An Overview of Obesity and Diabetes in the Diverse Populations of the Pacific

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Background: Pacific Islanders (PI) have some of the highest prevalence of obesity and type 2 diabetes in the world. Data related to PI are often reported as though the group is an aggregate; however, PI are a group of very diverse peoples.

Objective: To explore the obesity problem in PI by: 1) characterizing the major ethnic groups in the Pacific; 2) describing the most recent US census data on PI and their recent immigration patterns; and 3) synthesizing the literature on obesity in PI and type 2 diabetes mellitus.

Methods: Census information and anthropologic resources on the Pacific Islands and its peoples were obtained through an Internet search. Literature on obesity, diabetes, and body composition in PI were obtained through a systematic analysis of citations listed on Medline.

Results: Pacific Islanders (PI) are diverse people, culturally, biologically, and linguistically. Polynesians and some Micronesians have a very high prevalence of obesity and diabetes. Melanesians are among the most diverse ethnic groups in the world. Body mass index (BMI) cut-point values for Polynesians may be inaccurate.

Conclusions and Recommendations: The cause of obesity and diabetes in PI is unclear. Some factors involved are related to urbanization and migration. Obesity research should distinguish between island ethnicities and not aggregate all PI together. Research is needed to define body fat distribution of Polynesians in relationship to obesity co-morbidities, to determine normal growth of Polynesian children, to determine the relationship between growth abnormalities and adult obesity, and to determine the impact of immigration on PI. (*Ethn Dis*. 2005;15 [suppl 5]:S5-71–S5-80)

Key Words: Diabetes, Ethnicity, Obesity, Pacific Islander

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Introduction

The obesity epidemic is a significant global public health issue. In the United States, the prevalence of overweight in children six to 19 years of age has tripled in the last 20 years. Among adults, 65.1% are either overweight or obese; 30.4% are obese, and 4.1% are extremely obese.[1,2] Worldwide there are more than one billion people who are overweight and one third of these are clinically obese.[3] Closely following this increase in obesity has been a sharp rise in the prevalence of type 2 diabetes, the most common chronic disease associated with obesity. In 2002, 6%–8% of US adults had diabetes.[4] Pacific Islanders (PI) have some of the highest reported prevalence of obesity and type 2 diabetes in the world.[5,6]

Pacific Islanders (PI) make up a small but increasing portion of the US population. Increasing numbers of PI are migrating to the United States as well as to New Zealand and Australia. According to the 2002 US Census update, of the total US population of 288.4 million, 942,000 people reported that they were Native Hawaiian or other PI, an increase of 4% in just 2 years.[7] The 2001 New Zealand Census revealed that, of the total New Zealand population of 3.7 million, 6.2% or 231,798 people reported being PI.[8] Increasing PI out-migration, increased modernization and urbanization of Pacific Island countries, and the high prevalence of obesity and obesity-related illnesses underscore the importance of understanding the problem of obesity, its correlates and precursors, and the health disparities experienced by Pacific Island peoples.

There are several issues complicating our understanding of the health issues and health disparities experienced by Pacific Island peoples. The first is the term itself - Pacific Islanders. Data related to the health status of PI, including reports on the prevalence of obesity and diabetes are often presented as though this group is an aggregate. Such aggregation implicitly homogenizes these related but diverse people and creates an obstacle in itself to understanding correlates of complex health issues such as obesity.

Another issue is that health data on PI is sparse. Many obesity studies on PI were conducted years ago and have not been updated. In addition, some Pacific Island groups, such as islanders of Nauru, have been studied extensively while others, such as the Melanesians, have received little attention.

The overall aim of this review is to explore the problem of obesity and diabetes in Pacific Island peoples. The three main objectives to achieve this are: 1) to characterize the major ethnic groups in the Pacific within the three geographic areas of Polynesia, Micronesia, and Melanesia; 2) to describe the Pacific Island countries most closely associated with the United States in the context of their current political relationship with the United States, the most recent US Census data, and the immigration patterns to the United States; and 3) to synthesize the literature on obesity and type 2 diabetes mellitus in PI. The emphasis will be on Polynesians, including Native Hawaiians, since many obesity studies on PI include

Polynesians. Body composition studies on PI will be discussed in order to highlight the controversy about BMI cut-points for obesity in Polynesians.

METHODS

Sample

Data were obtained using three methodologies. Census information and anthropologic resources on PI were found through an Internet search using the search terms Pacific Islander, origins, pre-contact, migration, and Census. Information from reliable and verifiable sources was obtained through Internet web sites. Research literature relating to obesity and diabetes was found by a Medline search of articles through October 2004. Search terms used included obesity, overweight, body composition, body mass index, diabetes, Pacific Islander, Hawaii, Polynesia, Micronesia, Melanesia, and ethnic. The search was supplemented by manual searching of references from appropriate papers. Forty-four publications were reviewed.

Inclusion and Exclusion Criteria

Studies that could be reviewed in their entirety were included; however, studies that did not define obesity or type 2 diabetes were excluded. Studies that did not distinguish among Pacific Island ethnic groups were also generally excluded, since this assumes that different ethnic groups have similar risks.

Methodological and Conceptual Issues

One of the challenges of reviewing and comparing this historical database of articles is the changes in definitions of overweight, obesity and diabetes in adults. The definition of overweight and obesity in children has also changed recently from weight-for-height percentiles to BMI percentiles for age and sex. Definitions for each study have been included.

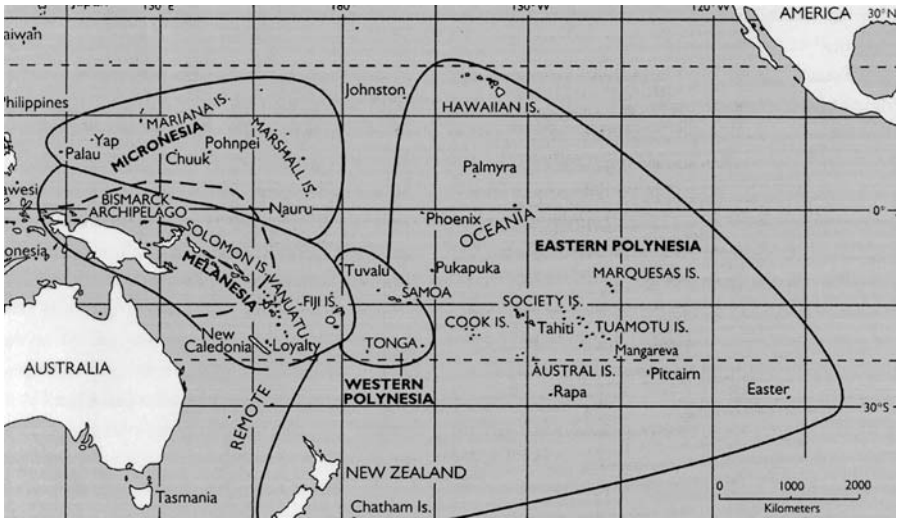

Fig 1. Oceania, showing the geographic areas of Polynesia, Melanesia and Micronesia. Permission for reprint granted from Kirch PV. *On the Road of the Winds: an Archeological History of the Pacific Islands before European Contact.* Los Angeles, CA: The Regents of the University of California. 2000

Analyses

Search data were entered into a matrix and analyzed for thematic threads using constant comparative analyses.[9] Themes generated included ethnic groups in the Pacific, US-associated Pacific Islands, Pacific Islanders in the United States, obesity in Polynesians, Native Hawaiians, body composition of Polynesians, BMI cut-points, Polynesian children, Micronesian, and Melanesians. Findings related to each of these categories are described below. Epidemiologic population surveys conducted in Pacific Island countries were used to identify prevalence of obesity and diabetes.

CHARACTERIZING THE MAJOR ETHNIC GROUPS IN THE PACIFIC WITHIN THE THREE GEOGRAPHIC AREAS OF POLYNESIA, MICRONESIA, AND MELANESIA

In 1932, the French explorer Dumond d'Uruville divided indigenous Pacific Islanders into the three racial groups: Polynesians, Micronesians, and Melanesians.[10] Although still commonly used today, these groupings have lost their historical importance as research has shown they obscure important genetic, linguistic, and cultural relationships. The labels provide "geographical referents" but should not be used to meaningfully subdivide segments of cultural history.

Studies show that Polynesian culture and language derived from a common ancestral root over a period of about 2,500 years. Research in biological anthropology has supported the homogeneity of Polynesian populations; morphologic features of Polynesians including large body size, and genetic features such as a characteristic nine-base-pair deletion in the mtDNA, are found in extremely high frequency throughout Polynesia.[10]

The islands of Polynesia are found within a triangle formed by Hawaii to the north, New Zealand to the southwest, and Easter Island to the southeast (Figure 1). Ethnographically Polynesia can be subdivided into two major divisions, Western Polynesia including Tonga, Samoa, Wallis, and Futuna and Eastern Polynesia including the Cook Islands, the Society Islands (Tahiti), the

Table 1. Political status of the US Associated Pacific Islands

Country	Political Status	Capital	Administration/Government	Status of Citizens
American Samoa	US Territory	Pagopago	Administered by US Dept of Interior	US Nationals who may become US citizens
Guam	US Territory	Agana	Administered by US Dept of Interior	US Nationals who may become US citizens
Commonwealth of Northern Marianas	US Commonwealth	Saipan	Administered by US Dept of Interior	US Citizens
Federated States of Micronesia	Independent Country	Pohnpei	Self-governing. US relationship outlined in Compact of Free Association	May freely migrate to US
Belau (Palau)	Independent Country	Koror	Self-governing. US relationship outlined in Compact of Free Association	May freely migrate to US
Republic of the Marshall Islands	Independent Country	Majuro	Self-governing. US relationship outlined in Compact of Free Association	May migrate freely to US

Marquesas, and the more isolated islands of Hawaii, Rapa Nui (Easter), and New Zealand. Archeological research has demonstrated that Western Polynesia was first settled around 1000–900 BC and was the geographic homeland of Ancestral Polynesians. Subsequent migration led to the settlements of Eastern Polynesia.[10]

The islands of Micronesia are located around and north of the equator and include the Marianas (Guam, Saipan) and Belau (Palau) to the east, the Federated States of Micronesia (Pohnpei, Yap, Kosrae, and Chuuk) centrally, the Marshall Islands to the west and Nauru and Kiribati to the south (Figure 1). In contrast to Polynesia, Micronesia does not form a ''monophyletic cultural group.'' Linguistic and archeological studies have shown that human settlement in Micronesia probably involved a three-part sequence. One group moved from the islands of Southeast Asia to the western Micronesian islands of Palau and the Marianas. Another group probably migrated from the Solomon Island-Vanuatu region to the central-eastern Micronesian islands including Kiribati, Kosrae, Pohnpei, and the Marshall Islands and a third group moved to the islands of Yap from the Bismarck Archipelago of Papua New Guinea.[10]

The islands of Melanesia, in the southwestern Pacific, include Papua New Guinea, the Solomon Islands, Vanuatu, New Caledonia, Maluku and Fiji (Figure 1). In terms of language, biological variation, and culture, the Melanesians are ''among the most diverse and heterogeneous to be found in any comparably sized geographic space on earth.''[10] Because of this, the term Melanesia should be used exclusively to describe a geographic region and should not imply ethnic, linguistic, or biologic uniformity.

In summary, the commonly used terms Polynesia, Micronesia, and Melanesia describe three geographic areas in the Pacific populated by many ethnic groups. Polynesians are ethnically the most homogeneous. Micronesians are made up of at least three cultural groups and Melanesians are among the most heterogeneous people in the world.

DESCRIBING THE PACIFIC ISLAND COUNTRIES MOST CLOSELY ASSOCIATED WITH THE UNITED STATES—THEIR CURRENT RELATIONSHIPS WITH THE UNITED STATES, US CENSUS DATA, AND RECENT IMMIGRATION PATTERNS

The largest PI immigrant groups in the United States are from the US-associated Pacific Islands—American Samoa and the Micronesian islands of Guam, the Commonwealth of the Northern Marianas (CNMI), the Federated States of Micronesia (FSM), Belau (formerly known as Palau), and the Republic of the Marshall Islands (RMI). An understanding of these islands' political history and current relationships with the United States helps to explain the increase in migration in recent years (Table 1).

The islands of Samoa are divided politically into American Samoa and Samoa, an independent island nation formerly known as Western Samoa and administered in the past by New Zealand. As a US territory, American Samoa is administered by the US Department of the Interior. The people of American Samoa are US nationals and may become naturalized citizens. Outmigration has been common and there are now more Samoans living abroad, especially in California and Hawaii, than in American Samoa.

Of the US-associated islands of Micronesia, Guam is the largest and, like American Samoa, is a territory of the United States. The native people of Guam are known as Chamorros. The islands north of Guam make up the Commonwealth of the Northern Marianas. Established in 1975, CNMI is administered under the US Department of the Interior with a local governing

body and all residents are US citizens. The Federated States of Micronesia (FSM) and the Republic of the Marshall Islands (RMI) were administered by the United States after World War II. In 1986 and 1990, FSM and RMI, respectively, became newly independent, self-governing nations. FSM and RMI governments each signed a Compact of Free Association with the United States to provide the citizens with critical economic development aid and the right to migrate freely to the United States, without a passport, in exchange for defense rights to their waterways and land. In 1994 Belau became in independent nation and ratified its own Compact with the United States. Since independence, large numbers of Micronesians from FSM, the RMI, and Belau have migrated to the United States. Migration has increased in recent years, possibly due to changes under the new compacts for FSM and RMI that place restrictions on the freedom to relocate to the United States.[11]

Pacific Islanders in the United States

According to the 2000 census, 401,000 people identified themselves as Native Hawaiian, either alone or in combination with one or more other races, making Native Hawaiians the largest PI group. Samoans were the second largest group with 133,000 followed by Chamorros or Guamanians with 93,000. Combined, Native Hawaiians, Samoans, and Guamanians accounted for 74% of all PI in the United States. In 2000 there were 22,971 Micronesians other than Guamanians, including 6,650 Marshallese, 3,469 Belauans, and 2,121 from the FSM states of Chuuk, Pohnpei, Kosrae, and Yap. Thirty-six percent of Native Hawaiians and other PI were under the age of 18, while only 5% were 65 or older.[12]

In 2000, 73% of PI lived in the Western United States, 14% in the South, 7% in the Northeast, and 6% in the Midwest. Over half, 58%, of the Pacific Islanders lived in just two states, California and Hawaii. The cities with the largest PI populations were Honolulu, New York, Los Angeles, and San Diego.[12]

SYNTHESIZING THE LITERATURE ON OBESITY AND TYPE 2 DIABETES MELLITUS IN PACIFIC ISLANDERS

Polynesians

Early European explorers first noted the striking, large, muscular build of Polynesians in comparison to other Pacific Islanders. Of the Samoans: ''The men were a remarkably fine looking set of people, and among them were several above six feet high, with Herculean proportions.'' Of the Maori: ''The Zealanders are generally tall and well built. Men of six feet are not at all uncommon among them.'' Another wrote of the New Zealander Maori that ''the inhabitants are of a fine stature but their legs are so thick that they appear swollen.''[13]

Polynesians may have always been ''big'' but they have not always been obese. Several population surveys were conducted from 1978 to 1991 by the International Diabetes Institute in Australia to determine the obesity prevalence in several Pacific Island countries. These included the Polynesian islands of Samoa, New Caledonia and Wallis Island, Cook Islands, Niue, and Tuvalu. Adults 25 to 69 years old were surveyed and height and weight measured. Body mass index (BMI) was calculated and obesity defined as a BMI greater than or equal to 30 kg/m^2.[14,15] Subjects were also given a standard 75 gm oral glucose tolerance test to determine prevalence of diabetes.

As in many developing countries, population surveys showed the prevalence of obesity increasing with urbanization and modernization. The surveys in (Western) Samoa in 1978 and 1991 showed an increase in obesity prevalence from 1978 to 1991 in all locations but most notably in the most rural community of Tuasivi where prevalence in males increased almost 300% to 39.3% and in females by 115% to 57.2%. In 1991 there were higher levels of obesity in urban vs rural areas; 74% of urban women and 56% of urban men were obese. Women tended to be more obese than men; the mean BMI in the urban community was 31.8 kg/m^2 in men and 34.8 kg/m^2 in females. Even relatively young subjects, 25 to 34 years old, were obese. More than 50% of women in all locations and 45% of urban young men were obese.[15]

Diabetes, the best documented consequence of obesity, is also very prevalent among Polynesians, especially among those who have become more westernized.[16–25] The longitudinal study in (Western) Samoa found a sharp rise in the prevalence of diabetes as the obesity prevalence climbed over the 13-year follow up in both rural and urban communities.[22] Between 1978 and 1991 diabetes increased in the rural community of Poutasi, from 0.1% to 5.3% in men. In Tuasivi, the most rural community, prevalence increased from 2.3% to 7.0% in men and from 4.4 to 7.5% in women. Age-standardized prevalence was highest in the urban center of Apia; 9.5% in men and 13.4% in women. Diabetes increased with age, peaking at 35.4% in women 55 to 64 years. However, diabetes was also seen at younger ages; 5.2% of men and 10.5% of women, ages 35–44 years.

A more recent survey of the Polynesian country of Tonga conducted between 1998 and 2000 showed an overall age-standardized prevalence of diabetes of 15.1%, 12.2% in men and 17.6% in women, of which 80% was previously undiagnosed. Standardized for the Segi world population aged 30 to 64 years, the prevalence of type 2 diabetes was 16.0% (13.3–18.6). Obesity was common; 60.3% had a BMI

Table 2. Body composition studies of Polynesian adults

Author	Methods	Results
Rush EC 1997[28]	**Subjects:** 42 Caucasian and 40 Polynesian women **Measurements:** BMI, skin fold thicknesses, waist and hip circumference **Body Composition:** Total body water using oxygen-18 dilution.	At a fixed %BF, BMI was higher in Polynesians compared with Caucasians. A BMI of 30 kg/m^2 for the Caucasian group corresponded to a BMI of 34 kg/m^2 for the Polynesians at an equivalent %BF (42%).
Swinburn B 1996[29]	**Subjects:** 189 Maoris, 185 Samoans, 241 Caucasians **Measurements**: BMI, skin-folds **Body Comp:** BIA and DXA	At higher BMI, Polynesians (Maori and Samoans combined) had significantly higher ratio of LM to FM compared with Caucasians. Polynesians with BMI greater than 25 kg/m^2 have more FFM and less FM than Caucasians and are significantly leaner.
Swinburn B 1999[30]	**Subjects:** 128 Polynesian Cook Islanders and 493 Caucasians **Measurements:** Weight, height, BMI **Body Composition:** BIA	Male and female Polynesians were younger and heavier than Caucasians. At every level of weight (adjusted for height and age), resistance was lower in Polynesians. At every level of BMI the predicted %BF was lower in Polynesians.
Craig P 2001[31]	**Subjects:** 543 Tongans and 393 Caucasians **Measurements:** BMI, waist/hip circumference, four skinfolds, midarm circumferences, elbow breath. **Body composition:** BIA	Tongans had significantly higher FFM, elbow width, and lower %BF than Caucasians (Australians). A %BF of 25% at a BMI of 30 kg/m^2 in Australian women was equivalent to a %BF of 28.8% at a BMI of 35.1 kg/m^2 in Tongan women. A %BF of 25% at a BMI of 30 kg/m^2 in Australian men was equivalent to a %BF of 27.5% at a BMI of 35.8 kg/m^2 in Tongan men.
Craig P 2003[32]	**Subjects:** 56 Tongans and 85 Caucasians **Measurements:** BMI **Body Comp:** TBF, CAF, A%F measured by DXA	Tongan males (BMI, 32.8 $\pm$ 4.6 kg/m^2) were heavier than Caucasian males (BMI, 27.1 $\pm$ 3.7 kg/m^2) but differences in TBF, CAF, and A%F were not significant. Tongan females (BMI, 34.3 $\pm$ 5.5 kg/m^2) were heavier than Caucasian females (BMI, 26.2 $\pm$ 6.3 kg/m^2) but differences in TBF and A%F were less than expected given the difference in BMI.

%BF=percent body fat; BMI=body mass index (kg/m^2); LM=lean mass; FM=fat mass; FFM=fat free mass; TBF=total body fat; CAF=central abdominal fat; A%F=abdominal percent fat; BIA=bioelectrical impedance; DXA=dual energy x-ray absorptiometry.

$\geq$30 mg/dl and the average BMI was 32.3 kg/m^2.[23]

Native Hawaiians

Native Hawaiians, like other Polynesians, also have a very high prevalence of obesity and diabetes.[5,24–26] According to the 2003 Hawaii State Department of Health Behavioral Risk Factor Surveillance Survey (BRFSS) telephone survey, 32.6% of Hawaiians reported they were overweight (BMI 25 to 30) and 32.9% reported they were obese (BMI>30). Of Hawaiians, 13.8% reported they had diabetes vs 7.6% prevalence in the general population.[26]

The Native Hawaiian Health Research Project studied 567 rural Native Hawaiians, 30 years of age and older, and found the combined prevalence of overweight (BMI 25–30 kg/m^2) and obesity (BMI>30 kg/m^2) was 81.5%.[5] Almost half of participants (49%) were obese. The percentage of Hawaiian ancestry was significantly associated with increased BMI, waist-to-hip ratio (WHR), and age; this association persisted after adjusting for age, leisure time physical activity and total dietary intake.

The same study, using the standard world population of Segi, found that the age-adjusted prevalence rates of impaired glucose tolerance and type 2 diabetes among rural native Hawaiians, ages 30 to 64 years, was 15.5% and 20.4%, respectively. This is the highest prevalence of diabetes in a Polynesian or part-Polynesian group reported. Prevalence of diabetes was significantly higher among full Hawaiians compared with part-Hawaiians (34.1% vs 19.3%).[27]

Polynesian Ethnicity, Body Composition and BMI

Clearly, large numbers of Polynesians are overweight or obese according to BMI cut-points accepted by the Center for Disease Control (CDC) and the World Health Organization (WHO). However, the point at which Polynesians move from simply being big in stature to being overly fat or obese, and at risk for obesity-related illness, is unclear. The importance of this point is underscored by the acceptance of large size in Polynesian culture. Body composition studies help to define this risk by determining the amount of body fat for a given BMI, and in some cases, the distribution of body fat.

Several studies on the body composition of Polynesian adults have concluded that BMI criteria for obesity in Caucasians may not be appropriate for Polynesian adults. Studies on Polynesians from Tonga, Samoa, the Cook Islands, and New Zealand (Maoris) have shown that Polynesians are leaner than Caucasians at a given BMI (Table 2). Body composition studies

have not been done in Micronesians or Melanesians.

BMI Cut-Points for Obesity in Polynesians

Body composition studies have shown that percent body fat (%BF) differs between ethnic groups. For the same %BF, Polynesians and African Americans have a higher BMI compared with Caucasians. Other studies have found that Asians have a lower BMI for a given body fat percent than Caucasians.[33–34] However, the question as to whether BMI cut points should be ethnic-specific remains controversial.

Stevens points out that obesity cut-points should be based on risk, rather than %BF.[35] Comparisons for risk must be done carefully for each outcome, such as diabetes or hypertension, since each may yield a different result. For example, Stevens showed that, for diabetes, African-American women with a BMI of 30 kg/m^2 have an equivalent risk to that of White women with a BMI ranging from 28.0 to 34.5 kg/m^2, depending on the measured effect (incidence rate, rate ratio, or rate difference). Stevens also demonstrated that the literature on BMI mortality associations showed no support for a lower cut-point for obesity in Asians compared to Caucasians.[36–37]

To address the same issue in Asians, WHO convened a panel of experts in 2003.[38] The panel concluded that, although Asians tend to have a higher %BF compared with Caucasians, the available data does not indicate clear BMI obesity cut-points applicable to all Asians. A substantial portion of Asians have risk factors for diabetes and cardiovascular disease below the WHO BMI cut-point of 25 kg/m^2. Lowering the value by three units may be appropriate for Hong Kong Chinese, Indonesians, and Singaporeans but is likely too high for other populations like the Japanese.

Thus, while Polynesians may be leaner than Caucasians, the mean BMI of adult Polynesians has rapidly increased over the last 20 to 30 years. This trend has been accompanied by an equally rapid increase in diabetes. Stevens commented, ''Even in groups such as Samoans, in which scientific evidence may indicate that a higher cut-point could be justified, a policy to set a higher BMI cut-point for obesity may not gain strong support.''[37]

Obesity, Body Composition and BMI Cut-Points in Polynesian Children

The question of whether ethnic-specific cut-points for BMI should be applied to children is even less clear. Body mass index (BMI) changes throughout childhood as body fat stores change, dropping to a low at about age 6 and increasing steadily thereafter. In the United States experts have recommended that children with a BMI for age and sex between the 85th and 95th percentiles should be considered at risk for overweight and that children above the 95 percentile considered overweight. However studies have suggested that BMI cut-points for children may also need to be ethnic specific. A study of Singapore Chinese, Beijing Chinese, and Dutch children showed that for the same BMI for age and sex, Singapore children had a higher %BF than the other children, implying that the relationship between %BF and BMI can differ among ethnicities in children.[39]

Those who know Polynesian children also have the general impression that they are ''bigger'' than Caucasian and Asian children. There are a limited number of studies on normal growth and the overweight prevalence of PI children, including Polynesian children. A study in the 1980s showed that the growth of Samoan children was markedly influenced by westernization.[40] Samoan children from more rural communities of (Western) Samoa were shorter and lighter for height compared with Samoan children from the more westernized American Samoa and Hawaii. Studies have shown that Polynesian children, including Native Hawaiian children, are taller and heavier, with a higher BMI, when compared with accepted US reference standards.[41,42]

In order to determine whether BMI standards are appropriate for PI children, a few studies have examined the relationship between BMI and body composition.[43,45] These studies, however, did not delineate among the different Pacific Island ethnic groups. A small study on children five to 14 years of age, using bioelectrical impedance analysis (BIA), showed that Maori and ''Pacific Island'' girls had lower %BF than Caucasian children for a given BMI.[43]

A large study by Tyrell et al conducted in New Zealand with >2000 children determined obesity prevalence among school children using BMI and %BF by BIA. All PI children except for Maoris were grouped together.[44,45] Obesity prevalence, based on BMI, varied with ethnicity and was highest among PI children and Maori children, 24.1% and 15.8%, respectively. A small but statistically significant effect of ethnicity on this relationship was thought to be due to the large number of PI children with BMI >30 kg/m^2 but Tyrell et al stated that this should not justify the use of different BMI percentiles for different ethnicities. Tyrell's study also indicated that in populations, such as PI, with high levels of obesity-related disease, accepting higher BMI values for PI children would be accepting a different level of health. These researchers concluded that ethnic-specific BMI percentiles for childhood obesity are not appropriate.

Micronesians

The prevalence of obesity and diabetes in some Micronesians is also very high.[46–48] In Nauru, a small island country now almost completely dependent on imported foods, 70.3% of Micronesian women are obese (BMI> 30). In 1987 the mean BMI of males was 34.2 for males and 34.9 for

females.[47] In accordance with this high level of obesity is an extremely high prevalence of diabetes. The prevalence, age standardized to Australia, was 37%, the second highest in the world after the American Pima Indians.[47] Diabetes was previously unknown in Nauru.

A survey of adults on Kosrae, an island state in the Federated States of Micronesia, also showed a very high prevalence of obesity and diabetes.[48] Like Nauruans, Kosraean lifestyles have become more sedentary and dependent on imported Western processed food. Of 2188 adults surveyed, 29% had a BMI 25–29 kg/m^2, 35% had a BMI 30–34 kg/m^2, and 24% had a BMI $\geq$35 kg/m^2. Twelve percent of the population had diabetes. In both Nauru and Kosrae, the risk of diabetes increased with BMI and age.

There are few obesity studies on western Micronesians, who have different ethnic origins than central-eastern Micronesians, such as those from Nauru, Kosrae, and the Marshall Islands. In addition, little has been published about nutritional problems and risk factors for adult disease in PI children including Micronesian children. A 1997 study in the Marshall Islands showed that while 50% of men and 60% of women were either overweight or obese, 35.5% of children 1–5 years of age and 36.3% of children 5–10 years of age were stunted. Almost a third of the households had at least one obese adult and one undernourished child.[49] Studies in other populations have suggested that low birth weight and nutritional stunting in early childhood may increase the risk of obesity, even central obesity.[50,51]

Melanesians

As stated previously, Melanesia has a complex history and thus, caution should be taken when making conclusions about epidemiologic and clinic studies from this geographic area. It is clear that Melanesians, like other Pacific Islanders, have also been affected by urbanization and westernization.[52,53] Few studies on the prevalence of obesity and diabetes have been done in Melanesia in the last 15 years; however, previous studies have shown a rising prevalence of both problems. The 1993 National Nutrition Survey in Fiji showed 29% of native Fijian women and 11.2% of native Fijian men were overweight. Diabetes prevalence was 12%, although the survey did not distinguish between native Fijians and Indo-Fijians.[54]

In a 1998 WHO report, 2.6% of rural men and 5.1% of rural women in Vanuatu were obese compared with 17.9% of urban men and 27.9% of urban women.[53] Similarly, a 1985 population survey of the same population showed a much lower prevalence of diabetes although rural vs urban differences persisted: 1.0% of rural men and 0.9% of rural women had diabetes compared with 2.1% of urban men and 12.1% of urban women. A survey in the Solomon Islands of rural and urban Melanesians showed an age standardized rate of impaired glucose tolerance plus diabetes of only 0.14% for males and 1.9% for females.[55]

DISCUSSION

Pacific Islanders are a diverse people —culturally, biologically, and linguistically. Although other reviews have addressed obesity in PI, these investigations have not distinguished among the different Pacific Island ethnicities.[56,57] Studies relating health risk to ethnicity are important, especially in light of health disparities experienced by PI. However, as Kaplan and Bennett note, ''for the discussion of disparities to be precise and meaningful, equal attention must be given to the way in which race and ethnicity are conceptualized and described and the rationale for reporting racial/ethnic differences.''[58]

Studies relating health risk to ethnicity are inherently difficult and complex. Kaplan and Bennett further note ''the complexity of individual identity, the lack of clear cut boundaries between categories used to capture socially defined constructs of race and ethnicity, and the lack of consistency across studies and datasets make it difficult to write about race/ethnicity with precision.'' In addition ''the racial/ethnic categories commonly used in biomedical sciences and epidemiology are broad and overlapping. Individuals do not fit neatly into these categories, and these broad groupings can obscure significant within-group heterogeneity.''[58] Self-identified ethnicities found in many studies often force a person to choose one ethnicity when he or she may, in fact, be biologically or culturally from several ethnicities.

Thus, caution must be taken when determining risk and making conclusions about health, especially when relying on data that arbitrarily aggregate people, such as PI. When reaching conclusions in a study involving ethnicity, researchers should remember that ''a statistically significant association between race or ethnicity and an undesirable health outcome does not by itself establish causality. Health outcomes usually have multiple causes that can be either direct or indirect and are often interrelated and interactive.''[58]

In the study of obesity, the distinction among PI subgroups is important since differences in body composition and body size among the island ethnicities are integral to both the understanding of normal growth of PI children and disease susceptibility of PI adults. Some have concluded that BMI cut-point values should be specific for all PI but this is probably not appropriate since body size and composition may differ across ethnic subgroups. Studies have shown that Polynesians are leaner than Caucasians with the same BMI but similar studies have

not been done on Micronesians and Melanesians.

The literature demonstrates that obesity and diabetes are common among many PI but the causes remain unclear. Factors involved are related to the rapidly changing lifestyles associated with urbanization and migration. Sedentary lifestyles, diets higher in fat and refined sugars, and decreased infant breastfeeding are now common among Pacific Islanders and have all been associated with obesity and diabetes.[59–61] The role of birth and childhood factors such as low birth weight, stunting, and malnutrition in the development of obesity remains unclear. However, studies have shown a relationship between these factors and obesity and its related illnesses such as diabetes.[50,51,62] Finally, the role of genetic susceptibility is unknown.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the peoples of the Pacific are diverse, and obesity and type 2 diabetes are common. Polynesians have been shown to be bigger and leaner than Caucasians. In light of the conflicting implications of inherently large size and high prevalence of obesity-related illnesses, it is unclear whether BMI cut-points should be specific for Polynesians. However, it is clear that because of the differences in anthropologic origins and the lack of research on the body composition of Micronesians and Melanesians, recommendations for ethnically specific BMI cut-points should not be generalized to all PI.

In order to further understand the health risks for Polynesians, research is needed to define the distribution of body fat in Polynesians as it relates to obesity co-morbidities, and to determine the consequences of sustaining higher BMI over time in Polynesians. Clearly more research is needed to determine normal growth of Polynesian children and to determine whether standard growth charts, such as those recommended by the CDC, are appropriate for Polynesian children. Further research is also needed to assess the relationship of growth abnormalities, such as stunting, to obesity-related illness and to define other risk factors in childhood that increase susceptibility to obesity and diabetes in this population.

Research is also needed on island populations that have been poorly studied, such as western Micronesians and Melanesians. Research is needed to further determine the impact of urbanization and migration on the health of PI.

Finally, until factors associated with obesity and its co-morbidities are further delineated, research on these problems should distinguish island groups and not aggregate all PI as one homogenous group.

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