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Trends in body size, diet and food availability in the Cook Islands in the second half of the 20th century

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Abstract

The body size of adult Cook Islanders on Rarotonga for the years 1952, 1966 and 1996 has been increasing. The rate of increase in stature of women aged 20–39 years was 0.5 cm per decade across the period 1952–1966, and 0.8 cm per decade for the period 1966–1996. The rate of increase of weight in the 20–29 years age group was 0.6 kg per decade in period 1, and 7.3 kg per decade in period 2. In the age group 30–39 years, the rates were 3.2 kg per decade and 5.1 kg per decade respectively. Changing food availability for the period 1961–2000 is used to compare estimates of dietary energy availability with estimates of physiological energy requirements. There has been reduced availability of traditional staples, a likely reduction in consumption of fish, increased consumption of meat, and a decline in the availability of dietary fats and oils. Daily per capita energy intakes in 1952 and 1966 greatly exceed an hypothetical physiological maximum value for energy expenditure, suggesting a large positive energy balance in 1952 and an even greater one in 1966, both predisposing to weight gain. Although daily per capita energy availability in 1996 is similar to the hypothetical physiological maximum value for energy expenditure, it exceeds the measured level of energy expenditure at that time. It is speculated that excessive energy intake relative to requirement is more likely to predispose to positive energy balance and weight gain than decline in energy expenditure, although to a lower extent than in 1966 and 1952.

JEL classification: I10; I31; O56

Keywords: Weight; Obesity; Diet; Energy expenditure; Pacific islanders

1. Introduction

Documentation from the voyages of Cook across the Pacific records the large body size and muscular build of Pacific Islanders, and of the generally greater than average weight of the nobility (Pollock, 1995). Photographs taken in the 1800s also indicate that body

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fatness was common among the upper classes of Islander societies (Baker, 1984). There is little evidence of significant body fatness more generally across all levels of other Pacific Islander societies prior to World War II; this may be due to a lack of obesity in general populations, or a lack of interest in this topic among public health researchers. However, League of Nations reports for Nauru do not record obesity as a health issue, in otherwise comprehensive documentation (Pollock, 1995). Furthermore, extensive pictorial records from Nauru taken in 1925 do not show obese subjects (Zimmet and Whitehouse, 1981).

The emergence of fatness and obesity generally among Pacific Islander populations began during the second part of the 20th century. Associations between economic modernisation and fatness have been sought in a number of these populations. Most commonly, dietary change and changes in patterns of physical activity associated with levels of education, occupational status, and rural residence have been invoked as being central to the emergence of obesity in Pacific Islanders (Hunter, 1962; Evans and Prior, 1969; Prior, 1971; Bindon and Baker, 1985; McGarvey, 1991).

In the Cook Islands, the prevalence of obesity has been shown to have increased since 1966, there being an associated secular trend toward increased stature of adults, largely because of improved nutritional status in childhood, which resulted in increased height as well as weight. The trends towards increased body size among adults is postulated to have started earlier on Rarotonga than elsewhere in the Cook Islands, and prior to 1966 (Ulijaszek, 2001a). This secular trend in stature has been shown to be associated with economic modernisation, as suggested by the greater body size of those born on Rarotonga compared those born elsewhere in the Cook Islands, as well as with level of education (Ulijaszek, 2001b). A number of modernisation effects are likely to be greater on Rarotonga than on the other Cook Islands. In 1991, the population of Rarotonga was 58% of the 18,000 total population of all of the Cook Islands. The high population density and concentration of economic resources on this island has resulted in greater economic opportunities at all levels, and a greater proportion of the population engaged in the money economy than any of the other Cook Islands (National Statistical Office, 1996). Furthermore, the dependency ratio (proportion of the population aged less than 15 years and greater than 65 years) is 38% lower on Rarotonga than on the other islands combined (National Statistical Office, 1996), due largely to declines in fertility rates and resulting in smaller household sizes. Thus, per capita access to resources acquired as a consequence of engagement in the cash economy is greater on Rarotonga than on any of the other islands.

Highly palatable and energy dense foods are available, affordable, and widely consumed on Rarotonga (Ulijaszek, 2002), and while explanations invoking dietary change (Ulijaszek, 2001a) and reductions in physical activity (Evans and Prior, 1969) have been put forward for the emergence of fatness, no associations have been found between physical activity and body fatness (Ulijaszek, 2001c). Furthermore, associations between intake determined by food frequency questionnaire and body fatness have not been demonstrated.

Limited anthropometric data collected prior to 1966 do exist (Fry, 1957a). In this article, changing body size of adult female Cook Islanders on Rarotonga is described for the period 1952–1996, to examine the notion that the secular trend toward increasing body size began on Rarotonga prior to 1966. This is a previously unreported comparison. Analyses of early dietary surveys on Rarotonga (Fry, 1957a,b) suggest that a traditional diet was consumed, but that this was clearly supplemented with significant amounts of imported foods.

We compare the food frequency surveys carried out in 1952 (Fry, 1957b) and 1996 (Ulijaszek, 2002), and describe the changing availability of major dietary components with high energy density (starchy staples, sugar, oils and fats, and meat) across the period 1961–2000, using analyses from the FAO (2002) FAOSTAT food balance data set. The extent to which the penetration of the world food system caused the emergence of obesity on Rarotonga is considered by comparing estimates of dietary energy availability from the FAO (2002) FAOSTAT analyses with estimates of physiological energy requirements estimated from mean body weights and heights of Rarotongan women, reported in the first part of this article.

2. Modernisation, the world food system, and obesity in the Pacific region

The concept of modernisation has been used in a number of contexts, despite there being no entirely satisfactory definition of the term (Bindon et al., 1991). In the industrialised world, it has come to mean all the developments which have followed in the wake of mechanisation and industrialisation, including the rise of bureaucratic states, the spread of capitalism, the secularisation of culture and education (Smith, 1994), the loosening of boundaries between social classes, increased social mobility, the growth of wide-spread education, and the emergence of procedures of industrial negotiation and of social welfare systems (Ulijaszek, 1995a). The experiences of most newer nation states, however, are different from those of the industrialised nations, and modernisation has been defined as 'the interaction of less complex energetic, technological and socio-economic systems characterised by regional production and consumption with contemporary economic systems of industrial technology influenced by the national and international market, social and political factors (McGarvey et al., 1989). The latter definition is the more appropriate in describing the changing socio-economic circumstances of the people of the Cook Islands during the second part of the 20th century, since their use of energy sources was low from colonial times when their connection to the global economy began, and has progressively increased in the second part of the 20th century. Modernisation should be considered in terms of interlocking global economic interdependence of societies and nations (Dressler et al., 1993), dietary change being a useful marker of behavioural change reflecting the interdependence of local and global economies. The world food system increasingly reflects the economic interdependence of nations and global regions, with the proportion of global food production being traded internationally increasing enormously during the last three decades of the 20th century (Dyson, 1996). On the Cook Islands, fast food has become increasingly available in the Rarotongan capital of Avarua, but much less so elsewhere. While tourism has been a modernising force elsewhere in the Pacific, tourism on Rarotonga is strongly controlled by the government, which has attempted to limit it to small numbers of high-income visitors.

Historically, traditional diets of the Pacific have been very low in fat and high in complex carbohydrates, dietary fibre, and foods of plant origin (Shintani and Hughes, 1994), comprising largely of bananas, yams, the root crop taro (Colocasia species), coconut and animal foods obtained from reefs (Bindon, 1982). Dietary change among populations experiencing modernisation in the Pacific region has been documented, showing a higher contribution

of fat and protein to total energy intake than among those practising traditional subsistence (Ringrose and Zimmet, 1979; Prior and Tasman-Jones, 1981; Hanna et al., 1986; Schendel, 1988; Hezel, 1992).

Food imports to the least developed Island nation states of the Pacific region, including Tuvalu, the Solomon Islands, and Kiribati (Fig. 1) increased more than six-fold in the period 1961–2000; the increase across the same time-frame being more than two-fold for the Cook Islands, and more than four-fold for Western Samoa (FAO, 2002). Hanna et al. (1986) observed that the modernisation of the Samoan diet through increased consumption of imported items is not just a recent phenomenon, but has taken place across most of the 20th century. In addition, these authors observed that the proportion of dietary energy from imported foods varied according to the degree of modernisation, being highest among Samoans on Hawaii, lowest among those in Western Samoa, and at an intermediate level in American Samoa. Galanis et al. (1999) found substantial differences in the diets of residents of American Samoa and of those of the less modernised country of Western Samoa. American Samoans consumed significantly more energy as carbohydrate and protein and less as total fat and saturated fat than Western Samoans (Western Samoa is now know as Samoa). The high levels of consumption of coconuts accounts for the higher percentage of fat and saturated fats among (Western) Samoans, relative to American Samoans. On the other hand, dietary cholesterol, from animal food products, was higher in American Samoa than (Western) Samoa. These two dietary trends are related ultimately to the economic resources available in the two polities. The conclusion is warranted that food choices may be profoundly affected by the process of modernisation within a country or by migration to a more economically developed locale. Hanna et al. (1986) reported greater dietary diversity with greater extent of modernisation and with migration among Samoans, speculating that this greater diversity may be associated with increased food consumption. In a comparison of urban and rural populations in Fiji, Kiribati and Vanuatu (Fig. 1), Taylor et al. (1992) found that urban diet contained more protein and fat than rural diet, with the exception of Kiribati, where rural communities consumed large amounts of coconut. However, in Kiribati imported food constituted a lower proportion of the daily energy intake of the rural population compared to the urban population (King et al., 1984). However, few studies in modern, modernising or traditional societies have found significant associations between measures of body fatness and dietary intake.

While it might be expected that families with members working for wages and/or receiving significant remittances in cash would be more likely to be involved in the global economy (Lockwood, 1971) and have greater access to imported foods, Pelletier (1984) found that the proportion of imported foods in the diet of Samoans in Western Samoa was similar regardless of the presence of wage earners in the household. Galanis et al. (1999) found strong and clear relations between a material lifestyle score, reflecting income and resources in the household, and several indicators of dietary or material lifestyle. This was true within both Samoas and across the archipelago when country of residence was controlled. In the Cook Islands, population has shown little increase between 1950 and 2000 (National Statistical Office, 2001). However, an estimate of emigrants based on known resident population and population in excess of replacement level calculated from total fertility rates of 7.3 in 1955 and 3.3 in 1991 (assuming a linear decline across this period), suggests that in the year 2000, emigrants are likely to have outnumbered residents by 2 to 1. The vast

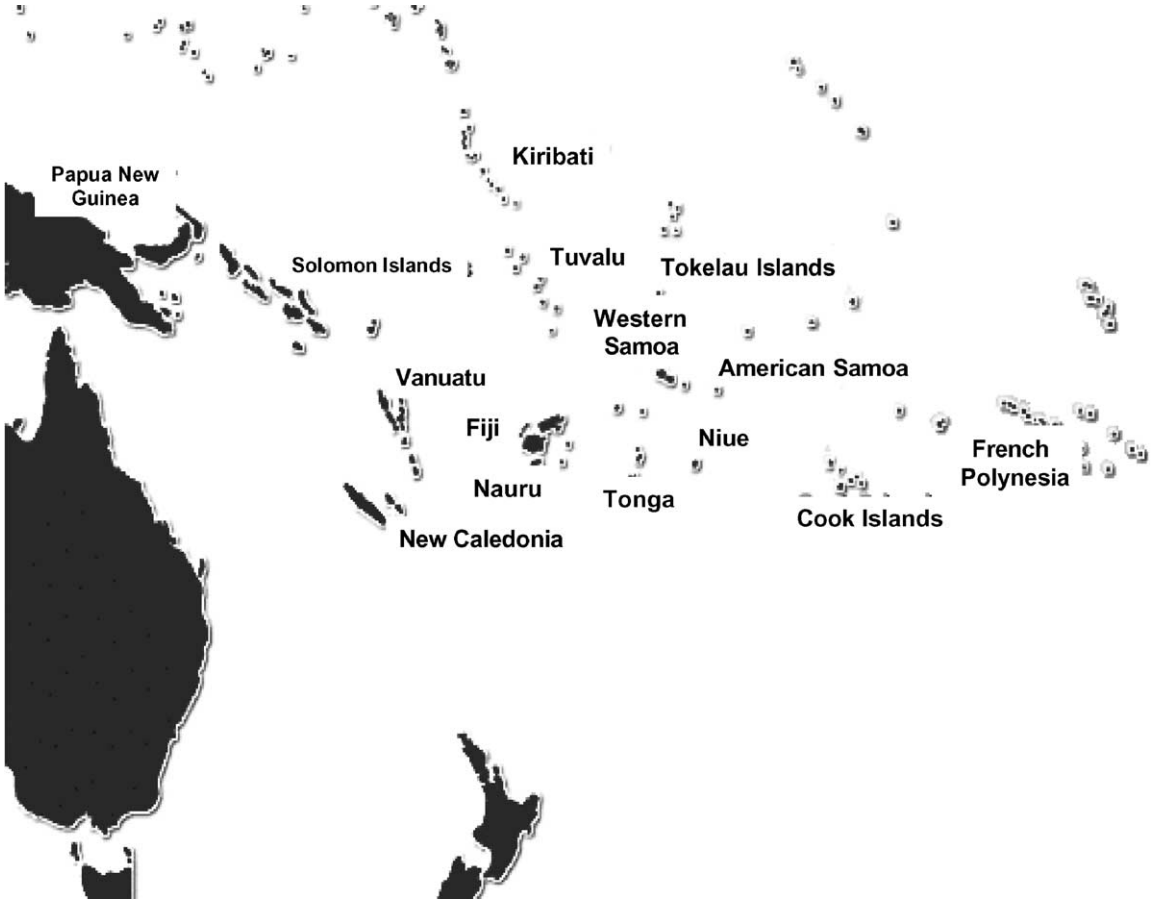

Fig. 1. Map of the South Pacific, showing location of South Pacific Island nations.

majority of Cook Islander migrants live in New Zealand and Australia, and it is possible that remittances from relatives in these countries provide much of the economic basis for the purchase of imported foods on the Cook Islands.

3. Secular trends towards increasing body size on Rarotonga

A survey carried out in 1966 in the Cook Islands showed adults living on the more modernised island of Rarotonga to be taller, heavier with greater body mass index (BMI) than those observed on the less modernised island of Pukapuka (Evans and Prior, 1969). Katoh et al. (1990) observed the adult population of Rarotonga to have higher prevalence of obesity than the population of the less modernised island of Mangaia. In a comparison of body size of adult Cook Islanders in 1966 and 1996, Ulijaszek (2001a) showed a secular trend toward greater stature and body fatness. A comparison of weight, height and calculated BMI data on Rarotonga women collected in 1952 by Fry (1957a) with similar data for 1966 and 1996 (Ulijaszek, 2001a) shows that the secular trend towards increasing body size of adults may have been underway prior to 1966.[1] However, this must be interpreted with caution, given the smaller sample size of the 1952 study ($n = 39$ (1952); compared with $n = 142$ (1966), and $n = 93$ (1996)). Furthermore, all three samples were obtained opportunistically, giving additional cause for caution; the 1966 survey was biased toward greater random opportunistic sampling of the younger adult population, while the 1996 sample was biased toward an older population more concerned with their blood pressure and their possible diabetes status (Ulijaszek, 2001a). Figs. 2–4 show the mean stature, weight and BMI respectively by age group, for adult females on Rarotonga in 1952, 1966 and 1996. With respect to stature, the rate of secular increase in the 20–29 years age group is 0.5 cm per decade for the period 1952–1966, and 0.63 cm per decade for the period 1966–1996. For the age group 30–39 years, the rates are 0.5 cm per decade (1952–1966) and 1.0 cm per decade (1966–1996). This secular trend is within the range of values reported for European populations by Hauspie et al. (1997). Mean stature of Rarotonga women in 1996 was 163.8 cm, well below the tallest population in the world, the Dutch, who have mean adult female stature of 171 cm (Cole, 1997), but on the 85th centile of stature for US women (Frisancho, 1990). With respect to weight, the rate of secular increase in the 20–29 years age group is 0.6 kg per decade in the period 1952–1966, and 7.3 kg per decade in the period 1966–1996. In the age group 30–39 years, the rates are 3.2 kg per decade (1952–1966) and 5.1 kg per decade (1966–1996). Mean weight of adult females lay between the 50th and 75th centiles of weight for US women (Frisancho, 1990) in 1952, but lay on the 85th centile of the same reference in 1966, rising to lie between the 90th and 95th centiles in 1996.[2] With respect to BMI, the mean values of 27.2 for the total 1952 sample and 28.9 for the total 1966 sample are within the range of values reported for Cook Islander women engaged in subsistence production on Atiu and Mitiaro by Hunter (1962) (BMI = 29.0) and Pukapuka by Evans and Prior (1969) (BMI = 26.4) respectively. The mean value of 33.8 for the combined 1996

[1] We focus on females because of the more complete availability of data.

[2] Nauru has the heaviest population in the world and the Cook Islanders are second by slight margin. There is a genetic component to obesity, but the genetics of multi-factorial trait disorders is far from resolved, because many genes are likely to be involved.

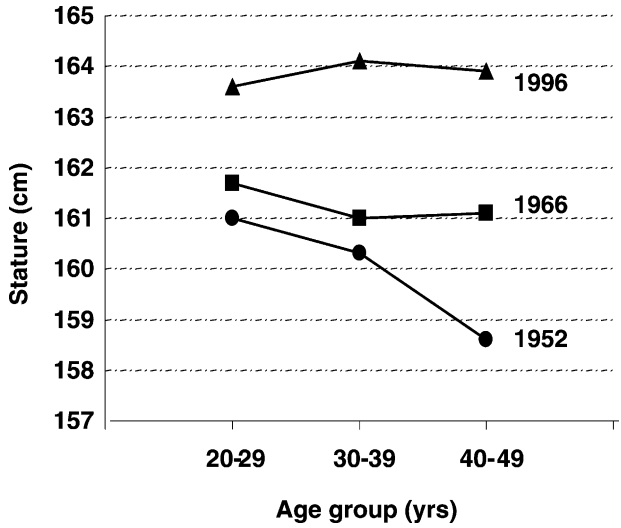

Fig. 2. Mean stature of females by age group (sample size adjusted means, 1952; age adjusted means, 1966, 1996).

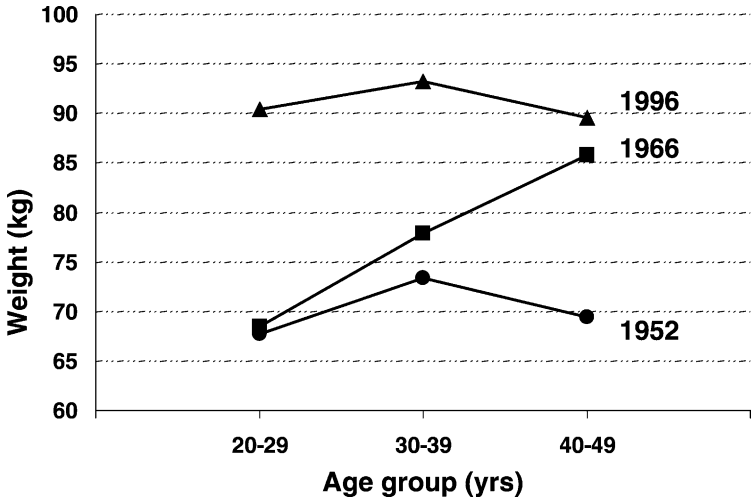

Fig. 3. Mean weight of females by age group (sample size adjusted means, 1952; age adjusted means, 1966, 1996).

sample is clearly above this range of values. Mean BMI of adult females lay between the 50th and 75th centiles of BMI for US women (Frisancho, 1990) in 1952, lay on the 75th centile of the same reference in 1966, rising to lie between the 90th and 95th centiles in 1996.[3]

[3] Obesity increases the risk of diabetes, cardiovascular disease and diet-related cancer (stomach, colon). In spite of such obvious health consequences of obesity, life expectancy at birth of Cook Islanders is not particularly low by international standards. It is 69 years for males, and 72 years for females.

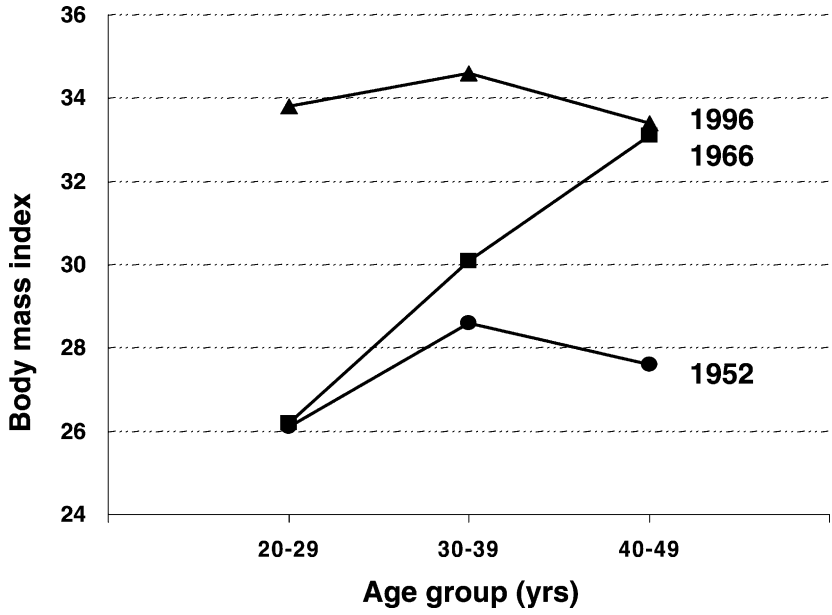

Fig. 4. Mean body mass index of females by age group (sample size adjusted means, 1952; age adjusted means, 1966, 1996).

4. Change in food availability and diet on Rarotonga

In 1952, the typical rural diet of Cook Islanders on Rarotonga largely comprised of the root crop taro (Colocasia species), banana, breadfruit, fresh fish and coconut, although significant amounts of bread and tea or coffee with sugar were also consumed (Fry, 1957a,b). Thus, food imports were clearly important on Rarotonga in 1952, increasing more than two-fold in the period 1961–2000 (FAO, 2002). Per capita daily availability of staple food types, sugar, oils and fats, and meats, respectively, for the Cook Islands population between 1961 and 2000, calculated from the FAO (2002) FAOSTAT food balance database are shown in Figs. 5–7. This database is one of several statistical on-line multilingual database currently containing over 1 million time-series records from over 210 countries and territories covering statistics on agriculture, nutrition, fisheries, forestry, food aid, land use and population. The database FAOSTAT-Nutrition gives the statistics on commodities, food supply, food balance sheets, food aid, and population size across the years 1961–2001, and uses the food balance data collected at national level for its information. Food balance sheets contain information on production, imports, and exports of a wide range of foods, both for local production, and commoditised. The database is as good as the data collection and reporting system for any given country, and reflects the commoditised food sector more precisely than production for local use. The data for the Cook Islands is considered to be reliable because collection was carried out by the Government of New Zealand prior to independence, in 1965. However, the Cook Islands remain self-governing in association with New Zealand to the present day,

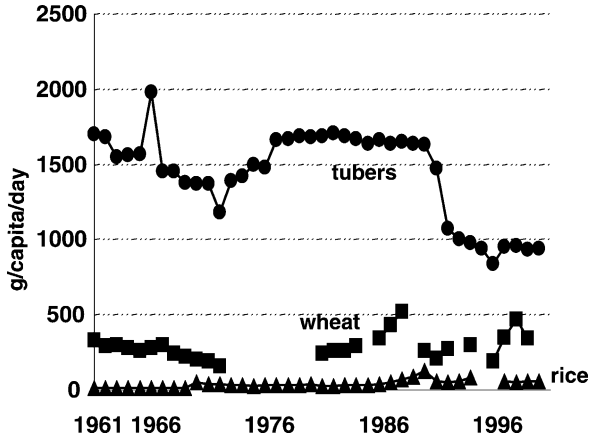

Fig. 5. Per capita daily availability (g) of staple food types between 1961 and 2000 (calculated from FAO (2002)).

and accurate reporting of food balance continues to reflect the strong interest of the New Zealand Government in accurate recording of rural economic activities.

Fig. 5 shows the per capita daily availability of staple food types between 1961 and 2000. Both rice and wheat and wheat products are imported to the Cook Islands, while tubers (which consist predominantly of taro) are indigenously grown. Rice availability increased in the period 1961–1990, from 18 g per person per day for the period 1961–1970, to 29 g per person per day for the period 1971–1980 and 47 g per person pre day in the period 1981–1990, then declined to 29 g per person per day in the period 1991–2000. Wheat availability has been greater than that of rice throughout the period 1961–2000, at between 160 and 520 g per person per day across this period. Tubers, predominantly taro, have remained the dominant staple type, although tuber availability declined greatly in 1992,

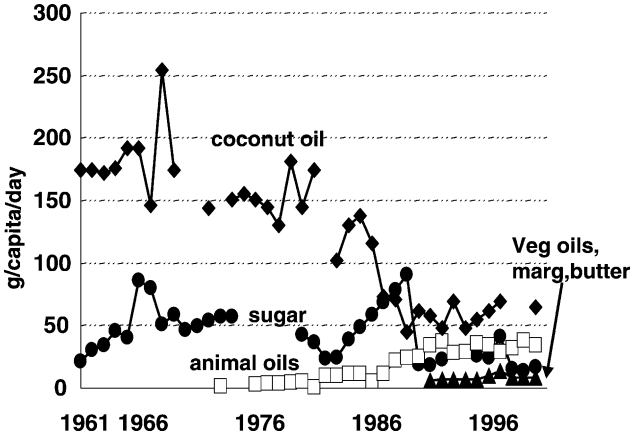

Fig. 6. Per capita daily availability (g) of sugar, oils and fats between 1961 and 2000 (calculated from FAO (2002)).

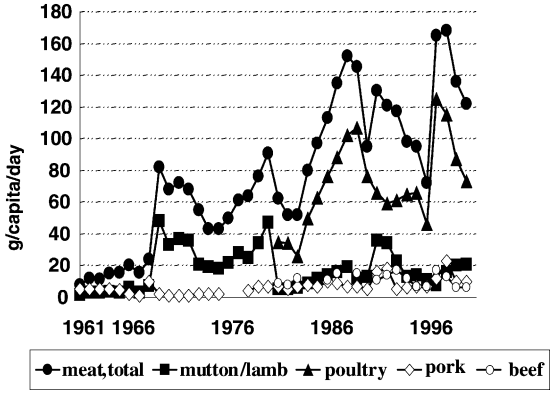

Fig. 7. Per capita daily availability of meat (g) between 1961 and 2000 (calculated from FAO (2002)).

to about two-thirds of the level of availability prior to that year. There was a severe taro blight throughout the Pacific in the mid-1990s that caused the decline in taro availability and consumption to, and by, Pacific Islands populations.

Sugar availability has not increased between 1961 and 2000, varying between a low of 14 g per person per day, to a high of 91 g per person per day, with a mean daily availability of 43 g per person per day (Fig. 6). Overall availability of dietary fats and oils has declined across this period, largely because of a decline in availability of coconut oil. The decline started in about 1972, increased in about 1986, and stabilised in the period 1987–2000 at levels of about 2.5-fold less than in the early 1960s. This has been compensated for to a small extent by a steady rise in the availability of both animal fats and vegetable oils. Total daily availability of dietary fats and oils was 179 g in 1961, and 107 g in the year 2000.

Per capita daily availability of meat to Cook Islanders increased dramatically from 8 g in 1961, to 122 g in the year 2000 (Fig. 7). The vast majority of this meat was imported, and the increase being broadly divided into three periods: 1961–1968, when availability was about 15 g per person per day; 1969–1983, when availability was about 63 g per person per day; and 1984–2000, when availability was about 120 g per person per day. About half of the increase in the period 1969–1983 is due to greatly increased importation of mutton and lamb from New Zealand; between 1969 and 1980, availability of mutton and lamb was about 31 g per person per day, representing 48% of total meat availability. This was then largely displaced by imported poultry, most importantly, frozen chicken. The greatly increased importation of frozen poultry resulted in the next great increase in meat availability, in the period 1984–2000. Across this period, poultry availability was about 75 g per person per day, representing 62% of total meat availability. Across the same time-frame, mutton and lamb represented 14% of total meat availability. Availability of pork has increased more than two-fold during the period 1961–2000, albeit from low levels. In the period 1961–1970, availability of pork was about 4 g per person per day, while in the period 1990–2000, availability was about 11 g per person per day.

Fish obtained using traditional subsistence methods was an important dietary item for Cook Islanders in 1952 (Fry, 1957a,b), but traditional fishing productivity is very poorly

Table 1
Proportion of families consuming different food categories, Rarotonga, the Cook Islands: across a 7–10-day period, per family, 1952 (Fry, 1957b); during the previous day, adults, 1996 (Ulijaszek, 2002)

	Percentage families, 1952	Percentage adults, 1996
Traditional staples (tubers)	100	91
Coconut	100	39
Fresh fish	95	37
Bread and rice	100	94
Tinned meat	83	62

represented in the FAOSTAT (2002) database. Furthermore, the FAOSTAT data represent food availability, and not consumption per se. To obtain some idea of possible change in consumption patterns, and of fish consumption in particular, Table 1 gives a comparison of food consumption frequency data collected on Rarotonga in 1952 by Fry (1957b), and in 1996 by Ulijaszek (2002). Data collection strategies were different in the two surveys; the 1952 data shows the percentage of families having eaten different foods across a 7–10-day period, while the 1996 data gives the proportion of women having eaten different foods in the previous 24 h. However, this necessarily crude comparison nonetheless shows some important differences. In both 1952 and 1996, bread and rice were eaten as often as traditional staples, although greater quantities of traditional staples were more likely to be consumed than imported wheat and wheat products, and rice. The frequency of consumption of coconut and fresh fish was apparently much lower 1996 than in 1952. Since fish and coconut cream are eaten in combination as part of the traditional diet of Cook Islanders (Fry, 1957b; Ulijaszek, 2002), and availability of coconut oil showed considerable decline across the period 1972–1987 (Fig. 5), it is likely that the difference in fish consumption frequency (Table 1) is a reflection of true dietary change. In 1952, fresh fish consumption was 1733 g per family per day, while consumption of coconut cream (not whole coconut) was 1393 g per family per day, both items being eaten daily among the vast majority of families (Fry, 1957a). In 1996, various informants, especially older ones, lamented the decline in subsistence fishing to the author, again suggesting a decline in the consumption of fish caught using traditional methods.

5. An estimate of the obesogenicity of the Cook Islands diet, 1952–1996

On the basis of changing availability of different food types (Figs. 5–7) and of intake studies (Fry, 1957a,b; Ulijaszek, 2002), it is clear that the diet of Cook Islanders has undergone considerable change, most notably with respect to: (1) reduced availability of traditional staples; (2) a likely reduction in consumption of fish; (3) increased consumption of meat (of mutton and lamb in the period 1969–1980, and of poultry, 1984–2000); (4) a decline in availability of dietary fats and oils; and (5) a large decline in availability of coconut oil, compensated for to some extent by increased availability of vegetable oils and animal fat. While dietary change and change in physical activity patterns have been invoked as being central to the emergence of obesity and fatness in Pacific Islands populations (Hunter, 1962; Evans and Prior, 1969; Prior, 1971; Bindon and Baker, 1985; McGarvey, 1991), it is unclear

from the above description of food availability and diet in the Cook Islands the extent to which changing diet might predispose to obesity. An estimate of the possible obesogenicity of the 1952 diet, and reconstructed diet from food availability in 1966 and 1996, was made in the following way. Per capita energy intake values for 1952 were taken from Fry (1957a), while daily per capita food availability values were calculated from FAOSTAT (2002) for the years 1966 and 1996, and converted into energy values using food composition tables for New Zealand (Athar, 2002), which include a range of Pacific Island foods. These energy intake values were then indexed against basal metabolic rate (BMR), which was predicted from body weight and stature for women in 1952, 1966 and 1996 (Fig. 2), using the Schofield (1985) equations for adult women aged 18–30 and 30–60 years, as appropriate. Although the equations of Schofield (1985) have been recommended for the global prediction of BMR (FAO/WHO/UNU, 1985), these have been shown to overpredict BMR among populations living in the tropics (Henry and Rees, 1991), and among Chinese adults (Liu et al., 1995). While there is no data on basal metabolic rate prediction among Pacific Islanders, it may be that the Cook Islanders of this study also experience lower basal metabolic rate than predicted from the Schofield (1985) equations, because they live in tropical regions. However, the greater muscularity of Pacific Islanders at a given body size relative to Europeans would give them higher BMR per unit of body size, due to the greater metabolic activity of muscle tissue relative to adipose tissue (Elia, 1992). These two effects may well compensate each other to some unknown degree. While there are equations for predicting BMR in tropical populations (Henry and Rees, 1991), when in doubt the default option is to use the Schofield (1985) equations (Ulijaszek, 1995b).

Table 2 gives daily per capita energy intake, predicted BMR, and energy intake divided by BMR (EA/BMR), for 1952, 1966, and 1996. Energy availability is highest in 1966, and lowest in 1996. However, in no case can any value of availability be considered low. Energy intake indexed against BMR (EA/BMR) is also highest in 1966, and lowest in 1996. The 1966 value for EA/BMR of 3.20 suggests that the diet was obesogenic, since it would require a physical activity level (PAL) of 3.2 in order for energy intake to match expenditure. There is no society in which this level of expenditure has been reported for women (Ulijaszek, 2000). In the Pacific region, Schendel (1989), working on Western Samoa, obtained PAL values of 1.7 and 1.8 for rural female villagers, and 1.9 for urban women, while on the Cook Islands, Ulijaszek (2001a,b,c) obtained an overall mean PAL of 1.5 for women of all occupations. Elsewhere in the world, the highest PAL value obtained for women engaged in traditional agriculture is 1.8 for sweet potato cultivators in Papua New Guinea (Norgan et al., 1974). A PAL value of 1.9 can be taken as a theoretical maximum for female cultivators in

Table 2
Daily per capita energy availability (kcal), Cook Islands, indexed against maintenance metabolism (kcal)

Year	EA[a]	BMR[b]	EA/BMR[c]
1952	3571	1469	2.43
1966	4941	1546	3.20
1996	3185	1693	1.88

[a] Daily per capita energy availability (kcal) from Fry (1957a) (1952); FAO (2002) (1996).
[b] Basal metabolic rate (kcal) predicted from body weight using appropriate equations of Schofield (1985).
[c] Energy available divided by basal metabolic rate.

the developing world. Of the three values given for EA/BMR in Table 2, the 1952 and 1966 values exceed the hypothetical maximum of 1.9, suggesting that the diets at those times were extremely obesogenic, the diet in 1966 more so than the diet in 1952. The 1996 value for EA/BMR is close to that of the hypothetical maximum PAL, but this does not indicate that women then were in energy balance, since energy expenditure measurements carried out on women on Rarotonga in 1996 gave a mean overall PAL value of 1.5 (Ulijaszek, 2001c). This indicates that the diet at this time is likely to have predisposed to positive energy balance and weight gain, although to a lower extent than in 1966 and 1952. It is not known whether physical activity was greater in 1966 and 1952 than in 1996. However, even if it reached the hypothetical maximum for women engaged in traditional agriculture elsewhere in the world, women would likely have had a large positive energy balance in 1952 and an even larger positive energy balance in 1966, both of which would have predisposed to significant weight gain. This is in accord with the body weight patterns across the period 1952–1996 shown in Fig. 2. Thus the greater increase in mean body weight and BMI observed in Cook Islanders in the second half of the 20th century may be attributed to obesogenic dietary change, although reductions in physical activity may also be important, although this cannot be assessed since there are no measures of this prior to 1996. Future work should involve more detailed observations of energy expenditure, especially longitudinal studies of the same subjects in populations where there is great variation in gain in body fatness across several years.

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