of obesity among girls was: 16% in Spain, 14% in Greece, 12% in Bulgaria and Hungary, and only 8% in Finland. In a very small ratio, obesity was less frequent among children of higher-educated parents [22]. Compared to our findings, the leading countries were the same; differences could be considered for the different cohorts examined. Considering the normal growth of children, differences in body parameters between genders were smaller than in the later age among adolescents [23].

The EU *Childhood Obesity Project* (CHOP) had a 5 year long follow-up period. Its main finding was that higher physical activity and lower sedentary behavior were the most effective tools for obesity prevention [24]. Different methods of recruitment could result in similar findings as well [25,26]. The methodology of these studies differed from the *Feel4Diabetes Study*, although there was wide agreement on the appropriate tools for obesity prevention and the importance of the topic.

5.3. Strengths and Limitations of the Study

The strengths of our study included a large sample size of measured children and a standardized method of measurement (conducted by trained researchers, not based on parents' reports). We did not find data sources from other countries where the real representation of national cohorts would be clearly described to help the appropriate comparison. To the best of our knowledge, no studies have been previously conducted investigating and following parallel the anthropometric parameters of children in more European countries.

This presentation of data had many limitations:

There were differences in the number of children measured at different age groups in different countries. In some of them, certain age groups were underrepresented.

Due to the nature of the collected and presented data, comparisons between different strata should be handled with special caution because, when several comparisons were made, the probability of the family-wise error could increase, which could lead to the production of false discoveries, therefore distorting the understanding of the results.

The populations examined could not be considered representative at a national level, although no comparable national data were found even without representatives. Although in some countries, low SES areas were targeted, the educational level of parents and their economic circumstances were not surely homogeneous. The socio-economic circumstances of the children's families may influence their individual somatic development.

While the *F4D study* had only a 2-year-long follow-up period, the data of these children was not available before and after the project.

The ongoing *F4D* project may have a certain effect on the parameters of children.

The year-long age cohorts compared (i.e., 6.0–6.99 y, etc.) could be too wide in this growing period of children, but we had no other option for the categorization of these measurements.

Mainly comparisons between countries and trends were described. It would be irrational to count the statistical analysis between countries; therefore, only some Hungary-related findings were described.

6. Conclusions

The main findings of this study support the importance of early obesity prevention. While other published outcomes of this 2-year long project are not presented here, it became clear that life-long interventions for the entire population and more political-economical support are needed, in addition to appropriate education on healthy lifestyles in schools, within the family and in the mass media as well.

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Institutional Review Board Statement: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the ethics committees in all countries (in Belgium, by the Medical Ethics Committee of the Ghent University Hospital; in Bulgaria, by the Ethics Committee of the Medical University of Varna; in Finland, by the hospital district of Southwest Finland ethical committee; in Greece, by the Bioethics Committee of Harokopio University; in Hungary, by the National Committee for Scientific Research in Medicine; in Spain, by the Clinical Research Ethics Committee). Written informed consent was obtained from all subjects (all parents/caregivers provided a signed informed consent form before being enrolled in the study). *Feel4Diabetes-study* was registered at clinicaltrials.gov; the registration number is NCT02393872.

Informed Consent Statement: Written informed consent was obtained from all subjects (all parents/caregivers provided a signed Informed consent form before being enrolled in the study).

Data Availability Statement: The datasets generated and/or analyzed during the current study are not publicly available due to the contract between the partners and the funding body but are available from the corresponding author on reasonable request.

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