International Journal of Obesity (2002) 26, 214–219
 0307–0565/02 $25.00
www.nature.com/ijo

PAPER

Prevalence and risk factors for overweight and obesity in children from Seychelles, a country in rapid transition: the importance of early growth

N Stettler[1,2]*, P Bovet[3,5], H Shamlaye[4], BS Zemel[1], VA Stallings[1] and F Paccaud[5]

[1]*The Children's Hospital of Philadelphia, Philadelphia, PA, USA;* [2]*Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania School of Medicine, Philadelphia, PA, USA;* [3]*Unit for Prevention and Control of Cardiovascular Disease in Seychelles, Republic of Seychelles;* [4]*Ministry of Health, Victoria, Republic of Seychelles; and* [5]*Institute for Social and Preventive Medicine, University of Lausanne, Switzerland*

OBJECTIVES: To establish the prevalence of overweight and obesity and related risk factors in children from Seychelles (Indian Ocean), a country in rapid economic and epidemiological transition.
DESIGN: Cross-sectional study with retrospective access to early life data.
SUBJECTS: All children from all schools of Seychelles, in four selected school grades (kindergarten, fourth, seventh and tenth year of obligatory school) in 1999. A total of 5514 children aged 4.5–17.4 y were measured, corresponding to 83.5% of the eligible population.
MEASUREMENTS: Overweight and obesity, using age- and sex-specific body mass index (BMI) cut-off points as defined by the International Obesity Task Force.
RESULTS: Some 12.6% (95% confidence interval: 11.8–13.5%) of the children were overweight and 3.8% (3.3–4.4%) were obese. Weight gain (kg) during the first year of life was strongly associated with subsequent overweight (odds ratio 1.46, 95% confidence interval 1.27–1.67) and obesity (1.59, 1.29–1.97) in childhood, independently of birth weight. Increased maternal BMI (kg/m^2) was also associated with overweight (1.07, 1.03–1.10) and obesity (1.09, 1.04–1.14) in the offspring.
CONCLUSION: Prevalence of overweight and obesity among school children in Seychelles was as high as or higher than in some industrialized countries. If confirmed in other environments, the strong association between weight gain during the first year of life and subsequent obesity in childhood could affect the way optimal infant weight gain is defined in countries where public health priorities are changing.
International Journal of Obesity (2002) **26,** 214–219. DOI: 10.1038/sj/ijo/0801860

Keywords: birth weight; child; growth; infant nutrition; Seychelles

Introduction

The prevalence of overweight/obesity among adults is increasing in high-income, as well as in low- and intermediate-income countries.[1,2] While the global epidemic of overweight/obesity is well described in the adult population, data on the prevalence of overweight/obesity in children of low and intermediate-income countries are still sparse.[3–5]

***Correspondence: N Stettler, Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania School of Medicine, 8th Floor Blockley Hall, 423 Guardian Drive, Philadelphia, PA 19104-6021, USA.**
E-mail: nstettle@cceb.med.upenn.edu
Received 21 February 2001; revised 29 June 2001; accepted 24 July 2001

The prevention of childhood obesity is an important public health goal, as childhood obesity tracks into adulthood,[6,7] is associated with adverse health outcomes,[8] and is difficult to treat. For prevention programs to be effective, risk factors associated with childhood overweight/obesity must be identified. The risk factors for childhood overweight/obesity in higher-income countries, such as hours of television viewing, high-energy diet, and low socioeconomic status may differ from those in low and intermediate-income countries, where the socio-cultural and economic environment may be quite different.

In the past, the lack of a well-accepted international definition for childhood overweight/obesity status made comparisons among countries difficult. Recently, the

International Obesity Task Force published a consensus definition of childhood overweight/obesity based on the body mass index (BMI).[9] This definition provides age- and sex-specific cut-off points for overweight and obesity corresponding to BMI of respectively 25 and 30 kg/m^2 at age of 18. Because more than 190 000 children from six developed and developing countries were included, these data provide the best currently available criteria for international comparisons.

In this study, we examine the prevalence of overweight/obesity and related risk factors in children of Seychelles (Indian Ocean). The Republic of Seychelles is a middle-income country experiencing rapid epidemiological transition, where a high prevalence of hypertension, obesity, type 2 diabetes mellitus and peripheral atherosclerosis has been documented in the adult population.[10–12]

Methods

The Republic of Seychelles is a small country of several islands in the Indian Ocean, 1800 km off the coast of Kenya, with a population of approximately 80 300. The ethnic distribution of the population is approximately: African 65%, European (Caucasian) 10%, Asian 5% and mixed 20%.[13] Seychelles has experienced rapid economic growth over the last two to three decades associated with a thriving tourist industry. The national gross domestic product per capita has grown from US$800 in 1976 to US$6500 in 1999.

Eligible subjects for this study were all children attending all public and private schools of Seychelles in four selected school grades (kindergarten, fourth, seventh and tenth year of obligatory school) in 1999. These grades were selected by the Seychelles Ministry of Health for routine medical visits several years ago, in order to focus its limited resources on four important stages in the development of school children: the beginning and end of public school, as well as two intermediate time points. No data are routinely collected in other grades. Data were collected during routine medical visits provided to all children in the selected grades every year by 17 school nurses. Nearly 100% of children attend school with approximately 96% attending public schools and 4% attending private schools. Weight and height were measured by the school nurses using precision electronic scales (Seca 870, Seca, Hamburg, Germany) and stadiometers fixed to the wall of the examination rooms in the schools (Seca 208). These measurements were performed by professional nurses, all trained in anthropometric techniques by the same team of experienced researchers, who also provided regular supervision to insure data quality. Nurses also asked children/parents about the number of older and younger siblings and the occupation of the parents (a parent generally attends the medical visits for kindergarten children). Other variables were compiled from available medical records and included maternal height and weight measured by the prenatal clinic nurses at the time mothers booked in the prenatal clinics, weeks of gestation at registration in the prenatal clinics, gestational age at birth, child weight at birth and child weight at 1 y of age, measured by the clinic nurses. The parents' occupation was categorized based upon the parent with the most qualified occupation: non-manual skilled (eg professional, teacher, nurse), intermediate skilled (eg mechanic, clerk), and unskilled (eg laborer, cleaner).

Age- and sex-specific prevalence of overweight/obesity were determined using the criteria defined by the International Obesity Task Force.[9] These values were obtained with a 6 month age precision (for example age 6.5 corresponds to ages 6.25 to 6.75 y). Note that, using this definition, overweight children also include obese children. *Z*-scores (ie standard deviation) for height-for-age (HAZ) and weight-for-height (WHZ) were calculated using the National Center for Health Statistics (NCHS)/World Health Organization (WHO) reference population (Anthropometric Software Program, Version 3.1, WHO and Centers for Disease Control, 1988, Atlanta, GA, USA). Cole's method, based on the same reference population, was used when no reference for WHZ was available.[14] Stunting and wasting were defined respectively as a HAZ and a WHZ below 2 standard deviations of the reference population. BMI was calculated as weight (kg) divided by height (m) squared. Maternal BMI was based on weight measured during pregnancy, adjusted for weeks of gestation. Weight gain during the first year of life was calculated as the difference between the weight measured at age one year and the weight measured at birth. The main independent variables were: sex, age, birth weight, gestational age, weight gain during the first year of life, stunting, maternal BMI, parental occupation category, first-born status and number of siblings.

The data are described by their median and the 10th and 90th percentiles, and proportion with 95% confidence intervals. Unadjusted associations between the independent variables and overweight/obesity status were tested using chi-square or simple logistic regression, as appropriate. Stratified analyses were performed to detect possible interactions, and homogeneity between strata was tested using the Mantel–Haenszel test. Multiple logistic regression was used to adjust analyses for potential confounding variables. Additionally, a multiple linear regression was used with WHZ as a continuous outcome. To test the impact of missing data, an additional analysis was conducted after imputation of missing values using best-subset regression.[15] Statistical significance was defined for two-tailed *P*-values <0.05. Statistical analyses were performed using Stata software 6.0 (Stata Corporation, College Station, TX, USA).

Results

In the four considered school grades, 5514 out of 6601 eligible children were measured (83.5%). The subjects' characteristics are described in Table 1. Prevalence of overweight and obesity in each grade are presented in Table 2 for boys and girls. Univariate analyses identified an association of overweight and obesity with female sex (odds ratio, 95%

Table 1 Anthropometric and socioeconomic characteristics of the subjects

	Observations (n)	*Median or proportion*	*10th–90th percentile*
Gender, female (%)	5514	51.5	NA
Age (y)	5514	11.7	5.5–16.1
Birth weight (kg)	4533	3.13	2.54–3.74
Gestational age at birth (weeks)	3724	40	38–40
First-year weight gain (kg)	2573	6.6	5.2–8.2
Stunting (%)	5514	4.3	NA
Wasting (%)	5500	4.2	NA
Highest of two parents' occupations:	5514		
Non-manual skilled		21.3	NA
Intermediate skilled		42.5	NA
Unskilled		27.8	NA
Other		8.5	NA
Number of siblings	5369	2	1–5
First-born status (%)	5369	33.9	NA
Maternal BMI, (kg/m^2)	2369	21.3	17.5–28.6

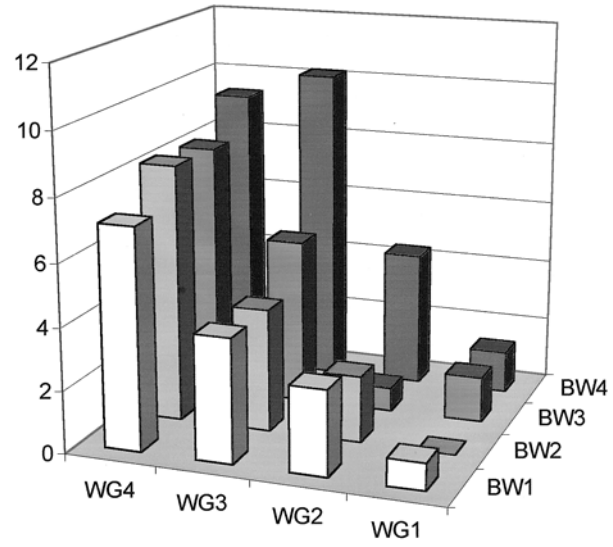

Figure 1 Prevalence of obesity (%) in school children from Seychelles by quartiles of birth weight (BW1, 1.64–2.90 kg; BW2, 2.91–3.16 kg; BW3, 3.17–3.48 kg; BW4, 3.49–5.32 kg) and quartiles of weight gain during the first year of life (WG1, 1.82–5.84 kg; WG2, 5.85–6.55 kg, WG3, 6.56–7.35 kg, WG4, 7.36–11.8 kg).

confidence interval, *P*-value, respectively for overweight and obesity: 1.86, 1.58–2.20, $P<0.001$; 1.48, 1.12–1.97, $P=0.006$), birth weight in kg (1.47, 1.23–1.76, $P<0.001$; 1.94, 1.43–2.62, $P<0.001$), weight gain during the first year of life in kg (1.46, 1.33–1.60, $P<0.001$; 1.62, 1.39–1.88, $P<0.001$), and maternal BMI in kg/m^2 (1.08, 1.06–1.10, $P<0.001$; 1.10, 1.06–1.13, $P<0.001$). Furthermore, children in the 7th grade had a higher risk for overweight status (Table 2, reference group kindergarten: 1.52, 1.20–1.91, $P<0.001$), and gestational age in weeks was associated with obesity (1.17, 1.03–1.33, $P<0.001$). Children from a family of an unskilled worker had a lower risk of overweight and obesity (reference group non-manual skilled, respectively: 0.73, 0.58–0.92, $P=0.008$; 0.46, 0.30–0.71, $P=0.001$). The results were similar in a sub-analysis comparing the more restrictive occupation category of 'laborer' instead of 'unskilled worker' (not shown). Stunting, number of siblings, and first-born status were not significantly associated with overweight or obesity. The associations observed between weight gain during the first year of life and overweight/obesity status in childhood may be different in children of various birth weights. However, after stratification by birth weight quartiles, in children born at term (ie gestational age between 37 and 42 weeks), no interaction was detected by stratified analysis (Figure 1, test for homogeneity $P>0.1$ in both cases, table available upon request). Although the association of weight gain during the first year of life and overweight/obesity in childhood was stronger in lower school grades, in similar analyses, no statistically significant interaction was detected (test for homogeneity $P>0.1$ in all cases). Parental weight status may affect tracking of weight in childhood;[6] however, in similar analyses stratified by maternal overweight status, no such interaction was detected (test for homogeneity $P>0.1$ in all cases).

In a multiple logistic regression model (Table 3), including the seven risk factors identified by the univariate analyses, weight gain during the first year of life and maternal BMI remained independently associated with both overweight and obesity in childhood. In an alternative model, con-

Table 2 Prevalence of overweight and obesity (95% confidence interval) by sex and school grade

			Boys		*Girls*	
School grade	*Median age (y)*	*Observations (n)*	*Overweight (%)*	*Obese (%)*	*Overweight (%)*	*Obese (%)*
Kindergarten	5.5	1310	8.4 (6.3–10.6)	3.4 (2.0–4.8)	12.3 (9.8–14.8)	3.9 (2.5–5.4)
4th grade	9.2	1417	9.0 (6.9–11.2)	3.1 (1.8–4.4)	15.8 (13.2–18.4)	4.3 (2.9–5.2)
7th grade	12.5	1412	12.1 (9.6–14.6)	3.8 (2.4–5.3)	17.6 (14.8–20.3)	4.5 (3.0–6.0)
10th grade	15.9	1375	7.2 (5.2–9.1)	2.1 (1.0–3.2)	17.6 (14.8–20.4)	5.4 (3.7–7.1)

Table 3 Multivariate analysis of the potential risk factors for overweight and obesity in children from Seychelles ($n=1362$) adjusted for each variable, birth weight and gestational age. Odds ratio (OR) and 95% confidence interval (95% CI)

	Overweight			*Obesity*		
	OR	*95% CI*	P-*value*	*OR*	*95% CI*	P-*value*
Female gender	1.50	1.07–2.10	0.02	1.26	0.72–2.19	0.4
First-year weight gain (kg)	1.46	1.27–1.67	<0.001	1.59	1.29–1.97	<0.001
Grade:						
Kindergarten[a]	1.00			1.00		
4th grade	1.25	0.83–1.88	0.3	0.98	0.50–1.92	0.9
7th grade	2.03	1.31–3.16	0.001	1.57	0.77–3.21	0.2
10th grade	1.48	0.71–3.07	0.3	1.21	0.36–4.11	0.8
Highest of two parents occupations:						
Non-manual skilled[a]	1.00			1.00		
Intermediate skilled	0.96	0.63–1.46	0.9	0.84	0.45–1.56	0.6
Unskilled	0.74	0.45–1.21	0.2	0.30	0.12–0.74	0.01
Other/unknown	1.45	0.78–2.70	0.2	0.31	0.07–1.38	0.12
Maternal BMI (kg/m^2)	1.07	1.03–1.10	<0.001	1.09	1.04–1.14	<0.001

[a]Reference group for comparisons.

structed to explore the potential interaction of maternal overweight status in the association between infancy weight gain and childhood obesity, no such interaction was detected ($P>0.1$ in all cases). As excess weight in childhood can also be considered as a continuous rather than a dichotomous outcome, we also performed a multiple linear regression with WHZ as an alternative outcome ($n=1362$). The results showed independent relationships between WHZ and female sex (regression coefficient 0.25, 95% confidence interval: 0.11–0.39, $P=0.001$), weight gain during first year of life in kg (0.31, 0.25–0.37, $P<0.001$), being in 7th grade (reference group kindergarten, 0.27, 0.09–0.46, $P=0.004$), maternal BMI in kg/m^2 (0.05, 0.03–0.06, $P<0.001$), and birth weight in kg (0.36, 0.19–0.53, $P<0.001$). The children with complete data who were included in this model and those who were not had a similar prevalence of overweight (13.0 *vs* 12.5, $P=0.7$) and obesity (4.3 *vs* 3.7%, $P=0.4$). Furthermore, after imputation of missing values by best-subset regression, an additional analysis gave similar results (not shown).

Discussion

In children aged 5–17 y in Seychelles, a country in rapid epidemiological transition, the prevalence of overweight was 12.6% and the prevalence of obesity 3.8%. These proportions are similar to or higher than those reported in some industrialized countries in the past few decades.[9] The most consistent independent risk factors for overweight and obesity were an increase in weight gain during the first year of life and maternal BMI.

This study has some limitations. Although weight and height are usually reliable measurements, small differences in reliability could not be excluded in the present study. Not all eligible children were included in the study, and information was not complete in all subjects. Therefore a bias cannot be excluded. However, missing information was mainly related to school nurse availability, rather than to individual characteristics of the subjects. Furthermore, Seychelles is a small (455 km^2, about the size of Andorra, or 2.5 times the size of Washington, DC) and relatively homogenous country, with no 'deprived areas'. The finding that the prevalence of overweight and obesity was similar in children with complete *vs* incomplete data is an indication that the results are unlikely to differ between these two groups. An additional analysis, using imputed values for missing data, gave similar results (not shown). It is therefore likely that the results of the present study can be generalized to the entire Seychelles population of children, and are not significantly biased. This study also had unique strengths. It is based on the entire population of Seychelles children in the selected grades, rather than on a sample, reducing the risk for a selection bias. Furthermore, unlike many other studies that investigate these associations, gestational age and socioeconomic status were assessed and could be adjusted for in the analysis.

The prevalence of obesity was higher in the children from Seychelles than from the UK, The Netherlands, Hong Kong or Singapore in the 1980s and 1990s and was similar to the prevalence observed in US children between 1963 and 1980 (Table 4).[9] However, it is likely that the prevalence of obesity has increased in these countries between the time it was measured and 1999 when it was measured in Seychelles, thus overestimating the Seychelles' apparent leading position. If no effective prevention is conducted, it is likely that Seychelles will also experience a similar increase in the prevalence of childhood obesity. Presently, 25.3% of Seychelles' adult population is overweight and 12.6% is obese.[11] However, if obesity tracks from childhood to adulthood in low and intermediate-income countries,[16] as has been described in high-income countries,[6,7] Seychelles may experience in the next decades a prevalence of adult obesity similar to or higher than those presently observed in the United States (17.9%).[17] Among the group of overweight or obese children, approximately 31% were obese in the Seychelles, as

Table 4 Prevalence of overweight and obesity (95% confidence interval) in boys and girls from Seychelles (1999), Brazil (1989), UK (1978–1993), Hong Kong (1993), the Netherlands (1980), Singapore (1993), and the USA (1963–1980)[a]

	Boys		*Girls*	
	Overweight (%)	*Obese (%)*	*Overweight (%)*	*Obese (%)*
Seychelles	9.2 (8.1–10.3)	3.1 (2.4–3.8)	15.9 (14.5–17.2)	4.5 (3.8–5.3)
Brazil	4.7	0.1	15.2	2.0
UK	9.6	0.9	11.7	1.2
Hong Kong	11.7	3.1	9.8	1.8
The Netherlands	5.5	0.3	6.5	0.3
Singapore	10.5	1.7	7.0	1.0
USA	18.1	3.3	16.5	4.0

[a]All countries, except Seychelles, from Cole *et al*.[9]

compared to approximately 5% in The Netherlands, 8% in Brazil, 10% in the UK, 15% in Singapore, 21% in the USA, and 22% in Hong Kong. The reasons for this high obese to overweight ratio in Seychelles are unclear, and may be associated with the relatively high prevalence of obesity in Seychelles. The prevalence of wasting and stunting was similar in Seychelles compared to high-income countries, demonstrating that malnutrition is not a major public health problem in Seychelles, unlike in neighboring countries, where access to food and medical care is more difficult.

The association between birth weight and obesity observed in the unadjusted analysis decreased after adjustment for maternal BMI and other confounding variables. This difference could be explained by a decrease in statistical power as the number of observations decreased from 4533 to 1362 from univariate to multivariate analyses. It may also suggest that birth weight is on the pathway of the association between maternal and offspring obesity. The association between weight gain during the first year of life and the risk for overweight or obesity was striking and independent of the birth weight. Each increment of 1 kg of weight gain during the first year of life was associated with an increased risk for overweight or obesity of approximately 50%. Furthermore, this association was of similar level across birth weight and age groups. This result suggests that weight gain early in postnatal life may have an important impact on the risk for overweight/obesity later in childhood, as has been described in previous studies[18,19] and in animal models through permanent brain or metabolic modifications.[20,21] The impact of intra-uterine growth on adult health has been well documented.[22] A low weight at birth is associated with hypertension,[22,23] type 2 diabetes,[22,23] and cardiovascular diseases.[22,24] These conditions are all associated with overweight, but a low birth weight is usually not associated with later development of overweight.[7,23] However, in the present study an increased rate of weight gain during the first year of life, which often takes place with low birth weight (catch-up growth), was also associated with increased risk for overweight/obesity. As an excessive weight gain early in life has also been shown to be a risk factor for cardiovascular diseases,[25] early life weight gain, rather than birth weight, may be the common risk factor between excess weight and cardiovascular disease, which often cluster in the same individuals. In general, breast-fed infants gain less weight than do formula-fed infants in the first year of life. These differences may contribute to the decreased risk for obesity, which was observed in breast-fed children of a different population.[26] The type of infant feeding was not recorded in the present study, and no recommendation on infant feeding can be made based on this study.

Maternal obesity represented a risk factor for overweight/obesity in the children from Seychelles, as has been described in other populations.[27–30] The present study design cannot distinguish whether this observed relationship corresponds to environmental or genetic factors. Paternal weight status was not recorded in the present study. A lower socioeconomic status was associated with a decreased risk of obesity in the children of Seychelles, as has been observed in other countries in economic and epidemiological transition, such as Mexico and Brazil,[4,5] but not in others, such as United Arab Emirates and Kuwait.[29,30] The result of the present study contrasts with studies in high-income countries, where a lower socioeconomic status is usually associated with an increased risk of obesity.[31] These differences may be explained by differences between socioeconomic groups of availability of high-density food and in opportunities for physical activity. Also in contrast to other studies,[27,32–35] family size, birth order and stunting were not associated with obesity in children from Seychelles. These differences may be explained by unmeasured confounding factors or may suggest that risk factors for obesity are not easily generalized across countries and environments and must be studied in different populations. The risk factors for overweight/obesity identified in this study provide important information for planning preventive strategies in this population and, possibly, other populations experiencing epidemiological transition.

Conclusions

The prevalence of overweight and obesity in children of Seychelles, a country in rapid economic and epidemiological transition, was similar to or higher than in some industrialized countries. Weight gain during the first year of life was strongly associated with overweight/obesity in childhood. If these results are confirmed in other countries experiencing epidemiological transition, they may affect the way optimal infant weight gain is defined in environments where public health priorities are changing.

Acknowledgements

The authors thank the nurses of the School Health Program and their program manager, Jeanne d'Arc Suzette, as well as George Madeleine and Bharathi Viswanathan from the Unit

for Prevention and Control of Cardiovascular Disease for their efficient assistance in the collection of the data, and Guy van Melle for advice on statistical analyses. The study was supported by the Ministry of Health of Seychelles, the University Institute of Social and Preventive Medicine of Lausanne (Switzerland), and the Nutrition Center of the Children's Hospital of Philadelphia (USA). The study benefited from a grant from the McCabe Fund of the University of Pennsylvania (USA) and a donation from the Rotary Club of Victoria (Seychelles).

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