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Review

The role of physical activity and exercise in obesity and weight management: Time for critical appraisal

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Abstract

The prevalence of overweight and obesity has increased dramatically during last 3 decades with devastating consequences to public health. Recommended strategies to reduce obesity have focused on healthier diet and physical activity (PA). Clearly, these approaches have not been successful, but whether this is due to failure to restrict energy intake or to maintain high levels of energy expenditure has been the subject of great controversy. Consequently, there has been a great deal of confusion about the role of PA and exercise in obesity and weight management. In this article, the theoretical basis for considering reduced PA and energy expenditure as the cause of obesity is appraised. Further, the role of PA in food intake and weight control is examined. The idea that obesity is caused by consistent decline in daily energy expenditure is not supported either by objective measures of energy expenditure or physiological theory of weight gain alone. However, since voluntary exercise is the most important discretionary component of total daily energy expenditure, it can affect energy balance. Therefore, PA and exercise hold potential as part of the solution for the ongoing obesity epidemic.

Keywords: Energy expenditure; Exercise; Obesity; Overweight; Physical activity

1. Introduction

The prevalence of overweight and obesity has increased substantially in all societies across the globe during last 3 decades (Fig. 1), and all indications are that this trend is likely to continue unabated in the coming years.[1] This is a major public health concern because obesity has far reaching negative effects on health. The risk of type 2 diabetes, cardiovascular disease, certain types of cancers, and even mortality are directly proportional to the degree of obesity.[2,3] Thus, it goes without saying that there is a need to reverse this modern epidemic. Public health actions to reduce obesity have mostly focused on individuals, encouraging them to eat healthier and to exercise more. But so far, these approaches are failing as not a single country has succeeded in reducing obesity rates in the past 30 years.[4] Whether this is due to failure to restrict energy intake or to maintain high levels of energy expenditure has yet to be determined conclusively, and the relative importance of these 2 elements has been the subject of sparking debate.[5–7] The lack of consensus has led to a great deal of confusion of the usefulness of physical activity (PA) in weight loss, and the media's messages about the futility of exercise have nothing but galvanized this perplexity. In this article, I will consider the role of PA in obesity development and its usefulness in weight management.

2. Secular trends in occupational and household-related PA appear to be congruent with the dynamics of the population weight gain

Conceptually, obesity is a condition in which the amount of body fat exceeds the biological need of an individual. Obesity is a manifestation of a positive energy balance that has been sustained over an extended period of time. However, the reason why this condition has spread inexorably across the globe over the past 3 decades with such speed is not well understood. Generally speaking, the human genome has not changed substantially during this time; therefore, the rise in obesity most likely reflects changes in the environment and/or behavior. During the past half-century mechanization has impinged upon

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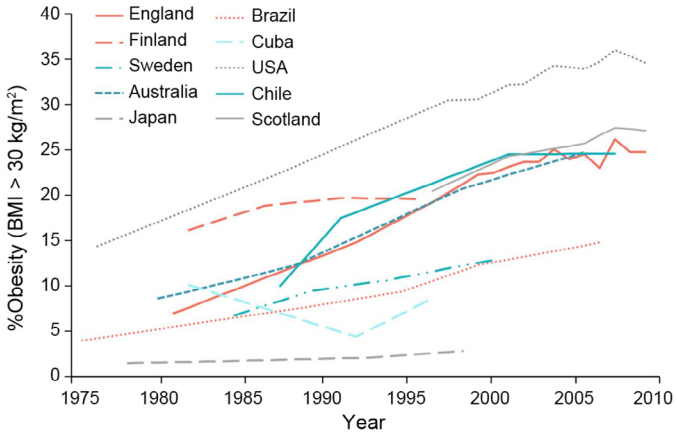

Fig. 1. Changes (%) in adult obesity prevalence over time in selected countries around the world.[50] BMI = body mass index. Reproduced with permission of World Obesity Federation.

our modes of living in diverse ways. Consequently, energy expenditure required for daily living has continuously declined. A recent study showed that in the US, daily energy expenditure due to work related PA has decreased by more than 100 kcal during last 50 years in both men and women, and this reduction is associated with the increase in mean body weight during this time frame.[8] Similar trends have also been observed in other countries including Finland, where daily energy expenditure during work reportedly decreased by more than 50 kcal between 1982 and 1992 while the average body weight relentlessly crept upward.[9] More recent studies indicated that these trends have continued unabated up to the present day.[10,11] Substantial reductions in daily energy expenditure have also occurred in developing countries such as China and Brazil, which have the highest absolute and relative rates of decline in total PA due to reductions in movement at work.[12] For this reason, it is believed that the obesity epidemic has also penetrated the low-income countries, particularly in the urban areas, and will continue to spread for the foreseeable future.[13]

There is also reason to assume that domestic mechanization of daily tasks (with the advent of labor-saving devices such as washing machines and dishwashers) have reduced energy expenditure over the years. Indeed, it was recently estimated that in women, daily housework-related energy expenditure has decreased by 360 kcal in the US since the 1960s.[14] The authors of the study concluded that such reductions in housework-related energy expenditure might have been substantial contributors to the rise in prevalence of obesity in women in last 5 decades. Because such labor-saving devices are habitually used in all affluent societies, their contribution to population energy balance in high-income countries has been considered substantive.[15] Domestic mechanization has also contributed to increased sedentariness, as time spent in house work has been replaced by sedentary activities such as watching television and use of other screen based media.[16] Many studies have implicated sedentary behavior, including passive transportation, with weight gain.[17–19] On the other hand, participation in leisure-time physical activity (LTPA) has progressively increased over the years;[20] however, it appears that on a secular basis, this has not been enough to offset increased sedentary behavior, as total PA is declining rapidly across the globe.[12]

3. Objective measurements of energy expenditure conflict the idea that obesity epidemic is attributable to reductions in daily energy expenditure

Based on the evidence presented above, it seems intuitive that the rise in bodyweight and obesity is attributable to decreases in daily energy expenditure. However, on closer scrutiny this idea seems highly improbable, and there is fair amount of evidence to support that contention. First, the "labor-saving" culture has not changed substantially since the 1960s and 1970s, whereas the obesity prevalence started to increase dramatically only around the 1980s. Second, doubly-labeled water studies (which provide the optimal method to measure energy expenditure in free-living individuals) show that daily energy expenditure has not declined between 1980 and 2005 in Europe or North America.[21] Similarly, recent meta-analyses of nearly 100 doubly-labeled water studies indicated that populations in industrialized countries do not have lower rate of daily energy expenditure compared with populations in developing countries.[22] Clearly, obese individuals have higher habitual energy expenditure compared with normal weight people[23] (due to their larger body size and resting metabolic rates). Leibel et al.[24] demonstrated that 10% weight gain increases daily energy expenditure from 370 to 530 kcal, depending on the baseline weight. The obvious implication of this is that the rate of energy intake must also increase accordingly, otherwise weight loss will ensue.

Consistent with this notion, Swinburn et al.[25] examined U.S. nutritional surveillance data and showed that the estimated daily energy intake in adults has increased on average by 500 kcal in the US between 1970s and 2000s. Similar findings have also been reported from several European countries.[26,27] However, a more recent examination by Archer et al.[28] suggested that once the measures of dietary intake in National Health and Nutrition Examination Survey (NHANES) were modified, no substantial difference in energy intake existed. Energy intake cannot be quantified as precisely as energy expenditure. The reason why daily energy intake is notably smaller than simultaneously estimated energy expenditure[28,29] may be explained by selective misreporting (over or under) and recall bias, which are well-known factors that confound studies investigating energy intake in humans.[30] Population energy intake can also be assessed from the national food availability data. These data show that daily energy intake in the US increased slowly until the early 1980s, and then started to increased rapidly.[31] Moreover, a recent global analysis concluded that increases in food-energy supplies are sufficient to explain increases in average population body weight, particularly in high-income countries.[32] Thus, it seems unlikely that decrements in daily energy expenditure are driving the ongoing obesity epidemic.

4. The role of PA in food intake and weight control

Decreases in daily energy expenditure may not be the primary cause of obesity, but that is not to say that PA or

exercise has no role in weight management and energy balance. One theory holds that energy balance may be easier to achieve when energy flux is high. This concept was originally developed by Mayer et al.[33] in the 1950s, and has subsequently been described by Blundell and King[34] and Hill et al.[35] According to this theory, a threshold for PA exists above which people are in the so called "regulated zone" of energy balance. Those who are in the regulated zone are able to meet high energy expenditure needs with energy intake, thus maintaining body weight. However, those who are below the PA threshold have lower energy expenditure, and thus are in the "unregulated zone" without the matching decrements in energy intake. In other words, this theory suggests that appetite may not be appropriately regulated at low levels of PA. This was recently demonstrated by Shook et al.;[36] they examined the relation between energy intake, PA, appetite, and weight gain during a 1-year follow-up, and reported that individuals with low PA had higher levels of cravings for foods compared with those who had high levels of PA. Furthermore, the authors noted that a threshold for achieving energy balance occurred at an activity level corresponding to 7116 steps per day. Thus, it may be that increase in sedentariness in the course of the years has allowed much steeper trajectory in population weight gain than what would have been otherwise.

Voluntary exercise is the most important discretionary component of total daily energy expenditure, and thus has the potential to affect energy balance. This has been illustrated in a number of longitudinal studies. For example, in a prospective study with 20 years of follow-up, Hankinson et al.[37] showed that maintaining high level of PA mitigates weight gain significantly, particularly in women. In that study, active individuals gained less weight during the followed period compared with those who were consistently inactive. Similar findings have been reported from the Finnish Twin Cohort, which can be considered as a natural experimental approach to investigate the role of PA and genes or other familial factors on future morbidity.[38] Twins who have been consistently discordant LTPA for over 30 years differ significantly from each other in terms of body weight and body composition; physically active co-twins have significantly lower body weight,[39] BMI,[40] and fat percent, and they have much less (50%) visceral and hepatic fat[41] compared with their inactive co-twin. This evidence clearly shows that persistently higher PA level is associated with decreased rate of weight gain even after controlling for genetic liability and childhood environment. There is also a wealth of evidence from controlled trials that exercise (or PA) carried out over long periods of time can generate energy deficit and thereby induce weight loss.[42–44] Series of reviews,[45,46] including a Cochrane Review[47] (which is considered as the golden standard in assessing evidence), indicate that exercise induces weight loss, and that the weight loss is even greater when coupled with energy restriction. Thus, both diet and exercise are important components in the programs intended for weight loss. However, the majority of the weight loss programs seem to fail in the long-term as people often regain weight.[48] Consequently, a general perception, particularly among the layman, is that only very few succeed in long-term maintenance of weight loss. However, long-term weight loss maintenance is a question of behavioral adherence. Studies have clearly shown that continued adherence to diet and exercise strategies are associated with long-term success.[49]

5. Conclusion

The increase in obesity epidemic is occurring against the background of continuous decline in the energy expenditure required for daily living. However, the idea that obesity is increasing because of consistent decline in daily energy expenditure is not supported either by objective measures of energy expenditure or physiological theory of weight gain. Clearly, obesity results from excessive energy intake that has sustained over a long period of time. Currently, we do not understand why people consume more energy than they expend. It may be that PA has the ability to regulate food intake, but in the contemporary environment that is conducive for sedentary behavior, this regulatory mechanism has gone astray. Increasing PA most certainly can create energy deficit through increased energy expenditure. For this reason PA and exercise hold potential as part of the solution for the ongoing obesity epidemic.

Competing interests

The author declares no competing financial interests.

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