Concerns in Assessing Overweight and Obesity in American Samoan Adolescents

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Abstract

A small number of well informed Samoans question the relevance of applying standards developed primarily from Caucasian populations when screening Polynesian children for obesity. They attribute higher body mass index values in Polynesian populations, in part, to anatomical factors other than higher body fat percentage. We attempted to allay these suspicions by assessing a sample of 380 American Samoan schoolchildren aged 11 to 18 for overweight and obesity using both the International Obesity Task Force and the Centers for Disease Control age- and sex-specific body mass index cutoffs and recently proposed age- and sex-specific waist circumference cutoffs for children and adolescents. We tested cholesterol and glucose levels as risk factors associated with obesity and hemoglobin levels for iron deficiency. We also compared body mass index values from our sample with those from a similar sample taken in American Samoa in 1978 and 1982. Both body mass index cutoffs categorized 62% of males and 70% of females as being either overweight or obese. Applying these cutoffs to body mass index data collected a quarter century ago, before the cutoffs were published, indicated that only 23.0% of males and 43.5% of females were either overweight or obese. Likewise, waist circumference cutoffs categorized 56% of males and 61% of females as having excessive abdominal fat. We failed to obtain evidence for elevated levels of cholesterol and glucose in overweight and obese individuals among 49 preprandial students. Six males and ten females had subnormal levels of hemoglobin but displayed no overt physical symptoms suggesting iron deficiency. By any measure, the prevalence of overweight and obesity among contemporary American Samoan adolescents make them an especially vulnerable faction of the global obesity epidemic.

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Introduction

Obesity is a rising epidemic worldwide, but rates are particularly high among urbanized Samoans.[1-4] Adolescent obesity is especially disturbing because it tends to persist into adulthood,[5-6] predisposing individuals earlier in life to a host of debilitating non-communicable diseases including cardiovascular disease, diabetes, and several types of cancer. For American Samoa, this will further tax an already overburdened healthcare system.

Between 1975 and 1982 four surveys were conducted on Samoan children, 4 to 20 years old, living in Western Samoa, American Samoa, Hawaii, and California.[3] They found that growth and adiposity were significantly greater in the latter three groups and attributed this to socioeconomic modernization, that is, changes in diet and level of physical activity.

Bindon[7] reported that in 1982 the diet in American Samoa was in transition from one based on locally produced foods and fishing to one based on imported foods. He noted that children were not very active, with television watching being the favorite activity of most. Before the end of the century, imported white rice had replaced plantation crops as the chief source of carbohydrate.[8] In September 2000 the first fast food franchise opened in American Samoa with enthusiastic fanfare. By 2008 six nationally known fast food restaurants were catering to a population of over 57,794 (July 2006 est.).[9] With more meals eaten at fast-food restaurants, fewer families tending plantations or gardens as their main source of food and regular exercise, and a greater reliance on video games and television to occupy children because of both parents working outside the home, it is imperative that the obesity epidemic affecting American Samoa's children be recognized and addressed by the local community. Yet a small number of creditable Samoans question the relevance of applying metrics, developed using predominantly Caucasian reference populations, for classifying Polynesians as overweight or obese. They note the disproportionally large number of Samoans playing for U.S. college and professional football teams and the considerable number of soldiers attached to the local U.S. Army Reserve who are flagged for exceeding the Army's body fat standard,[10] though they pass the Army Physical Fitness Test. They are understandably wary of having their children considered obese based on standards developed on a nonrepresentative population by distant experts. Their skepticism is abetted by a lack of consensus as to which anthropometric index and cutoff value best assesses childhood obesity.

We attempted to address these valid criticisms in two ways: First, by assessing overweight and obesity in a sample of 197 males and 183 females aged 11-18 years using two widely-accepted body mass index standards together with recently proposed age- and sex-specific waist circumference cutoffs for children and adolescents. Second, by comparing our body mass index data with data collected in American Samoa in 1978 and 1982 on 130 males and 138 females between the ages of 11-18 to show a significant increase in the body mass index for all ages and both sexes.

We also screened for risk factors of cardiovascular disease and diabetes by measuring levels of total cholesterol and glucose in blood, and for evidence of iron deficiency by measuring hemoglobin levels.

Materials and Methods

Our study sample comprised 380 children, or about 5.5% of the population who identified themselves as being of pure Samoan or mixed Samoan ethnicity enrolled in grades 7-12 on Tutuila Island, American Samoa, in 2005. Parental consent forms, printed in English and Samoan and approved by the Institutional Review Board of the American Samoa Department of Health, were given to principals at three of six high schools (Leone, Tafuna, and Fagaitua) and three of twenty-six elementary schools (Leone Midkiff, Pago Pago, and Manumalo) for distribution to all students in our selected grades. These schools represented a population of children from mostly low- to medium-income families island wide. Students who returned signed forms, which averaged over 95%, were then randomly selected for the study.

Between 6 April and 23 August 2005 we visited schools for anthropometric measurements and finger sticks. Students were measured for height, weight, and waist circumference while bare-footed and dressed in lightweight school uniforms. Heights were taken using a Perspective Enterprises Portable Adult/Infant Measuring Unit, weights using a Tanita Model BWB-800S Digital Scale, and waist circumferences using a fiberglass tape. We pricked the tip of either the second or third finger with an auto-retracting, single-use lancet pre-armed with a 1.8 mm needle and wiped away the first drop of blood before collecting subsequent drops for cholesterol, hemoglobin, and blood glucose tests. Total cholesterol levels were measured with a CardioChek Meter using Polymer Technology Systems PANELS test strips, hemoglobin with a HemoCue B-Hemoglobin Photometer, and glucose levels with a Roche Accu-Chek Advantage Meter.

We categorized students as being of normal weight, overweight, or obese according to the terminology and criterion of the age- and sex-specific International Obesity Task Force (IOTF) body mass index (BMI, as kg m^{-2}) cutoffs.[11] We chose the IOTF cutoffs for relating body mass index to obesity primarily because the IOTF cutoffs have the advantage of being constructed from a more ethnically diverse population. For comparison with United States studies, we included BMI category distributions derived from the 2000 Centers for Disease Control and Prevention[12] (CDC) growth charts for children and adolescents. Because the very idea of associating weight-related health risks to BMI is under challenge,[13, 14] we evaluated our data using recently proposed waist circumference cutoffs for children and adolescents.[15]

Using SigmaStat 3.1, we performed two-way analysis of variance (ANOVA) with sex and IOTF BMI category as factors. We recorded the mean, x, and standard deviation, s, as $x \pm s$ followed by the sample size, n. Data that failed the normal distribution criterion for t-tests were compared using the Mann-Whitney Rank Sum Test with medians, rather than means, reported if significantly different.

Results

Eighty percent of the students reported that both parents were of Samoan ancestry while 20% reported having only one Samoan parent. Based upon IOTF BMI cutoffs, 75 of 197 males had normal weights, 57 were overweight, and 65, or 33%, were obese. Of 183 females, 53 were of normal weight, 64 overweight, and 66, or 36%, were obese (Table1).

TABLE 1. Comparison of International Obesity Task Force (IOTF) cutoffs to the Centers of Disease Control (CDC) cutoffs for categorizing body mass index.

	IOTF ($kg\ m^{-2}$)			CDC (Percentile)		
Age (years)	< 25	25-30	>30	< 85th	85th-95th	> 95th
Male						
11	9	1	2	8	2	2
12	21	10	7	20	7	11
13	7	8	9	7	7	10
14	12	9	13	12	6	16
15	12	12	8	12	10	10
16	6	8	11	7	7	11
17	7	6	9	7	4	11
18	1	3	6	1	3	6
Subtotals	75	57	65	74	46	77
Female						
11	6	3	4	6	3	4
12	15	8	11	12	10	12
13	5	10	6	5	7	9
14	7	5	7	7	5	7
15	7	16	13	7	14	15
16	6	11	15	7	9	16
17	5	9	7	8	6	7
18	2	2	3	3	1	3
Subtotals	53	64	66	55	55	73
Totals	128	121	131	129	101	150

The IOTF categorizes body mass index (BMI) values less than 25 as "normal weight," BMI between 25 and 30 as "overweight," and BMI greater than 30 as "obese." The CDC categorizes BMI percentiles less than the 85th as "normal weight," percentiles between the 85th and 95th as "at risk of overweight," and percentiles greater than 95th as "overweight." A BMI $\geq$ 95th percentile among youth is approximately equivalent to a BMI $\geq$ 30 among adults.

Using CDC BMI cutoffs and terminology, which defines children above the 95th percentile as overweight, about 40% of both sexes were overweight (Table 1).This was far above the estimated 16% of children and adolescents ages 6-19 years that were overweight in the United States[16] or the highest US ethnic group rate of 23.6% for 12- to 19-

year-old non-Hispanic Blacks.[17] It was also higher than the 27.9% obesity rate reported in some Polynesian schools during a 2002 survey of children aged 6-12 years from 13 Pacific countries.[18]

Taylor et al.[15] provided age- and sex-specific 80th percentile cutoffs for waist circumference as a screen for high trunk mass in children aged 3-19 years that had a sensitivity of about 88% and a specificity of about 93% when evaluated against dual-energy X-ray absorptiometry. These cutoffs, they reported, closely approximated the 85th percentile of the CDC BMI growth curves for both sexes. Applying these cutoffs to our data, 57% of males and 61% of females had a waist circumference suggestive of high trunk fat mass. These percentages are similar to the 62% of males and the 70% of females who were either overweight or obese according to either BMI standard.

During 1978 and 1982, Bindon and others collected BMI data on 130 males (n_{1978} = 90 and n_{1982} = 40) and 138 females (n = 78 and 60, respectively) in American Samoa aged 11 to 18 years (see Acknowledgements). We pooled data from both years after paired t-tests on average BMI values for each age and sex suggested that the samples were drawn from the same population. Retroactively applying IOTF BMI cutoffs to the 1978/1982 cohort data, the incidence of obesity for males and females was 3.8% and 8.0%, respectively, while the incidence of overweight was 19.2% and 35.5% (Figs. 1 and 2).

We repeated the paired t-tests to compare the pooled data of the 1978/1982 cohort with that of our 2005 cohort. It gave highly significant differences ($P < 0.001$) between means for both sexes. Average BMI values increased 4.9 kg m^{-2} for males and 3.8 kg m^{-2} for females during the past quarter century (Table 2).

TABLE 2. Comparison of Average Body Mass Indices (kg m^{-2}) of 1978/1982 cohort with 2005 cohort.

	1978/1982 cohort[1]		2005 cohort		
Age (years)	x + s	(n)	x + s	(n)	Difference
Male					
11	18.18 ± 1.93	(16)	21.59 ± 4.87	(12)	3.41
12	19.38 ± 1.98	(20)	22.88 ± 5.09	(38)	3.50
13	21.70 ± 5.24	(16)	26.04 ± 6.46	(24)	4.34
14	20.95 ± 2.04	(22)	28.96 ± 11.17	(34)	8.01
15	22.32 ± 3.03	(16)	25.60 ± 4.87	(32)	3.28
16	22.67 ± 1.79	(16)	30.28 ± 8.78	(25)	7.61
17	24.34 ± 3.51	(18)	29.68 ± 7.76	(22)	5.34
18	27.97 ± 8.71	(6)	32.05 ± 6.05	(10)	4.08
Female					
11	20.06 ± 2.65	(26)	24.24 ± 5.96	(13)	4.18
12	20.53 ± 3.01	(28)	25.28 ± 6.11	(34)	4.75
13	21.97 ± 2.40	(14)	26.07 ± 4.98	(21)	4.10
14	24.99 ± 4.73	(16)	27.69 ± 6.64	(19)	2.70
15	26.88 ± 4.47	(11)	30.27 ± 7.39	(36)	3.39
16	24.33 ± 4.28	(19)	29.85 ± 6.16	(32)	5.52
17	26.04 ± 3.26	(16)	28.75 ± 7.53	(21)	2.71
18	24.72 ± 1.91	(8)	28.03 ± 5.69	(7)	3.31

[1] From Bindon (see Acknowledgements)

In addition to higher percentages of both males and females in the 2005 cohort categorized as obese, they entered this category at a much younger age and with much higher BMI values when compared with the 1978/1982 cohort (Figs. 1 and 2).

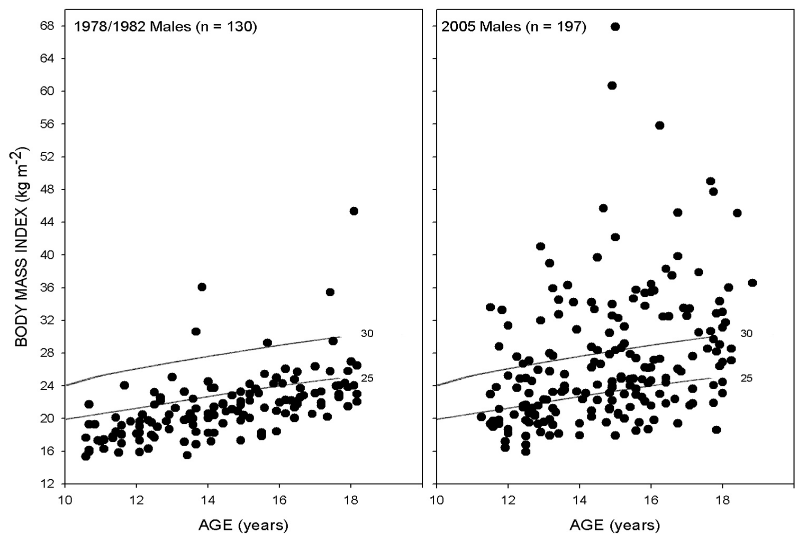

Figure 1. Distributions of body mass indexes (BMI) for males from the 1978/1982 cohort (left panel; from Bindon – see Acknowledgements) and 2005 cohort (right panel) superimposed on International Obesity Task Force cutoffs for overweight and obesity, passing through BMI 25 and 30 kg m^{-2}, respectively, at age 18.

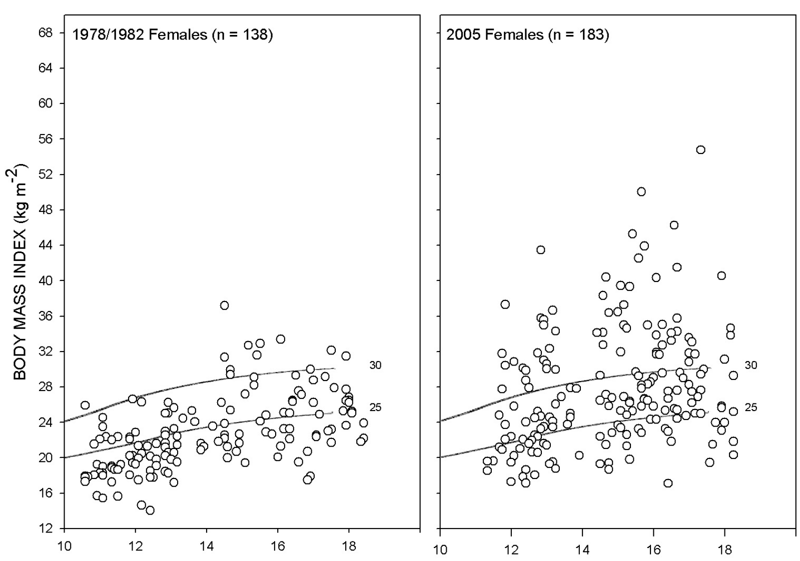

Figure 2 Distributions of body mass indexes (BMI) for females from the 1978/1982 cohort (left panel; from Bindon – see Acknowledgements) and 2005 cohort (right panel) superimposed on International Obesity Task Force cutoffs for overweight and obesity, passing through BMI 25 and 30 kg m^{-2}, respectively, at age 18.

All but 49 students had reported eating breakfast prior to testing for total cholesterol and blood glucose levels. Two-way ANOVAs by sex and IOTF BMI category did not reveal a significant difference in mean cholesterol or glucose levels among students who had fasted. Nor was there a difference (t-tests) in mean cholesterol levels between those who fasted (3.45 $\pm$ 0.70 mmol L^{-1}, n = 23 and 3.35 $\pm$ 0.56 mmol L^{-1}, n = 18 for males and females, respectively) and those who did not (3.37 $\pm$ 0.63 mmol L^{-1}, n = 145 and 3.57 $\pm$ 0.84 mmol L^{-1}, n = 150). One male had a high cholesterol reading[19] of 5.57 mmol L^{-1} and two others had borderline readings[19] of 4.40 and 4.95 mmol L^{-1}. All three were categorized as obese.

Neither did we find a difference in median blood glucose levels between preprandial (5.33 mmol L^{-1}, n = 23) and postprandial (5.39 mmol L^{-1}, n = 160) females. Fasting males, however, had a significantly lower ($P = 0.023$) median (5.22 mmol L^{-1}, n = 26) than postprandial males (5.56 mmol L^{-1}, n = 171). No male had a glucose level above 8.0 mmol L^{-1}, but one normal weight and one obese postprandial female had levels of 11.1 and 14.2 mmol L^{-1}, respectively, which were above the maximum level of 10.0 mmol L^{-1} for nondiabetics.[20]

We did not distinguish between pre- and postprandial students when analyzing the hemoglobin data. But hemoglobin levels were not amenable to ANOVA owing to unequal variances despite attempts to transform the data. Four normal weight and one overweight male had levels below 100 g L^{-1}, as did four normal weight and six overweight females.

Discussion

One objection to using the CDC BMI growth chart cutoffs on children of Samoan ancestry is that they were developed using a nationally representative reference population of children and adolescents from 2 to 20 years of age based on racial/ethnic compositions in the United States between 1963 and 1994.[21] This composition was overwhelmingly non-Hispanic White, with Asian/Pacific Islanders constituting 4% or less. Still, the CDC recommends their growth charts for all racial and ethnic groups, attributing differences among children of certain high-risk populations to a greater sensitivity to, or a lesser ability to avoid, causal factors when present.[21] Nevertheless, the IOTF undertook the task of developing age- and sex-specific growth charts based on a reference population of pooled data from several countries, including the United States.[11] At least one attempt to improve upon the IOTF BMI cutoffs for a single ethnic group has failed.[22]

Both the IOTF BMI and the CDC BMI cutoffs did equally well in identifying students of either sex as having a healthy weight. They differed, however, in that the IOTF BMI cutoffs classified fewer students as obese and more as overweight. In screening for adolescent obesity, minimizing the proportion who would be incorrectly considered obese may be more important than maximizing the proportion who would be correctly identified as obese.[23] For this reason the IOTF BMI cutoffs may be more appropriate for categorizing Samoan youths.

A small number of Samoans believe that they and their children track higher on BMI owing to more lean body mass, thicker bones, and denser body builds rather than to adipose tissue. Several studies[24-31] corroborate this claim. For instance, Pawson[24] found that Samoan adults were significantly heavier for a given height than the US norm. This held true even for individuals from Western Samoa where excessive obesity was uncommon.[24] Rush et al.[31] noted that Maori and Pacific Island girls had, on average, 3.7% less body fatness than New Zealand European girls of the same body size. However, the difference in body composition between Polynesians and other racial groups does not belie the higher prevalence of non-communicable diseases in Polynesian adults.[25] When higher BMI thresholds were applied to Maori and Pacific Island peoples, they still remained twice as likely to be obese than Europeans and to have a much higher prevalence of type 2 diabetes.[24]

Waist circumference has the advantage of circumventing the arguments used to diminish the significance of high BMI values for Samoan youth. It provides a measure of truncal adiposity free of the undefined influences of bone thickness, denser body build, and lean body mass elsewhere than around the abdomen. Waist circumference, along with hip circumference and waist-to-hip ratio, were found to be better predictors for cardiovascular disease in adults from several major ethnic groups than was BMI.[14] Waist circumference also had a high correlation with cardiovascular risk factors in prepubertal children.[32] Recently proposed age- and sex-specific waist circumference cutoffs[15] for Caucasians 3-19 years old, when applied to our data, showed that the proportion of students having a waist circumference suggestive of high trunk fat approximates the proportion who are either overweight or obese according to either BMI standard.

While the IOTF BMI cutoffs mitigate the perceived bias of the CDC BMI cutoffs in being more pertinent for Caucasians, they further dilute representation by Polynesians by including populations from Brazil, Great Britain, Hong Kong, the Netherlands, and Signapore.[11] And although waist circumference provided independent attestation in support of a prevalence of overweight and obesity in Samoan adolescents, the cutoffs for children and adolescents were based on an exclusively Caucasian sample.

We avoided any confounding effects of race/ethnicity altogether by contrasting average BMI values of contemporary American Samoan youth with values recorded a quarter century ago by Bindon on a comparable sample of children. Results showed a dramatic increase in BMI at all age groups and for both sexes. For males BMI increased an average of 0.20 kg m^{-2} $year^{-1}$, while for females the increase was a more modest, yet striking, 0.15 kg m^{-2} $year^{-1}$. As a consequence the percentage of overweight males increased from 19.2% to 28.9%, while the percentage of obese males increased nearly 9-fold from 3.8% to 33.0%. The percentage of overweight females remained unchanged at 35%, but the percentage of obese females increased from 8.0% to 36.1%. Furthermore, BMI values exceeding the 30-BMI cutoff appeared at an earlier age and at higher values in the 2005 cohort for both sexes.

Only one of 24 preprandial males had an elevated level of cholesterol. While no preprandial student had an elevated level of blood glucose, two of 158 postprandial females had levels indicative of hyperglycemia. Strong evidence for biochemical risk factors associated with cardiovascular disease and diabetes was, therefore, lacking. Neither did we detect an expected link between iron deficiency and overweight or obesity.[33] Insufficient dietary intake of iron in overweight and obese children and increased iron needs is generally attributed to unbalanced nutrition or repeated short-term restrictive diets.[33] But regular consumption of red meat, especially as hamburger, in American Samoan children may provide sufficient iron in their diet.

To our knowledge ours is the first attempt to measure blood biochemical markers in Samoan adolescents. Studies during the late 1970s that measured total plasma cholesterol and triglycerides in Samoan adults found that, despite higher rates of obesity, levels of total cholesterol were well below those of the United States population at all ages and in both sexes.[34] Samoans had much lower total cholesterol levels at any level of BMI than the levels found in other developed countries, suggesting a physiology characteristic that results in low plasma cholesterol levels relative to body fatness and dietary fat intake.[34] The absence of these markers in our study must be interpreted with caution, since they conflict with evidence for such markers in studies[35, 36] of obesity in non-Samoan adolescents and the prevalence of cardiovascular disease, diabetes, and other lifestyle-related chronic diseases in American Samoan adults.

Our results argue for a serious obesity problem affecting American Samoan adolescents. While it may be desirable and practical to eventually tailor an obesity screening tool specifically for Polynesians, the ramifications of unchecked obesity in American Samoan youth make it imperative that the problem be addressed now based on the best available evidence rather than wait for the best possible evidence.

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