Original Article

The prevalence of childhood obesity in primary school children in urban Khon Kaen, Northeast Thailand

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Childhood obesity is a serious public health problem because of its strong association with adulthood obesity and the related adverse health consequences. The published literature indicates a rising prevalence of childhood obesity in both developed and developing countries. However no data exists on the prevalence in Northeast Thailand, one of the poorest regions of the country and one that has experienced a recent economic transition. The objective of this study was to estimate the prevalence of obesity in seven to nine year old children in urban Khon Kaen, Northeast Thailand. A cross-sectional school based survey was conducted to determine the prevalence of obesity in children of urban Khon Kaen, Thailand. Multi-staged cluster sampling was used to select 12 school clusters of 72 children each between the ages of 7 and 9 years, in primary school grades 1, 2 and 3 from government, private and demonstration schools. A total of 864 seven to nine year old school children were studied. Anthropometric measurements of standing height and weight were taken for all subjects to the nearest tenth of a centimetre and tenth of a kilogram respectively. Childhood obesity was defined as a weight-for-height Z-score above 2.0 standard deviations of the National Center for Health Statistics/World Health Organisation reference population median. The prevalence of childhood obesity was 10.8% (95% CI: 7.6, 13.9). Obesity was significantly more prevalent in boys than girls. The biggest difference was observed between the three school types, with the highest prevalence of obesity found at teacher training demonstration schools and the lowest at the government schools. This study provides the first data on childhood obesity prevalence in Northeast Thailand. The prevalence of 10.8 per cent is lower than that found in two other urban areas of Thailand but slightly higher than expected for this relatively poor region. If this prevalence rate increases, as observed in other countries in economic transition, the incidence of non-communicable diseases associated with obesity is also likely to increase, thus raising cause for concern and reason for intervention to both control and prevent obesity during childhood.

Key Words: prevalence, childhood obesity, Southeast Asia, Thailand, Khon Kaen, school children.

Introduction

There is currently a global epidemic of obesity. Obesity prevalence figures as high as 70% in adults and 30% in children have been reported for some countries.[1,2] However the seriousness of the problem has only recently been recognised, with obesity only being defined as a disease since 1997.[3] In adults, obesity is associated with increased morbidity and mortality from chronic diseases including hypertension, coronary heart disease, gall bladder disease, gallstones, kidney stones, digestive diseases, certain cancers and social or psychological problems.[4,5] The economic cost of adult obesity to society is high with an estimated 2% to 8% of total national health care costs in the West being attributable to obesity.[6] If indirect costs such as loss of wages and productivity reduction are included, the estimated cost of obesity is even higher. In children, obesity can cause hypertension, high cholesterol, impaired glucose tolerance, respiratory problems, dermatological manifestations and orthopaedic problems as well as negative psychological effects and an increased risk of obesity in adulthood.[6] Not only are developed countries faced with the increasing problem of childhood obesity but also developing countries such as Thailand.[7] In developing countries, obesity has been linked to extreme and rapid changes in lifestyle, including changes in physical activity and diet, brought about by urbanisation and rapid economic development.[8, 9]

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Table 1. Prevalence data from studies focusing on childhood obesity

Place	Author/Year	Age range	Result Prevalence (%)
Thailand: southern	Tontisirin 1999[10]	Primary school age	14%
Thailand: Hat Yai	Mo-suwan *et al.* 1993[9]	6-12 years	15.6%
Thailand: Bangkok	Suttapreyasri *et al.* 1990[7]	6-18 years	14.3%
Indonesia: Jakarta	Droomers *et al.* 1995[11]	2-5 years	16.1%
Taiwan	Chen 1997[12]	7-9 years	9%-14%
Kuwait	Al-Isa 1998[13]	0-5 years	8.2%
Italy	Maffeis *et al.* 1998[14]	8 years	22.3%
USA: New York City	Melnik *et al.* 1998[15]	Primary school age	17.8%-19.9%
USA: Florida	Hernandez *et al.* 1998[16]	Preschool age	32%
USA: Alabama	Figueroa-Colon *et al.* 1997[17]	7-9 years	12%-22% (whites) 20%-33% (blacks)
USA: Central Harlem	Okamoto *et al.* 1993[18]	5-11 years	13.8%
USA: Texas	Muecke *et al.* 1992[19]	Primary school age	30%

Prevalence data for obesity in adults is available for many countries.[1,2] However, comparison is difficult because these surveys use a variety of definitions of obesity and employ a range of different measures. The International Obesity Task Force (IOTF) and the World Health Organization (WHO) have reported that about 20% of Western Europeans and white North Americans between the ages of 20 to 60 years are obese, while 40% of Mediterranean and Eastern Europeans and African American women are obese according to the WHO criteria (BMI 30.0-39.9 kg/m^2).[1] The highest rates have been reported in Melanesian, Micronesian and Polynesian populations where prevalence rates are as high as 70% for women and 65% for men.[1] Although the prevalence for obesity is lower within Africa and Asia, obesity is on the rise in these regions, coexisting with a high prevalence of undernutrition.[1]

Compared to adult obesity, there is relatively little data available on childhood obesity prevalence and trends globally. A summary of the results of prevalence studies that have been published on children is shown in Table 1. The reported prevalence ranges from 12% to 33% in the US and Europe and 3% to 16% in Asia. The identification of the problem in child populations is important because of the strong association between childhood and adult obesity, and the demonstrated difficulty in treating the condition in adulthood.

The Northeast is the poorest economic region of Thailand.[20] Like other regions of Thailand, the Northeast has experienced a recent economic transition, shifting from a principally agriculture-based economy to a more industrial-based one. This change has brought about an increased level of rural to urban migration.[21] The study location, the municipality of Khon Kaen city (the third biggest city in Thailand with a population of 152,601) is located in Muang District, Khon Kaen province. Khon Kaen province is a region characterised by having 85% of its people involved in rain fed rice farming. The region also supports industrial activities in manufacturing (fish net, plastic, welded and cast iron), wholesale and retail trade, construction and services (cleaning, laundry and pest control).[22,23] The population has the lowest average household income and the highest average household size of the entire Kingdom of Thailand.

Childhood obesity prevalence rates ranging from 3% to 15.6% have been reported in other urban regions of Thailand (Table 1). However, no published information is available on the prevalence of childhood obesity in urban Khon Kaen. The aim of the study described in this paper was to determine the prevalence of childhood obesity in Khon Kaen city and to identify specific at risk groups within this population. Prevalence differences were examined by sex, age and school type.

Subjects and methods

This prevalence study was part of a larger study of childhood obesity in urban Khon Kaen City, which also included the identification of determinants of childhood obesity and the eliciting of perceptions and beliefs about excess weight in childhood. The specific methods and findings of these additional components are beyond the scope of this paper and are reported elsewhere.[24]

Selection of Sample

Children aged seven to nine years were selected for this study because in this age range growth velocity is more linear than at any other stage in childhood and adolescence. Before the age of seven, children go through a period of adiposity rebound, which leads to an unclear picture of longer term obesity.[25] Most research indicates no significant association between obesity in children below 3 years and adulthood obesity.[16,26-28] Children older than nine years are beginning puberty, where the growth spurt means that height temporarily catches up with weight so that obesity can be temporarily hidden.[19]

It was estimated that a randomly selected sample of 864 children was required,[29] calculated using a 5% error rate, an absolute precision of 2% and an expected prevalence of obesity of 10% (based on current literature[7,9,30] and a pilot study). The expected prevalence was calculated from a pilot study, which involved pre-testing of data collection methods in two non-selected schools of the sampling area and running preliminary analyses on the anthropometric results.

Khon Kaen municipality has 19 primary schools, made up of 4 private catholic schools, 2 teacher-training demonstration schools and 13 government schools.[23] School enrolment records indicated that the target population consisted of 9085 seven to nine year old children from grades 1, 2 and 3. Children were randomly selected from 12 clusters. A cluster was defined as 24 children from the first class in each grade 1, 2 and 3 (a grade sometimes containing several classes). Therefore 12 clusters from 8 of the 19 schools were selected using probability proportional to school size (1 school having 3 clusters, 2 schools having 2 clusters and the remaining 5 schools having 1 cluster each). Based on the analysis of the anthropometric measurements obtained during the pilot phase of the study, the calculated design effect was 1. Random selection of the 24 children from each class was achieved using random numbers allocated according to the age criteria, excluding those less than 7 and greater than 9 full years of age. (Between 7 and 9 years of age was defined as age equal to or greater than 7 years, 0 days and less than or equal to 9 years, 364 days).

Ethical clearance for this research was sought and approved by the Australian Centre for International and Tropical Health and Nutrition (ACITHN) and University of Queensland ethics committees and also by the head of the Khon Kaen Education Department. The principal of each school gave permission for the study to be carried out in their school. All parents of the selected children received an information sheet, which provided information about the purpose and objectives of the study, requesting permission and gave assurance about the confidentiality of the information gathered.

Data collection took place from December 2nd 1999 to February 1st 2000. The three researchers visited each school on a prearranged day with two interpreters. At each school, a list of 72 children to be included in the study cluster was compiled using random number tables. The teacher of each selected class organised the selected children to be weighed and measured by the researchers at a location separate to the classroom. Another randomly selected child immediately replaced any selected child absent from school.

Measurements

Childhood obesity was determined using the weight and height measurements and classified as a weight-for-height greater than + 2.0 Z-scores of the NCHS reference population.[31] This method was chosen because it is relatively non-invasive and inexpensive, reflecting body weight relative to height, thus more closely reflecting body fatness than other methods. It is sensitive to current nutritional status and relatively independent of ethnicity and age in pre-pubertal children. It is the method of measuring childhood obesity recommended by the World Health Organisation.[1]

A standard measurement routine was established. The first researcher weighed each child once on Seca digital scales (SECA 220/220 000, Mess - und Wiegetechnik. Vogel & Halke BmbH & Co. P.O.B. 76 11 80. 2000 Hamburg 76. tel: 040/20 0000-0, fax: 040/20 0000 50) to the nearest 0.1 kg (the subjects being in light clothes with emptied pockets and without shoes). The second researcher would take height measurements using standard methods of each child twice with the wooden stadiometer (locally constructed PTU-KKU, Thailand) without shoes to the nearest 0.1cm. The children stood straight with their heels, shoulders and backsides against the vertical plank and their head was in the Frankfurt plane (the line from the hole in the ear to the bottom of the "orbit" i.e. bone of the eye).[32] The third researcher recorded weight and height data on the recording form. Tasks were rotated on a daily basis between the three researchers. The calibration of the anthropometric equipment was checked at each new location and after long breaks at the sites.

Analysis

The data was entered into EPI INFO (version 6c) and verified by double entry. One boy and 43 girls had recorded heights greater than the upper limit of the NCHS curves (145cm and 137cm for boys and girls respectively). The 44 records of these students could not be analysed using the EPI-Info program. Thus, weight-for-height Z scores for these individuals were calculated separately and entered manually. Analysis was based on all 864 children in the original sample.

Data quality

Outlying values for all variables were identified then checked against the researchers' field records to discount data entry errors, and when necessary compared against recent school health records. Values were amended when found to be incorrect. The 44 outlying height measurements were re-checked against school records and participants were remeasured for validation of data. The ages were verified through consulting birth certificate based school cards in order for all participants to adhere to the strict entry age criteria of this survey (between 7 and 9 full years only).

The prevalence of obesity in children was analysed by child's age, weight, average height (from both readings), sex, grade level, and school type. The anthropometric index of weight-for-height was calculated in Epi-Info (V6c) using the National Centre for Health Statistics (NCHS) reference population. The weight-for-height Z-scores (WHZs) were grouped into 'obese' (> +2.0 WHZs), 'normal' (-2.0 WHZs to +2.0 WHZs) and "wasted" (<-2.0 WHZs) so that the obesity prevalence could be obtained. Since a Student's *t* test indicates whether the difference between two sample means of a continuous variable is significant or not, this was used to compare mean weight and height between the male and female children. For the investigation of an association of weight and height with age, three sample means of a continuous variable were investigated using ANOVA.

Table 2. Summary measures of height and weight for the sample population

Variable	N	Heights (cm)			Weights (kg)			BMI$^{\alpha}$		
		Mean ± SD	Median	Range	Mean ± SD	Median	Range	Mean ± SD	Median	Range
Gender										
Girls	435	126.5 ± 7.6	125.7	109.3 - 150.0	26.6 ± 6.9	24.9	15.6-59.6	16.4 ± 2.8**	15.6	11.8-29.0
Boys	429	126.2 ± 6.7	126.8	104.8 - 149.4	27.1 ± 7.3	25.1	16.0-65.4	16.8 ± 3.2**	15.8	12.6-33.2
Child age groups										
7 year olds	358	122.0 ± 5.4*	121.9	104.8 - 136.3	24.3 ± 5.8*	23.0	15.7-50.2	16.1 ± .8***	15.4	11.8-27.5
8 year olds	297	127.1 ± 5.9*	127.2	109.4 - 147.6	26.9 ± 6.4*	25.0	15.6-57.0	16.5 ±2.9***	15.6	12.6-29.6
9 year olds	209	132.8 ± 6.2*	132.2	114.7-150.0	31.2 ± 7.9*	29.4	17.5-65.4	17.5± 3.3***	16.5	12.4-33.2
Total Sample	864	126.4 ± 7.2	126.4	104.8 - 150.0	26.9 ± 7.1	25.0	15.6-65.4	16.6 ± 3.0	15.7	11.8-33.2

Significantly different from means of other age groups and genders (ANOVA) *P<0.001, **P<0.01, ***P<0.05.
$^{\alpha}$Body Mass Index (BMI) measures have been provided for the readers' interests as BMI child growthcharts [40] have been published since the survey.

Table 3. Summary measures of WHZ of the sample population with obesity prevalence by gender, age and grade

Groupings	Mean ± SD of WHZ	Median of WHZ	Range of WHZ	Obesity prevalence of total sample (95% CI)	Obesity prevalence of 820 non-flagged children	Obesity prevalence based on BMI$^{\alpha}$
Girls	0.1 ± 1.2	0.0	-2.8 – 4.8	8.0% (5.7% - 11.1%)*	8.7% (5.8% - 11.5%)	10.1%
Boys	0.4 ± 1.6	0.0	-2.4 – 6.5	13.5% (10.5% - 17.2%)*	13.3% (8.4% - 18.3%)	15.6%
7 year olds	0.2 ± 1.5	0.0	-2.8 – 6.2	11.7% (8.7% - 15.6%)	11.7% (7.6% - 15.9%)	12.6%
8 year olds	0.2 ± 1.4	0.0	-2.4 – 6.5	9.8% (6.6% - 13.7%)	10.0% (5.8% - 14.3%)	11.8%
9 year olds	0.4 ± 1.3	0.1	-2.2 – 6.1	10.5% (6.7% - 15.5%)	11.6% (6.9% - 17.3%)	14.8%
1st graders	0.2 ± 1.4	-0.0	-2.8 – 6.2	10.8% (6.0% - 15.5%)	10.8% (6.0% - 15.5%)	n/a$^{\beta}$
2nd graders	0.2 ± 1.5	-0.0	-2.4 – 6.5	11.5% (8.0% - 15.0%)	11.6% (8.1% - 15.1%)	n/a
3rd graders	0.2 ± 1.3	0.1	-2.2 – 6.1	10.1% (5.6% - 14.5%)	10.9% (6.0% - 15.8%)	n/a
Total sample	0.2 ± 1.4	0.0	-2.8 – 6.5	10.8% (7.6% - 13.9%) Deff. 2.392	11.1% (8.0% - 14.2%)	12.8%

Significantly different from obesity prevalence in other sex (t test) * P<0.01. CSAMPLE analysis in Epi-Info version 6c taking into account the design effect caused by clustering. $^{\alpha}$ The BMI cut-off for obesity is the 95th percentile curve on the CDC growth charts.[40]
$^{\beta}$ Obesity prevalence is not available by grades as the BMI measure is based on age and sex

The chi-square test was used to identify associations between the row and column variables of categorical data displayed in a *2 x c* table, for example obesity status with the type of school that was attended. CSAMPLE analysis was performed in addition to EPIINFO to account for the multi-cluster sampling technique.

Results

The 864 children in the sample comprised of 9.5% of the total 1st, 2nd and 3rd graders of urban Khon Kaen. There were 429 (49.7%) boys and 435 (50.3%) girls in the sample. There were a greater proportion of younger children compared to older ones within the chosen range of 7 to 9 year olds (Table 2). On average, two children per class, or a total of 8.3% of the randomly selected sample were absent each day of anthropometric measurements. The age, sex, weight or height of the absent children was unknown, as was the reason of absence. Height and weight data from the 864 children is presented in Table 2 by gender and age. There was no significant difference between the mean height and weight of boys and girls, but there were significant differences in the mean height and weight between age groups, as would be expected. The prevalence of obesity in the study population using WHZ was 10.8% (95%CI: 7.6% - 13.9%) (Table 3).

The age adjusted childhood obesity prevalence figure of this sample is 10.7% (95%CI: 7.4% – 13.9%). Age adjustment was performed because there were more 7 year old children than 8 and 9 year olds in the sample. When the 44 flagged children (those taller than the upper limits of the NCHS reference curves) were omitted, the childhood obesity prevalence of the remaining 820 children was 11.1% (95%CI: 8.0% - 14.2%). Taking into account the design effect, the variance was estimated to be 2.4 times that for a simple random sample resulting in wider confidence intervals. Based on BMI, the prevalence of obesity was 12.8%.

The study population was taller and heavier on average than the NCHS reference population. The mean WHZs show that in this sample boys had a significantly higher mean WHZ than girls and the corresponding prevalence of obesity was also greater (P=0.005) (Table 3). There was no significant difference in the prevalence of obesity among the three age groups, or grade levels, although the highest prevalence of obesity was amongst the 7 year olds and the 2nd graders.

The association between school environment and obesity was investigated by comparing obesity prevalence across the three school types: government, private and demonstration schools (Table 4). The prevalence of obesity in the school types differed significantly (χ^2=14.33, P=0.006). The demonstration school had the highest obesity prevalence. The government schools had the lowest obesity prevalence. The proportion of mothers who had completed tertiary education was significantly greater for children attending the demonstration school, compared to those at private schools or government schools (χ^2=54.78, P<0.001). A similar pattern was found for father's high education status across the school types (χ^2=56.46, P<0.001). Most children attending the demonstration school (57.5%) were from high income households (>30,000 Baht monthly income), while private and government schools had a lower representation of children from high income households (χ^2=125.71,P <0.001).

Discussion

Khon Kaen municipality is an urban centre located in a relatively poor area of Thailand, which is more likely to have experienced greater economic transition than the adjacent rural areas. The prevalence of 10.8 per cent found in this study in urban Khon Kaen was slightly lower than the prevalence of childhood obesity reported in other urban studies carried out in southern[10,30] and central Thailand[7] where the prevalence was around 14 per cent. Increasing economic development in a region is often associated with increasing prevalence of obesity, not only in industrialized countries but also in newly developed nations such as Brazil.[33-35] The international literature has portrayed developing countries as having relatively low levels of obesity coexisting with high prevalence of wasting.[1] In contrast, this study shows a developing country region with a relatively high prevalence of childhood obesity (10.8%) coexisting with a low prevalence (1.2%) of wasting. This pattern of nutritional status is similar to that observed in Brazil and supports the observation that the Khon Kaen region of Thailand is in a transitional phase of its economic development.[21] It also demonstrates the degree of heterogeneity in health and nutrition problems in developing countries.

As this study was cross-sectional and no previous obesity prevalence studies have been carried out in Khon Kaen, changes in the prevalence of childhood obesity over time could not be ascertained. However, preliminary qualitative research in Khon Kaen shows that most child caregivers (primary school teacher, parent or grandparent) interviewed believed that the proportion of children carrying excess weight had increased over a 20-year period.[24] In a study on childhood obesity in Taiwan, Chen (1997)[12] reported that in 1954 no primary school children were found to be obese, in 1970 he found a 2% obesity prevalence, and 16 years later in1986, the prevalence of obesity in school children had risen to 17.4%. This increase of childhood obesity coincides with

Table 4. Prevalence of obesity by school type and characteristics of environment

School Type:	Government	Private	Demonstration	Total
N	576	144	144	864
Obesity prevalence	8.3% (6.1% - 10.6%)	13.2% (7.7% -18.7%)	18.1%* (11.8% - 24.3%)	10.8% (7.6% - 13.9%)
% of children from household incomes > 30,000 baht per month	11.1% (6.5% - 15.7%)	18.5% (10.5% - 26.6%)	57.5%** (47.3% - 67.7%)	20.5% (9.3% - 31.6%)
% of children of mothers with tertiary education	45.3% (34.0% - 56.6%)	56.3% (56.1% - 56.4%)	82.8%** (77.7% - 87.9%)	53.7% (42.4% - 65.0%)
% of children of fathers with tertiary education	51.3%** (43.9% - 58.8%)	75.2%** (74.2% - 76.2%)	85.1%** (84.2% - 86.0%)	61.2% (51.4% - 71.0%)

Significantly different from other categories reading across (Chi squared test) *P<0.01, **P<0.001.

the strong economic growth that has been experienced in the region since 1952 through to the present-day, Taiwan being one of the Asian economic 'Tigers'.[36]

In the current study, boys were more likely to be classified obese than girls. A study carried out by Mo-suwan and Geater in southern Thailand found no significant difference in the prevalence of obesity between the sexes.[30] The finding of our study may be due to cultural factors specific to the Northeast region of Thailand. As reported elsewhere we observed that older child caregivers said that it was acceptable for boys to carry excess weight but not girls, indicating a possible culturally influenced gender bias.[24] This is supported by studies carried out in the United States of America across different ethnic groups that found the association between gender and weight status to vary according to cultural influences. For example, Melnik and colleagues found a greater proportion of obese second grade males compared to females on average in the USA.[15] However, when analysed by population subgroups it was found that girls of Hispanic backgrounds were the most at risk of being obese when compared to non-Hispanic girls. Thus the weight status of a child is suggested to be affected differentially depending on their sex and the associated culturally defined influences.

The measurement board and the footboard of the wooden stadiometer used for measuring children's heights was not precisely perpendicular. This inherent limitation of the measuring instrument could have resulted in height measurement error but this is likely to have been non-differential. Skinfold thickness measurements can be used to determine whether excess weight is due to fat or fat-free mass.[31] Indirect adiposity measures were not used as a further screening tool in this study. This may have led to an over- or under-estimation of prevalence in this study, however, this was considered to be a minor source of error in a study population of children where muscle development does not markedly differ between individuals.

Children with excess weight are more susceptible to illness and thus more likely to be absent from school.[24] Our study did not seek to include children who were absent from school on the day anthropometric measurements were taken. This phenomenon is similar to that of the healthy worker effect, with obese children being more prone to health problems and therefore more likely than non-obese children, to stay home from school. This may have led to an under-estimation of the obesity prevalence in 7-9 year old children in Khon Kaen.[37, 38]

In conclusion, the proportion of obese seven to nine year old children in urban Khon Kaen was found to be 10.8% (95% CI: 7.6% – 13.9%). This prevalence is a concern because if it increases, as has been the pattern in populations undergoing rapid economic transition, it is likely that Khon Kaen will experience a resulting increase in non-communicable diseases associated with obesity in adults of the future. Based on estimates of carriage of obesity into adulthood, approximately 5% of the study population will become obese adults, a total of 450 adults of this cohort. This figure is based on data from studies carried out in Western societies where percentage estimates of obese children becoming obese adults are 42-63% for school age children. This suggests that public health intervention should focus on the control and prevention of obesity in children through an integrated community approach. Additional obesity prevalence surveys should be carried out in the 7 – 9 year old age group at regular intervals in order to be able to assess the probable rate of increase so that programs can be paced accordingly. Cole and others have recently established a standard definition for child overweight and obesity worldwide.[39] The newly developed childhood obesity BMI cutoffs should be used in future research in order to eliminate inconsistencies in choice of measurements, cutoffs, and also to facilitate international comparisons.

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References

1. WHO 1996: http://www.who.int/nut/malnutrition_worldwide.htm#oao
2. UNICEF Statistics: http://www.unicef.org/statis/ Apr 1998
3. Gill TP, Antipatis VJ, James WPT. The global epidemic of obesity, Asia Pacific J Clin Nutr 1999; 8 (1): 75-81.
4. Saw SM, Rajan U. The Epidemiology of Obesity: A review. Ann Acad Med (Singapore) 1997; 26: 489-493.
5. James WPT. The epidemiology of obesity. The origins and consequences of obesity. Paper presented to Ciba Foundation Symposium 201: Wiley: Chichester; 1996; 1-16.
6. Schonfeld-Warden N, Warden CH. An overview of etiology and treatment. Pediatr Clin North Am 1997; 44 (2): 339-356.
7. Suttapreyasri D, Kanpoem J, Suthontan N, Krainam J, Boonsuya C. Weight-control training-models for obese pupils in Bangkok. J Med Assoc (Thai) 1990; 73 (7): 394-400.
8. Popkin BM. The nutrition transition in low-income countries: an emerging crisis. Nutrition Reviews 1994; 52 (9): 285-298.
9. Mo-suwan L, Junjana C, Puetpaiboon A. Increasing obesity in school children in a transitional society and the effect of the weight control program. Southeast Asian J Trop Med Pub Health 1993; 24 (3): 590-594.
10. Tontisirin K. The changing climate of health and nutrition in Thailand: A report from the Institute of Nutrition at Mahidol University. Food and Nutrition Bulletin 1999; 20 (2): 228-230.
11. Droomers M, Gross R, Schultink W, Sastroamidjojo S. High socio-economic class preschool children from Jakarta, Indonesia are taller and heavier than NCHS reference population. Eur J Clin Nutr 1995; 49: 740-744.
12. Chen W. Childhood obesity in Taiwan. Acta Paediatrica 1997; 38 (6): 438-442.

13. Al-Isa AN, Moussa MAA. Obesity among Kuwaiti pre-school children aged 0-5 years: prevalence and comparison with the NCHS/CDC reference population. Nutrition and Health 1998; 12: 235-246.
14. Maffeis C, Talamini G, Tato L. Influence of diet, physical activity and parents' obesity on children's adiposity: a four-year longitudinal study. Int J Obes Relat Metab Disord 1998; 22 (8): 758-764.
15. Melnik TA, Rhoades SJ, Wales KR, Cowell C, Wolfe WS. Overweight school children in New York City: prevalence estimates and characteristics. Int J Obes Relat Metab Disord 1998; 22: 7-13.
16. Hernandez B, Uphold CR, Graham MV, Singer L. Prevalence and correlates of obesity in preschool children, J Pediatric Nursing 1998; 13 (2): 68-76.
17. Figueroa-Colon R, Franklin FA, Lee JY, Aldridge R, Alexander L. Prevalence of obesity with increased blood pressure in elementary school-aged children', Southern Medical Journal, 1997; 90 (8): 806-813.
18. Okamoto E, Davidson LL, Conner DR. High prevalence of overweight in inner-city schoolchildren. AJDC 1993; 147: 155-159.
19. Muecke L, Simons-Morton B, Huang IW, Parcel G. Is childhood obesity associated with high-fat foods and low physical activity? J School Health 1992; 62 (1): 19-23.
20. The National Statistics Office. Essential Statistics of Thailand. The Office of the Prime Minister, Thailand, 1999.
21. United Nations. Frameworks for population and development integration - Vol.2: Asian population studies series. Bangkok: Economic and Social Commission for Asia and the Pacific, 1989.
22. Khon Ministry of Interior, Department of Local Administration (DOLA), Khon Kaen Municipality. Khon Kaen Comprehensive Urban Development Framework. Danish Cooperation for Environment and Development (DANCED). Thailand, 1998.
23. Khon Kaen City Municipality. Report on the Activities of Khon Kaen City Municipality. Khon Kaen City Municipality. Thailand, 1998.
24. Langendijk G, Van Wyk M, Wellings S. Prevalence and patterns of obesity in seven to nine year old children in urban Khon Kaen, Northeast Thailand. Master of Community Nutrition thesis; ACITHN, University of Queensland, Brisbane, Australia, 2000.
25. Rolland-Cachera MF, Brambilla P, Manzoni P, Akrout M, Sironi S, Del Maschio A, Chiumello G. Body composition assessed on the basis of arm circumference and triceps skinfold thickness: a new index validated in children by magnetic resonance imaging. Am J Clin Nutr 1997; 65: 1709-1713.
26. Shetty PS. Childhood obesity in developing societies. Bulletin of Nutrition Foundation of India 1999; 20 (2): 1-4.
27. Power C, Lake JK, Cole TJ. Body mass index and height from childhood to adulthood in the 1958 British cohort. Am J Clin Nutr 1997; 66: 1064-1101.
28. Whitaker RC, Wright JA, Pepe MS, Siedel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. N Engl J Med 1997; 337 (13): 869-873.
29. Kirkwood BR. Essentials of Medical Statistics. Blackwell Science, 1996.
30. Mo-suwan L, Geater AF. Risk factors for childhood obesity in a transitional society in Thailand. Int J Obes Relat Metab Disord, 1996; 20: 697-703.
31. Gibson RS. Principles of Nutritional Assessment. New York: Oxford University Press, 1990.
32. United Nations. How to weigh and measure children assessing the nutritional status of young children in household surveys. Department of Technical Cooperation for Development and Statistical Office. New York: United Nations, 1986.
33. Monteiro CA, Mondini L, de Souza AL, Popkin BM. The nutrition transition in Brazil. Eur J Clin Nutr 1995; 49 (2): 105-13.
34. Monteiro CA, D'A Benicio MH, Conde WL, Popkin BM. Shifting obesity trends in Brazil. Eur J Clin Nutr 2000; 54 (4): 342-6.
35. World Bank. Data 1999. http://www.worldbank.org/data/countrydata/countrydata.html
36. CIA Factbook 2000. http://www.cia.gov/cia/publications/factbook/geos/#Econ
37. Criqui M H, Barrett-Connor E, Austin M. Differences between respondents and non-respondents in a population based cardiovascular disease study. Am J Epidemiology 1978; 108: 367.
38. Jazon L, Hanson B S, Isacsson S O. Factors influencing participation in health surveys: results from prospective population study 'Men born in 1914' in Malmo, Sweden. J Epidemiology Community Health 1986; 40: 174.
39. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000; 320: 1240.
40. US National Center for Health Statistics, and National Center for Chronic Disease Prevention and Health Promotion, 2000. http://www.cdc.gov/growthcharts