Temporal Trends in the Prevalence and Extent of Overweight among 9-11 Year-Old Australians: 1985-2002

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INTRODUCTION

There are reports of increasing overweight and obesity among Australian children in recent times (Booth et al., 2002; Magarey et al., 2001). Current prevalence data provide relative proportions of children in normal weight, overweight and obese categories, but this information falls short of describing the extent to which overweight children exceed thresholds. Among adults, health risks increase with increasing body mass index (BMI); for example, the risk of heart failure increases by 5% in adult men and 7% in adult women with every unit increase in BMI (Kenchaiah et al., 2002). Kurth and colleagues (2002) described a 6% increase in the relative risk of stroke per unit increase in BMI in men. While there is little such evidence among youth, it is reasonable to extrapolate from the adult data that more severely overweight children carry greater physiological and psychological health risks (Jolliffe, 2004).

To quantify the severity of overweight in children, Jolliffe (2004) developed an index coined the extent of overweight (EOW), which is the difference between the overweight child's BMI and the age- and sex-specific BMI threshold, expressed as a percentage of the threshold. This variable is best used in conjunction with prevalence data, as it provides additional insight into the distribution of continuous adiposity variables, which is obscured by prevalence alone. A more detailed account of the utility of the EOW has been published elsewhere (Jolliffe, 2004).

Most reports of adiposity trends and patterns of distribution have been restricted to BMI, presumably due to the relative convenience of measuring height and weight in large surveys. The insensitivity of BMI to differences in fat mass and fat-free mass between individuals is a widely recognised limitation (Lobstein et al., 2004). Skinfold measures are a more direct indication of adiposity than BMI, while waist girth has been established as an acceptable field indicator of central adiposity (Lobstein et al., 2004). This is an important component of anthropometric surveys as central adiposity has been shown to be more strongly associated with a range of morbidities, such as type 2 diabetes and dyslipidaemia, than overall fatness in adults (Kannel et al., 1996; Rexrode et al., 1998). As waist girth tracks moderately well from childhood to adulthood (Daniels et al., 2000), it is important to understand its distribution in the youth population.

The aim of this study was to describe changes in prevalence of overweight (POW) and EOW, as defined by BMI, skinfolds and waist girth, among 9-11 year old Australians over the last 20 years.

METHODS

Subjects and Sampling

The participants in this study were 9-11 year old children from all states of Australia measured in the 1985 Australian Health and Fitness Survey (Pyke, 1987), and South Australian schoolchildren from a survey conducted in 2002 (see Table 1 for sample characteristics). In 1985, a self-weighted sample was drawn by selecting schools with probability proportional to enrolment numbers, and then using simple random sampling to select 10 children per age/sex category within each school. Ninety percent of invited schools agreed to participate (n=109), and 77.5% of students selected in the initial sample received parental consent to participate. A total of 1800 9–11 year olds (885 boys) were tested on anthropometric measures in the 1985 survey.

In 2002, all 9–11 year olds from 34 South Australian primary schools (91.5 % of schools sampled) were invited to participate. Within participating schools 78% of children agreed to take part. The distribution of selected schools between metropolitan and non-metropolitan areas, and between government and non-government sectors, closely matched the overall distribution across the state. A total of 1024 9–11 year olds (527 boys) were tested on anthropometric measures in the 2002 survey.

Approval for the 1985 survey was granted

through the then State Directors General of Education, while the 2002 survey was approved by the South Australian Department of Education and Children's Services and the University of South Australia Human Research Ethics Committee.

Anthropometric Measures

The 2002 survey closely replicated the anthropometric protocols of the 1985 survey (Pyke, 1987). Body weight (to 100 g) and stretch stature (to 0.1 cm) were measured using electronic scales and portable stadiometers, respectively. Stretch stature was used to minimise the effect of diurnal variation in stature, so that assessments could be made at any time during school hours. The process involves application of gentle upward pressure through the mastoid processes during measurement. BMI was calculated as weight (kg)/stature $(m)^2$. Skinfold thicknesses (biceps, triceps, subscapular, suprailiac and abdominal) were assessed according to the published protocols of the 1985 survey (Pyke, 1987), using Harpenden calipers in 2002 and Holtain calipers in 1985. Waist girth was measured using constant tension metal tapes at the level of umbilicus. Duplicate measures were taken for each skinfold and girth, with a third measure taken if the difference between the first two exceeded 10% for skinfolds and 2% for waist girth. The average of two and the median of three measures were used as the final score. No data on reliability and accuracy of anthropometric measures were reported from the 1985 survey. In the 2002 survey, the mean intra-tester technical errors of measurement (TEM) for skinfolds and girth measurements were 1.9% and 0.7% respectively, while the inter-tester TEMs (established against a criterion anthropometrist; Norton, 1996) were 6.2% and 2.0%.

Development of OW Categories

Three measures were used to test the differences between surveys in POW and EOW: BMI, the sum of five skinfolds (sum5), and waist girth. For BMI, the recently published cut-offs of Cole and colleagues (2000) were used to derive age and sex-specific categories of normal weight and overweight (including obese). As there are no agreed cut-offs for risk according to skinfolds and waist girth in children, the age and sex-specific 85^{th} percentiles for these variables from the 1985 Australian Health and Fitness Survey were used (Pyke, 1987). For all three variables, the EOW formula was applied to those exceeding the assigned threshold, resulting in EOW/BMI, EOW/sum5 and EOW/waist as continuous variables.

Statistical Analyses

Boys and girls were compared on all anthropometric data, separately by survey year, using ANOVA. BMI, sum5 and waist girth were log transformed to correct for skewness.

Percentile changes in all anthropometric variables between 1985 and 2002 were visually represented. At the 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles the differences between the 1985 and 2002 datasets were plotted as a percentage of the mean value of these percentiles.

POW/BMI, POW/sum5 and POW/waist were compared between surveys using Pearson's chi-square. EOW/BMI, EOW/sum5 and EOW/waist were treated as continuous variables and compared between survey years using Mann-Whitney U. The prevalence of obesity, defined by Cole cut-offs (Cole, 2000), was also compared between surveys, but the extent of obesity was not compared due to the relatively small numbers in these categories and therefore low statistical power of this analysis.

RESULTS

As shown in Table 1, boys exhibited lower sum5 and higher waist girths than girls, in both the 1985 and 2002 surveys. Percent differences between surveys at the 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles are displayed in Figure 1. With the exception of girls' sum5, it is evident that changes have been relatively greatest at the highest percentiles, indicating that distributional shifts had occurred in each of the anthropometric variables.

Between 1985 and 2002, the prevalence of obesity had increased from 1.3% to 7.4% among boys and from 1.3% to 7.0% in girls (both $p<0.0001$). Table 2 compares survey years for the POW and EOW in relation to BMI, sum5 and waist girth. Between 1985 and 2002, the POW had increased in boys and girls, as represented by all three anthropometric variables. POW/BMI (including obese) had increased at an average of

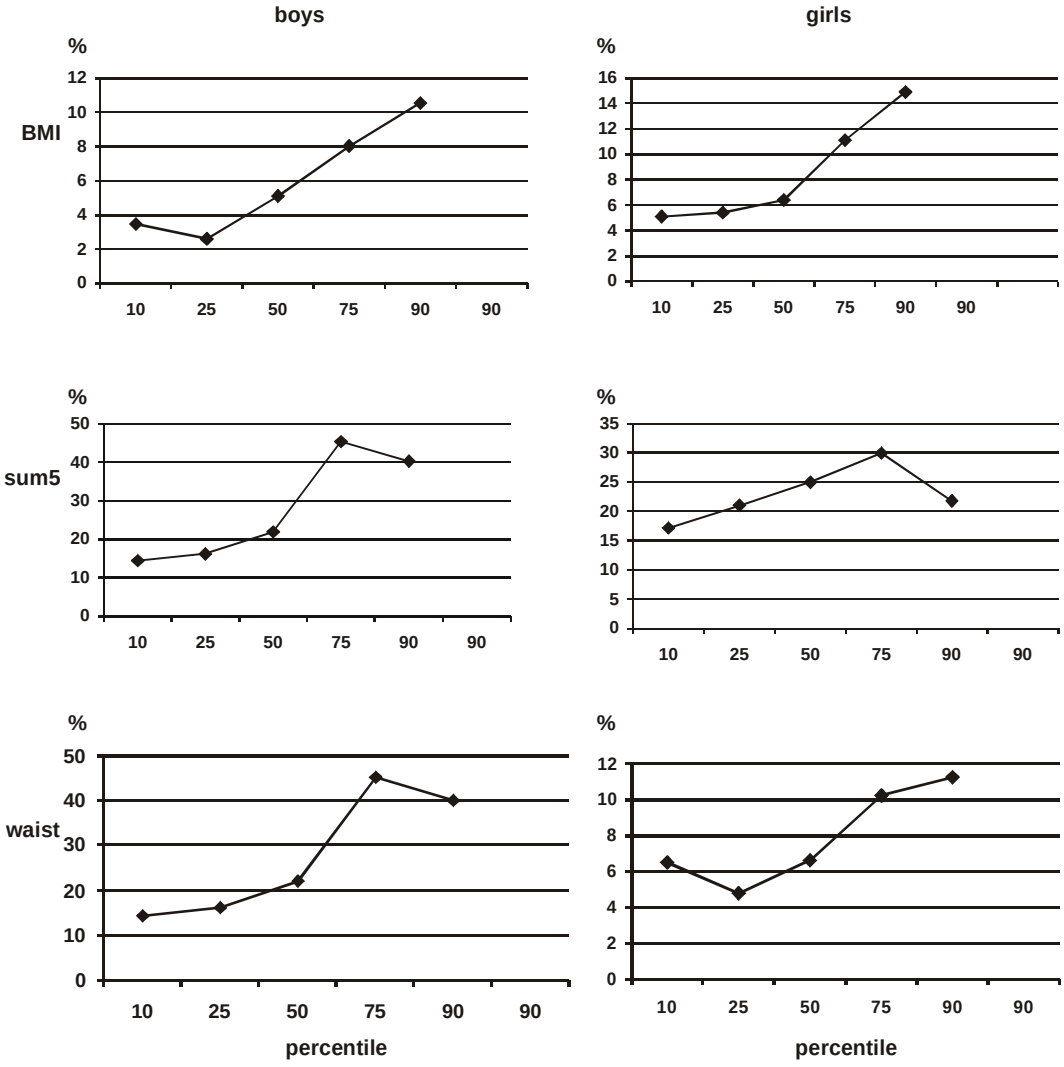

Fig. 1. Changes in the distribution of BMI, sum5 and waist girth, between 1985 and 2002.

Table 1: Descriptive statistics and differences between boys and girls in 1985 and 2002 samples

	1985				2002			
	Boys		*Girls*		*Boys*		*Girls*	
Age (y)	9.96	(0.56)	9.97	(0.57) ^{ns}	9.79	(0.37)	9.79	(0.37)^{ns}
Height (cm)	138.2	(6.4)	138.0	(7.1) ^{ns}	140.0	(6.7)	139.0	(6.7)*
Weight (kg)	32.97	(5.87)	33.22	(6.48) ^{ns}	35.98	(7.97)	35.90	(8.27)^{ns}
BMI (kg.m^{-2})	17.17	(2.22)	17.32	(2.32) ^{ns}	18.23	(2.99)	18.43	(3.16)^{ns}
Waist girth (cm)	60.8	(6.0)	60.0	(6.8) **	65.8	(9.0)	64.4	(8.7)**
Sum5 (mm)	38.5	(20.2)	51.3	(25.6) ***	51.4	(29.0)	65.6	(33.2)***

* p<0.05, ** p<0.01, *** p<0.0001, ^{ns} not significant

Table 2: Differences in POW and EOW between 1985 and 2002 samples, separately in boys and girls

	1985	*2002*
Boys		
POW/BMI (%) [1]	12.8	26.0 ***
EOW/BMI (%) [2]	7.1 (14.6)	11.0 (17.2) *
POW/waist (%) [3]	14.9	35.6 ***
EOW/waist (%) [2]	5.1 (10.3)	10.5 (14.9) ***
POW/sum5 (%) [3]	15.1	35.3 ***
EOW/sum5 (%) [2]	35.3 (62.2)	49.8 (60.0) [ns]
Girls		
POW/BMI (%) [1]	16.0	28.8 ***
EOW/BMI (%) [2]	6.0 (10.8)	11.1 (15.4) **
POW/waist (%) [3]	15.1	34.5 ***
EOW/waist (%) [2]	6.7 (8.9)	9.0 (12.8) *
POW/sum5 (%) [3]	14.7	28.4 ***
EOW/sum5 (%) [2]	26.6 (36.0)	36.4 (49.3) [ns]

*p<0.05, ** p<0.01, *** p<0.0001, [ns] not significant
POW = prevalence of overweight; EOW = extent of overweight
[1] threshold defined by cut-offs of Cole (2000)
[2] presented as median (inter-quartile range)
[3] threshold defined as >85th percentile from 1985 sample
Comparisons of POW by Pearson's chi-square
Comparisons of EOW by Mann-Whitney U

7.8% per decade for boys and 7.5% per decade for girls. POW/waist had increased at a rate of 12.2% per decade for boys and 12.0% per decade for girls, while for POW/sum5, the equivalent rates were 11.9% and 8.5% per decade, respectively.

EOW had increased for all anthropometric variables, but the differences between surveys for EOW/sum5 were not significant. Rates of change per decade were 2.3% for boys and 3.0% for girls in EOW/BMI, 8.5% for boys and 5.8% for girls in EOW/sum5, and 3.2% for boys and 1.4% for girls in EOW/waist.

DISCUSSION

Implications

The results of this study confirm substantial increases in the prevalence of overweight in youth, as represented by weight for height (BMI), fatness (sum5) and central adiposity (waist girth). Not only have there been increases in overweight prevalence, but the extent to which overweight children exceed defined thresholds has also increased, elevating the risk of associated morbidities.

The rates of increasing prevalence of overweight/obesity in this study, defined by BMI cut-offs (7.5% per decade for girls and 7.8% decade for boys) were similar to those observed among United States adolescents, defined as ≥ 95th percentile (5.1% and 6.8% per decade), between 1988-2000 (Jolliffe, 2004). The rate of change among South Australian children is also similar to trends observed in other Australian states for this age group. Using data collected in 1985 and 1997, overweight/obesity prevalence among 9 year olds in New South Wales had increased by 7.8% per decade in boys and 4.8% per decade in girls, while in Victoria the rates of change across the same time period were 4.2% per decade in boys and 9.8% per decade in girls (Booth et al., 2002).

Jolliffe (2004) confirmed that both POW and EOW in US youth had increased from 1971 to 2000, as defined by BMI thresholds. Notably, the EOW had increased more dramatically than POW; those 2-19 year olds at risk of overweight (in excess of the 95th percentile of age- and sex-adjusted BMI) had increased by 86%, while the EOW increased by 174% over the same period. In the current study, rates of increase in POW tended to be higher than rates of change in EOW. Nevertheless, significant changes in both variables point to the additional information provided by the EOW, in that the severity of total and central fatness is on the rise in young South Australians.

A worrying aspect of the observed trends is the rapid rate of change, with an approximate doubling of the prevalence of overweight according to BMI and skinfolds between 1985-2002, and even greater increases in those exceeding the assigned threshold for waist girth. The relatively greater rate of increase for POW/waist than for measures of overall adiposity (BMI and sum 5), particularly among girls, represents a serious public health concern. Among youth, visceral adipose tissue is directly associated with low density lipoprotein cholesterol (LDL-C) and triglycerides (TG), and inversely related to high density lipoprotein cholesterol (HDL-C; Brambilla et al., 1994).

Limitations

There are a number of limitations of this trend analysis. Trend studies of body composition are confounded by secular advances in maturational

status, with the average age of puberty decreasing at about 3 months per decade (Roche, 1979). As higher levels of adiposity would be expected among more mature girls, the observed trends in girls' adiposity in this study can be partly attributed to this phenomenon. However, the fact that similar patterns were found in boys, few of whom would have entered puberty, suggests that other mechanisms are at play.

Another limitation of this study is that state-based data from 2002 were compared with national data from 1985. However, within the 1985 sample South Australian 9-11 year-olds were no different to other states combined, for height (girls, p= 0.37; boys, p = 0.90), weight (girls, p= 0.83; boys, p = 0.60) and skinfolds (girls, p= 0.52; boys, p = 0.59). For waist girth, there was no difference between South Australians and other states for boys (p = 0.36), but South Australian girls had smaller waists (p = 0.03) than their counterparts from the rest of Australia. Overall, this suggests that the observed trends between 1985 and 2002 in this study are likely to represent a national picture of rising total and central adiposity.

CONCLUSION

This study examined trends in adiposity measures among Australian children, using two measures that are sensitive to temporal shifts in distributional characteristics: the prevalence and extent of overweight. The results confirm that there have been changes in the distribution of anthropometric attributes of Australian children. Between 1985 and 2002, there have been increases of 7 – 12% per decade in the prevalences of BMI, skinfolds and waist girth. As further evidence of distributional trends, the extent to which overweight children exceed thresholds for these variables is increasing, raising even greater concerns for the immediate health of the current generation of youth as well as their future health as adults.

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ABSTRACT The aim of this study was to identify trends in the prevalence of overweight (POW) and extent of overweight (EOW) in primary age Australians between 1985 and 2002. Anthropometric measures (body mass index, BMI; 5 skinfolds, sum5; and waist girth) were compared for 9-11 year olds from 1985 (n=1800; 885 boys) and 2002 (n=1024; 527 boys). The POW was assessed using age- and sex-specific international cut-offs for BMI, and the 85th

percentile from the 1985 survey for sum5 and waist girth. The EOW was defined as the extent to which overweight children exceeded the defined cut-off for that variable, expressed as a percentage. Between 1985 and 2002, the POW had increased in boys and girls (all $p<0.0001$), as represented by each anthropometric variable: POW/BMI from 12.8-22.6% for boys and 16.0-28.8% for girls; POW/sum5 from 15.1-35.3% for boys and 14.7-28.4% for girls; and POW/waist from 14.9-35.6% for boys and 15.1-34.5% for girls. The EOW had increased for all anthropometric variables, but the differences between surveys for EOW/sum5 were not significant: EOW/BMI from 7.1-11.0% for boys ($p\leq0.05$) and 6.0-11.1% for girls ($p\leq0.01$); EOW/sum5 from 35.3-49.8% for boys and 26.6-36.4% for girls; and EOW/waist from 5.1-10.5% for boys ($p\leq0.01$) and 6.7-9.0% for girls ($p\leq0.05$). Unfavourable adiposity levels and fat patterning became more prevalent and severe in Australian children between 1985-2002, suggesting that widely reported prevalence trends based on BMI are under-estimating the likely impact of this public health crisis.

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