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Original Contribution

Impact of Energy Intake, Physical Activity, and Population-wide Weight Loss on Cardiovascular Disease and Diabetes Mortality in Cuba, 1980–2005

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Cuba's economic crisis of 1989–2000 resulted in reduced energy intake, increased physical activity, and sustained population-wide weight loss. The authors evaluated the possible association of these factors with mortality trends. Data on per capita daily energy intake, physical activity, weight loss, and smoking were systematically retrieved from national and local surveys. National vital statistics from 1980–2005 were used to assess trends in mortality from diabetes, coronary heart disease, stroke, cancer, and all causes. The crisis reduced per capita daily energy intake from 2,899 calories to 1,863 calories. During the crisis period, the proportion of physically active adults increased from 30% to 67%, and a 1.5-unit shift in the body mass index distribution was observed, along with a change in the distribution of body mass index categories. The prevalence of obesity declined from 14% to 7%, the prevalence of overweight increased 1%, and the prevalence of normal weight increased 4%. During 1997–2002, there were declines in deaths attributed to diabetes (51%), coronary heart disease (35%), stroke (20%), and all causes (18%). An outbreak of neuropathy and a modest increase in the all-cause death rate among the elderly were also observed. These results suggest that population-wide measures designed to reduce energy stores, without affecting nutritional sufficiency, may lead to declines in diabetes and cardiovascular disease prevalence and mortality.

cardiovascular diseases; Cuba; diabetes mellitus; energy intake; exercise; mortality; weight loss

Abbreviation: ICD-10, *International Classification of Diseases*, Tenth Revision.

Excess body weight and a sedentary lifestyle are well-established risk factors for cardiovascular disease and type 2 diabetes (1). Randomized trials have shown that significant reductions in the incidence of type 2 diabetes can be achieved through a combination of weight loss and increased physical activity (2–4). However, the impact of sustained population-wide weight loss on cardiovascular disease and total mortality remains unknown.

In contrast to many nonindustrialized countries, Cuba has an extensive primary health-care network and virtually complete ascertainment of vital events (5). In 2005, Cuba had a life expectancy of 77 years and an aging population in

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which cardiovascular disease had emerged as the leading cause of death (6). Cuba has been subjected to an economic embargo by the United States since the 1960s. After the loss of the Soviet Union as a trading partner in 1989, Cuba entered a prolonged economic crisis known as the ''Special Period.'' The crisis worsened continuously over the next 5 years, with economic output reaching a nadir in 1995 of about half the level in 1990 (7). Foreign trade contracted by 80 percent, dramatically reducing imports and the local supply of fuel, agricultural products, and many food items. Sustained shortages in the food-rationing system led to reductions in per capita daily energy intake, and the lack of public transportation resulted in increased energy expenditure from walking and cycling (8). Complete economic recovery did not occur until 2000. Nutritional studies conducted in adults during a neuropathy outbreak in 1993 documented that 27 percent of Cuban adults had lost more than 10 percent of their body weight in the previous 12 months, an average loss of 5–10 kg, and 43 percent had experienced severe caloric restriction (9–11).

We examined Cuban vital statistics and data from population surveys to determine the impact of this marked population-wide weight loss on mortality from cardiovascular disease and type 2 diabetes.

MATERIALS AND METHODS

We performed a systematic literature search for all available data on energy intake, body weight, and physical activity in Cuba between 1980 and 2005. We used the databases MEDLINE, EMBASE, and Scientific Electronic Library Online (SciELO), which includes all Cuban journals. From 96 potentially relevant references, we selected seven publications that presented data on the defined exposures from population-based surveys (8, 11–16). Publications not accessible in electronic databases were obtained by the lead author (M. F.) at the National Statistics Office of the Cuban Ministry of Public Health and the National Institute of Hygiene, Epidemiology, and Microbiology.

Energy intake

Per capita energy intake was measured as apparent intake, defined as the total per capita amount of food available after subtracting the food allocated to the tourism industry and losses due to distribution and cooking. These measurements were conducted by the National Institute of Hygiene, Epidemiology, and Microbiology from 1980 to 1999 (14). The Food and Agriculture Organization of the United Nations also provided data on per capita food availability by dividing total calories available for human consumption by the total population consuming the food supply during the reference period (17). Data from the Food and Agriculture Organization were available for 1983–2003.

Physical activity

Physical activity was measured in a population sample from Havana in 1987 (8) and in the First and Second National Surveys on Risk Factors and Chronic Diseases, conducted in 1995 and 2001, respectively (16, 18). These surveys used probability sampling schemes to represent the Cuban population. The 1995 report noted that higher levels of physical activity had prevailed during the years 1991–1994 as a result of widespread use of bicycles and walking as means of transportation (18). For these three surveys, participants were designated ''active'' if they engaged in regular physical exercise, defined as at least 30 minutes of moderate or intense physical activity at least 5 days per week.

Height and weight

Anthropometric data were collected in surveys carried out in Havana in 1982, 1994, and 1998. The 1982 survey was part of a national survey that measured height and weight in 31,662 adults (15). In these surveys, professional examiners from the Cuban National Census collected anthropometric data while participants stood in light street clothes. Height and weight were also measured in three cross-sectional surveys in the city of Cienfuegos, on the southern coast of Cuba, in 1991, 1995, and 2001, among 1,657, 1,351, and 1,667 adults, respectively (12). The Cienfuegos surveys were based on stratified probability samples from the urban population aged 15–74 years. Height and weight were measured by professional examiners while participants stood in light street clothing. The city of Cienfuegos had cardiovascular disease mortality rates similar to nationwide levels (6). The Second National Survey on Risk Factors and Chronic Diseases, conducted in 2001, measured height and weight in 19,519 adults (16). Data on body mass index (weight (kg)/height $(m)^2$) and the prevalence of obesity, defined as a body mass index of 30 or more, were available from each survey.

Smoking

National per capita use of cigarettes was calculated as the total number of cigarettes sold per year divided by the population aged 15 years and over (19). The prevalence of smoking was obtained from studies carried out in Havana (1985) (20), the three surveys from the city of Cienfuegos (1991, 1995, and 2001), and the national surveys conducted in 1995 and 2001 (19). Smoking was defined as self-reported current smoking of cigarettes and/or cigars, although in Cuba 95 percent of smokers are cigarette smokers (6).

Mortality

Annual age-adjusted mortality rates per 100,000 population were obtained from the Cuban Ministry of Public Health for type 2 diabetes (equivalent *International Classification of Diseases*, Tenth Revision (ICD-10), codes E10–E14), coronary heart disease (ICD-10 codes I20–I25), stroke (ICD-10 codes I60–I69), cancer (ICD-10 codes C00–C97), and total mortality for the period 1980–2005 (21). The population of the 1981 Cuban census was the standard population used for age adjustment. Vital records in Cuba are essentially complete. At the Cienfuegos University Hospital, postmortem examinations include up to 85 percent of cardiovascular disease deaths (22). In the national vital

statistics, ill-defined causes constituted 0.7 percent of reported causes of death in 2005 (21).

RESULTS

Average per capita daily energy intake, as measured in the Cuban Food Survey, declined from 2,899 kcal in 1988 to 1,863 kcal in 1993 (14). Food and Agriculture Organization data, which reflected food availability at the population level, were consistent with the trends in the Cuban Food Survey showing a strong drop in daily per capita food availability from the late 1980s to 1995 (figure 1). Food supplies rebounded in the second half of the 1990s and reached precrisis levels in 1999 (figure 1).

In 1987, only 30 percent of the population living in Havana was characterized as physically active. In national data, approximately 70 percent of Cubans were considered physically active in 1991–1995, and 67 percent were active in 2001 (figure 1).

The prevalences of obesity in Havana were 11.9 percent, 5.4 percent, and 9.3 percent in 1982, 1994, and 1998, respectively. In Cienfuegos, prevalences were 14.3 percent, 7.2 percent, and 12.1 percent in 1990, 1995, and 2001, respectively, reflecting a 49 percent fall during the economic crisis. The 2001 national survey data showed a prevalence of 11.7 percent (figure 1).

Using data from the Cienfuegos surveys of 1991 and 1995, we obtained kernel density plots of the distributions of body mass index and body mass index categories (figure 2). The upper half of figure 2 demonstrates a systematic shift of 1.5 body mass index units from 1991 to 1995. In the lower half, a change consistent with a shift in the distribution is demonstrated with reference to discrete body mass index categories. The abrupt fall in obesity from a prevalence of 14.3 percent in 1991 to 7.2 percent in 1995 follows a population shift in weight from all initial levels. The reduction in the obesity category translated into additions of 1, 3.8, and 2.3 percentage points to the overweight, normal weight, and underweight categories, respectively.

The prevalence of smoking was 34.5 percent in Havana in 1985 and 33.8 percent in Cienfuegos in 1991. The national surveys conducted in 1995 and 2001 showed prevalences of 36.8 percent and 31.9 percent in 1995 and 2001, respectively (figure 1). Per capita use of cigarettes continued a decreasing trend from 1980 to 1997 (figure 1), almost halving the number of cigarettes smoked. This incongruence between the decrease in cigarette use and the sustained high prevalence of smoking translated into a reduction in the number of cigarettes smoked per day but not a reduction in the prevalence of smokers.

The years at the end of the crisis, 1997–2000, and two postcrisis years, 2001–2002, were characterized by substantial declines in coronary heart disease, type 2 diabetes, and all-cause mortality (figure 3). Recent trends in type 2 diabetes mortality can be divided into four distinct phases: In phase I, from 1980 to 1987, mortality steadily increased; in phase II, from 1988 to 1996, a plateau was reached corresponding to the period of food shortage, increased physical activity, and the reduction in obesity (figure 1); in phase III, from 1997 to 2002, type 2 diabetes mortality declined by 51 percent; and in phase IV, from 2003 to 2005, mortality increased again (figure 3).

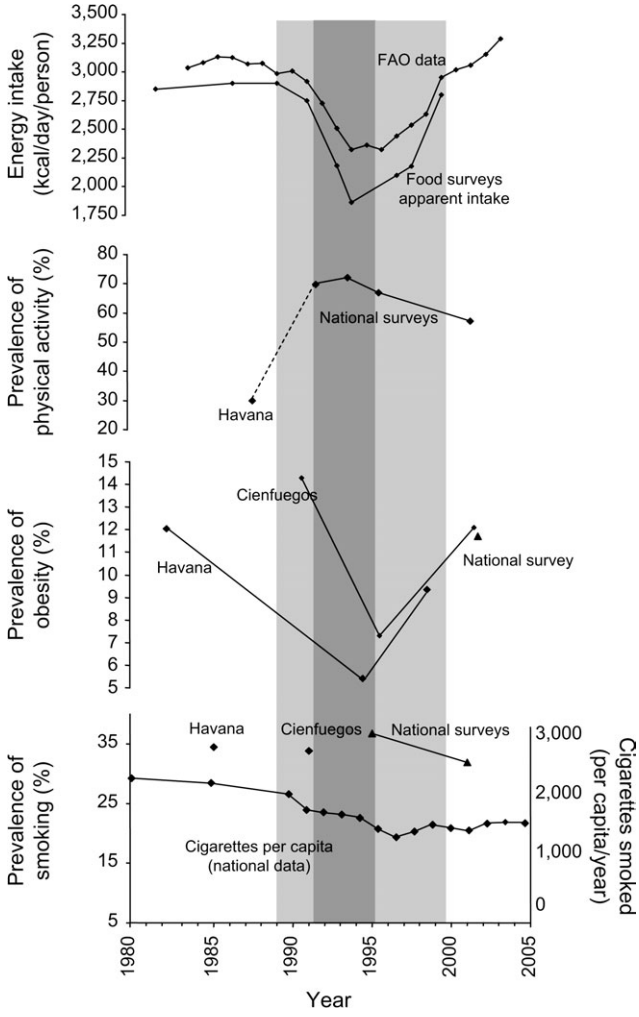

FIGURE 1. Energy intake (kcal/day/person), prevalences (%) of physical activity, obesity, and smoking, and per capita cigarette use (per year) in Cuba, 1980–2005. The shaded zones illustrate the period of economic crisis (1989–2000) and the most severe years of the crisis (1991–1995). FAO, Food and Agriculture Organization.

Coronary heart disease mortality declined slowly from 1980 through 1996 and then turned sharply downward from 1997 through 2002, with a 35 percent cumulative decline. From 2003 through 2005, coronary heart disease mortality increased slightly (figure 3). Stroke mortality trends followed a similar pattern, with a 20 percent decline from 1997 to 2002 (data not shown). Cancer mortality followed a different pattern, declining slightly from 1980 to 1995, followed by a slight increase (figure 3).

Total mortality mostly followed trends in coronary heart disease and stroke, though the curve was almost flat from 1980 to 1996, falling dramatically (18 percent) from 1997 to 2002 and subsequently rising slightly (figure 3).

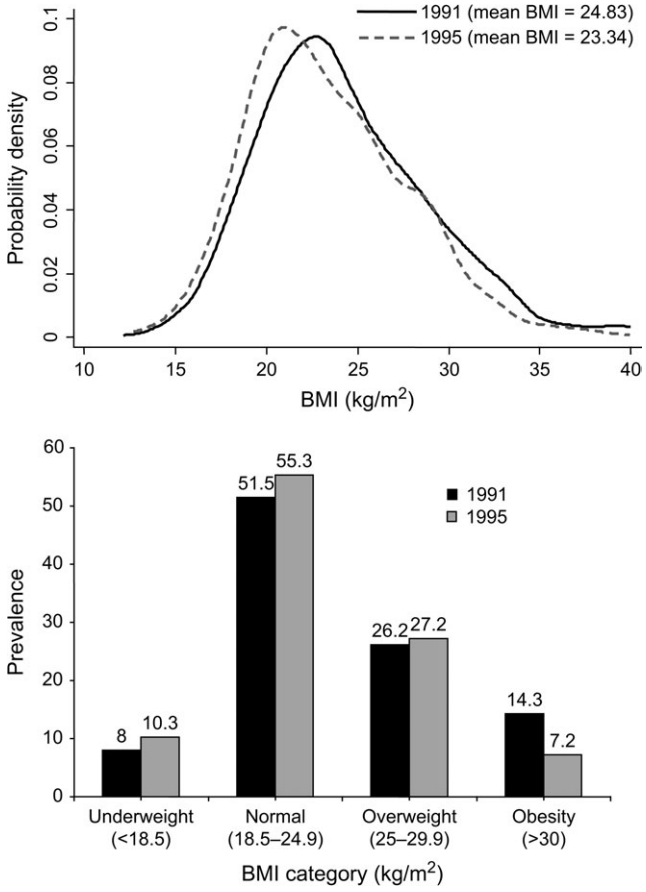

FIGURE 2. Distributions of body mass index (BMI; weight (kg)/height (m)^2) (top) and BMI categories (bottom) in Cienfuegos, Cuba, in 1991 and 1995.

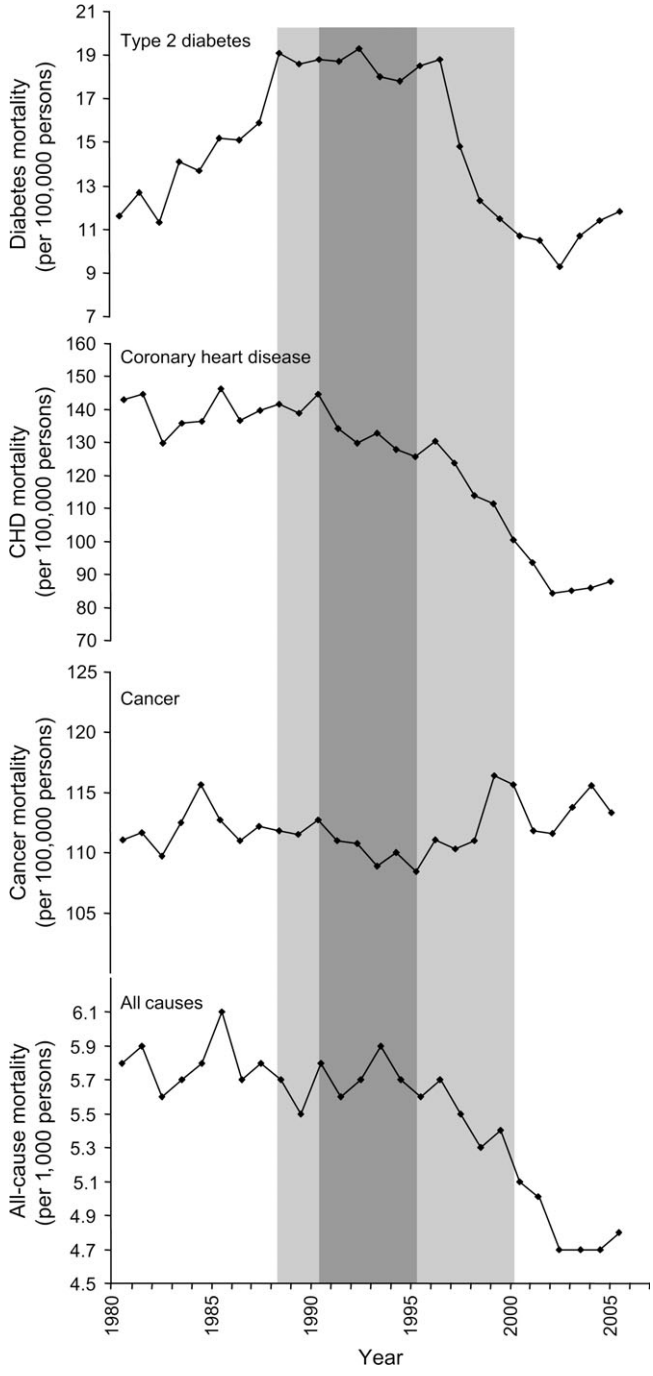

FIGURE 3. Trends in age-adjusted mortality from type 2 diabetes, coronary heart disease (CHD), cancer, and all causes in Cuba, 1980–2005. The shaded zones illustrate the period of economic crisis (1989–2000) and the most severe years of the crisis (1991–1995).

DISCUSSION

During the years of the most severe economic crisis in Cuba, 1991–1995, per capita energy intake decreased substantially, while energy expenditure increased as a result of the need to walk or use bicycles as means of transportation. Lower energy input and high levels of energy consumption led to a sustained population-wide weight loss. The prevalence of obesity decreased by half, while the prevalence of overweight increased slightly; the prevalence of normal weight exhibited the greatest percentage increase. The shift in the mean body mass index of 1.5 units that we documented in the Cienfuegos population, when applied to a person 5′8″ (174 cm) tall, is equivalent to a loss of 10 pounds (4.5 kg) or 5.6 percent of body weight. The neuropathy outbreak studies also reported weight reductions on the order of 10–20 pounds (4.5–9.1 kg) (9–11). When examining the distribution of change in body mass index categories, we observed a 50 percent reduction in obesity. The subsequent shift to lower body mass index categories resulted in increases of 1, 3.8, and 2.3 percentage points in the overweight, normal weight, and underweight categories, respectively. The observation that the prevalence of overweight did not decrease means that the results from this study shed no additional light on the current controversy regarding the mortality effects of being overweight (23, 24).

In subsequent years (1997–2002), rates of mortality from type 2 diabetes, coronary heart disease, and all causes

dropped 51 percent, 35 percent, and 18 percent, respectively. Reductions in diabetes mortality are consistent with observational studies of populations that intentionally lost weight (25, 26), although the impact of weight loss occurred only in persons with preexisting illness. In the present study, we could not address whether mortality reductions occurred differentially in persons with and without established chronic conditions.

Although mortality reductions have been observed in several studies, some of which were summarized in Keys' classic report (27), to our knowledge negative energy balance has not been shown to reduce type 2 diabetes and cardiovascular disease mortality to this degree in an entire country. Previous historical episodes of food shortage in the Nordic countries during World War II were associated with immediate improvements in mortality from cardiovascular disease and diabetes (28, 29). Investigators studying those episodes attributed mortality declines primarily to reductions in fat intake rather than sustained weight loss, a biologic mechanism that could extend over a period of years. In contrast to the shorter periods of exposure to lower fat intake during World War II, mortality declines in Cuba occurred during a decade of negative energy balance (1989–1999), high levels of physical activity, and associated prolonged weight loss that lasted 4–8 years (1991–1999). The results of the present study are, to some extent, consistent with the findings of several recent studies carried out in market economies (30–32), in which declines in total mortality and mortality due to cardiovascular disease and other causes were found during periods of economic crisis or recession. However, during World War II, prolonged reductions in caloric intake—like those seen in Cuba in the 1990s—did not occur.

We propose that sustained weight loss might have delayed clinical sequelae of type 2 diabetes and coronary heart disease and resulted in a slight temporal lag in mortality. The impact of sustained weight loss on mortality remains unknown. The still-ongoing Look AHEAD trial was designed to achieve 7 percent weight loss in the first year among people with diabetes (33). Cohort studies are potentially biased by reverse causality (i.e., persons with prior illness might be more likely to lose weight). In diabetes prevention trials, reductions in incidence of 50 percent have been observed over 3–6 years after significant weight loss (2–4). Thus, there are clearly plausible biologic mechanisms that could explain how weight loss could affect death from type 2 diabetes and cardiovascular disease, with a lag observed due to sustained weight loss having a mechanism of longer duration.

Although the number of cigarettes smoked per day in Cuba has declined in the last 20 years, the prevalence of smoking consistently remained over 30 percent from 1985 to 2001, remaining high by international standards (e.g., in 2000, prevalences of smoking were 26.5 percent in the United Kingdom and 22 percent in the United States (34)). The reduction in cigarette use should certainly be playing a role in the ongoing mortality reduction (6, 13). A recent analysis of the decline in coronary heart disease in the United States from 1980 to 2000 suggested that 2 percent of the total reduction in coronary heart disease mortality was due to smoking, based on a reduction in prevalence from 36 percent to 24 percent (35).

No significant changes in total cancer mortality were observed, consistent with the current knowledge that obesity is not strongly associated with this condition. The lag observed for diabetes and cardiovascular disease might well differ for cancer, however, and effects might be restricted to specific cancer sites. If this were so, these effects must have been small.

Mortality trends could also have been influenced by other important unmeasured variables, such as hospitalizations and types of treatments, all of which are susceptible to secular changes. Given the ecologic nature of this study, the independent role of increased physical activity in cardiovascular risk across the population likewise cannot be independently assessed; however, it is reasonable to assume that more walking and cycling increased the magnitude of weight loss and reduced the risk of type 2 diabetes and cardiovascular disease for some people, given the well-established association between physical activity and all-cause mortality among persons with type 2 diabetes (36).

Diet composition in Cuba also changed during the study period. By 1993, carbohydrate, fat, and protein contributed 77 percent, 13 percent, and 10 percent of total energy, respectively, whereas in 1980 their respective contributions were 65 percent, 20 percent, and 15 percent (8). The primary sources of energy during the crisis were sugar cane and rice (37). Increases in consumption of refined carbohydrates are currently considered diabetogenic by some authorities. However, this may not be the case during a period of sustained negative energy balance. Given the reduction in intake of animal products, it is likely that serum cholesterol levels may have also declined, further contributing to the reduced coronary heart disease risk. Unfortunately, we had no trend data on serum lipid levels. The reduction in fat content during the crisis might have mimicked the effects observed during World War II; however, the absence of standardized and repeated dietary surveys precluded any conclusions regarding a specific role.

Because of the restricted access to many drugs during the crisis period, the Cuban Ministry of Public Health called for heightened attention to noncommunicable diseases and developed a series of new clinical guidelines. Type 2 diabetes care was prioritized, and many people with type 2 diabetes received care in hospitals to assure appropriate management. The impact of these measures also cannot be assessed at this time.

There were limitations in these analyses. The use of death records is clearly not as informative for type 2 diabetes burden as are data based on diagnostic tests, such as glucose tolerance. Trends in the coding of death records for deaths attributed to type 2 diabetes might have explained to some extent the observed mortality declines. It is unlikely, however, that large shifts in certification practices occurred over this relatively short period. Indeed, parallel declines in coronary heart disease, where much of the effect of type 2 diabetes would be expected, support the inference that the disease burden fell dramatically.

In contrast to prevention trials targeting high-risk groups (2–4), the social conditions during this period in Cuba

affected the whole population, leading to a classic ''shift of the mean,'' which can explain the large aggregate effect (38). While population-wide strategies are the optimal preventive approaches for some continuously distributed risk factors, such as high blood pressure and elevated serum cholesterol levels, this has not been demonstrated for relative weight. In fact, there is currently considerable debate regarding the optimal body mass index. Thus, weight loss may have been beneficial for some persons, while putting others at greater risk. In terms of cardiovascular disease outcomes, at least, it appears that overall it conferred substantial benefits.

The sharp reduction in food availability during the crisis also had some important negative consequences. All-cause mortality among persons over the age of 65 years increased 13 percent from 1989 to 1996, primarily because of excess deaths from infections (21). The secular decline in infant mortality was interrupted for 3 years, and the incidence of low birth weight increased from 7.3 percent to 9.0 percent between 1989 and 1993 (21). An epidemic of optical and peripheral neuropathy attributed in part to vitamin and protein deficiencies affected 50,000 people between 1992 and 1993 (10, 39).

Currently, the Cuban economy is growing consistently, with reports of a 9 percent increase in gross domestic product recorded for 2005 (40). Per capita energy intake and food availability have increased, and public transportation has improved. As was noted above, mortality from type 2 diabetes and heart disease reached a nadir in 2001 and increased for the next 4 years. The current public health challenge in Cuba, as well as in all other countries, is to implement similarly effective planned nutritional and physical activity interventions to prevent these common diseases (41).

In conclusion, the rapid and simultaneous declines in type 2 diabetes and coronary heart disease mortality in Cuba between 1997 and 2002 occurred during and after a period of change in major risk factors, including total energy and fat intake, physical activity, the number of cigarettes smoked per day, and the prevalence of obesity. Specific causal associations between weight loss and mortality cannot be inferred, since all of the cardiovascular risk factors mentioned above are also associated with weight loss and mortality, making it extremely difficult to disentangle all of the possible causal effects (24). Nonetheless, the substantial effect on type 2 diabetes is consistent with data from controlled trials and suggests the scale of the public health impact that could be achieved with a population intervention. These mortality reductions were partially offset by excess deaths in the elderly and an epidemic of neuropathy, both of which could be prevented by less drastic reduction in the variety of foodstuffs. Under circumstances that did not sacrifice nutritional sufficiency, measures designed to reduce energy stores could substantially decrease the burden of cardiovascular disease.

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