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Research Article

WHO European Childhood Obesity Surveillance Initiative: Impact of Type of Clothing Worn during Anthropometric Measurements and Timing of the Survey on Weight and Body Mass Index Outcome Measures in 6–9-Year-Old Children

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Background. The World Health Organization European Childhood Obesity Surveillance Initiative (COSI) conducted examinations in 6–9-year-old children from 16 countries in the first two rounds of data collection. Allowing participating countries to adhere to their local legal requirements or adapt to other circumstances required developing a flexible protocol for anthropometric procedures. *Objectives*. (1) Review intercountry variation in types of clothing worn by children during weight and height measurements, clothes weight adjustments applied, timing of the survey, and duration of data collection; (2) assess the impact of the observed variation in these practices on the children's weight or body mass index (BMI) outcome measures. *Results*. The relative difference between countries' unadjusted and clothes-adjusted prevalence estimates for overweight was 0.3–11.5%; this figure was 1.4–33.3% for BMI-for-age Z-score values. Monthly fluctuations in mean BMI-for-age Z-score values did not show a systematic seasonal effect. The majority of the monthly BMI-for-age Z-score values did not differ statistically within a country; only 1–3 monthly values were statistically different within some countries. *Conclusions*. The findings of the present study suggest that the built-in flexibility in the COSI protocol concerning the data collection practices addressed in the paper can be kept and thus do not necessitate a revision of the COSI protocol.

1. Introduction

In 2013, 42 million children under five years old were overweight or obese, and, in 2014, more than 1.9 billion adults aged 18 years and older were overweight or obese, according to the World Health Organization's (WHO) global estimates [1]. Halting the rise in the proportion of overweight children, adolescents, and adults is one of the nine targets of the global monitoring framework on noncommunicable diseases [2]. In order to monitor the magnitude of this public health problem at the population level and to interpret and compare prevalence estimates of overweight and obesity across countries in a meaningful way, valid anthropometric measurements, such as body weight and height, are crucial [3]. For example, the choice and validation of equipment, adherence to measurement protocols, and level of training among field staff are critical aspects that apply to all settings in which these measures are taken and used [4].

The WHO European Childhood Obesity Surveillance Initiative (COSI) was established in 2006 with the aim to set up a harmonized surveillance system across the WHO European Region in order to monitor the progress of the obesity epidemic and to make intercountry comparisons within the Region [5]. The system includes weight and height measurements of primary-school children aged 6–9 years whereby each participating country ensures that data are collected according to the common COSI protocol [6, 7]. To enable countries to adhere to the protocol according to country-specific legal and ethical requirements (e.g., those that prohibit the collection of entire birth dates of children or those that require active written parental consent) or to adapt to other local circumstances (e.g., schools that do not provide education in the morning), some intercountry variation in data collection procedures has been permitted. Identifying intercountry variations in data collection procedures is essential in order to assess the validity and precision of cross-country comparisons and may lead to changes in future monitoring practices.

The COSI protocol allows flexibility in terms of (1) methodological factors associated with the examiner (e.g., the selection of the examiners or the duration of training that was provided to them); (2) methodological factors associated with the child (e.g., age determination of the child based on complete dates of birth and complete dates of measurement or only on month and year of birth or month and year of the measurement timing); and (3) other data collection practices (e.g., choice of anthropometric measurement equipment, timing and duration of data collection during the school year, the time of day when measurements were taken, and types of clothing worn by children during their weight and height measurements) [5].

This paper focuses on the third group of data collection practices for which intercountry differences were observed during the COSI rounds that took place in school years 2007/2008 and 2009/2010. In particular, two practices will be addressed for which data were available for all measured children: (1) the type of clothing worn by children during their weight and height measurements and the weight adjustments applied by the participating countries for the clothes worn and (2) the timing of the survey within a COSI data collection round and the duration of the anthropometric measurements. The purpose of this paper is to determine the impact of the observed intercountry differences of these two practices on the estimates of countries' mean age-adjusted Z-score values of children's weight or body mass index (BMI) and on the countries' prevalence estimates of overweight or obesity. If the results suggest a possible impact that could not be corrected in the data analyses, we would need to revise the protocol in order to minimize intercountry variations in future COSI rounds.

2. Materials and Methods

2.1. COSI Project. At the first consultation with Member States in 2005 [8] in the process leading to the WHO European Ministerial Conference on Counteracting Obesity in 2006 [9], Member States recognized the need for harmonized surveillance systems among primary-school children, which would include measured weight and height data on which policy development within the Region could be based. The

WHO Regional Office for Europe and some Member States established COSI in response to this need [5]. The first COSI data collection round took place in school year 2007/2008, with 13 countries participating: Belgium (Flemish region), Bulgaria, Cyprus, Czech Republic, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia, and Sweden. The second round was conducted in school year 2009/2010, with four new countries joining—Greece, Hungary, Spain, and the former Yugoslav Republic of Macedonia—and two initial countries deciding not to participate in the second round (Bulgaria and Sweden) [5]. All countries' datasets, except those from Cyprus in rounds 1 and 2 and Malta in round 2, were delivered in line with the COSI protocol [6, 7] and are used for this paper.

COSI targets 6-, 7-, 8- and 9-year-old children whereby countries can choose one or more of these four age groups. The entire population of interest was included by Belgium (Flemish region) and Malta (all second grade primary-school classes). Nationally representative samples of children were drawn in all other countries in which most of them applied a two-stage cluster sampling using the primary school as the primary sampling unit and school classes as the secondary sampling unit. Further details about the sampling procedures in each country have been described elsewhere [5, 10, 11]. Because data from Madeira were collected one year after the other Portuguese regions in both rounds, these data were excluded from the Portuguese dataset. In addition, the data collected in the Czech Republic from October to December 2009 and from January to April 2011 in round 2 were not taken into account. This way, the time span in round 2 for the Czech Republic was kept the same as the time span in round 1 (January–December) and did not go beyond one year.

The COSI protocol [6, 7] is in accordance with the international ethical guidelines for biomedical research involving human subjects [12]. Depending on country policies, the procedures were approved by local ethical committees. Parents were fully informed about all study procedures, and their informed consent was obtained. Children's consent was obtained prior to the anthropometric measurements, and confidentiality of all collected and archived data was ensured [5].

2.2. Adjusting for the Weight of Clothes. The COSI protocol for both data collection rounds indicates that during anthropometry children should wear normal, light indoor clothing without shoes or socks [6, 7]. If this was not the case, the children were asked to take off all heavy clothing (coats, sweaters, jackets, etc.), their shoes, and socks. They were also asked to remove wallets, mobile phones, key chains, belts, or any other objects, including hair ornaments, and braids were undone. The clothes worn by a child during the weight and height measurements were indicated on the examiner's record form by using four predefined types of clothing: "underwear only," "gym clothes (e.g., shorts and t-shirt only)," "light clothing (e.g., t-shirt, cotton trouser, or skirt)," or "heavy clothing (e.g., sweater and jeans)." When an examiner found it difficult to choose one of these four answer options, the examiner had to specify the clothes in detail, had to select the answer option "other," and had to make an estimate of the weight of these clothes afterwards.

In the data elaboration, we adjusted the measured body weight values for the weight of the clothes worn by the children during anthropometry. For the countries that preferred to use their own clothes adjustment weights for the four predefined types of clothing, these country-specific adjustment weights were used. The country-specific adjustment weights were obtained by measuring a sample of clothes for each type of clothing or taken from other country surveys. For those countries that did not have their own clothes adjustment weights, we used for each of the four predefined types of clothing the average of the clothes adjustment weights provided by Bulgaria, Latvia, Lithuania, Malta, Norway, Portugal, and Sweden in round 1, hereafter called "average non-country-specific adjustment weights."

2.3. Timing of the Survey. The COSI protocol for both rounds indicates that data should be collected once in a given school year [6, 7]. Having the data collection taken place during the same time period of the year was not mandatory. Thus, countries could decide the seasonal period when measurements could take place. However, it was specified that data collection should be avoided during the first two weeks of a new school term or immediately after a major holiday. Countries were also requested to carry out the measurements in all sampled children over the shortest possible period, preferably within four weeks and no longer than eight (round 1 protocol [6]) or 10 weeks (round 2 protocol [7]).

The date that weight and height measurements were taken was recorded for each child. This was mandatory for all countries in both rounds. For each country and for each round separately, we calculated the duration of data collection in days by subtracting the first measurement date from the last measurement date that appeared in a country-specific dataset.

2.4. Anthropometry. Children's weight and height were measured by fieldworkers who were trained in measuring according to WHO standardized techniques [3, 6, 7]. Body weight was measured in kilograms with portable digital scales (mainly manufacturer-calibrated) and recorded to the nearest 100 grams (0.1 kg). Body height was measured in centimetres, standing upright, with portable stadiometers and the reading was taken to the last completed 1 millimetre (0.1 cm). BMI was calculated using the formula: weight (kg) divided by height squared (m^2).

For each entire country-specific dataset by round, we computed, as outcome measures for the analyses, mean weight-for-age (W/A) and BMI-for-age (BMI/A) Z-scores and we estimated prevalence figures of overweight (BMI/A >+1 Z-score) and obesity (BMI/A >+2 Z-scores) using the 2007 WHO growth reference [13]. According to WHO criteria, the prevalence estimates for overweight children include those who are obese [3]. To evaluate the influence of the weight adjustments made for the clothes worn on these outcome measures, a first set of computed outcome measures was based on the unadjusted child's body weight measurement, and the second set was based on the body weight measure that was adjusted for the clothes worn using the average non-country-specific adjustment weights for the four predefined types of clothing. In addition, we computed a third set of outcome measures for the countries that provided their own country-specific clothes adjustment weights, whereby the body weight measure was adjusted for the clothes worn using these adjustment weights. We also calculated relative difference percentages between the unadjusted and clothes-adjusted Z-score values and prevalence figures.

In addition, in order to evaluate monthly fluctuations in mean BMI/A Z-score values, we split the entire data collection period of a country-specific dataset in each round in calendar months. By country and targeted age group, for each month that included at least 5% of the total group of measured children, we calculated the mean BMI/A Z-score value, whereby we used the clothes adjustment weights as applied by the countries. Children with a biologically implausible BMI/A Z-score value below −5 or above +5 relative to the WHO growth reference median [13] were excluded from these calculations.

2.5. Statistical Analyses. All statistical analyses, except the Games-Howell *post hoc* tests [14], were performed in Stata version 10.1 (StataCorp, College Station, TX, USA) and a P value of 0.05 was used to define statistical significance. The Games-Howell *post hoc* tests were performed in SPSS version 20.0 (IBM, Armonk, NY, USA).

2.5.1. Adjusting for the Weight of Clothes. Descriptive statistics (mean, standard deviation (SD), and interquartile range values for continuous variables and frequencies (%) for categorical variables) were used to summarize the types of clothing worn during the anthropometric measurements and the clothes adjustment weights applied for each country-specific dataset in both rounds. Analytical statistics included Pearson's chi-squared tests for categorical variables.

2.5.2. Timing of the Survey. For each country that measured children over a continuous period of three months or more in each round, whereby each month included at least 5% of the total group of measured children, a two-way analysis of variance (ANOVA) was applied to assess the statistical interaction of monthly period and sex of the child on mean BMI/A Z-score values by each of the four targeted age groups. This was to review whether further analyses would need to be done for boys and girls separately. In the case of a statistically significant interaction, a one-way ANOVA was performed to assess significant differences across monthly periods by sex. In the case of no significant interaction effect, two-way ANOVA without the interaction term (additive model) was performed to assess the main effects of monthly period and sex on the values. Moreover, Levene's test [15] was used to assess the homogeneity of variances between the monthly periods. In the cases of heterogeneity of variances, of a significant main effect of monthly period in the one-way ANOVA models for boys or girls, or of a significant main effect of monthly period in the two-way ANOVA additive model, the Games-Howell *post hoc* test [14] was applied for the multiple comparisons of mean BMI/A Z-score values between monthly periods. Eligible country-specific datasets for these comparative analyses of anthropometric outcome measures across at least three calendar months came from Belgium, Czech Republic, and Sweden in round 1 and from Belgium, Czech Republic, Greece, Lithuania, and Spain in round 2.

3. Results

3.1. Adjusting for the Weight of Clothes. A total of 168 864 children (85 906 boys and 82 858 girls) from 12 countries were included in the data analyses for round 1 and a total of 224 920 children (114 457 boys and 110 463 girls) were from 13 countries for round 2. Table 1 displays for both rounds the proportion of children that wore underwear only, gym clothes, light clothing, or heavy clothing when their weight and height were measured. The proportion of children wearing any of the first three mentioned types of clothing covered the entire range from 0% to 100% between countries, whereas the range for "heavy clothing" was slightly narrower (0–60.8%). Apart from some measurements in Latvia, Norway, Portugal, and Sweden (see Table 1), examiners generally did not find it difficult to choose one of the four predefined answer options for the clothes worn by a child. In both rounds, the distribution of the number of anthropometric measurements over the four predefined types of clothing was different for the various countries (Pearson's chi-squared test $P < 0.001$).

Table 2 presents the adjustment weights as applied by the countries for each type of clothing. Ten countries used their own clothes adjustment weights for the predefined types of clothing. The other countries used the average non-country-specific clothes adjustment weights for the four categories: "underwear only": 0 grams, "gym clothes": 130 grams, "light clothing": 195 grams, and "heavy clothing": 600 grams. Table 2 also presents the overall mean clothes adjustment, as obtained by multiplying the clothes adjustment weights used for each type of clothing with the proportion in which each type of clothing occurred. For those 10 countries with their own adjustment weights, an overall mean country-specific clothes adjustment could be calculated, resulting in an average weight adjustment of 244 grams in round 1 and 302 grams in round 2. It should be noted that some of these countries did not use all predefined types of clothing (see Table 2). For all countries, an overall mean clothes adjustment was calculated using the average non-country-specific adjustment weights. The use of these average clothes adjustments resulted in an average body weight adjustment of 190 grams in round 1 and 179 grams in round 2. For those 10 countries with their own adjustment weights, the overall mean country-specific clothes adjustment was higher than the overall mean non-country-specific clothes adjustment, 18 grams in round 1 and 93 grams in round 2 (Table 2).

Table 3 shows the unadjusted and clothes-adjusted mean W/A Z-score values and mean BMI/A Z-score values for each country by round. Reviewing the 10 countries in Table 3 that used their own country-specific clothes adjustments, the unadjusted and country-specific clothes-adjusted mean W/A Z-score and BMI/A Z-score values were the same for

Table 1: Proportion (%) of children aged 6–9 years wearing different types of clothing during their weight and height measurements by COSI round and country.

Round and country	Targeted age group (years)	Sample size* (n)	Clothes worn when weight and height were measured (%)				
			Underwear only	Gym clothes	Light clothing	Heavy clothing	Other†
Round 1							
Belgium	6, 7, 8, 9	126 078	ND	100	ND	ND	ND
Bulgaria	7	2511	17.68	26.96	50.34	5.02	0
Czech Republic	7	915	99.23	0.11	0.66	0	0
Ireland	7	2383	0	3.73	93.24	3.02	0
Italy	8, 9	7997	0.13	0.54	38.50	60.84	0
Latvia	7	3251	20.79	10.77	49.65	18.79	0
Lithuania	7	3309	6.44	18.98	53.37	21.21	0
Malta	6	2115	ND	ND	100	ND	ND
Norway	8	2834	0	ND	53.92	37.93	8.15
Portugal	7	1815	84.24	7.11	6.83	1.27	0.55
Slovenia	6, 7, 8	11 940	ND	100	ND	ND	ND
Sweden	7, 8	3716	5.54	83.88	7.75	1.53	1.29
Round 2							
Belgium	6, 7, 8, 9	133 156	ND	100	ND	ND	ND
Czech Republic	7	1271	97.72	0.24	1.81	0.24	0
Greece	7, 9	5269	0.15	75.59	18.03	6.23	0
Hungary	7	1235	34.74	14.01	44.45	6.80	0
Ireland	7, 9	1986	0	1.41	93.81	4.78	0
Italy	8, 9	41 672	0.15	1.08	39.96	58.81	0
Latvia	7	2838	21.39	15.61	52.64	8.14	2.22
Lithuania	7, 9	6721	35.35	10.73	50.96	2.96	0
Norway	8	2621	0	ND	64.82	30.60	4.58
Portugal	7	1813	68.95	3.81	22.12	3.25	1.88
Slovenia	6, 7, 8, 9	15 938	ND	100	ND	ND	ND
Spain	6, 7, 8, 9	7656	ND	ND	100	ND	ND
The former Yugoslav Republic of Macedonia	7	2744	ND	ND	100	ND	ND

COSI: Childhood Obesity Surveillance Initiative; ND: not determined because the country did not use this type of clothing in the questionnaire to describe the clothes worn by the child when anthropometric measures were taken.
*Only children whose age fell within the country-specific targeted age group(s) were included.
†This answer option was selected when an examiner found it difficult to choose one of the other four predefined answer options for the clothes worn by a child.

Table 2: Adjustment weights (grams) for different types of clothing as applied by the countries and weighted mean clothes adjustment (grams) for the entire country dataset by COSI round and country.

Round and country	Clothes adjustment weights (grams)					Weighted mean clothes adjustment (grams)*		
	Underwear only	Gym clothes	Light clothing	Heavy clothing	Other[†]	Country-specific[‡]	Non-country-specific[§]	Absolute change country-specific non-country-specific
Round 1								
Belgium[#]	0	130	195	600	ND	NA	130	NA
Bulgaria	85	220	270	590	ND	240	163	−77
Czech Republic[#]	0	130	195	600	ND	NA	1	NA
Ireland[#]	0	130	195	600	ND	NA	205	NA
Italy	0–92[¶]	137–250[¶]	260–450[¶]	455–734[¶]	ND	478	441	−37
Latvia	0	165	300	800	ND	317	224	−93
Lithuania	0	265	380	625	ND	386	256	−130
Malta	ND	ND	230	ND	ND	230	195	−35
Norway	0	ND	100	500	0–500[¶]	275	364	+89
Portugal	0	0	0	600	0	8	30	+22
Slovenia[#]	0	130	195	600	ND	NA	130	NA
Sweden	0	0	100	500	0–500[¶]	17	135	+118
Interquartile range	0[‖]	220[‖]	200[‖]	125[‖]	ND	228	110	141[!!]
Mean (SD)	14 (35)[‖]	130 (124)[‖]	197 (134)[‖]	603 (110)[‖]	ND	244 (164)	190 (125)	−18 (88)[¡]
Round 2								
Belgium[#]	0	130	195	600	ND	NA	130	NA
Czech Republic[#]	0	130	195	600	ND	NA	5	NA
Greece[#]	0	130	195	600	ND	NA	171	NA
Hungary[#]	0	130	195	600	ND	NA	146	NA
Ireland[#]	0	130	195	600	ND	NA	213	NA
Italy	28–92[¶]	108–250[¶]	252–449[¶]	455–826[¶]	ND	470	432	−38
Latvia	0	165	300	800	130–800[¶]	254	177	−77
Lithuania	0	265	380	625	ND	241	131	−110
Norway	0	ND	100	500	0–500[¶]	236	328	+92
Portugal	0	100	400	600	0–400[¶]	112	68	−44
Slovenia	ND	300	ND	ND	ND	300	130	−170
Spain[#]	0	130	195	600	ND	NA	195	NA
The former Yugoslav Republic of Macedonia	ND	ND	500	ND	ND	500	195	−305

Table 2: Continued.

Round and country	Clothes adjustment weights (grams)					Weighted mean clothes adjustment (grams)*		
	Underwear only	Gym clothes	Light clothing	Heavy clothing	Other†	Country-specific‡	Non-country-specific§	Absolute change country-specific non-country-specific
Interquartile range	0‖	150‖	100‖	163‖	ND	234	65	132‼
Mean (SD)	0 (0)‖	208 (92)‖	336 (150)‖	631 (125)‖	ND	302 (138)	179 (108)	−93 (123)¦

COSI: Childhood Obesity Surveillance Initiative; NA: not applicable because the country did not use its own clothes adjustment weights; ND: not determined, because none of the children were classified into this category; SD: standard deviation.
*The weighted mean of the clothes adjustment weights for the entire country dataset was calculated by firstly multiplying the clothes adjustment weight used for each type of clothing by a country and the proportion that each type of clothing occurred in a dataset and secondly by adding up the weighted mean for each type of clothing.
†This answer option was selected when an examiner found it difficult to choose one of the four other predefined answer options for the clothes worn by a child.
‡The country-specific clothes adjustment weights that were provided for all predefined types of clothing were applied to calculate the weighted mean of the clothes adjustment weights for the entire country dataset.
§The average non-country-specific clothes adjustment weights were applied for the four predefined answer options ("underwear only": 0 grams, "gym clothes": 130 grams, "light clothing": 195 grams, and "heavy clothing": 600 grams) and country-specific clothes adjustment weights for the option "other" (if applicable) to calculate the weighted mean of the clothes adjustment weights for the entire country dataset.
#This country did not provide its own country-specific clothes adjustment weights; thus, the average non-country-specific adjustment weights were applied, based on the single country-specific adjustment weights provided by Bulgaria, Latvia, Lithuania, Malta, Norway, Portugal, and Sweden for each predefined type of clothing in round 1.
¶Various adjustment weights, based on a description of the clothes worn, were used; hence, a range is indicated.
‖All single country-specific clothes adjustment weights for a type of clothing (except those from Italy) were included in the calculation of these values.
‼The interquartile range of the absolute change values of the countries is given.
¦The mean (SD) of the absolute change values of the countries is given.

Table 3: Unadjusted and clothes-adjusted mean values of weight-for-age Z-score and BMI-for-age Z-score of children aged 6–9 years* and relative difference between the unadjusted and clothes-adjusted values, by COSI round and country.

Round and country	Mean W/A Z-score			Relative difference between unadjusted and clothes-adjusted mean W/A Z-score (%)		Mean BMI/A Z-score			Relative difference between unadjusted and clothes-adjusted mean BMI/A Z-score (%)	
	Unadjusted	Clothes-adjusted country-specific†	Clothes-adjusted non-country-specific‡	Country-specific†	Non-country-specific‡	Unadjusted	Clothes-adjusted country-specific†	Clothes-adjusted non-country-specific‡	Country-specific†	Non-country-specific‡
Round 1										
Belgium	0.43	NA	0.40	NA	−7.0	0.28	NA	0.24	NA	−14.3
Bulgaria	0.47	0.41	0.43	−12.8	−8.5	0.44	0.35	0.38	−20.5	−13.6
Czech Republic	0.51	NA	0.51	NA	0	0.17	NA	0.17	NA	0
Ireland	0.61	NA	0.56	NA	−8.2	0.62	NA	0.55	NA	−11.3
Italy	0.92	0.82	0.83	−10.9	−9.8	1.01	0.88	0.89	−12.9	−11.9
Latvia	0.62	0.54	0.56	−12.9	−9.7	0.38	0.26	0.30	−31.6	−21.1
Lithuania	0.72	0.63	0.66	−12.5	−8.3	0.42	0.28	0.33	−33.3	−21.4
Malta	0.55	0.48	0.49	−12.7	−10.9	0.74	0.64	0.66	−13.5	−10.8
Norway	0.60	0.54	0.52	−10.0	−13.3	0.37	0.29	0.26	−21.6	−29.7
Portugal	0.68	0.68	0.67	0	−1.5	0.72	0.72	0.71	0	−1.4
Slovenia	0.82	NA	0.79	NA	−3.7	0.49	NA	0.45	NA	−8.2
Sweden	0.59	0.59	0.56	0	−5.1	0.31	0.31	0.27	0	−12.9
Round 2										
Belgium	0.43	NA	0.39	NA	−9.3	0.27	NA	0.22	NA	−18.5
Czech Republic	0.58	NA	0.57	NA	−1.7	0.28	NA	0.28	NA	0
Greece	1.18	NA	1.15	NA	−2.5	1.09	NA	1.05	NA	−3.7
Hungary	0.61	NA	0.57	NA	−6.6	0.39	NA	0.33	NA	−15.4
Ireland	0.56	NA	0.51	NA	−8.9	0.55	NA	0.49	NA	−10.9
Italy	0.85	0.76	0.76	−10.6	−10.6	0.90	0.77	0.78	−14.4	−13.3
Latvia	0.60	0.54	0.56	−10.0	−6.7	0.36	0.27	0.30	−25.0	−16.7
Lithuania	0.63	0.58	0.60	−7.9	−4.8	0.31	0.24	0.27	−22.6	−12.9
Norway	0.68	0.63	0.61	−7.4	−10.3	0.48	0.41	0.38	−14.6	−20.8
Portugal	0.68	0.66	0.67	−2.9	−1.5	0.66	0.62	0.63	−6.1	−4.5
Slovenia	0.82	0.75	0.79	−8.5	−3.7	0.50	0.40	0.46	−20.0	−8.0
Spain	0.89	NA	0.85	NA	−4.5	0.89	NA	0.83	NA	−6.7
The former Yugoslav Republic of Macedonia	0.77	0.64	0.72	−16.9	−6.5	0.77	0.58	0.69	−24.7	−10.4

BMI: body mass index; BMI/A: BMI-for-age; COSI: Childhood Obesity Surveillance Initiative; NA: not applicable because the country did not use its own clothes adjustment weights; W/A: weight-for-age.

*Only children whose age fell within the country-specific targeted age group(s) were included (see Table 1).

†Body weight was adjusted for the clothes worn when measured using country-specific adjustment weights for all four predefined types of clothing and the clothing answer option "other."

‡Body weight was adjusted for the clothes worn when measured using the average non-country-specific adjustment weights for the four predefined types of clothing "underwear only," "gym clothes," "light clothing," and "heavy clothing," and country-specific adjustment weights for the clothing answer option "other."

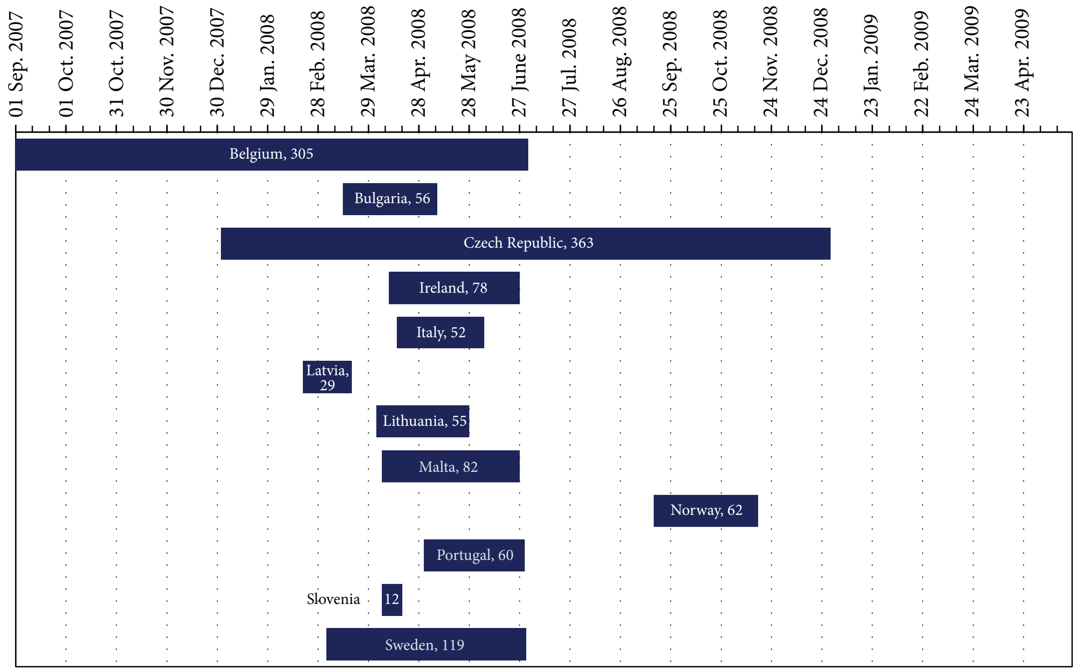

FIGURE 1: Time span of data collection and number of days over which the anthropometric measurements were taken in children aged 6–9 years (only children whose age fell within the country-specific targeted age group(s) were included (see Table 1)) by 12 countries in COSI round 1. COSI: Childhood Obesity Surveillance Initiative. *Notes*. The interval between the major vertical lines is 30 days. The numbers in the blue bars represent the duration in days of the data collection period, which was calculated by subtracting the first measurement date from the last measurement date in the country-specific dataset.

Portugal and Sweden in round 1. The unadjusted mean W/A Z-score values were reduced by 10–13% in round 1 and by 3–17% in round 2 when body weight was adjusted for the clothes worn. The country-specific clothes-adjusted mean BMI/A Z-score values were 13–33% lower in round 1 and 6–25% lower in round 2 than the unadjusted values. In absolute terms, the country-specific clothes-adjusted mean BMI/A Z-score values in Bulgaria, Italy, Latvia, Lithuania, Malta, Norway, Portugal, and Slovenia were about 0.04–0.14 Z-score lower than the unadjusted values, and in the former Yugoslav Republic of Macedonia it was 0.19 Z-score lower. Furthermore, Table 3 highlights that the use of the average non-country-specific clothes adjustments led to smaller reductions of the unadjusted values than the use of country-specific clothes adjustments in all countries except Norway (both rounds), Portugal (round 1), and Sweden (round 1). In general, the country-specific clothes-adjusted W/A Z-score values were 1.1–10.4% higher than the non-country-specific clothes-adjusted values, relative to the unadjusted values; the country-specific clothes-adjusted BMI/A Z-score values were 1.0–14.3% higher than the non-country-specific clothes-adjusted values, relative to the unadjusted values.

Table 4 gives the unadjusted and clothes-adjusted overweight and obesity prevalence estimates for each country by round. Irrespective of the kind of clothes adjustment weights used (country-specific or average non-country-specific ones), Table 4 indicates that the clothes-adjusted overweight prevalence estimates were relatively lower than the unadjusted estimates by as much as 12%, and the clothes-adjusted obesity prevalence estimates were relatively lower than the unadjusted estimates by as much as 10%. Referring to the 10 countries with their own clothes adjustment weights, Table 4 also suggests that the use of the average non-country-specific clothes adjustments led to smaller reductions of the unadjusted overweight and obesity prevalence estimates than the use of country-specific clothes adjustments in all countries, except in Norway (both rounds), Portugal (round 1), and Sweden (round 1) where the opposite was observed. In general, the clothes-adjusted country-specific overweight estimates were 0.4–6.9% higher than the clothes-adjusted non-country-specific overweight estimates, relative to the unadjusted estimates; the clothes-adjusted country-specific obesity estimates were 0.7–4.8% higher than the clothes-adjusted non-country-specific obesity estimates, relative to the unadjusted estimates.

3.2. Timing of the Survey. Figure 1 portrays that in round 1 the majority of the countries started the anthropometric data collection in the first semester of 2008. Figure 2 illustrates that, in round 2, seven countries started the anthropometric data collection in the first semester of 2010 and five countries in the second semester of 2010. Furthermore, five out of 12 countries in round 1 took the anthropometric measures within the indicated period of maximum eight weeks (or

Table 4: Unadjusted and clothes-adjusted prevalence of overweight (including obesity) and prevalence of obesity in children aged 6–9 years* and relative difference between the unadjusted and clothes-adjusted values, by COSI round and country.

Round and country	Prevalence of overweight† (%)			Relative difference between unadjusted and clothes-adjusted prevalence of overweight (%)		Prevalence of obesity† (%)			Relative difference between unadjusted and clothes-adjusted prevalence of obesity (%)	
	Unadjusted	Clothes-adjusted country-specific‡	Clothes-adjusted non-country-specific§	Country-specific‡	Non-country-specific§	Unadjusted	Clothes-adjusted country-specific‡	Clothes-adjusted non-country-specific§	Country-specific‡	Non-country-specific§
Round 1										
Belgium	22.8	NA	21.9	NA	−3.9	7.4	NA	7.2	NA	−2.7
Bulgaria	29.4	28.3	28.8	−3.7	−2.0	13.1	12.6	12.7	−3.8	−3.1
Czech Republic	21.0	NA	21.0	NA	0	7.9	NA	7.9	NA	0
Ireland	31.4	NA	29.5	NA	−6.1	9.8	NA	9.3	NA	−5.1
Italy	48.4	45.2	45.4	−6.6	−6.2	23.1	21.8	21.8	−5.6	−5.6
Latvia	24.3	21.6	22.4	−11.1	−7.8	7.4	6.7	7.0	−9.5	−5.4
Lithuania	25.8	23.0	24.1	−10.9	−6.6	9.3	8.4	8.6	−9.7	−7.5
Malta	35.1	32.4	32.7	−7.7	−6.8	14.5	13.9	13.9	−4.1	−4.1
Norway	25.2	23.0	22.3	−8.7	−11.5	7.2	6.7	6.5	−6.9	−9.7
Portugal	38.1	38.1	38.0	0	−0.3	14.8	14.8	14.7	0	−0.7
Slovenia	31.3	NA	30.3	NA	−3.2	12.7	NA	12.4	NA	−2.4
Sweden	24.2	24.1	23.3	−0.4	−3.7	7.4	7.3	7.2	−1.4	−2.7
Round 2										
Belgium	22.4	NA	21.5	NA	−4.0	7.5	NA	7.3	NA	−2.7
Czech Republic	24.2	NA	24.2	NA	0	9.1	NA	9.1	NA	0
Greece	51.2	NA	50.4	NA	−1.6	24.4	NA	23.6	NA	−3.3
Hungary	28.0	NA	27.0	NA	−3.6	12.6	NA	12.3	NA	−2.4
Ireland	31.3	NA	29.5	NA	−5.8	8.7	NA	8.2	NA	−5.7
Italy	45.0	42.0	42.2	−6.7	−6.2	20.5	18.9	19.0	−7.8	−7.3
Latvia	24.8	23.4	23.8	−5.6	−4.0	9.7	9.2	9.3	−5.2	−4.1
Lithuania	24.8	23.5	24.0	−5.2	−3.2	9.1	8.5	8.8	−6.6	−3.3
Norway	29.5	27.7	27.0	−6.1	−8.5	9.4	9.0	8.7	−4.3	−7.4
Portugal	35.1	34.1	34.5	−2.8	−1.7	13.8	13.5	13.6	−2.2	−1.4
Slovenia	31.5	29.5	30.5	−6.3	−3.2	13.3	12.5	12.9	−6.0	−3.0
Spain	43.7	NA	41.9	NA	−4.1	17.8	NA	17.1	NA	−3.9
The former Yugoslav Republic of Macedonia	35.0	31.2	33.6	−10.9	−4.0	16.9	15.7	16.3	−7.1	−3.6

BMI/A: body mass index-for-age; COSI: Childhood Obesity Surveillance Initiative; NA: not applicable because the country did not use its own clothes adjustment weights; WHO: World Health Organization.
* Only children whose age fell within the country-specific targeted age group(s) were included (see Table 1).
† Prevalence estimates were based on the 2007 WHO recommended growth reference for school-age children and adolescents [13]. Overweight and obesity were defined as the proportion of children with a BMI/A value above +1 Z-score and above +2 Z-scores, respectively.
‡ Body weight was adjusted for the clothes worn when measured using country-specific adjustment weights for all four predefined types of clothing and the clothing answer option "other."
§ Body weight was adjusted for the clothes worn when measured using the average non-country-specific adjustment weights for the four predefined types of clothing "underwear only," "gym clothes," "light clothing," and "heavy clothing" and country-specific adjustment weights for the clothing answer option "other."

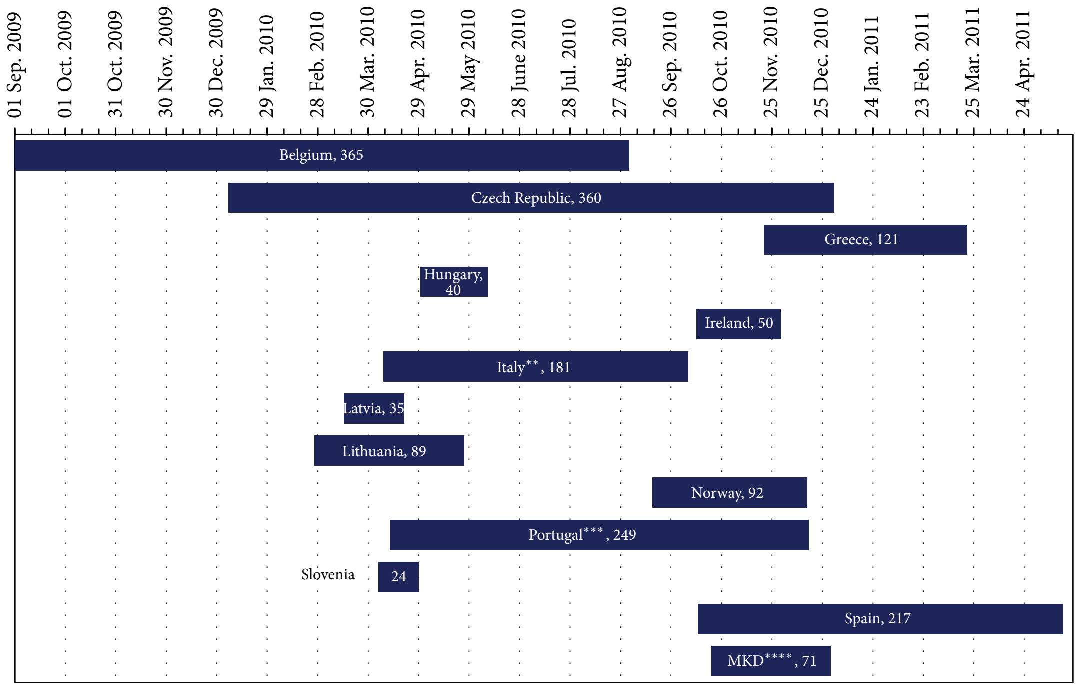

Figure 2: Time span of data collection and number of days over which the anthropometric measurements were taken in children aged 6–9 years (only children whose age fell within the country-specific targeted age group(s) were included (see Table 1)) by 13 countries in COSI round 2. COSI: Childhood Obesity Surveillance Initiative. *Notes*. The interval between the major vertical lines is 30 days. The numbers in the blue bars represent the duration in days of the data collection period, which was calculated by subtracting the first measurement date from the last measurement date in the country-specific dataset. **The majority of data were collected from April to June 2010. One local health unit in the Veneto Region (Italy) collected data from September to October 2010. No data were collected in July and August 2010. ***The majority of data were collected in May and June 2010. Few children were measured in April and December 2010. No data were collected from July to November 2010. ****MKD is the International Organization for Standardization (ISO) 3166-1 alpha-3 country code for the former Yugoslav Republic of Macedonia.

56 days) (Figure 1) and nearly five out of 13 countries in round 2 measured the children within ten weeks (or 70 days) (Figure 2). Belgium and Czech Republic took measures over almost an entire year period in both rounds.

Figure 3 shows the mean BMI/A Z-score values (combined sexes) by monthly period for each of the targeted age groups in the three eligible countries in round 1, and Figure 4 shows the mean BMI/A Z-score values by monthly period for each of the targeted age groups in the five eligible countries in round 2. No statistically significant differences in mean BMI/A Z-score values between monthly periods were observed in Czech Republic, Lithuania, and Sweden, whereas significant monthly fluctuations were observed in 6- and 9-year-olds in Belgium in round 1 (Figure 3) and in some of the targeted age groups in Belgium, Greece, and Spain in round 2 (Figure 4). Table 5 gives the results of the multiple comparisons that were performed for these three countries with statistically significant monthly fluctuations. A few monthly periods were different from the other ones. For instance, the mean BMI/A Z-score values among Belgian 9-year-olds in round 1 did not differ from October 2007 to April 2008 (range: 0.27–0.34) whereas the mean value of 0.16 for September 2007 was statistically significantly different. The mean values among Spanish 8-year-olds in round 2 did not statistically significantly differ between December 2010 and March 2011 (range: 0.73–0.90) and between January and April 2011 (range: 0.87–1.04).

4. Discussion

We have addressed in this paper two data collection practices for which the COSI protocol in rounds 1 and 2 allowed some flexibility. The aim was to assess the impact of this flexibility on weight or BMI outcome measures.

4.1. Adjusting for the Weight of Clothes. The first practice refers to the clothes worn by the children during measurement and the weights used to adjust for the children's measured body weight. According to the COSI protocol, children should wear light indoor clothing during the weight and height measurements. Although this was followed by 95% or more of the children in almost all countries, Latvia and Lithuania in round 1 and Italy and Norway in both rounds did not adhere to the standardization of this practice. In these four countries, 19–61% of the children wore heavy clothing (Table 1), probably due to low temperature in the measurement rooms. For example, because heating did not work appropriately in some schools in Latvia, the children could not be asked to take off their heavy clothing. On the other hand, adherence to this aspect of the protocol is not that

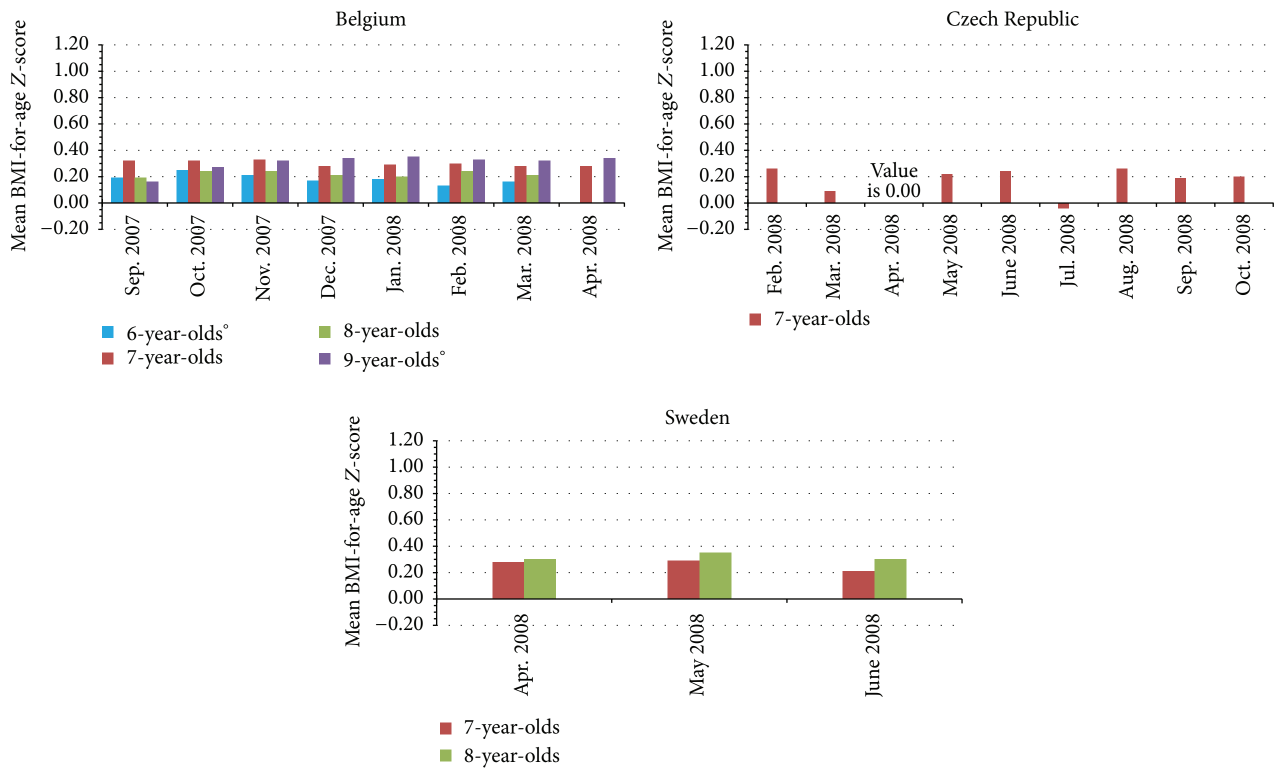

Figure 3: Mean BMI-for-age Z-score values in children aged 6–9 years by monthly period in three countries in COSI round 1. ANOVA: analysis of variance; BMI: body mass index; BMI/A: BMI-for-age; COSI: Childhood Obesity Surveillance Initiative; WHO: World Health Organization. *Notes.* Body weight was adjusted for the clothes worn: country-specific clothes adjustment weights by Sweden; average non-country-specific adjustment weights by Belgium and the Czech Republic. Only children whose age fell within the country-specific targeted age group(s) (see Table 1) and those with a BMI/A Z-score value between −5 and +5 relative to the WHO growth reference median [13] were included. By targeted age group, monthly BMI/A Z-score values were computed for the months that included at least 5% of the total group of children in a country-specific dataset. °Statistically significant difference of mean value across monthly periods for the indicated age group (two-way ANOVA without interaction term; $P \leq 0.0001$).

important, since we may adjust for the heavy clothing worn in the data elaboration of the measured body weight.

Although the examiners had four predefined options for the classification of the children's clothing, it is not surprising that most classifications of the children's clothing arrived in the first three options. This is most likely due to the protocol's description "wearing light indoor clothing." In fact, some countries (Belgium, Malta, Slovenia, Spain, and the former Yugoslav Republic of Macedonia) used one answer option for all children (e.g., "gym clothes" or "light clothing"), probably because it was organized that way. In Slovenia, for example, COSI is integrated into a procedure that assesses during physical education classes the growth and motor development (including measurements of weight and height) of children that fall within the COSI age range, which thus meant that all children wore gym clothes and not any other type of clothing [5].

The protocol allows countries to use country-specific clothes adjustment weights for each type of clothing. Since these adjustment weights differ significantly between countries, it seems wise to maintain country-specific adjustment weights. On the other hand, some countries did not collect country-specific data and used the average non-country-specific adjustment weights for each category, based on the values of other participating countries. The difference between the country-specific and the average non-country-specific weights was small, which resulted in a difference of 14% or less only between the clothes-adjusted country-specific and the clothes-adjusted non-country-specific outcome measures, relative to the unadjusted values. In future COSI rounds, if more country-specific adjustment weights become available and thus the average non-country-specific adjustment may be based on more data, then the difference between country-specific and average non-country-specific adjustments weights will probably become even less.

The next question is whether adjusting for the weight of clothes matters. The COSI sample size calculation is based on an 80% power to detect a minimum difference of 0.10 Z-score in mean BMI/A per year at a two-sided 5% significance level [6, 7]. In other words, a change in BMI/A Z-score of 0.10 unit per year is considered as important. A difference of around 0.10 Z-score between clothes-adjusted and unadjusted values was observed in some countries. The clothes adjustments applied seem to be important in assessing

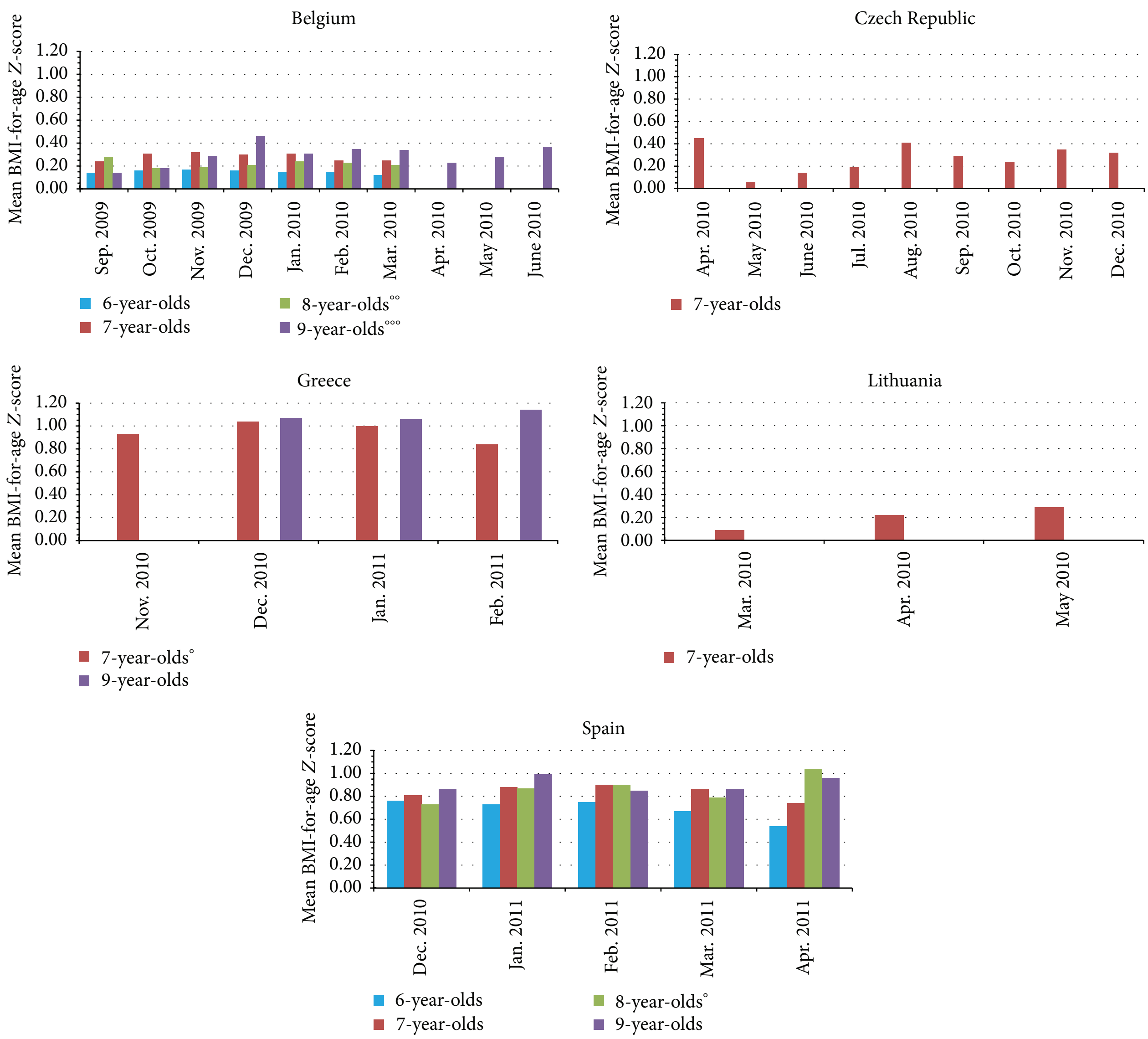

Figure 4: Mean BMI-for-age Z-score values in children aged 6–9 years by monthly period in five countries in COSI round 2. ANOVA: analysis of variance; BMI: body mass index; BMI/A: BMI-for-age; COSI: Childhood Obesity Surveillance Initiative; WHO: World Health Organization. *Notes*. Body weight was adjusted for the clothes worn: country-specific clothes adjustment weights by Lithuania; average non-country-specific adjustment weights by Belgium, the Czech Republic, Greece, and Spain. Only children whose age fell within the country-specific targeted age group(s) (see Table 1) and those with a BMI/A Z-score value between −5 and +5 relative to the WHO growth reference median [13] were included. By targeted age group, monthly BMI/A Z-score values were computed for the months that included at least 5% of the total group of children in a country-specific dataset. °Statistically significant difference of mean value across monthly periods for the indicated age group (two-way ANOVA without interaction term; $P < 0.05$). °°Statistically significant difference of mean value across monthly periods for the indicated age group (two-way ANOVA without interaction term; $P < 0.001$). °°°Statistically significant difference of mean value across monthly periods for the indicated age group (two-way ANOVA without interaction term; $P < 0.0001$).

the countries' absolute mean values of the BMI/A Z-score and the countries' overweight or obesity prevalence estimates and, consequently, in their intercountry comparisons in a data collection round. It would, thus, be advisable to continue adjusting for the clothes worn during the measurements, although the application of clothes weight adjustments may have less impact when studying the change over time of these outcome measures within a country (i.e., interround analyses). However, this would only be the case when the type of clothing worn and the country-specific adjustments weights applied will not be different between measurement rounds in a country.

Instead of using clothes adjustment weights for the clothes worn during the anthropometric measurements, the COSI protocol could require that all children should wear underwear only during the measurements. However, this could not be recommended if COSI were to remain a population surveillance system that is acceptable in all participating

Table 5: Mean BMI-for-age Z-score values in 6-, 7-, 8- and 9-year-olds in three countries with results of multiple comparisons procedures, by monthly period.

Monthly period	Mean BMI/A Z-score			
	6-year-olds	7-year-olds	8-year-olds	9-year-olds
Belgium, round 1				
Sep. 2007	0.19[a,b,c]	ND	ND	0.16[a]
Oct. 2007	0.25[b]	ND	ND	0.27[b]
Nov. 2007	0.21[a,b]	ND	ND	0.32[b]
Dec. 2007	0.17[a,c]	ND	ND	0.34[b]
Jan. 2008	0.18[a,c]	ND	ND	0.35[b]
Feb. 2008	0.13[c]	ND	ND	0.33[b]
Mar. 2008	0.16[a,c]	ND	ND	0.32[b]
Apr. 2008	NS	ND	ND	0.34[b]
Belgium, round 2				
Sep. 2009	ND	ND	0.28[a]	0.14[a]
Oct. 2009	ND	ND	0.18[b]	0.18[a]
Nov. 2009	ND	ND	0.19[b,c]	0.29[b]
Dec. 2009	ND	ND	0.21[a,b]	0.46[c]
Jan. 2010	ND	ND	0.24[a,c]	0.31[b]
Feb. 2010	ND	ND	0.23[a,b]	0.35[b,c]
Mar. 2010	ND	ND	0.21[a,b]	0.34[b]
Apr. 2010	ND	ND	NS	0.23[a,b]
May 2010	ND	ND	NS	0.28[a,b]
June 2010	ND	ND	NS	0.37[b,c]
Greece, round 2				
Nov. 2010	NA	0.93[a,b]	NA	ND
Dec. 2010	NA	1.04[a]	NA	ND
Jan. 2011	NA	1.00[a,b]	NA	ND
Feb. 2011	NA	0.84[b]	NA	ND
Spain, round 2				
Dec. 2010	ND	ND	0.73[a]	ND
Jan. 2011	ND	ND	0.87[a,b]	ND
Feb. 2011	ND	ND	0.90[a,b]	ND
Mar. 2011	ND	ND	0.79[a,b]	ND
Apr. 2011	ND	ND	1.04[b]	ND

BMI: body mass index; BMI/A: BMI-for-age; NA: not applicable, because this age group was not one of the country's targeted age group; ND: not determined, because no statistically differences were found in mean value across monthly periods in this targeted age group; NS: not specified, because fewer than 5% of the total group of children for this age group were measured.

[a,b,c,d] By country and round: within each age group mean values that share the same superscript letter do not statistically significantly differ from each other (Games-Howell *post hoc* test). For example, for the Belgian 9-year-old children in round 1, the mean value of the children who were measured in September 2007 significantly differ from the other seven monthly periods, whereas the mean values found in the monthly periods October 2007–April 2008 do not significantly differ from each other.

countries. COSI was designed with the aim to be as simple as possible and not require a major investment of public resources [6, 7]. To measure children wearing underwear only will most likely take more time and may accentuate children's sensitivities about their own size, which could increase the potential psychological harm (e.g., anxiety or shame) [16]. Censi et al. have performed a validation study with the aim to compare children's body weight measured in underwear with children's weight measured in clothing and then adjusted for the weight of the clothes [17]. Their findings suggest a slight error in the estimation of body weight, which led to a small miscalculation of BMI and a negligible difference in overweight and obesity prevalence estimates.

4.2. Timing of the Survey. The second practice for which the COSI protocol allowed some flexibility refers to the timing of the survey within a COSI data collection round (i.e., what months or season of the year?) and duration of the anthropometric measurements (i.e., within how many weeks?). According to the COSI protocol, countries could decide on the data collection period within a school year. Indeed, large intercountry variation was found in the timing of data collection (Figures 1 and 2). Moreover, the countries were asked to measure the children in all sampled classes over the shortest period possible but not longer than 8–10 weeks, with which eight countries could not adhere. However, the monthly fluctuations in clothes-adjusted mean BMI/*A Z*-score values were only statistically significant in three out of six countries for some targeted age groups (Figures 3 and 4), whereby 1–3 monthly values only were statistically different within some countries (Table 5). The results found in these three countries did not show a systematic seasonal effect (i.e., a particular month/season was different from the others in all countries) and thus do not give us a reason to require countries to measure children in the same seasonal period of the year in next COSI rounds.

Seasonal changes in BMI or weight among schoolchildren are described by several studies that surveyed well-nourished populations and often had primary aim to report on the effects of school versus nonschool period (summer vacation or other school holidays) [4, 18–26]. The findings from these studies were inconsistent. Some indicated that the mean BMI/*A Z*-score values did not change significantly over the school year [20], during the summer season [20], or during a winter break from December to January [22], while one study found a significant increase in BMI/*A Z*-score values during the summer season [18]. The COSI protocol stresses that data collection should be avoided during the first two weeks of a new school term or immediately after a major holiday, and thus it is unlikely that nonschool periods have had an influence on our results.

5. Conclusions

The variation found between countries in the timing of the survey and the duration of the anthropometric measurements had no impact or a minor impact on the average children's weight and BMI outcome measures. The intercountry differences observed in the type of clothing worn by children and the clothes weight adjustments used changed the unadjusted outcome measures in almost all countries, thus, taking into account the clothes worn during anthropometry in the analyses remains essential. The difference between the country-specific and the average non-country-specific clothes adjustment weights was small. In conclusion, the findings of the present study suggest that the built-in flexibility in the COSI protocol concerning the data collection practices addressed in the paper can be maintained in the upcoming COSI rounds and thus do not necessitate a revision of the protocol.

Disclaimer

Trudy M. A. Wijnhoven and João Breda are staff members of the WHO Regional Office for Europe. The authors alone are responsible for the views expressed in this paper and they do not necessarily represent the decisions or the stated policy of WHO.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Authors' Contribution

Trudy M. A. Wijnhoven conceptualized and drafted the paper and conducted all analyses; Joop M. A. van Raaij made substantial contributions to the conception and drafts of the paper, as well as interpretation of the results; Pieter van 't Veer was involved in critically reviewing drafts of the paper; Angela Spinelli, Agneta Yngve, and Lauren Lissner gave substantial input to a draft of the paper and contributed to data collection and data cleaning; Igor Spiroski, Victoria Farrugia Sant'Angelo, Napoleón Pérez-Farinós, Éva Martos, Mirjam Heinen, and Marie Kunešová reviewed a draft of the paper and contributed to data collection and data cleaning; and Ana I. Rito, Ragnhild Hovengen, Gregor Starc, Vesselka Duleva, Iveta Pudule, Ausra Petrauskiene, Lien Braeckevelt, Maria Hassapidou, and João Breda contributed to data collection and data cleaning. All authors contributed to and approved the final paper.

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