Prevalence of overweight and obesity among Austrian children (3 - 15 y): using three different sets of reference values for body mass index (BMI)

Prävalenz von Übergewicht und Adipositas bei österreichischen Kindern (3 - 15 J.): unter Verwendung von drei verschiedenen Referenzwerten für den Body Mass Index (BMI)

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Summary

Background: It is more difficult to determine the prevalence of overweight and obesity in children than in adults since there is a lack of consistent international reference values.
Objective: To estimate the prevalence of overweight and obesity in Austrian children, determined by three different sets of reference values for body mass index (BMI).
Design: Descriptive cross-sectional survey in 2172 children aged 3 to 15 years.
Results: Depending on the reference values used the prevalence of overweight (incl. obesity) in Austrian children varied (e. g. between 13.6 and 17.6 % in 6- to 10-year-olds).
Conclusions: Considerable differences in prevalence estimates of overweight and/or obesity in children are obtained by the use of different reference values for BMI. For international comparisons the International Obesity Taskforce (IOTF) reference values are useful. However, to monitor childhood overweight and obesity in Austria consistent and country specific reference values still seem to be more appropriate.

Keywords:
BMI reference values, Austrian children, prevalence, overweight, obesity

Zusammenfassung

Hintergrund: Bei Kindern und Jugendlichen ist es schwieriger als bei Erwachsenen, die Prävalenz von Übergewicht und Adipositas zu ermitteln, da es keine international anwendbaren Referenzwerte gibt.
Ziel: Ziel der Studie war es, die Prävalenz von Übergewicht und Adipositas bei österreichischen Kindern anhand von drei verschiedenen Referenzwerten für den Body Mass Index (BMI) zu ermitteln.
Design: Querschnittstudie mit 2172 Kindern zwischen 3 und 15 Jahren.
Ergebnisse: In Abhängigkeit von den verwendeten Referenzwerten variierte die Prävalenz von Adipositas bei österreichischen Kindern (z. B. zwischen 13,6 und 17,6 % bei den 6- bis 10-Jährigen).
Schlussfolgerung: Die errechnete Prävalenz von Übergewicht und Adipositas bei Kindern kann je nach verwendeten BMI-Referenzwerten beträchtlich variieren. Für internationale Vergleiche eignen sich die von der International Obesity Taskforce (IOTF) vorgeschlagenen Referenzwerte, für die nationale Gesundheitspolitik sind sie weniger geeignet.

Kennwörter:
BMI-Referenzwerte, österreichische Kinder, Prävalenz, Übergewicht, Adipositas

Introduction

Overweight and obesity have reached epidemic proportions worldwide and in many countries an increasing prevalence can be observed with severe public health consequences. Moreover, overweight is becoming increasingly prevalent among younger adults and children. Immediate consequences of overweight in childhood are often psychosocial but also include impaired glucose tolerance, high cholesterol levels and other adverse health effects [1, 2]. In addition, overweight children are likely to become overweight adults [3], which consequently may lead to an increased cardiovascular morbidity in the future [2]. It is more difficult to determine the prevalence of overweight and obesity in children than in adults since there is a lack of consistent international reference values for the definition of childhood overweight and obesity. Children can be defined as overweight or obese on the basis of a variety of reference values and depending on the criteria used, the prevalence estimates may deliver clearly different results. For international comparisons the body mass index (BMI) is recommended to determine a population prevalence of obesity. Although BMI is probably not the best measure in children, it was selected because it is easy to measure and it is repro-

ducible and valid [4]. However, BMI values in children change with age, so BMI cut-offs to define overweight and obesity in adults are not appropriate. Therefore, cut-offs related to age are needed to define childhood overweight and obesity, for example using reference percentiles, which are now available in many countries, and the definitions BMI > 85th (overweight) and BMI > 95th percentiles (obesity) are widely used [5]. On the other hand, the International Obesity Taskforce (IOTF) defined the cut-offs for children by back-extrapolating from the percentiles of BMI corresponding to values of > 25 kg/m^2 (overweight) and 30 kg/m^2 (obesity) at age 18 [6]. A report, using this international definition of overweight and obesity in childhood, showed a tendency for a higher prevalence of overweight (including obesity) among children in western and especially southern Europe [7]. National surveys in Europe also indicated high prevalence rates of overweight and obesity in children [8, 9]. The aim of this paper was to provide prevalence estimates of overweight and obesity among 3- to 15-year-old children in Austria, determined by three different reference values for BMI, and to discuss the differences between these reference values.

Subjects and methods

The data is derived from the Austrian Study on Nutritional Status (ASNS). ASNS is a series of cross-sectional studies, conducted since 1991 in different Austrian population groups by the Department of Nutritional Sciences of the University of Vienna. In this paper two nutrition surveys were considered, which were carried out between 2001 and 2002. One survey included 3- to 6-year-old preschool children and the other one 6- to 15-year-old schoolchildren. The final sample sizes by sex and age group are shown in *Tab. 1*.

All surveys included standardized questionnaires about dietary habits, anthropometric information and socio-demographic data. All interviewers were master students of nutritional sciences at their final stages and followed a training period before data collection in each survey. A written consent was obtained from the parents as well as from the responsible (nursery) school boards.

Subgroup	Male	Female	Total
Preschoolers 3 - 6 y	227	214	441
School children 6 - 10 y	414	486	900
School children 11 - 15 y	370	461	831

Tab. 1: Number of survey respondents by sex and age groups

Preschoolers (3 - 6 y)

The study population were Austrian preschoolers aged 3 to 6 years. A convenience sample was drawn from eight regions of Austria and a total of 19 nursery schools. The design considered different geographical regions as well as different socio-economic groups. The valid participation rate for the anthropometric measurements was 85.5 %. The remaining 14.5 % failed to return a parental consent form, refused to participate in the measurement or were absent on the day of the survey. The data were collected from February 2001 through May 2001. Weight (in kilograms) was measured for each individual, barefoot and in light indoor clothing, using calibrated electronic scales ("Soehnle" +/- 500 g). Height (in centimetres) was measured standing, barefoot and head in upright position (+/- 1 mm).

Schoolchildren (6 - 15 y)

The study population of Austrian schoolchildren included a final number of 1731 children aged 6 to 15 years. In four geographical regions a convenience sample of 32 schools was selected. The overall average valid response rate was 62.5 %. Most of the children who did not complete the study either failed to answer the height and weight questions or had not been granted permission by their parents to participate in the survey. The data was collected from November 2001 through June 2002. To calculate the BMI for schoolchildren we used weights and heights as reported by the children (with assistance of their parents).

Reference values and definition of overweight and obesity

Body mass index (BMI) is calculated as weight in kilograms divided by the square of the height in metres (kg/m^2). Children with a BMI at or above the cut-off values at the corresponding age and gender group were defined as overweight or obese.

The prevalence of overweight and obesity in children was determined by comparing the BMIs to Austrian [10], German [11] and international reference values [6]. The latter are adopted by the IOTF and recommended for international comparisons. A sample of the three different BMI reference values is shown in *Tab. 2* for girls aged 6 to 15 years in one-year intervals. As the results for boys are very similar, the corresponding reference values for boys are not shown.

The Austrian reference values of *Zarfl* and *Elmadfa* [10] include BMI percentiles for 5- to 18-year-olds and give values at one-year intervals for both sexes. The data were derived from a large cross-sectional study in 5145 Austrian children and adolescents (5 - 18 y). The field work took place from 1991 to 1993, covering all geographical regions. Height and weight were measured using standardized procedures.

To define overweight, a BMI ≥ 85th percentile was chosen as the 85th percentile was also suggested in the literature to define overweight in adults. A cut-off point

Age, y	Cut-off values for overweight			Cut-off values for obesity		
	Austrian reference values[1] 85th percentile	German reference values[2] 90th percentile	IOTF[3] adult equivalent 25 kg/m²	Austrian reference values[1] 97th percentile	German reference values[2] 97th percentile	IOTF[3] adult equivalent 30 kg/m²
6	17.6	17.99	17.34	19.1	19.67	19.65
7	17.8	18.51	17.75	19.4	20.44	20.51
8	18.1	19.25	18.35	20.0	21.47	21.57
9	18.7	20.04	19.07	21.1	22.54	22.81
10	19.6	20.80	19.86	22.3	23.54	24.11
11	20.5	21.61	20.74	23.3	24.51	25.42
12	21.6	22.48	21.68	24.5	25.47	26.67
13	22.4	23.33	22.58	25.3	26.33	27.76
14	23.0	24.05	23.34	25.9	27.01	28.57
15	23.5	24.59	23.94	26.2	27.45	29.11

Tab. 2: Examples of BMI (kg/m²) reference values for girls of selected age categories

for obesity was not explicitly proposed by the Austrian authors, however in order to compare the Austrian reference data with the two other data sets a BMI ≥ 97th percentile was considered to indicate obesity.

In the German reference values BMI percentiles for 0- to 18-year-olds, calculated at 0.5-y intervals for both sexes, are presented. To determine the cut-off values, *Kromeyer-Hauschild et al.* [11] used data from 17 cross-sectional studies, which were conducted after 1985 in different regions of Germany with a total number of 17.245 girls and 17.147 boys (0 - 18 y). A BMI at or above the sex- and age-specific 90th and 97th percentiles were suggested to define overweight and obesity, respectively. The decision to choose these particular percentiles is primarily based on the statistical distribution of the reference values; the 90th and 97th percentile represent one standard deviation (SD) and two SD respectively and in addition, the chosen percentiles correspond more or less to the values of 25 kg/m² and 30 kg/m² at adult age.
The International Obesity TaskForce (IOTF) suggested a new definition of overweight and obesity in childhood, which should encourage direct comparison of trends in child obesity worldwide [6]. In this definition pooled international data (from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States) of 97.876 males and 94.851 females from birth to 25 years of age for BMI is linked to the widely used adult cut-off points of 25 kg/m² and 30 kg/m² for overweight and obesity. The reference values are presented for 2- to 18-year-olds in 0.5-y intervals and both sexes.

Statistical analyses

Data were analyzed using SPSS (version 11.5); prevalence rates were expressed as percentages. Differences by sex and age group were compared using the chi-square statistic, considering p-values < 0.05 for significant. In addition, the standardized residuals (converted to a z-score) were calculated, considering +/- 1.96 as critical values (corresponding to a p-value < 0.05).

Results

Tab. 3 shows the prevalence of overweight and obesity in 3- to 15-year-old Austrian children. Depending on the BMI reference values used, the prevalence of overweight varied between 10.0 and 14.1 % for 3- to 6-year-olds (measured weights and heights) and between 7.1 and 13.1 % for 6- to 15-year-olds (self-reported weights and heights). The prevalence of obesity varied between 4.1 and 4.8 % for 3- to 6-year-olds (measured weights and heights) and between 1.4 and 7.4 % for 6- to 15-year-olds (self-reported weights and heights), depending on the reference data used.
No significant differences of overweight or obesity between boys and girls were found, except for the prevalence of obesity in 11- to 15-year-olds using the IOTF reference values; in this age group significantly ($p < 0.05$) more boys were classified being obese than girls.
The age-group of 6- to 10-year-olds had a higher prevalence of obesity than did the age group of 11- to 15-year-olds ($p < 0.05$), irrespective of the applied reference values. No statistical tests were performed to compare the group of preschoolers (3 - 6 y) with

[1] BMI reference values calculated for Austrian children, derived from Zarfl and Elmadfa [10].
[2] BMI reference values calculated for German children, derived from Kromeyer-Hauschild et al. [11].
[3] BMI reference values derived from Cole et al. [6] and adopted by the International Obesity Taskforce (IOTF).

		Prevalence overweight			Prevalence obesity		
Sex	Age, y	≥ 85th Austrian reference values[1]	≥ 90th German reference values[2]	IOTF[3] adult equivalent 25 kg/m²	≥ 97th Austrian reference values[1]	≥ 97th German reference values[2]	IOTF[3] adult equivalent 30 kg/m²
Both sexes	3 - 6	-	10.0	14.1	-	4.8	4.1
	6 - 10	10.2	8.7	13.1	7.4*	4.9*	4.0*
	11 - 15	8.2	7.1	11.1	4.0	2.4	1.4
Female	3 - 6	-	9.7	13.7	-	3.5	3.1
	6 - 10	10.3	8.4	12.6	7.6*	3.7*	3.1*
	11 - 15	7.8	6.5	10.0	3.7	1.5	0.2#
Male	3 - 6	-	10.3	14.5	-	6.1	5.1
	6 - 10	10.1	8.9	13.8	7.2	6.3	5.1
	11 - 15	8.6	7.8	12.4	4.3	3.5	3.0

Tab. 3: Prevalence of overweight and obesity (%) in Austrian children (3 - 15 y) by sex and age group, using three different sets of reference values for body mass index

** p<0.05 compared with the age-group 11 - 15 y.*
 # p<0.05 compared with boys at the same age.

the older age-groups as the data quality is different (measured vs. self-reported). The prevalence of overweight in Austrian children (6 - 15 y), determined by a BMI at or above the age and sex specific 85th percentile of the Austrian reference values, increased in both sexes during the last decade (*Tab. 4*).

		Prevalence of overweight	
Sex	Age, y	≥ 85th Austrian reference values[1] 1991 - 1993*	≥ 85th Austrian reference values[1] 2001 - 2002**
Female	6 - 10	15.2	17.9
	11 - 15	8.2	11.5
Male	6 - 10	11.0	17.3
	11 - 15	10.0	12.9

Tab. 4: Prevalence of overweight (%) in Austrian children (6 - 15 y) by sex and age group, 1991 - 1993 compared to 2001 - 2002

** BMI derived from measured weight and height.*
*** BMI derived from self-reported weight and height.*

Discussion

Although an increasing prevalence of overweight and obesity can be observed worldwide, considerable differences in prevalence rates between regions and populations are evident. Especially in children, the use of different reference values for the definition of overweight and obesity may introduce unintended variance. Depending on the BMI reference values used in this paper, the estimated prevalence of overweight (including obesity) in Austrian children varied between 14.8 and 18.2 % among 3- to 6-year-olds, between 13.6 and 17.6 % among 6- to 10-year-olds and between 9.5 and 12.5 % among 11- to 15-year-olds.
The highest prevalence rates for overweight (excluding obesity) in all three age-groups and both sexes were obtained with IOTF reference values and the lowest with German references. For obesity the highest rates were obtained with Austrian references and the lowest with IOTF references. The differences between methods appear to be systematic, even though higher discrepancies in the prevalence estimates can be observed in girls than in boys.
Reilly et al. [12] pointed out that obesity prevalence in epidemiological studies will be underestimated when using IOTF references. Our findings confirm their suggestion, especially in girls the prevalence of obesity is reduced by more than half when using IOTF references compared with the Austrian reference values. Comparisons of overweight and/or obesity prevalence rates in children between studies clearly have to consider differences in the BMI reference values used.
For the compilation of the IOTF Childhood Obesity Report, which shows prevalence data from 21 surveys in Europe, a single definition of overweight in childhood was used (IOTF references). In southern European countries the prevalence of overweight (including obesity) is reported to be 20 - 35 % and in northern

[1] BMI at or above the sex- and age-specific 85th or 97th percentile calculated for Austrian children, derived from Zarfl and Elmadfa [10].
[2] BMI at or above the sex- and age-specific 90th or 97th percentile calculated for German children, derived from Kromeyer-Hauschild et al. [11].
[3] BMI at or above the sex- and age-specific percentiles, equivalent to an adult BMI of 25 kg/m² and 30 kg/m² for adult overweight and obesity, derived from Cole et al. [6] and adopted by the International Obesity Taskforce (IOTF).

European countries 10 - 20 % [7]. Applying the same definition to Austrian data the estimated prevalence of overweight (including obesity) in Austrian 3- to 15-year-old children is 12.5 - 18.2 %.

We should, however, point out that the findings of our study are subject to several limitations. First, data on weight and height in 6- to 15-year-old children is self-reported, whereas for the age-group of 3- to 6-year-olds measured BMI data could be used. Nevertheless, *Strauss* [13] reported that 94 % of 12- to 16-year-olds correctly classified their weight status and concluded that self-reported heights and weights were extremely reliable for predicting obesity related morbidities and behaviours. Another study showed that adolescent self-report of height and weight resulted in a correct classification of obesity in 96 % of adolescents [14].

The second limitation of our study is that the sample was drawn from selected areas of Austria and may therefore not be representative of the entire population.

Third, the response rate differed notably between different schools and regions, ranging from 55 - 89 %. Therefore the health profiles of the participating children may differ from those who did not.

For assessing overweight and obesity in children a choice has to be made about whether to use national or international reference values.

Arguments against the use of international BMI reference values include lack of a satisfactory screening ability, lack of evidence of biological validity and practical issues (the international standards do not provide a recommendation for underweight) [15].

On the other hand, there are also arguments against the use of national BMI reference values. The most obvious one is that international comparisons are impossible as different prevalence estimates are obtained according to which percentile standards are used. Another problem refers to the use of updated percentile standards which are themselves affected by the increasing prevalence of obesity; e. g. the use of the 85th percentile would always lead to a prevalence of 15 % overweight if this cut-off is applied to contemporary standards, and thus, obscuring the true nature of trends in childhood obesity [16].

The Austrian BMI reference percentiles do also not provide references for children younger than five years of age and the age categories are divided in one-year intervals only. Moreover, the statistical power may depend on the sample size of the reference population (e. g. 5145 in the Austrian sample vs. 192.727 in the international pooled sample). As an alternative to the Austrian BMI references the German BMI references may be used as differences in body composition between Austrian and German children are probably not substantial.

A recent systematic review recommended the use of national BMI reference values in clinical practice and epidemiology as its ability to successfully classify overweight or obese children and adolescents is usually high and, international BMI reference values may require further testing, with evidence of external validity [17].

Health professionals should be aware that depending on the BMI reference values used, considerable differences in prevalence estimates of overweight and/or obesity in children are obtained. The IOTF reference values are useful for international comparisons. However, to monitor childhood overweight and obesity in Austria consistent and country specific reference values still seem to be more appropriate.

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