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ORIGINAL COMMUNICATION

Prevalence and socio-demographic associations of undernutrition and obesity among preschool children in Cyprus

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Objective: To estimate the prevalence of undernutrition and obesity in preschool children in Cyprus and identify possible associations.
Design: Cross-sectional study.
Setting: Private and public nursery schools.
Subjects: A representative sample ($n = 1412$) stratified by age, gender, district and area of residence.
Interventions: Weight (kg) and height (cm) were obtained and BMI (kg/m^2) was calculated. Z scores for weight-for-age, height-for-age, and weight-for-height were calculated using the cutoffs from the CDC/WHO 1978 reference. Socio-demographic associations with nutritional status were examined in a logistic regression analysis.
Results: The prevalence of undernutrition (WHO definition, Z-scores < -2) was low. Specifically the prevalence of underweight was 2.3%, wasting 2.8%, and stunting 1.1%. Undernutrition was associated with a low birth weight (LBW); odds ratio (OR) for underweight 4.1 (95% CI: 1.4, 12.2), $P = 0.012$, stunting 5.2 (95% CI: 1.1, 23.3), $P = 0.033$, and wasting 4.2 (95% CI: 1.3, 14.3), $P = 0.021$.The prevalence of obesity (IOTF definition) was higher than undernutrition, and increased with age: 1.3% in 2 y olds to 10.4% in 6 y olds. Overweight and obesity prevalence were higher in rural (16.1%) than urban children (12.8%; $P = 0.046$). Obesity in preschool children was associated with paternal obesity, OR 3.24 (95% CI: 1.59, 6.61), $P = 0.001$, and maternal obesity 3.91 (95% CI: 1.78, 8.59), $P = 0.001$. A birth weight (BW) ≥ 4000 g was associated with obesity compared to a BW between 2501 and 3000 g, OR 7.63 (95% CI: 1.91, 30.52), $P = 0.004$.
Conclusions: The prevalence of undernutrition among preschool children in Cyprus was low but obesity prevalence was higher. Parental obesity and high BW were significantly associated with obesity while LBW was associated with undernutrition in preschool children.
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Introduction

Adequate nutrition, undernutrition, and overnutrition are important determinants of health and disease. In modern societies, overeating and obesity have emerged as new challenges in public health (Lobstein *et al*, 2004). The nutritional transition observed in developing countries has also led to a significant decrease in underweight prevalence in preschool children since 1980 (de Onis *et al*, 2000) and this decrease is expected to continue (de Onis *et al*, 2004a), whereas obesity is increasing in some developing countries (Uauy *et al*, 2001).

The assessment of growth in children is a valuable tool for the evaluation of their health and nutritional status.

The World Health Organization (WHO) has been monitoring child growth and malnutrition since 1986 in a Global Database on Child Growth and Malnutrition, which aims to facilitate international comparison, identification of populations in need, evaluation of national public health interventions, and monitoring trends in child growth (de Onis & Blossner, 2003). In this database, prevalences of wasting, stunting, underweight, and overweight in preschool children are presented using *Z*-scores based on the National Center for Health Statistics (NCHS)/WHO international reference population. This reference is still in use despite several limitations (Anonymous, 1995), until new international growth curves based on breast-fed infants and young children are made available by the WHO (de Onis *et al*, 2004b).

In Cyprus, overweight and obesity rates have recently been estimated in school-aged children and adolescents (Savva *et al*, 2002), and these rates were comparable to the high rates of overweight and obesity in childhood in Mediterranean countries (Lobstein *et al*, 2004). The prevalence of overweight or underweight, however, in preschool children is not known. The aim of this study, therefore, was to estimate the prevalence of undernutrition and obesity in a representative sample of preschool children in Cyprus.

Subjects and methods

The study was carried out in May and June of 2004 (end of school year) by the Research and Education Foundation of Child Health (REFCH) in cooperation with the University of Crete. The ministry of Education and Culture of Cyprus gave approval for the survey in the selected schools. Parents of selected children were informed in writing about the purposes of the study and were asked to give written consent for participation.

Sample selection

The study was carried out at the nursery schools. All public and private nursery schools were included in the sampling procedure. A multistage sampling procedure was used, which took into account subjects' gender, age, residence in urban or rural areas, and population distribution in the five accessible districts of Cyprus.

In brief, the total population of ages 2–6 y in Cyprus, according to the 2001 census, was 47.301 children. It was estimated that 990 children 2–6 y old (ie about 2% of the population of that age) would satisfy the needs of the survey. The sample was doubled, however, to 2000 children, to compensate for possible nonparticipation; the participation rate from previous surveys performed by the REFCH in older children and adolescents was more than 90%, but we expected that the participation rate in preschool children would be lower. This sample was drawn from the five districts depending on the districts' population size, that is, Nicosia 37%, Limassol 28%, Larnaca 18%, Paphos 10%, and Famagusta 7%. Subjects with diseases or treatments that are known to affect growth were excluded from analysis.

Questionnaire data

Parents who gave consent were also asked to complete a questionnaire covering demographic, household, parental and personal data, including self-reported body weight and height, which was used to calculate parental body mass index (BMI). Although the self-reported measurements were not validated in this study, other studies have shown that there is a tendency to overestimate height and underestimate weight in self-reported data (Reed & Price, 1998). The sensitivity and specificity for correctly determining obesity status ($BMI \geq 30\,kg/m^2$), however, was 83 and 96%, respectively, for men and 89 and 97%, respectively, for women, as determined in a Scottish study (Bolton-Smith *et al*, 2000).

The birth date was reported in the questionnaire and it was used to calculate subjects' precise age at the evaluation day. Parents were asked to quote gestational age and birth weight from the health booklet where this information is recorded.

Body measurements

Four groups of trained investigators of REFCH performed the survey. Body weight and height were measured in every child. Briefly, weight (in kg) was measured after breakfast with a portable scale, with the child in light clothing and without shoes. Children were asked to void before they were weighed. Height (0.1 cm) was measured with a portable stadiometer in the standing position for children aged 3 y and over, whereas it was measured in the supine position for children less than 3 y of age. The portable scale and stadiometer were calibrated daily. BMI was calculated from the formula weight/height^2 (kg/m^2).

Data analysis

In order to obtain comparable estimates of undernutrition and overweight/obesity indices across other national surveys, data were analysed using the proposed procedures and cutoffs by the WHO (de Onis & Blossner, 2003) and International Obesity Task Force (IOTF), respectively (Lobstein *et al*, 2004).

Undernutrition was estimated using *z*-scores for weight-for-age (underweight, WAZ), height-for-age (stunting, HAZ), and weight-for-height (wasting, WHZ). *Z*-scores were calculated using EPI INFO for Windows software (NUTSTAT module). Prevalences for all three indices were calculated using the proposed cutoffs of 2 and 3 standard deviations (*z* scores) below the age- and sex-specific medians of the three indices from the CDC/WHO 1978 reference (Dibley *et al*, 1987).

Overweight and obesity prevalences were estimated using both the NCHS/WHO and IOTF criteria. Using the NCHS/WHO method, overweight was defined as a WHZ > 1 (corresponding approximately to the 84th percentile) and obesity as a WHZ > 2 (corresponding approximately to the 98th percentile). The IOTF recommended cutoffs are based on the age-specific values of BMI extrapolated to the adult values of 25 kg/m^2 (overweight) and 30 kg/m^2 (obese) (Cole *et al*, 2000).

Means, standard deviation, and the 25th, 50th, and 75th percentiles, as well as the respective *z* scores were calculated for all anthropometric indices. The prevalence of undernutrition and overweight/obesity is reported in relation to age, gender, and area of residence. Specifically, calculations included the 2.0–4.9 y age group, in order to comply with the WHO guidelines to assist national comparisons. Undernutrition and overweight/obesity rates were compared between groups using the χ^2 test.

The association of underweight, stunting, and wasting to low birth weight and gestational age was examined using logistic regression analysis models adjusted for age, sex, and parental weight and height. Continuous variables were entered in the models after logarithmic transformation whenever they were not normally distributed.

Associations of obesity, that is, BMI age- and sex-equivalent to adult BMI cutoff of 30 kg/m^2 (IOTF definition), were examined using logistic regression analysis models adjusted for log age and sex. In all analyses a P value < 0.05 was considered as statistically significant.

Results

A total of 2000 children were randomly selected to participate in the study, but only 1503 (participation rate 75%) returned completed consent and questionnaire forms. Only 1412 of these children (52.8% males) were present on the day of measurements at their schools, and thus data on only these children were included in the analysis. Subjects' distribution in relation to district and area of residence was very similar to the actual distribution of preschool children according to the year 2001 census in Cyprus. Table 1 presents the characteristics of the sample. The mean age of the parents was 37.2±6.0 y for fathers and 33.2±5.1 y for mothers. The prevalence of overweight and obese fathers based on self-reported weight and height is substantially higher than the prevalences in mothers. These percentages are similar to those reported in a previous study in Cyprus, also based on self-reported data (Savva *et al*, 2002).

Table 2 depicts the anthropometric indices of subjects in males and females and within two age groups, that is, 2.0–4.9 y and 5.0–6.9 y, whereas Table 3 depicts the prevalence of underweight, stunting, and wasting. Overall the prevalence of underweight (WAZ < −2 s.d., 2.3%) and wasting (WHZ < −2 s.d., 2.8%) is somewhat higher than the expected prevalence of 2% (Dibley *et al*, 1987), and there are no substantial differences between males and females or urban and rural areas. On the other hand, stunting is approximately half of the expected prevalence of 2% (HAZ < −2 s.d., 1.1%). Data in Table 3 are presented in the whole group, but also in the age group 2.0–4.9 y to comply with the WHO guidelines (de Onis & Blossner, 2003). Underweight, stunting, and wasting are all associated with low birth weight (that is < 2500 g). As shown in Table 4 children with low weights at birth were more likely to be underweight (OR = 4.09; 95% CI, 1.37–12.24), stunted (OR = 5.15; 95% CI, 1.14–23.31) and wasted (OR = 4.22; 95% CI, 1.25–14.27) as preschool children than their counterparts of normal birth-weight. These models were adjusted for age, sex, gestational age, and parental weight and height. Undernutrition indices,

Table 1 Characteristics of study subjects (n = 1412)[a]

Category	n	%
Sex, males	744	52.8
Residence, urban	867	61.5
Birth weight (gr)		
≤2500	131	9.7
2501–3000	350	25.9
3001–3500	589	43.7
3501–4000	234	17.3
>4000	45	3.3
Education status, paternal		
College/university	483	37.7
High school graduate	508	39.7
Some high school/elementary	289	22.6
Education status, maternal		
College/university	618	47.6
High school graduate	508	39.1
Some high school/elementary	172	13.3
Living with parents		
Both	1242	92.7
One	46	3.4
None	52	3.9
Father's BMI categories (kg/m^2)		
<25	474	38.1
25–30	614	49.3
>30	157	12.6
Father's BMI (kg/m^2)		
20–29 y	81	25.1 (3.2)[b]
30–39 y	795	26.1 (3.1)[b]
≥40 y	368	26.9 (3.5)[b]
Mother's BMI categories (kg/m^2)		
<25	1047	80.2
25–30	194	14.9
>30	65	5.0
Mother's BMI (kg/m^2)		
20–29 y	299	22.0 (3.4)[b]
30–39 y	869	22.5 (3.7)[b]
≥40y	138	24.6 (4.1)[b]

[a]Numbers of subjects (except for sex and residence) vary due to missing data.
[b]Numbers represent means (standard deviation).

Table 2 Subjects' anthropometric indices

		Males						Females					
					Percentiles						Percentiles		
Parameter	*Age (y)*	n	*Mean*	*s.d.*	*25th*	*50th*	*75th*	n	*Mean*	*s.d.*	*25th*	*50th*	*75th*
Weight (kg)	2.0–6.9	744	19.4	4.4	16.5	19.0	21.5	668	18.8	4.4	15.6	18.5	20.8
	2.0–4.9	333	16.9	3.2	14.7	16.5	19.0	319	16.6	3.4	14.0	16.0	18.5
	5.0–6.9	411	21.4	4.1	18.5	20.5	23.0	349	20.7	4.2	18.0	20.0	22.5
Height (cm)	2.0–6.9	744	110.6	8.7	105.0	111.4	116.8	667	109.1	8.3	103.2	109.4	115.0
	2.0–4.9	333	104.0	7.2	99.3	104.2	109.2	320	103.1	6.7	98.3	103.0	107.0
	5.0–6.9	411	115.9	5.6	112.0	115.7	120.0	347	114.5	5.5	111.0	114.2	118.2
BMI (kg/m^2)	2.0–6.9	744	15.7	2.0	14.5	15.4	16.4	666	15.6	2.1	14.2	15.3	16.5
	2.0–4.9	333	15.5	1.7	14.5	15.4	16.2	319	15.5	1.8	14.2	15.3	16.3
	5.0–6.9	411	15.8	2.2	14.5	15.4	16.7	347	15.7	2.3	14.1	15.3	16.6
Weight-for-age (*z*-score)	2.0–6.9	744	0.20	1.4	−0.74	−0.03	0.85	666	0.27	1.4	−0.71	0.19	0.92
	2.0–4.9	333	0.05	1.4	−0.86	−0.16	0.72	319	0.14	1.4	−0.81	0.04	0.87
	5.0–6.9	411	0.32	1.5	−0.59	0.09	0.98	347	0.39	1.4	0.49	0.29	1.01
Height-for-age (*z*-score)	2.0–6.9	744	0.27	1.1	−0.43	0.25	0.94	666	0.34	1.1	−0.45	0.35	0.97
	2.0–4.9	333	0.30	1.1	−0.41	0.25	0.95	319	0.41	1.2	−0.42	0.46	1.05
	5.0–6.9	411	0.25	1.0	−0.45	0.24	0.94	347	0.27	1.0	−0.48	0.28	0.91
Weight-for-height (*z*-score)	2.0–6.9	744	0.02	1.3	−0.83	−0.12	0.56	666	0.12	1.3	−0.78	0.06	0.81
	2.0–4.9	333	−0.13	1.2	−0.88	−0.23	0.38	319	0.02	1.2	−0.93	0.02	0.68
	5.0–6.9	411	0.14	1.4	−0.74	−0.02	0.75	333	0.22	1.4	−0.73	0.13	0.93

Table 3 Prevalence of underweight, stunting, and wasting in relation to age, sex, and area of residence

		Weight-for-age		Height-for-age		Weight-for-height	
Age group (y)	n	*−3s.d.*	*−2s.d.*	*−3s.d.*	*−2s.d.*	*−3s.d.*	*−2s.d.*
Males and Females							
2.0–6.9	1413	0.1	2.3	0.1	1.1	0.3	2.8
2.0–4.9	653	0.2	3.2	0.2	1.1	0.3	2.8
2.0–2.9	78	0.0	1.3	0.0	0.0	0.0	5.1
3.0–3.9	203	0.5	3.9	0.0	1.5	0.5	3.9
4.0–4.9	372	0.0	3.2	0.3	1.1	0.3	1.6
5.0–5.9	492	0.0	1.6	0.0	1.2	0.0	2.9
6.0–6.9	268	0.0	1.1	0.4	1.1	0.7	2.6
Males							
2.0–6.9	745	0.0	2.4	0.3	1.2	0.1	2.6
2.0–4.9	333	0.0	2.7	0.3	1.2	0.0	2.4
Females							
2.0–6.9	668	0.1	2.1	0.0	1.0	0.5	3.0
2.0–4.9	320	0.3	3.8	0.0	0.9	0.6	3.1
Urban							
2.0–6.9	867	0.1	2.3	0.1	1.2	0.2	2.7
2.0–4.9	487	0.2	3.3	0.0	0.8	0.2	3.1
Rural							
2.0–6.9	546	0.0	2.2	0.2	1.1	0.4	2.9
2.0–4.9	166	0.0	3.0	0.6	1.8	0.6	1.8

however, were not associated with gestational age itself (data not shown).

Overweight and obesity prevalence in relation to gender and area of residence is presented in Table 5. The WHO definition obviously classifies more children both as overweight and obese than the IOTF definition. Overall the prevalence of obesity is 7.8% using the WHO definition or 5.5% using the IOTF definition whereas overweight prevalence is 18.4 and 14.1%, respectively. The prevalence of overweight and obesity increased with increasing age. There are no gender differences in obesity prevalence using either definition (IOTF M: 5.4%; F: 5.7%; WHO M: 7.8%; F: 7.8%) but there are some marginal gender differences in overweight rates with girls exhibiting somewhat greater rates than boys both with IOTF definition (M: 12.8%; F: 15.6%;

Table 4 Logistic regression analysis to evaluate the associations of underweight, stunting, and wasting with low birth weight (birth weight <2.500 g)

	Adjusted* odds ratio	
Low birth weight	*OR (95% CI)*	P-*value*
Underweight (WAZ ≤−2)		
No	1.0	
Yes	4.09 (1.37, 12.24)	0.012
Stunting (HAZ ≤−2)		
No	1.00	
Yes	5.15 (1.14, 23.31)	0.033
Wasting (WHZ ≤−2)		
No	1.0	
Yes	4.22 (1.25, 14.27)	0.021

*Adjusted for log age, sex, log gestational age, log father's height, log father's weight, mother's weight, and log mother's height.

Table 5 Overweight and obesity prevalence by age, sex, and urban/rural residence according to WHO and IOTF definitions

		WHO definition		IOTF definition	
		Weight-for-height z-score		BMI equivalent (kg/m^2)	
Age group	n	>1	>2	25	30
Males and females					
2.0–6.9	1413	18.4	7.8	14.1	5.5
2.0–4.9	653	14.4	5.4	10.6	2.9
2.0–2.9	78	6.4	5.1	7.7	1.3
3.0–3.9	203	10.8	4.4	6.9	3.0
4.0–4.9	372	18.0	5.9	13.1	3.2
5.0–5.9	492	18.3	8.6	14.6	6.3
6.0–6.9	268	28.1	12.4	21.6	10.4
Males					
2.0–6.9	745	17.0	7.8	12.8	5.4
2.0–4.9	333	12.0	4.2	8.4	2.7
Females					
2.0–6.9	668	19.8	7.8	15.6	5.7
2.0–4.9	320	16.9	6.6	12.8	3.1
Urban					
2.0–6.9	867	16.8	6.9	12.8	4.7
2.0–4.9	487	14.4	5.3	10.5	2.9
Rural					
2.0–6.9	546	20.8	9.2	16.1	6.8
2.0–4.9	166	14.5	5.4	10.8	3.0

$\chi^2 = 2.804$; df = 1, $P = 0.055$) and the WHO definition (M: 17.0%; F: 19.8%; $\chi^2 = 2.158$; df = 1, $P = 0.081$). Although overweight and obesity prevalence were higher among subjects from rural areas than their counterparts from urban sites, the differences were significant only for overweight prevalence, using both the IOTF definition (rural: 16.1%; urban: 12.8%; $\chi^2 = 3.141$; df = 1, $P = 0.046$) and the WHO definition (rural: 20.8%; urban: 16.8%; $\chi^2 = 3.511$; df = 1, $P = 0.036$).

In logistic regression analysis models presented in Table 6 (adjusted for age and log-age), parental obesity and birth weight proved significant predictors for obesity in the subjects. In particular in full-term children (ie, those with a reported gestational age ≥37 week) the higher the birth weight, the higher the chances that the child is obese at the age of 2.0–6.9 y. The odds ratio for a birth weight more than 4000 g compared to a birth weight between 2501 and 3000 g was 7.63 (95% CI 1.91, 30.52), $P = 0.004$. The risk, however, in children with a low birth weight (≤2500 g) was the same as in children with a birth weight of 2501–3000 g. OR for obesity when the father is obese was estimated at 3.24 (95% CI 1.59, 6.61), $P = 0.001$ and similarly when a mother is obese at 3.91 (95% CI 1.78, 8.59), $P = 0.001$. Finally, parental education level and area of residence were not significantly associated with obesity status of the preschool children.

Table 6 Logistic regression analysis to estimate the associations to obese (IOTF definition, BMI equivalent to 30 kg/m^2) *vs* nonobese subjects (BMI equivalent less than 25 kg/m^2)

	Adjusted[a] odds ratio	
Parameter	OR (95% CI)	P-value
Father's BMI (kg/m^2)		
18.5–24.9	1.0	
25.0–30.0	1.26 (0.69, 2.32)	NS
>30.0	3.24 (1.59, 6.61)	0.001
Mother's BMI (kg/m^2)		
18.5–24.9	1.00	
25.0–30.0	2.70 (1.49, 4.88)	0.001
>30.0	3.91 (1.78, 8.59)	0.001
Paternal education		
Some high school/elementary	1.0	
High school graduate	0.84 (0.46, 1.54)	NS
College/University	0.67 (0.34, 1.27)	NS
Maternal education		
Some high school/elementary	1.0	
High school graduate	1.31 (0.61, 2.83)	NS
College/University	1.13 (0.52, 2.46)	NS
Residence		
Urban areas	1.0	
Rural areas	1.32 (0.77, 2.28)	NS
Birth weight (gr)[b]		
≤2500	0.89 (0.10, 7.75)	NS
2501–3000	1.0	
3001–3500	2.77 (1.10, 6.99)	0.031
3501–4000	4.61 (1.67, 12.73)	0.003
>4000	7.63 (1.91, 30.52)	0.004

[a]Adjusted for age and sex.
[b]Analysis restricted only to full term infants (ie, gestational age ≥37 week).

Discussion

This study has estimated the prevalence of undernutrition and obesity in preschool children for the first time in Cyprus. Estimations were based on WHO (de Onis & Blossner, 2003) and IOTF (Lobstein *et al*, 2004) recommendations for the evaluation of undernutrition and obesity respectively, in order to ensure that results can be comparable to other similar surveys.

The prevalence of undernutrition was low (underweight 2.3%, stunting 1.1% and wasting 2.8%). These values are comparable to the prevalence rates of 2% based on a reference population (Dibley *et al*, 1987). There were small and inconsistent variations in these indices between 1 y age intervals. The underweight prevalence in this study (WAZ<-2 s.d., 2.3%) compares to the 'pooled' prevalence of underweight in developed countries estimates in 1990 which was 1.6%, and is substantially lower than the developing regions of the world that were estimated at 30.2% for 1990 (de Onis *et al*, 2004a). No significant variation was identified in relation to gender, area of residence, and parental education level (data not shown).

Undernutrition, in general, is declining worldwide, although in some instances the situation deteriorates due to political changes and other economic and national crises (Katona-Apte & Mokdad, 1998; de Onis *et al*, 2000; Wang *et al*, 2002). Social inequalities are associated with undernutrition in developed countries. Social deprivation, for example, has been associated with malnutrition (Armstrong *et al*, 2003), but the prevalence of malnutrition varies within developed countries depending on the social class (Bhandari *et al*, 2002). The present study has not, however, found any associations of undernutrition with such parameters, including single parent families, maternal and parental level of education, and area of residence. Low birth weight in the present study proved a significant predictor of underweight, stunting, and wasting even after controlling for age, sex, parental weight and height, and gestational age. Despite the low prevalence of undernutrition in this sample, health professionals should focus on these children since stunting (Liu *et al*, 2000; Leenstra *et al*, 2005) and underweight (Falkner *et al*, 2001; Leenstra *et al*, 2005) may have adverse effects in subjects' psychosocial development, final height, and age of menarche.

The prevalence of overweight and obesity were, overall, substantially higher than undernutrition. Using the IOTF definition for overweight (including obesity) prevalence was 14.1% and obesity prevalence 5.5%. A striking increasing trend was observed both for obesity and overweight as age increased, with obesity rates ranging between 1.3% in 2 y olds and 10.4% in 6 y olds. Similar trends have been observed elsewhere (Whitaker, 2004). The high rates of overweight and obesity in the 6.0–6.9 y age group are in agreement with rates observed 5 y earlier in the same age group (Savva *et al*, 2002). The prevalence of obesity among preschool children is substantial in certain developed countries with some reporting higher levels than this study (Ogden *et al*, 1997; Canning *et al*, 2004), but varies considerably in developing countries (Martorell *et al*, 2000). Longitudinal data indicate that obesity in preschool children in developed countries has increased significantly in the last decades (Ogden *et al*, 1997; Bundred *et al*, 2001; Vaska & Volkmer, 2004), but mainly in 4- and 5-y olds and not in younger ages (Ogden *et al*, 1997).

Parental obesity and birth weight were found to be the most significant predictors of obesity in preschool children in this study. Parental obesity (Gallaher *et al*, 1991; Lake *et al*, 1997; Danielzik *et al*, 2002; Sekine *et al*, 2002) and maternal obesity during pregnancy (Whitaker, 2004) have been shown as major predictors for offspring obesity. Genetic and environmental factors may play a role in this association. For example, specific aspects of the home environment (Strauss & Knight, 1999), family lifestyle (Burke *et al*, 2001), and sedentary activities and lack of physical activities (Faith *et al*, 2001; Trost *et al*, 2001). Similarly preschool (Gallaher *et al*, 1991) and school-aged children (Kromeyer-Hauschild *et al*, 1999) with high birth weight are reported to have a higher risk for obesity. This study did not, however, find any associations between obesity in preschool children and parameters such as maternal education level and household size which have been shown to be significant in other studies (Kromeyer-Hauschild *et al*, 1999). Low family incomes, low cognitive stimulation (Strauss & Knight, 1999), and persistent child tantrums over food and less sleep time in childhood (Agras *et al*, 2004) have also been shown to be associated with obesity in preschool children; these factors were not, however, examined in this study.

Childhood obesity is still under-recognized and under-treated by paediatric primary care providers despite its high frequency (O'Brien *et al*, 2004). It has been shown that the lowest rates of obesity identification occurred among preschool children (O'Brien *et al*, 2004). Only a small percentage of primary healthcare providers are aware of published national recommendations for the management of childhood obesity and even fewer adhere to these recommendations (Kolagotla & Adams, 2004), although it has been argued that at the individual level treatment in preschool aged children is more successful than with older children (Davis & Christoffel, 1994). On the other hand, it has been shown that several population prevention measures such as school-based programmes, family-based intervention, and behaviour modification programmes may be successful although these measures need further refinement given that most studies were methodologically diverse (Wilson *et al*, 2003).

The cross-sectional nature of this study is the main limitation. Further longitudinal surveillance will provide better insight of this issue and will help define the secular trends of obesity in this age group in Cyprus. Also the relatively high percentage of randomly selected subjects that did not give written consent to participate in the study may have modified results. The results of this study suggest, however, that a national strategy for the prevention and management of obesity and its consequences is warranted and should begin as early as the preschool age.

In conclusion, the prevalence of undernutrition in preschoolers in Cyprus is considerably low, whereas the prevalence of overweight and obesity is remarkably higher. The most significant predictors of obesity in this age group, were a high birth weight and parental (both paternal and maternal) obesity. These results suggest the need of implementation of drastic population preventive programmes to reduce the prevalence of obesity and consequently to reduce short-term and long-term complications.

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References

Agras W, Hammer L, McNicholas F & Kraemer H (2004): Risk factors for childhood overweight: a prospective study from birth to 9.5 years. *J. Pediatr.* **145**, 20–25.

Anonymous (1995): An evaluation of infant growth: the use and interpretation of anthropometry in infants. WHO Working Group on Infant Growth. *Bull. World Health Organ.* **73**, 165–174.

Armstrong J, Dorosty AR, Reilly JJ, Child Health Information Team & Emmett PM (2003): Coexistence of social inequalities in undernutrition and obesity in preschool children: population based cross sectional study. *Arch. Dis. Child.* **88**, 671–675.

Bhandari N, Bahl R, Taneja S, de Onis M & Bhan M (2002): Growth performance of affluent Indian children is similar to that in developed countries. *Bull. World Health Organ.* **80**, 189–195.

Bolton-Smith C, Woodward M, Tunstall-Pedoe H & Morrison C (2000): Accuracy of the estimated prevalence of obesity from self reported height and weight in an adult Scottish population. *J. Epidemiol. Commun. Health* **54**, 143–148.

Bundred P, Kitchiner D & Buchan I (2001): Prevalence of overweight and obese children between 1989 and 1998: population based series of cross sectional studies. *BMJ* **322**, 326.

Burke V, Beilin L & Dunbar D (2001): Family lifestyle and parental body mass index as predictors of body mass index in Australian children: a longitudinal study. *Int. J. Obes. Relat. Metab. Disord.* **25**, 147–157.

Canning PM, Courage ML & Frizzell LM (2004): Prevalence of overweight and obesity in a provincial population of Canadian preschool children. *Can Med. Assoc. J.* **171**, 240–242.

Cole TJ, Bellizzi MC, Flegal KM & Dietz WH (2000): Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* **320**, 1240.

Danielzik S, Langnase K, Mast M, Spethmann C & Muller M (2002): Impact of parental BMI on the manifestation of overweight 5–7 year old children. *Eur. J. Nutr.* **41**, 132–138.

Davis K & Christoffel KK (1994): Obesity in preschool and school-age children. Treatment early and often may be best. *Arch. Pediatr. Adolesc. Med.* **148**, 1257–1261.

de Onis M & Blossner M (2003): The World Health Organization Global Database on Child Growth and Malnutrition: methodology and applications. *Int. J. Epidemiol.* **32**, 518–526.

de Onis M, Blossner M, Borghi E, Frongillo EA & Morris R (2004a): Estimates of Global Prevalence of Childhood Underweight in 1990 and 2015. *JAMA* **291**, 2600–2606.

de Onis M, Frongillo E & Blossner M (2000): Is malnutrition declining? An analysis of changes in levels of child malnutrition since 1980. *Bull. World Health Organ.* **78**, 1222–1233.

de Onis M, Garza C, Victora C, Onyango A, Frongillo E & Martines J (2004b): The WHO Multicentre Growth Reference Study: planning, study design, and methodology. *Food Nutr. Bull.* **25**, S15–S26.

Dibley M, Goldsby J, Staehling N & Trowbridge F (1987): Development of normalized curves for the international growth reference: historical and technical considerations. *Am. J. Clin. Nutr.* **46**, 736–748.

Faith MS, Berman N, Heo M, Pietrobelli A, Gallagher D, Epstein LH, Eiden MT & Allison DB (2001): Effects of contingent television on physical activity and television viewing in obese children. *Pediatrics* **107**, 1043–1048.

Falkner NH, Neumark-Sztainer D, Story M, Jeffery RW, Beuhring T & Resnick MD (2001): Social, educational, and psychological correlates of weight status in adolescents. *Obes. Res.* **9**, 32–42.

Gallaher M, Hauck F, Yang-Oshida M & Serdula M (1991): Obesity among Mescalero preschool children. Association with maternal obesity and birth weight. *Arch. Pediatr. Adolesc. Med.* **145**, 1262–1265.

Katona-Apte J & Mokdad A (1998): Malnutrition of children in the Democratic People's Republic of North Korea. *J. Nutr.* **128**, 1315–1319.

Kolagotla L & Adams W (2004): Ambulatory management of childhood obesity. *Obes. Res.* **12**, 275–283.

Kromeyer-Hauschild K, Zellner K, Jaeger U & Hoyer H (1999): Prevalence of overweight and obesity among school children in Jena (Germany). *Int. J. Obes. Relat. Metab. Disord.* **23**, 1143–1150.

Lake JK, Power C & Cole TJ (1997): Child to adult body mass index in the 1958 British birth cohort: associations with parental obesity. *Arch. Dis. Child.* **77**, 376–380.

Leenstra T, Petersen L, Kariuki S, Oloo A, Kager P & Kuile F (2005): Prevalence and severity of malnutrition and age at menarche; cross-sectional studies in adolescent schoolgirls in western Kenya. *Eur. J. Clin. Nutr.* **59**, 41–48.

Liu Y, Albertson-Wikland K & Karlberg J (2000): Long-term consequences of early linear growth retardation (Stunting) in Swedish Children. *Pediatr. Res.* **47**, 475–480.

Lobstein T, Baur L & Uauy R (2004): Obesity in children and young people: a crisis in public health. *Obes. Rev.* **5** (Suppl 1), 4–104.

Martorell R, Kettel Khan L, Hughes M & Grummer-Strawn L (2000): Overweight and obesity in preschool children from developing countries. *Int. J. Obes. Relat. Metab. Disord.* **24**, 959–967.

O'Brien SH, Holubkov R & Reis EC (2004): Identification, evaluation, and management of obesity in an academic primary care center. *Pediatrics* **114**, e154–e159.

Ogden CL, Troiano RP, Briefel RR, Kuczmarski RJ, Flegal KM & Johnson CL (1997): Prevalence of overweight among preschool children in the United States, 1971 through 1994. *Pediatrics* **99**, e1.

Reed D & Price R (1998): Estimates of the heights and weights of family members: accuracy of informant reports. *Int. J. Obes. Relat. Metab. Disord.* **22**, 827–835.

Savva S, Kourides Y, Tornaritis M, Epiphaniou-Savva M, Chadjigeorgiou C & Kafatos A (2002): Obesity in children and adolescents in Cyprus. Prevalence and predisposing factors. *Int. J. Obes. Relat. Metab. Disord.* **26**, 1036–1045.

Sekine M, Yamagami T, Hamanishi S, Handa K, Saito T, Nanri S, Kawaminami K, Tokui N, Yoshida K & Kagamimori S (2002): Parental obesity, lifestyle factors and obesity in preschool children: results of the Toyama Birth Cohort study. *J. Epidemiol.* **12**, 33–39.

Strauss RS & Knight J (1999): Influence of the home environment on the development of obesity in children. *Pediatrics* **103**, e85.

Trost S, Kerr L, Ward D & Pate R (2001): Physical activity and determinants of physical activity in obese and non-obese children. *Int. J. Obes. Relat. Metab. Disord.* **25**, 822–829.

Uauy R, Albala C & Kain J (2001): Obesity trends in Latin America: transiting from under- to overweight. *J. Nutr.* **131**, 893S–899S.

Vaska V & Volkmer R (2004): Increasing prevalence of obesity in South Australian 4-year-olds: 1995–2002. *J. Paediatr. Child Health* **40**, 353–355.

Wang Y, Monteiro C & Popkin BM (2002): Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. *Am. J. Clin. Nutr.* **75**, 971–977.

Whitaker RC (2004): Predicting preschooler obesity at birth: the role of maternal obesity in early pregnancy. *Pediatrics* **114**, e29–e36.

Wilson P, O'Meara S, Summerbell C & Kelly S (2003): The prevention and treatment of childhood obesity. *Qual. Saf. Health Care* **12**, 65–74.