Ten-year trends in obesity among Israeli schoolchildren: 1990-2000

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Abstract

Aim: To analyze trends in childhood body mass index (BMI) in Israel between 1990-2000, and to determine the proportion of obese children using US and population-specific reference values.

Methods: Cross-sectional data from 13,284 second- and fifth-grade schoolchildren were collected, including age, sex, height, weight, country of birth and time since immigration. Age- and sex-specific BMI means and centiles were calculated, and the prevalence of obesity was determined using Israeli and US reference values.

Results: BMI values at the 95th centile increased monotonously over time in all age and sex categories. Between 1990 and 2000, 95th centile values increased by 12.7% and 11.8% among second-grade boys and girls, respectively. Among fifth-grade children, 95th centile values increased by 10.2% and 8.4%, respectively. Among second graders in 2000, 11.4% of both boys and girls exceeded the BMI value recorded at the 95th centile in 1990. Among fifth-graders in 2000, 10.7% of boys and 11.1% of girls exceeded the 1990 BMI reference value (P for all comparisons <0.001). The proportion of obese children increased over time using both Israeli and US reference values.

Conclusion: This substantial increase in childhood obesity poses a serious health threat, and requires implementation of suitable public health interventions.

Keywords: *body mass index, children, obesity, secular trends*

Introduction

The prevalence of overweight and obesity among children in many countries has increased drastically over the last 30 years, and the proportion of overweight children in the US has doubled since the early 1970s [1-3]. In the US, the 95th centile of body mass index (BMI) for age and sex, based on nationally representative survey data, has been recommended as a cutoff point for the definition of obesity [4,5]. This definition, while widely accepted, may be of limited external validity for international use, due to cultural, demographic and nutritional differences between different countries. Thus, an additional means of monitoring BMI trends must be used, such as pooled international data [5] or comparison to historic references in the study population [1].

Israel, an industrialized Middle Eastern country, has been characterized by pronounced demographic and economic changes in recent years. Between the years 1990-2000, Israel absorbed approximately one million immigrants, principally from the Commonwealth of Independent States (CIS) and, to a much lesser extent, Ethiopia. During this period Israel also experienced substantial economic development, and the country's gross domestic product per capita increased from $15,000 to $19,000, while mean private consumtion expenditure per capita rose from $7,500 to $10,500. Few published data have followed BMI trends among the population of Israeli children during this period of immigration and economic development. The objectives of this study were to analyze secular trends in childhood BMI measurements in Israel between 1990-2000, to assess the proportion of obese children in Israel during this time using both US and population-specific reference values, and to investigate the effects of immigration on these outcomes.

Methods

Study population. We collected data in four cross-sectional samples within the context of serial school-based health surveys conducted by the Barzilai Medical Center in the Ashkelon District of Israel during the years 1990, 1994, 1997 and 2000 [6]. All elementary schools in the district were included in the sampling frame, and were eligible for selection based on a random cluster sample approach, designed to achieve a representative sample of second- and fifth-graders; 50% of eligible schools were included in the final selection. Among second-graders, >95% were aged 86-101 months, and among fifth-graders, >95% were aged 122-137 months.

Data collection. Each child was weighed shoeless wearing shorts and a T-shirt. Scales were calibrated prior to use. Barefoot standing height ±0.5 cm was measured by stadiometer. BMI was calculated as weight (kg)/height $(m)^2$. In addition, a questionnaire was filled out by each child's parents, which included information regarding the child's country of birth and, for immigrants, time since immigration to Israel. Study protocols were approved by the Ministry of Health ethical committee, and by local educational authorities.

Definition of obesity. We used two types of cutoff points in determining BMI trends and age- and sex-specific proportions of obese children. In order to compare subsequent study populations to the 1990 component, the 1990 means, medians and 95^{th} centiles were taken as reference values, and we computed the proportion of subjects in later components with BMI values higher than the 1990 references. For purposes of external comparison, we also calculated the proportion of obese children in each study component using 95^{th} centile BMI values derived from the US Centers for Disease Control and Prevention National Center for Health Statistics 2000 growth charts [4]. Using the US data, we computed composite reference values to express the 95^{th} BMI centile for the subpopulation of US children aged 86-101 months (corresponding to the present study's second graders) and for children aged 122-137 months (corresponding to the present study's fifth graders).

Data analysis. Age- and sex-specific BMI means and centiles were calculated for each study period, and relative changes in these values over the study period were computed. A $\chi 2$ test was used to compare the 1990 and 2000 proportions. Finally, multivariate logistic regression analysis was used to control for the potentially confounding effects of immigration status on the risk of obesity. In the logistic models, obesity (yes or no) served as the dependent outcome variable. Independent covariates included in the models were study component year, sex, age (second or fifth grade), continent of birth (Africa-Asia, CIS, Europe-America or Israel), and, for immigrants, number of years since immigration (<5 or ≥5). Statistical analysis was conducted using the PEPI suite of computer programs [7] and SPSS© for Windows® computer software (SPSS Inc., Chicago, Illinois).

Results

Study population characteristics are shown in Table 1. The overall study population numbered 13,284 children. Mean, median and 95th centile BMI values by sex, age and study component are shown in Table 2. No sustained upward or downward trends occurred over time in mean and median BMI values. However, the BMI value representing the 95th centile increased monotonously over time in all age and sex categories. Among second grade boys and girls, the 95th centile values in 2000 values were 12.7% and 11.8% higher, respectively, than the 1990 references. Among fifth grade boys and girls, the 2000 values were by 10.2% and 8.4% higher, respectively.

Table 3 presents the proportion of subjects in 1990 and 2000 with BMI measurements greater than the 1990 reference values. Appropriately, 50% of the subjects in 1990 had values greater than the reference median, and 5% had values greater than the 95th centile. In 2000, however, more than twice as many study subjects had comparable 95th centile BMI values. Among second graders, the value which marked the 5% most overweight children in 1990 was exceeded by 11.4% of both boys and girls in 2000. Among fifth graders, 10.7% of the boys and 11.1% of the girls in 2000 exceeded BMI values previously attained by only 5% of children their age ten years earlier (P for all comparisons <0.001). Among fifth grade boys there was a significant increase over 10 years in the proportion of children exceeding both the 1990 mean and median BMI reference values (P=0.01 and 0.05, respectively). Among girls, the increase was significant for the proportion exceeding the median value (P=0.02), and neared statistical significance for the proportion exceeding the mean (P=0.06).

Distribution curves of BMI by age and sex for the 1990 and 2000 study components are shown in Figure 1. An identical pattern is seen in all four panels of the figure: relative to the 1990 curve, a smaller proportion of the 2000 observations are distributed around the mode, while a greater proportion have shifted towards the higher end of the BMI scale ("skewing to the right"). The values of the 95th centiles are thus higher for the latter study component, while little change is noted for the remainder of the overall distributions.

Figure 2 shows trends over time for 95th centile BMI values, with comparison values based on

US population standards for 2000 [4]. The figure demonstrates that the 5% most overweight children have become increasingly obese over time. When compared to the 2000 reference US population, the top 5% of Israeli children in 1990 and 1994 were less obese than their US counterparts. As of 1997, however, the BMI value at the 95th centile exceeded that of the US reference population.

Table 4 shows the proportion of obese children in each study component, as defined by both current CDC and 1990 Israeli cutoff points. There was a clear monotonic increase in the proportion of obese children over time across all age and sex categories and under both obesity definitions. The 1990 study component values proved to be a more stringent definition of obesity than the US values, and consistently classified a higher proportion of children as being obese.

Logistic analysis models were constructed to quantify the odds of obesity associated with each of the covariates listed in Table 1. Study year was the only predictor variable significantly associated with an increased risk of obesity, with each subsequent study component posing a greater risk than those preceeding it. Relative to the risk of obesity in 1990, the odds ratios in subsequent years were 1.7 (95% CI 1.2-2.4) in 1994, 3.0 (2.2-4.0) in 1997, and 3.1 (2.2-4.2) in 2000 (P value for all estimates <0.004). None of the other covariates examined, including country of birth and time since immigration, was associated with an increased risk of obesity in either the univariate or multivariate models.

Discussion

In this study, we demonstrate an upward shift in BMI distribution among Israeli schoolchildren over the decade between 1990-2000, with a significantly increased prevalence of obesity over time. Until recently, overweight and obesity have generally been perceived as problems of developed countries such as the US, Australia, Canada and western Europe. [3,8-13]. However, problems relating to overnutrition are increasing even in developing countries, and significant increases in the prevalence of overweight and obesity have been reported worldwide [1,14-20]. Furthermore, for developed countries and low-mortality developing countries, overweight is now a major risk factor of overall disease burden. [21]

Although there remains an unresolved dispute in the literature as to the optimal definition of obesity among children aged 2-20 years, [1,5,20] the widely-accepted cutoff value is the 95th centile of sex-specific BMI-for-age growth charts. [4] According to this definition, approximately 11% of all US children and adolescents were overweight in the early 1990's, while among 6-11 year olds the age-specific rate was 11.3%. [2] By the end of the 1990's this proportion had increased to 15%, and by 2002 it was 16.5%. [9,22] Interestingly, examination of BMI distribution in the US between the 1960's and the 1990's showed that the heaviest children were markedly heavier in later studies, but the rest of the distribution showed little change [2,23]. This pattern is strikingly similar to the results of the current study, which demonstrate a "right-sided skewing" of the BMI curves, indicating that the severity of overweight is increasing. This characteristic shift in BMI is most likely the result of increased environmental effects over time on the segment of the population most susceptible to obesity [1].

There is some question as to the appropriate reference against which to measure trends in childhood obesity. Over time, the children in a given population may diverge from the body composition of their historic "reference child", making it unclear whether they should be compared to the centiles of the current population or to those of an earlier one in which there was a lower fat mass. [1] In the current study, the 1990 study component values consistently classified a higher proportion of children as being obese than did the CDC reference values. This discrepancy is likely due to the higher prevalence of obesity in the US compared to Israel. During the decade between 1990 and 2000, the prevalence of obesity among US children aged 6-11 increased from approximately 11.3% to 15.3% [2,8,22], while our results indicate that during this same time period and using identical US cutoff points, the prevalence of obesity among Israeli children of comparable ages increased from 2.3% to 6.9%. This represents not only an absolute increase of 4.6%, but more importantly a relative increase of 200%. Finally, the BMI value at the 95^{th} centile among Israeli children has increased by 8.4%-12.7% since 1990, indicating that the heaviest 5% of children are substantially heavier today than they were a decade ago. While US children may still be more obese than their Israeli counterparts, our data would suggest that the latter are rapidly closing the gap. However, a measure of caution should be exercised in interpreting these results. While the relative increase in the proportion of obese children is dramatic, the absolute increase remains small compared to the US. Although the present public health impact may be modest, these ongoing trends must be monitored closely.

While these findings are a cause for concern, they may, in fact, underestimate the true prevalence of obesity among children. Validity studies of BMI in adolescents have shown good specificity but a poorer sensitivity, so that some obese subjects may not be identified by BMI screening. [24] Additionally, a study of British youth [12] found that trends in waist circumference during the past 10-20 years have greatly exceeded those in BMI, so that studies measuring BMI may have systematically underestimated the prevalence of obesity in children.

One potential limitation of this study may be the appropriateness of generalizing its findings to Bedouin and Arab children, due to their lack of representation in the study sample. A previous study [25], however, demonstrated no significant difference in the prevalence of obesity between Jewish and Bedouin children, so that the present results may reflect current trends among non-Jewish children in Israel. An additional concern is the potential effect of immigration on the time trends of BMI in the Israeli population. In an ethnically heterogenous population, it may not be appropriate to use a single national reference, and an ethnic-specific reference may be preferable. Evidence to this effect has been provided previously in Israeli military recruits, who showed distinct BMI distribution patterns based on ethnic origin. [26] However, origin-based variability has not been demonstrated in younger Israeli children, and the results of the present study do not support its existence in children aged 7-11.

In conclusion, it seems that childhood obesity continues to pose a serious health threat to today’s children and tomorrow’s adults in Israel and elsewhere. Appropriate and effective public health planning and intervention will require further collection and analysis of population-specific obesity data.

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Table 1: Characteristics of study component samples, 1990-2000

		1990	1994	1997	2000	Total
Sample size (n)		1,968	2,394	5,988	2,934	13,284
Grade (%)	2 [age 86-101 months]	51.7	51.9	49.0	50.5	50.3
	5 [age 122-137 months]	48.3	48.1	51.0	49.5	49.7
Sex (%)	Boys	50.3	47.9	46.6	42.8	46.6
	Girls	49.7	52.1	53.4	57.2	53.4
Place of birth (%)	Africa-Asia	0.8	1.3	2.2	1.6	1.7
	CIS*	0.4	10.8	18.4	18.7	14.4
	Europe-America	1.4	2.8	1.6	1.5	1.7
	Israel	97.5	85.2	77.8	78.2	82.2
Years in Israel (%)†	<5	40.5	84.7	35.0	31.3	39.3
	≥5	59.5	15.3	65.0	68.7	60.7

* CIS – Commonwealth of Independent States

† Limited to immigrants

Table 2: Mean, median and 95th centile BMI values, by age, sex and study year

			1990	1994	1997	2000
2nd grade	Boys	Mean	15.71	15.49	16.30	16.01
		Median	15.38	15.02	15.83	15.45
		95th centile	19.20	19.71	21.01	21.64
	Girls	Mean	15.63	15.51	16.42	16.04
		Median	15.37	15.09	15.86	15.50
		95th centile	19.22	20.05	21.42	21.48
5th grade	Boys	Mean	17.06	16.93	17.71	17.57
		Median	16.46	16.22	16.89	16.89
		95th centile	21.88	22.04	23.74	24.12
	Girls	Mean	17.50	17.38	18.12	18.02
		Median	17.05	16.86	17.54	17.36
		95th centile	22.60	22.94	24.44	24.50

Table 3: Proportion of 1990-component and 2000-component subjects with BMI greater than 1990 reference values, by age and sex.

		Reference BMI values (1990 component)		Proportion (%) over reference BMI value		Odds ratio*	P value
				1990	2000		
2nd grade	Boys	Mean	15.71	41.6	44.0	1.11 (0.87-1.41)	0.39
		Median	15.38	50.0	50.5	1.02 (0.81-1.29)	0.84
		95th centile	19.20	5.0	11.4	2.40 (1.49-3.97)	<0.001
	Girls	Mean	15.63	45.1	47.6	1.10 (0.88-1.39)	0.39
		Median	15.37	50.0	51.9	1.08 (0.86-1.36)	0.50
		95th centile	19.22	5.0	11.4	2.47 (1.57-4.02)	<0.001
5th grade	Boys	Mean	17.06	40.3	48.1	1.37 (1.07-1.76)	0.01
		Median	16.46	50.0	55.8	1.27 (1.00-1.63)	0.05
		95th centile	21.88	5.0	10.7	2.27 (1.38-3.86)	<0.001
	Girls	Mean	17.50	43.4	48.6	1.23 (0.99-1.54)	0.06
		Median	17.05	50.0	56.5	1.29 (1.04-1.62)	0.02
		95th centile	22.60	5.0	11.1	2.32 (1.47-3.81)	<0.001

*Odds of a child's BMI in 2000 being greater than the 1990 reference value, relative to the odds of a similar child in 1990.

Table 4: Proportion of obese children, by age, sex, year and BMI cutoff value.

Obesity cutoff values, in BMI units			Percent classified as obese by US (Israel) values			
		US* (Israel†)	1990	1994	1997	2000
2nd grade	Boys	19.88 (19.20)	2.9 (5.1)	5.9 (6.0)	7.4 (10.3)	8.6 (11.4)
	Girls	20.48 (19.22)	1.8 (5.3)	3.8 (7.8)	5.1 (11.1)	5.5 (11.4)
5th grade	Boys	22.99 (21.88)	2.5 (5.0)	4.1 (5.4)	6.2 (9.8)	7.2 (10.7)
	Girls	23.90 (22.60)	2.1 (4.9)	3.4 (5.7)	6.1 (9.7)	6.6 (11.1)

*95th centile of BMI-by-age growth charts, CDC, 2000 [4]

†95th centile of 1990 component of present study

Figure 1: Distribution of BMI values by age, sex and year. Broken line represents 1990, solid line represents 2000. (For graphic clarity, x-axis values are cut at BMI=12.)

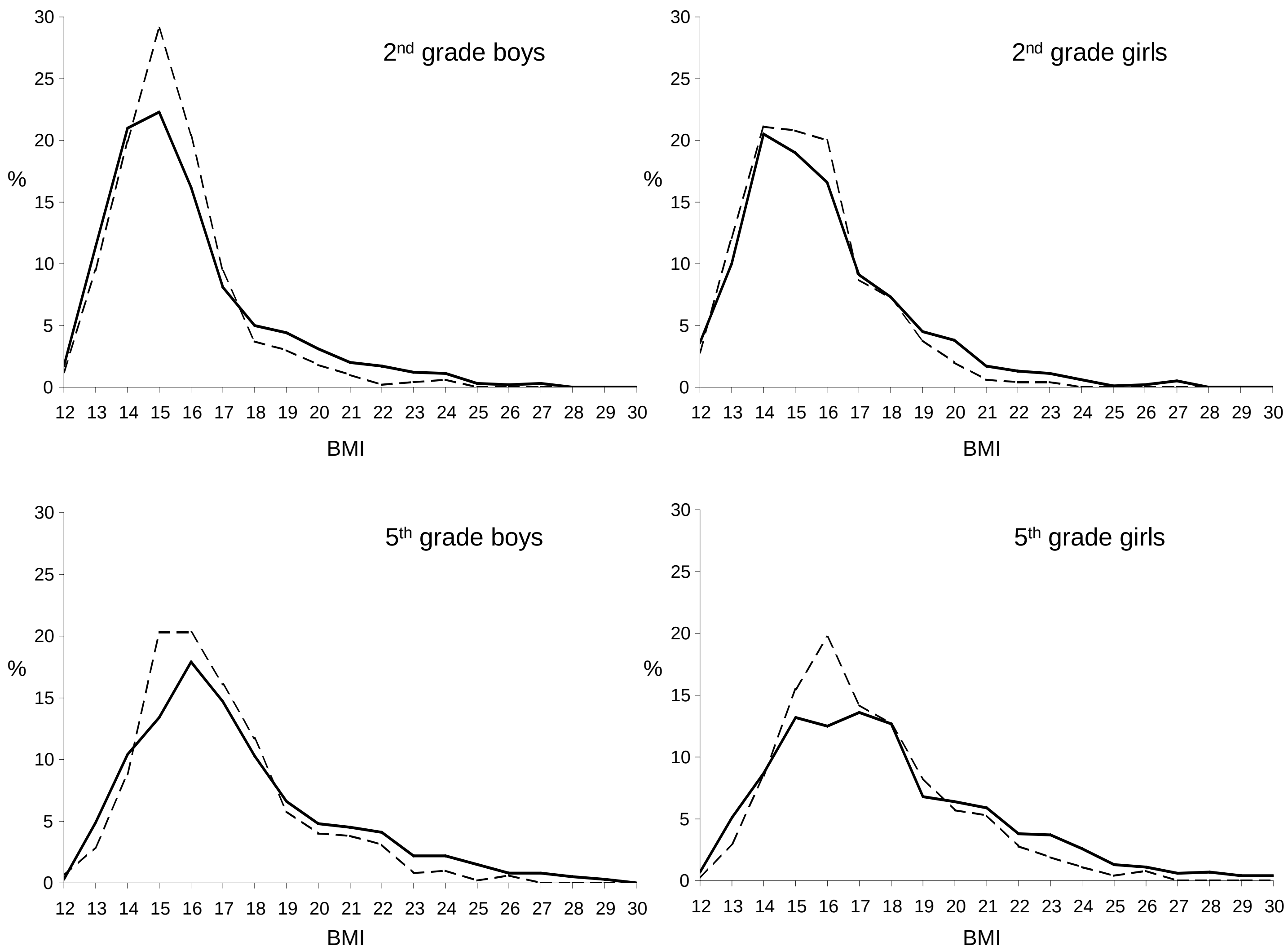

Figure 2: 95th centile BMI values and US references, by age, sex and year.