Abstract: In Aotearoa, it has been revealed that 14.7% of European adults are obese, compared with 2 7.5% for Maori adults. It has been difficult to elucidate the recent trends in children and adolescents without large-scale population analysis, but a recent study of obesity in Auckland schoolchildren revealed a prevalence rate of 15.8% for Maori children, compared with 8.6% for European children. This essay will review factors affecting the etiology of obesity in Maori children. The classification of obesity will be examined before a discussion of short term and long term factors leading to obesity in this ethnic group. Measuring Obesity in Children

It has been recommended that the BMI range for overweight in Maori be increased to 27-32, and obesity a BMI greater than 32. Unfortunately though, there is no consensus among researchers and some studies may use the conventional obesity range of a BMI greater than 30 for both Maori and non-Maori children.

Maori disproportionately occupy low socioeconomic strata in Aotearoa. The significant discrepancy between obesity prevalence rates for Maori and European children indicates that other factors are involved. Dietary fat intake, and by extension obesity, tend to be more prevalent for people in low socioeconomic groups, as numerous studies have shown. Therefore, the Maori-European obesity discrepancy can be further explained by the discrepancy in socioeconomic status between these two groups, as national census data reveal that Maori are disproportionately represented in all negative socioeconomic indices. However, for completeness, it is necessary to understand exactly why Maori dominate these indices. (Pacific Health Dialog 2003, Vol. 10, No.2,. Pg 141-148)

Introduction

In recent years, the incidence of obesity in developed countries has been increasing, with some describing the trend as an "obesity epidemic".[1] The United States has reported a 53% increase in the prevalence of obesity in the general population during the decade 1990-2000.1A 98% increase in obesity was observed in 6-11 year-olds, and a 64% increase noted in 12-17 year-olds.'

A recent study in the United Kingdom, revealed 21% of women and 17% of men were obese, an increase of 3-fold from 1980 levels of 8% for women and 6% for men.2 Australian data reveal that obesity has reached epidemic proportions in Australian adults, with those in lower socio-economic groups more likely to be affected.'[,3] Further, obesity is becoming more common in children, with BMI increasing by an average of approximately one unit between 1985 and 1997 in children aged 9-15.3

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In Aotearoa, it has been revealed that 14.7% of European adults are obese, compared with 27.5% for Maori adults.[4] It has been difficult to elucidate the recent trends in children and adolescents without large-scale population analysis, but a recent study of obesity in Auckland schoolchildren revealed a prevalence rate of 15.8% for Maori children, compared with 8.6% for European children.5

Obesity in children is a serious health concern because it has been strongly linked to the etiology in adulthood of several chronic diseases including type 2 diabetes, coronary artery disease, hypertension, and osteoarthritis.[167] More specific to children and adolescents are the increased incidence of early-onset diabetes, SUFE, irregular menses, genu valgum, sleep apnea, asthma, and decreased self-esteem associated with overweight and obesity."-[12] An analysis of the total health care costs of obesity in Aotearoa produced a conservative estimate of 2.5% of the total health budget, which is similar to other western countries.12

Finally, research has revealed that different ethnic groups store fat at different rates.[13] For example, many former recent hunter-gatherer groups such as Australian Aborigines and Polynesians are believed to have a genotype conducive to rapid fat storage." The International Taskforce on Obesity has blamed the weight-gain trend in these people on a move away from traditional diets towards fattier, western style foods and a more sedentary lifestyle, with exacerbation of the problem for those in a low socioeconomic environment.'

At a fundamental level, obesity is simply believed to be due to over-nutrition and decreased activity. [14] These two factors are seen increasingly throughout western societies, where the general population now have easy access to a vast array of high-energy foods and perform a less active lifestyle.

This essay will review factors affecting the etiology of obesity in Maori children. The classification of obesity will be examined before a discussion of short term and long term factors leading to obesity in this ethnic group. Short-term factors include those occurring since European contact, such as an increasingly sedentary lifestyle, abandonment of traditional food sources, and displacement to the lowest socioeconomic strata. An analysis of long term factors of Maori pediatric obesity involves selective pressures during Polynesian migrations, and how these may function in a non-adaptive way in modern western society.

Measuring Obesity in Children

Multiple classification systems exist for grouping people into different weight categories such as underweight, healthy weight, overweight, and obese. At an individual level, accurate classification provides targeted identification, monitoring, and intervention for those at risk of underweight, overweight and obesity. On a population level, accurate classification allows the identification of temporal trends in different groups, and comparison with environmental changes.

At a fundamental level, obesity is simply believed to be due to over-nutrition and decreased activity.

Examples of different classification systems in use include the measurement of absolute weight, weight for height, percent ideal body weight, various skin fold measurements, abdominal circumference, waist/hip ratio, body mass index (BMI), and bioelectrical impedance analysis (BIA).

BIA has been shown to be an accurate measurement tool [15], but may not be easily accessible in some centres. Consequently, BMI has become a widely accepted reference tool because of the ease with which measurements can be made, repeated, and interpreted. Unfortunately however, the BMI also has notable limitations.

Firstly, although BMI is widely supported as a useful measurement tool in adults, it has varying relevance in children and adolescents, due to natural developmental changes in weight and height ratios during growth.16

Second, BMI reference ranges have not been found to be generalisable across different ethnic groups. For example, the quoted healthy weight range of 20-25 has been found to be inappropriately high for Indian and Asian people who typically have more gracile anatomy. Conversely, a BMI as high as 30 may be considered healthy in Polynesians who typically have higher bone and muscle density than Caucasians.17

In response to such shortfalls, Sweden, Britain, and Italy have developed population-specific BMI-for-age charts. [16] Additionally, the World Health Organisation (WHO) is developing growth reference levels for infants and children from birth to 5 years. [16] Currently, there are no population-specific centile charts for children in Aotearoa.

It has been recommended that the BMI range for overweight in Maori be increased to 27-32, and obesity a BMI greater than 32. [17] Unfortunately though, there is no consensus among researchers and some studies may use the conventional obesity range of a BMI greater than 30 for both Maori and non-Maori children.

Short Term Factors

At the time of first contacts with Europeans in the 18'8 and 19[18] centuries, Maori people lived an active lifestyle with an agrarian food supply supplemented with periods of hunter gathering. Kumara, fern roots, birds, fish, and the Polynesian dog comprised their staple plant and animal intake. [18] Obviously, comparative anthropometric data are not available from this time, but inferences based on written and graphic material can be made.

Various records from early European travelers portray Maori people as "healthy and robust", "of commanding stature and great muscular strength", and "of tall and athletic build". [19] Wright-St Clair's analysis of the journals of Cook, de Surville, and D'Urville revealed Maori as "a healthy and hardy race with a better than average physique by European standards". [18,20]

The author goes further, summarising that "the introduction of European foods and an easier way of life brought obesity to the Maoris [sic] for the first time".18 Cook's chief science officer Joseph Banks recorded "So simple a diet accompanied with moderation must be productive of sound health, which indeed these people are blessed with in a very high degree...such health drawn from such sound principles must make Physicians almost useless".18

Unfortunately, few detailed written physical descriptions of Maori children remain, but since obesity in children has been shown to continue into adulthood in up to 70% of cases,[21] it is reasonable to assume that the absence of obese adults was accompanied by a paucity of obese children. Fortunately however, portraits of children are found in numerous works by prominent artists of the early to mid-contact period such as Lindauer and Goldie. It is significant that in over three hundred portraits by these artists, there is a complete absence of obviously overweight or obese Maori adults and children.[22,23] Therefore, if these conditions were present, the available evidence suggests that it was an extremely rare event.

How then, has an ethnic population with an apparent prevalence of obesity of 0% in the 18th century developed prevalence rates of 15.8% in children, and 27.5% of adults in such a short amount of time? It would be simplistic to attribute the change to decreased energy intake, and insufficient activity alone. While these remain valid explanations to a degree, the discordance between Maori and European pediatric obesity levels5 indicates additional factors are involved.

In developed countries like Aotearoa, low socioeconomic status has been significantly associated with overweight and obesity.[1,4,24-26] In many countries, the inverse correlation between income and BMI has been well documented.[27,33] In general, people in low socioeconomic strata tend to have less knowledge of healthy nutrition, are less active, consume less fruit and vegetables, and spend more time watching television.4 Interestingly, 60% of television advertising targeting 9-17 year olds promotes high energy foods such as biscuits, chocolate, takeaways, and soft drinks.[4] Although children in these low socioeconomic groups may consume the same total number of daily calories as other socioeconomic groups, they tend to obtain a greater percentage of their daily calories from saturated fats and processed sugars.4

Maori disproportionately occupy low socioeconomic strata in Aotearoa. Generally, they have lower incomes and lower formal educational attainment than non-Mbori.[35] Accordingly, they have been shown to have a higher mean daily energy intake from fat than non-Maori, and to be least likely to meet Healthy Eating guidelines of daily fruit and vegetable intake produced by the Ministry of Health.[4] Consequently, an understanding of the short term factors contributing to the development of obesity in Maori children requires a historical understanding of why Maori children are disproportionately represented in the poorest socioeconomic sectors of society.

The strength of an economic base for an individual or group is related to their relative control over one or more of the four factors of production: land, labour, capital, and enterprise.[36] To understand why Maori dominate low socioeconomic indices in Aotearoa, the historical changes to each of these factors follows, and their effects on Maori are discussed.

Land may be defined economically as "resources of nature in and on the land, sea, and air".[36] At the time of the signing of the Treaty of Waitangi in 1840, Maori controlled 66 400 000 acres (99%) of Aotearoa.13 Through a combination of imperially and colonially sanctioned military action and numerous legislative breaches of the Treaty of Waitangi (such as the 1894 Validation of Invalid Land Sales Act), Maori controlled only 3 million acres (4%), frequently in the most arable areas, by 1999.38.3'

Economically, labour refers to the human resources, or population utilisable, as labour.[36] Captain Cook estimated a total Maori population of 100 000 individuals during his first expedition to Aotearoa in 1769.[38] However, this estimate has been criticised as being too low due to Cook's inclusion of only coastal settlements.[38] Anthropologist Sir Peter Buck has made a revised estimate of 200 000 individuals which includes Maori in inland regions.[38] Interestingly, with a founding population of 56 women (as suggested by mitochondria) DNA research) and an equivalent number of males, an average of Cook and Buck's estimates totaling 150 000 individuals could have been attained with a population growth rate of only 0.94%.[39] In summary, these population approximations reveal a thriving group of people who had adapted well to a new environment where their traditionally domesticated taro, banana, and yam plants would not take hold.4°

Over time however, through the combined effects of introduced germs, war, and malnutrition, the Maori population had been decimated by approximately 72% to a low of 41 993 individuals as recorded in the 1896 census.[38] Such a drastic population decline fuelled the 19[10] century concept of Maori as a dying race illustrated by MP Isaac Featherston's statement in 1856 that "the Maoris [sic] are dying out, and nothing can save them. Our plain duty as good, compassionate colonists is to smooth down their dying pillow. Then history will have nothing to reproach us with."'" Therefore, though Maori

were in the advantageous position of making up 99.9% of the total population at the time of the signing of the Treaty of Waitangi, today they make up only 15% of the country's population. 19,35

Capital has been defined as the resources that assist with production. [36] These items took the form of agricultural machinery, mills, and transport vessels.42 Contrary to general opinion, Maori rapidly adapted their existing economic systems toward the development and acquisition of capital. For example, by "1857 the Bay of Plenty, Taupo, and Rotorua natives – being about 8000 people – had upwards of 3000 acres of land in wheat, 3000 acres in potatoes, nearly 2000 acres of maize, and upwards of 1000 acres of kumara. They owned nearly 1000 horses, 200 head of cattle, 5000 pigs, 4 water-power mills, and 96 ploughs, as well as 43 coasting vessels averaging nearly 20 tons each". [42] This pattern of economic development was seen in other regions such as the Waikato, Taranaki, the East Coast of the North Island, Manawatu, Auckland, and the South Island.42 Produce was used to supply the local iwi population, and surpluses were sold to nearby settlers, towns, and even exported to Sydney using vessels owned by the iwi. Examples include "as early as 1842, Bishop Selwyn writes that for potatoes, maize, leeks, kumara, pork, and firewood the English people at Nelson were almost entirely dependent upon native supplies."[42] Additionally, "in a single year 1792 native canoes entered Auckland harbour, bringing to market by this means alone 200 tons of potatoes, 1400 baskets of onions, 1700 baskets of maize, 1200 baskets of peaches, besides very many tons of firewood, fish, pigs, and kauri gum." [42] Such a scale of production of predominantly introduced domesticated plants and animals could only have been achieved through the rapid acquisition, development, and use of capital.

With such economic growth in the mid 1800's, it was understandable that "taken as a whole the Maori seemed well on the way to economic prosperity." [42] Unfortunately though, the New Zealand Wars of the mid to late 191h century resulted in the destruction or confiscation of vast amounts of capital, contributing to the erosion of the economic base of Maori." Additionally, legislation was introduced which limited or prohibited Maori production (such as the 1866 Oyster Fisheries Act), or criminalised the purchase of Maori products when a European seller was available.43.44

The fourth and final factor of production is enterprise (or entrepeneurship) which refers to special leadership resources related to the ability to plan and bear uncertainty. [36] The economic direction of tribal groups was determined largely by the paramount chief, who acted as guardian and trustee of the interests of the people.42 During the New Zealand Wars, leadership figures were targeted specifically, and were either killed, imprisoned indefinitely (without trial using the 1879 Peace Preservation Bill, the 1880 Maori Prisoners' Act, the 1880 West Coast Settlement Act, the 1881 West Coast Preservation Act, and 1908 Tohunga Suppression Act), or deported. [37•43'44]

In summary, Maori presently occupy the lowest socioeconomic strata in society through the systematic destruction of the four factors of production which comprised their economic base. This occurred over the past 200 years through the combination of legislative violations of the Treaty of Waitangi, state-sanctioned military action, and introduced diseases.

Long Term Factors

Historically in Western society, overweight and obesity had negative connotations with gluttony regarded as a sin. [45] Such prejudice has continued into contemporary times, with overweight children variously stereotyped as lazy, unintelligent, and overweight because of their own actions. [8.10.11] Popular opinion has promoted the view that people are a homogenous group with regard to energy expenditure, and that obese people simply eat too much or exercise too little. However, in recent years research has revealed how heterogeneous human metabolism is on an individual and population level. On a population level, the important effects of genetics have become apparent, and trends for specific ethnic groups have been identified.

Maori presently occupy the lowest socioeconomic strata in society through the systematic destruction of the four factors of production which comprised their economic base.

Studies in knockout mice have shown that the alteration of a single gene allowed the consumption of a high fat diet without any weight gain, compared to control mice who became obese. [46] In humans however, biochemical regulation of adiposity is believed to be multigenic, with estimates of between 20 and 30 genes involved."

Comparisons of identical twins have revealed significantly greater similarity in BMI compared with dizygotic twins. [47] Additionally, twins raised apart have greater BMI concordance with each other than with siblings in their destination families:[47.48] Finally, single children who have been adopted show higher BMI

correlation with their biological parents compared with their adoptive parents.47

The effects of genotype are seen on a population level by comparing different ethnic groups. Research reveals that different ethnic groups have differing propensity for gaining weight. For example, African Americans and Hispanics become obese 2.5 times faster than Americans of European ancestry. [13] These ethnospecific differences are also seen in Pima Indians.49,5°

Traditionally, the Pima Indians of Lower Western North America lived an active lifestyle as agriculturists supplemented with hunter gathering. [51,52] Domesticated native American species of potatoes, corn, and beans formed their staple plant intake, with their cultivation supported by the Gila River. [40] Unfortunately though, the Gila River was dammed and diverted, for which the United States Government generously provided money and western foods. [51] Today, the Pima Indians of Arizona consume a predominantly western diet and have the highest obesity and type 2 diabetes rates on the planet.49 Furthermore, although the Arizona Pima have the same general caloric intake as other Americans, their obesity rate is 79% compared with 27% for other Americans.',50 In review, the rate of obesity in Aotearoa is 17% for adults and 14.3% for children.'

Before European contact populations like Pima Indians, Native Australians, African Americans, Hispanics, and Polynesians all underwent heavy evolutionary selective pressures in Paleolithic and Neolithic times, and in some cases were still hunter gatherers on first contact with Europeans. [40] In summary, an active lifestyle and periodic food shortages naturally selected as survivors those who had a propensity to store sufficient energy in their adipose tissue. Such an adaptation was an advantage in our evolutionary history, but is deleterious in an environment where dietary fat is abundant.

Overall these effects have been attributed to the effects of a thrifty genotype which promotes fat deposition. The 'thrifty gene' hypothesis suggests that harsh or unstable environments, combined with geographical isolation would naturally select for those individuals with highly efficient energy metabolism.53 Additionally, such an adaptation would be detrimental in conditions of abundance, and contribute to the development of obesity and related illnesses like diabetes.53

It is likely that Polynesian migrations into the Pacific provided significant selective pressures for muscle and fat deposition. Archeological, linguistic, and biological studies indicate that Polynesians migrated eastward into the Pacific during the past 4 thousand years. [38,54] Genetic analysis of their y-chromosomal and mitochondrial DNA reveals admixture of Melanesian, Indonesian, and Native Taiwanese genetic material.55

Computer simulations of thermal stress during voyaging expeditions support strong directional selection for a large muscular body. [54] Additionally, the insulative value of fat during cold exposure in humans has been described. [54.56] Furthermore, food shortages are well documented for Pacific Islands in typhoon areas.56 Finally, when new islands were settled, food supply may have lagged until imported plant domesticates were productive enough to support a new community.40

The suggestion of a thrifty genotype in Polynesians is supported by research in Native Hawaiians. Maori likely share a common ancestry with Native Hawaiians as recently as 400AD. [55] After adjusting for energy intake and expenditure, the percentage of Hawaiian ancestry has been shown to be significantly correlated with BMI.57 In short, those with more Native Hawaiian ancestry tend to have a higher BMI.

Clearly, for a given energy intake, the Polynesian genotype is highly efficient at storing fat. [57] This metabolic efficiency also appears to manifest itself through decreasing energy requirements for basal metabolism. A recent study demonstrated that Polynesian women have a significantly lower resting metabolic rate (RMR) compared with Caucasian women. [58] A lower RMR is also seen in Pima Indians compared with Caucasians.50

In summary, it is likely that the recent hunter-gatherer lifestyle and environmental challenges of Pacific colonisation have contributed to a highly efficient Polynesian genotype. This genotype efficiency manifests itself in at least two mechanisms; firstly, a high propensity toward fat deposition, and second, a lower resting metabolic rate. These mechanisms were highly adaptive in Polynesian history, but are detrimental in modern western society.

Conclusion

The World Health Organisation's International Taskforce on Obesity has called the increasing trend in obesity an epidemic.' The increase has been most evident in those nations with a western lifestyle and dietary pattern, or developing nations in transition toward such a pattern.' Additionally, the incidence of obesity seems to be disproportionately high in non-European ethnic groups. [14.29.52] This essay aimed to identify those factors that have contributed in the short term and long term to the high rate of obesity in children of Maori ethnicity.

While the high rate of obesity has been attributed to increased dietary fat intake and insufficient activity, [14] this explanation is only partially sufficient. The significant discrepancy between obesity prevalence rates for Maori and European children [4,5] indicates that other factors are involved. These factors act to either exaggerate poor diet and inactivity, or act as intrinsic physiologic idiosyncrasies specific to certain ethnic groups.

Dietary fat intake, and by extension obesity, tend to be more prevalent for people in low socioeconomic groups, as numerous studies have shown.[14,24-33] Therefore, the Maori-European obesity discrepancy can be further explained by the discrepancy in socioeconomic status between these two groups, as national census data reveal that Maori are disproportionately represented in all negative socioeconomic indices. [35] However, for completeness, it is necessary to understand exactly why Maori dominate these indices.

It was demonstrated that prior to European contact Maori people lived an active lifestyle, and that overweight and obesity were rare occurrences. [15,19,20] Furthermore, the evidence suggests that in the early post-contact period, many iwi successfully adapted their economic systems to take advantage of European technology.[42]

Polynesians, Pima Indians, and other recent hunter gatherer populations, have been demonstrated to have specific metabolic adaptations which would favour their survival in difficult environments.

However, many of these innovations, along with the majority of the indigenous population, were decimated by the combined effects of war, legislation, and introduced germs. [37,35] In combination, the effects of these three were sufficient to collapse the Maori economic base, and relegate them to the bottom of the socioeconomic heap.

Polynesians, Pima Indians, and other recent hunter gatherer populations, have been demonstrated to have specific metabolic adaptations which would favour their survival in difficult environments. [14,50,57,55] It is believed that these adaptations resulted from an evolutionary period of erratic nutritional supply. Such a time would create a genetic bottleneck, with survivors naturally selected to be able to make the most of available nutritional resources. These adaptations are consistent with elements of the thrifty gene hypothesis.

Thrifty environmental adaptations appear to manifest themselves in Polynesians in at least two known mechanisms. Research reveals that for a given energy intake, native Hawaiians tend to store more adipose tissue than others do. [57] Furthermore, Polynesian women, tend to have a lower resting metabolic rate than Europeans. [58] It is thought that these mechanisms may have been developed or refined during Polynesian exploration and colonisation of the Pacific.

In conclusion, obesity in Maori children has been shown to have multiple causes. Some of these causes happened minutes or hours ago, at the last meal that these children ate. Other causes are founded in events which took place 200 years ago, while yet others are related to the rigours and challenges of our deep evolutionary past, occurring over millennia. Therefore, an effective effort to reverse the obesity trend in Aotearoa should address the multiple levels of factors involved in the etiology of obesity in Maori children.

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