High Levels of Childhood Obesity Observed among 3- to 7-Year-Old New Zealand Pacific Children Is a Public Health Concern

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ABSTRACT This cross-sectional, community-based survey was designed to assess attained growth and body composition of 3- to 7-y-old Pacific children (n = 21 boys and 20 girls) living in Dunedin, New Zealand, and to examine nondietary factors associated with the percentage of body fat. Fat mass, lean tissue mass and the percentage of body fat were measured using dual energy X-ray absorptiometry. One trained anthropometrist also measured height, weight, skinfolds (triceps, subscapular) and circumferences (mid-upper arm, chest, waist, calf). Compared with the National Center for Health Statistics and National Health and Examination Surveys I and II reference data, these Pacific children were tall and heavy for their age with high arm-muscle-area-for-height. Median (quartiles) Z-scores for height and BMI-for-age and arm-muscle-area-for-height were 1.33 (0.60, 2.15), 1.20 (0.74, 4.43) and 1.09 (0.63, 1.85), respectively. Their median (quartile) percentage of body fat was 21.8% (15.0, 35.5) of which 38.5% was located in the trunk. The estimated percentage of children classified as obese ranged from 34 to 49% depending on the criterion used. Over 60% of the children had levels of trunk fat above 1 so of reported age- and sex-specific Z-scores for New Zealand children. The nondietary factors examined (hours of television viewing and hours playing organized sports, as reported by parents) were not associated with variations in the percentage of body fat, after adjusting for age, sex and birth weight. These extremely high levels of obesity and truncal fat among very young New Zealand children will have major public health implications as these children age.


KEY WORDS: • Pacific • children • obesity • growth • anthropology

The prevalence of obesity is increasing rapidly worldwide (1). In New Zealand (NZ), interethnic group differences in the prevalence of overweight and obesity exist. The limited cross-sectional information on children shows that in 5- to 11-y-old Auckland children, 24% of Pacific compared with 9% of Caucasian were classified as obese (2). Skinfold measurements also indicate a more central pattern of fat distribution in Pacific compared with non-Pacific populations (3,4). This is of concern, because chronic diseases in adulthood are even more strongly associated with central obesity than with overall obesity, although the latter is also a risk factor (5). Of particular concern is type 2 diabetes because of its high prevalence in the NZ Pacific community (6).

The specific etiology of obesity in Pacific people living in NZ is unknown, but will be related to a combination of environmental and genetic factors. The dramatic rise in body weight of Pacific adults and children after migration to Westernized countries, and the differences in body weight comparing rural with urban populations in the Pacific Islands (7,8) indicate a genetic susceptibility to weight gain when introduced to the Western diet and/or lifestyle. Evidence for an evolutionary adaptation toward efficient fat deposition via a relatively low resting metabolic rate has also been reported (3).

To date there is only limited information on the growth and body composition of NZ Pacific children (2,4,9,10) and an absence of direct measurements of adipose and lean body tissue mass. The advantages of direct measurement techniques, such as dual energy X-ray absorptiometry (DXA) over the indirect measurements of height, weight, skinfolds and bioelectrical impedance analysis used in previous studies (2,4,9,10) include its higher accuracy and precision as well as the ability to analyze regional fat distribution (11). Such information on young Pacific children will more fully characterize their growth and body composition. This study, therefore, aimed to provide an in-depth analysis of the growth, body composition and fat patterning of 3- to 7-y-old Pacific children living in Dunedin, NZ. Nondietary factors potentially associated with obesity such as parental reported hours of television watching and hours of participation in organized sports were also investigated.

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3 Abbreviations used: DXA, dual energy X-ray absorptiometry; NCHS, National Center for Health Statistics; NHANES, National Health and Examination Surveys; NZ, New Zealand.

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GROWTH AND BODY COMPOSITION OF PACIFIC CHILDREN

SUBJECTS AND METHODS

A cross-sectional, community-based survey of 3- to 7-year-old Pacific children living in Dunedin, NZ was carried out between May and November 2000. This survey was performed in collaboration with the Pacific Islands Advisory Council. In this survey, anthropometric measurements and a DXA scan were made during one clinic visit conducted between 0845 and 1300 h. The Ethics Committee of the University of Otago, and the Southern Regional Ethics Committee, Dunedin, NZ approved this study.

Children (n = 41) were recruited via community networks from the Pacific communities in Dunedin. This method of recruitment was used instead of random sampling because there was no existing sampling framework, and to enhance the response rate. Selection criteria included children who had lived in NZ for at least 2 y, were 3–7 y old inclusive, apparently healthy and whose parents were both of Pacific descent. If there were more than two eligible children per family, then one child was randomly selected to participate, using a computer-generated random number. Of the 46 eligible children identified, five refused to participate, providing an 89% response rate.

The participants’ parents completed a pretested, self-administered general questionnaire that provided information on general sociodemographic characteristics, the child’s health, their hours per week of television viewing and participation in organized sports (i.e., after school sports, local sports clubs and community/church group organized sports). The questionnaire was written in English and a translator was available, if needed.

All anthropometric measurements were performed by one trained anthropometrist following standardized procedures (12). A trained assistant recorded all measurements and helped with positioning. Serial, duplicate measurements of height, weight, circumferences (mid-upper arm, chest, waist, and calf) and skinfold thicknesses (triceps and subscapular) were made on all children after they had removed their shoes and clothing from their upper bodies. The calf and arm circumferences, as well as the skinfold measurements were made on marked measurement sites on the right hand side of the body.

Height was measured using a stadiometer accurate to within ± 0.1 cm. Weight was measured using a Seca 770 Alpha Scale (Seca, Weighing and Measuring System, Columbia, MD) accurate to within ± 0.1 kg, which was calibrated with a 5.3-kg weight before weighing each child. The circumferences were measured using a Rubone diameter tape (Rubone, Birmingham, UK) accurate to within ± 0.1 cm. Measurements of skinfolds were made using the Lange caliper (Lange, Cambridge, Cambridge, MD) accurate to within ± 1.0 mm, which was calibrated with a Gage block before each measurement session. If the measurements differed by more than ± 0.5 kg for weight, ± 0.5 cm for height and the circumferences, or ± 0.5 mm for the skinfolds, then a third measurement was taken. The closest two measurements were then averaged. The intra-examiner percentage of technical error of measurement was 2.2% for the triceps skinfold, 4.2% for the subscapular skinfold, < 0.5% for height and weight, and < 2% for all of the circumferences.

Arm-muscle-area, and arm-fat-area were calculated for each child from the triceps skinfold and mid-arm circumference measurements, using standard equations (13). Currently, reference data do not exist for Pacific children; therefore, height-for-age and weight-for-height Z-scores were calculated using the National Center for Health Statistics (NCHS) reference data in the Epidemiology Information version 6 (USDA, Stone Mountain GA). The new version of Epidemiology Information (2000) could not be used because it accommodated heights only up to 121.5 cm for the weight-for-height Z-score, and some participants were taller than that. The BMI Z-score was calculated from NCHS data files with the LMS values and the equation released in May 2000 (14). Z-scores for skinfolds-for-age (triceps, subscapular, sum of triceps + subscapular), mid-upper arm circumference-for-age, arm-fat-area-for-age and arm-muscle-area-for-height were calculated using the LMS method for constructing normalized growth standards (15) and the National Health and Examination Surveys (NHANES-I and II) reference data (16). There was no existing material with three bone-stimulating chambers of known bone mineral content. Three times a week, a spine phantom was also scanned. All met fixed accuracy and precision standards (16). The in vivo precision of our DXA scanning procedures, assessed previously in six healthy young adults, each scanned ten times over ten consecutive working days, is 2.6, 2.5 and 1.1% for the CV for total fat mass (kg), percentage of fat, and bone-free lean tissue mass (kg), respectively. DXA scanning time was used instead of random sampling because there was no existing sampling framework, and to enhance the response rate. Selection criteria included children who had lived in NZ for at least 2 y, were 3–7 y old inclusive, apparently healthy and whose parents were both of Pacific descent. If there were more than two eligible children per family, then one child was randomly selected to participate, using a computer-generated random number. Of the 46 eligible children identified, five refused to participate, providing an 89% response rate.

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RESULTS

The study population ranged in age from 36 to 93 mo (mean ± SD, 62.6 ± 16.2 mo); 51% were male and 49% were female, and their mean reported birth weights were 3.7 ± 0.5 kg. Among the children, 46% were Samoan, 22% Tongan, 12% were Cook Island and the other 20% were other Pacific or mixed Pacific groups. The majority of children were born in NZ (80.5%).

The simple anthropometric data showed that these Pacific children were taller, heavier, had larger girths and higher levels of subcutaneous body fat than the reference population (Table 1). The median percentage of body fat of these young Pacific children, as assessed by DXA, was 21.8% of which 38.5% was located in the trunk region (Table 1). Over 75% of the children had >15.0% total body fat.

The estimated prevalence of obesity ranged from 34 to 49%, depending on the index used (Table 2), and was generally lowest when estimated using DXA percentage of body fat > 30%. All children with a percentage body fat > 30% were also classified as obese using the other three definitions. Most children (61%) had high regional trunk fat. Over 29% of the children also had high (>1.65 SD) Z-scores for skinfolds-for-age, arm-fat-area-for-age and arm-muscle area-for-height (Table 2). For height-for-age, 42% had Z-scores > 1.65 (data not shown).
Comparing children who watched $< 15$ h of television per week showed that the age- sex- and birth-weight adjusted geometric mean percentage of body fat was 22% for $< 15$ h per week ($n = 20$) and 25% for $> 15$ h per week ($n = 17$), percentages that did not differ significantly. Similarly, participation in organized sports ($n = 10$) did not have an effect on the percentage of body fat, which was 21% for nonparticipants ($n = 31$) vs. 26% for participants (age- sex- and birth-weight adjusted geometric means).

**DISCUSSION**

This is the first study to provide such comprehensive data on the growth and body composition of Pacific children in NZ. No previous work has established high adiposity in Pacific children of such a young age using the objective method of DXA. Even though these results are only preliminary, given the small sample size and nonrandom method of recruitment, the recruitment method provided the most effective approach to gain community support and to honor our partnership with the Pacific Island communities.

Our results clearly showed that on average, this group of 3- to 7-year-old Dunedin Pacific children were taller, heavier, had a more truncal fat distribution and a higher arm-muscle-area than the American reference population or Caucasian NZ children (13,24). The levels of childhood obesity were high regardless of the definition of obesity and the method used to measure fat status. These rates and the mean BMI were also substantially higher than those of 3- to 7-year-old Caucasian children living in Dunedin ($n = 268$) who were measured as part of the screening process for another component of this study (unpublished data, University of Otago, 2000). For example, the estimated prevalence of obesity in these predominantly Caucasian children ranged from 7 to 13%, compared with 42–49% in the Pacific children, depending on the crite-

**TABLE 1**

Measurements of attained growth and body composition for forty-one 3- to 7-year-old New Zealand Pacific children

<table>
<thead>
<tr>
<th>Simple anthropometry</th>
<th>Median (quartiles)</th>
<th>Z-scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height, m</td>
<td>1.19 (1.04, 1.25)</td>
<td>Height-for-age 1.33 (0.60, 2.15)</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>24.9 (18.5, 34.0)</td>
<td>Weight-for-height 1.32 (0.73, 3.62)</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>18.3 (16.9, 22.8)</td>
<td>BMI-for-age 1.20 (0.74, 4.43)</td>
</tr>
<tr>
<td>Arm circumference, cm</td>
<td>19.7 (17.8, 23.2)</td>
<td>Triceps-for-age 0.54 (–0.16, 5.20)</td>
</tr>
<tr>
<td>Chest circumference, cm</td>
<td>61.0 (57.0, 70.8)</td>
<td>Subscapular-for-age 0.79 (–0.07, 9.14)</td>
</tr>
<tr>
<td>Calf circumference, cm</td>
<td>26.4 (23.9, 30.0)</td>
<td>Sum skinfold-for-age 0.57 (–0.13, 8.16)</td>
</tr>
<tr>
<td>Triceps skinfold, mm</td>
<td>12.2 (9.1, 22.4)</td>
<td>MUAC4-for-age 0.96 (0.31, 2.81)</td>
</tr>
<tr>
<td>Subscapular skinfold, mm</td>
<td>8.8 (5.9, 21.4)</td>
<td>Arm fat area-for-age 0.59 (–0.13, 6.43)</td>
</tr>
<tr>
<td>Arm-fat-area, cm²</td>
<td>10.6 (8.2, 22.2)</td>
<td>AMA5-for-height 1.09 (0.63, 1.85)</td>
</tr>
<tr>
<td>Arm-muscle-area, cm²</td>
<td>19.4 (17.2, 22.2)</td>
<td>DXA6</td>
</tr>
</tbody>
</table>

1 Arm-fat-area = [(triceps skinfold × arm circumference)/2] – [π × (triceps skinfold)²/4].
2 Arm-muscle-area = [arm circumference – (π × triceps skinfold)²/4π].
3 Sum skinfold thicknesses = sum of triceps + subscapular skinfold thicknesses (mm).
4 MUAC, mid-upper arm circumference.
5 AMA, mid-upper arm muscle area.
6 DXA, dual energy X-ray absorptiometry.
7 Lean tissue represents mass for which values exclude the weight of the bone mineral content.

**TABLE 2**

The number ($n$) and percentage (95% CI) of forty-one 3- to 7-year-old New Zealand Pacific children with high regional trunk fat, high Z-score values, and classified as obese, using various classification criteria

<table>
<thead>
<tr>
<th>% Obese</th>
<th>Z-score &gt; 1.65</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>% (95% CI)</td>
</tr>
<tr>
<td>BMI30 by Cole¹</td>
<td>17</td>
</tr>
<tr>
<td>WHZ-score² &gt; 1.65</td>
<td>20</td>
</tr>
<tr>
<td>BMI  &gt; 95th percentile</td>
<td>20</td>
</tr>
<tr>
<td>Body fat  &gt; 30%⁴</td>
<td>14</td>
</tr>
<tr>
<td>High trunk fat⁵</td>
<td>25</td>
</tr>
</tbody>
</table>

¹ Defined by Cole et al. as a BMI = 30 kg/m² in young adulthood (19).
² Weight-for-height Z-score as defined by Frisancho (13).
³ Sum skinfold = sum of triceps + subscapular skinfold thicknesses (mm).
⁴ Measured by dual energy X-ray absorptiometry and defined by Ellis (20).
⁵ Defined by Taylor et al. (17).
ria used. The levels of obesity in these Dunedin Pacific children were also higher than similar aged non-Pacific children in the United States, United Kingdom and Australia (25–28), which were reported to be <12% (27,28), using similar classification criteria.

The results from our study are consistent with a study recently carried out on 5- to 11-y-old Auckland school children (2), which showed that 24% of Pacific children vs. 9% of Caucasian children were defined as obese using NHANES I reference data for BMI (>95th percentile). However, the estimated level of obesity was lower for the Auckland Pacific children than for these Dunedin children, when defined using the same criteria for BMI (24 vs. 63%), even though it was similar when based on percentage of body fat (49 vs. 46%). Potential reasons for these discrepant results include interstudy differences in measurement techniques for percentage of body fat (i.e., bio-electrical impedance vs. DXA) (20) and the ethnic make-up of the study populations. In addition, the smaller sample size in the current study may have resulted in a potential selection bias for both studies might have contributed to the differences. Nevertheless, a lower rather than higher estimate of obesity rates would have been expected in the current study compared with the Auckland study because obesity tends to increase with age (29). This indicates regional differences in the body composition of Pacific children might exist in NZ, perhaps reflecting regional differences in environmental and/or cultural factors. This, however, would need confirmation in a larger survey.

The high mean height-for-age Z-scores of the Dunedin Pacific children indicate that the estimates for obesity must be interpreted cautiously. Pacific adults are not taller than the general NZ population (30), which suggests that our Pacific children were maturing earlier than other NZ children. A recent longitudinal study of African-American and Caucasian girls showed that early maturation rates partially accounted for the higher prevalence rates of obesity and higher sum of skinfold thicknesses among the African-American compared with Caucasian girls (31). In our study, early maturation probably did not fully account for the observations, however, because the percentage classified as obese decreased only from 42 to 34%, using Cole’s definition (19), when 2 y were added to each child’s actual age.

In our study, the estimated percentage of obese children was higher when indices were based on weight and height than when based on more direct measures of fat (i.e., skinfolds and percentage of body fat). The exception was the subscapular skinfold Z-score > 1.65 so, which was biased upward by the more truncal fat distribution of these Pacific compared with Caucasian children. In adults, a higher BMI cut-off value is used for Pacific adults than for Caucasians, because of ethnic differences in musculature (32). In these Pacific children, greater muscularity may also have contributed to the inter-obesity index differences observed. However, the arm-muscle-area index itself was biased upward by the high regional trunk fat distribution, suggesting that, unlike in adulthood, the role of muscularity was, if anything, minor.

The etiology underlying the high levels of obesity in these Pacific children was unclear. We found no significant associations between activity (hours of television viewing and participation in organized sport) and obesity. However, this may merely reflect the small sample size, and error or poor precision in the indices used to assess activity (parental reported activity levels). A genetic propensity for excessive weight gain may also be an important contributing factor (3).

The high rates of obesity among Pacific children living in NZ observed here and elsewhere (2,10) is a public health concern regardless of the etiology. Children who are obese are more likely to become overweight adults, and therefore suffer the associated health problems (24,33). Even in childhood, obesity has been related to high blood lipid concentrations, raised blood pressure and elevated blood insulin levels (21,22), as well as premature onset of atherosclerotic plaques of the coronary arteries (34). Type 2 diabetes is four times more common and occurs at an earlier age in Pacific compared with Caucasian New Zealanders (6). It is, therefore, imperative to reduce these high levels of childhood obesity in Pacific children to improve their health status in later years.

Finally, the potential selection bias (nonrandom sample), the small sample size and the stringency of subject selection criteria (both parents had to be Pacific) in the current study must be noted. Even though the response rate was high (59%), these factors limit the generalizability of these preliminary results. Nevertheless, our results do confirm that high weight-for-height indices reflect high levels of body fat in young Pacific children.

In summary, the high rates of obesity observed in these very young Dunedin Pacific children, and confirmed using a variety of definitions and methods, is of concern, especially given the high truncal fat distribution. Detailed information on the types and quantities of foods NZ Pacific children are eating, as well as their physical activity levels, are required to better understand the etiology of obesity in this group. Current reference data, based on Caucasian populations, must also be interpreted with caution when used for Pacific children, because of ethnic differences in regional fat distribution. In the meantime, community-based nutrition and exercise programs for all family members, including preschoolers may help decrease levels of obesity in this clearly vulnerable group. This in turn should decrease morbidity and mortality from noncommunicable diseases in this population.

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LITERATURE CITED