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Association between physical activity level and obesity prevalence: recent cross-sectional and longitudinal data. A review.

by

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Abstract

In general physical activity level is inversely associated with adiposity. Most of the evidence showing this relationship came from cross-sectional data. However, recently more cross-sectional and follow-up studies have been performed. Larger populations were examined and/or more precise methods to estimate physical activity were used. These investigations have emphasized again the importance of habitual physical activity and regular exercise in preventing overweight and obesity. These recent studies are reviewed in the article.

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Obesity, physical activity, epidemiology, follow up.

Introduction

Obesity is defined as a body mass index (BMI = body weight divided by body length^2) exceeding 30 kg/m^2 (1). Since the prevalence of obesity and consequently its co-morbidities is increasing worldwide the focus should be on prevention of this threatening chronic condition (2, 3). Adopting a life style which results in a stable energy balance is an effective mode of prevention. The energy balance is the result of energy intake and energy expenditure. A perfect balance resulting in a stable weight to prevent overweight and obesity is achieved when energy expenditure and energy intake are matched. This can be achieved by using a diet lower in calories and fat, and by increasing habitual physical activity over a longer period of time.

It seems obvious that low energy intake is associated with a reduced prevalence of obesity. However the association between a high level of physical activity and reduced adiposity is less evident.

The reason for this is that the impact of physical activity on body weight can not be determined accurately. The activity level in the general population is rather low, and methods to assess habitual activity are not precise (observations, questionnaires,...) or only short term (heart rate monitoring, electronic motion sensors, doubly labeled water method). Physical activity patterns change over time while assessments are only done once or twice over time. For this reason most of the evidence came from cross-sectional studies, while longitudinal studies were not always conclusive (4, 5).

The last few years however, more results from follow-up studies concerning physical activity and adiposity in adults and in children were published.

Adiposity in these studies is most frequently estimated from BMI, abdominal and limb circumferences or skinfold thickness, because these measures are easy to obtain in larger populations and correlate sufficiently with more precise methods of body composition analyses (6).

In some studies more accurate methods to estimate daily physical activity from daily energy expenditure were used such as doubly labeled water method, which is considered to be the golden standard (7).

The habitual physical activity considered is a combination of daily physical activity (household, occupation, moving from and to the work-place, ...) and more organized, regular, repetitive exercise in leisure time (sports, walking, cycling, gardening,...).

In the next section data from the recent literature to emphasize the importance of physical activity in obesity prevention will be depicted.

The reported results are summarized in tables 1 and 2.

Cross sectional data

In adults

Physical activity is directly related to physical fitness. Physical inactivity and lack of physical fitness are directly related to increased mortality due to cardiovascular disease (8). The relationship between BMI and prevalence of physical inactivity was J-shaped in men and even more in women aged 18-74 years in the Canadian Heart Health Surveys Research Group Study (9). This suggests that a higher prevalence of physical activity is associated with lower BMI, except in the lowest BMI categories.

In adult Pima Indians prevalence of obesity is genetically very high. In this population, physical activity in men and women was negatively related with BMI in a significant way, while television watching, which is a typical sedentary behavior was positively related in Pima men (10). In an earlier study in this population, Ravussin and Swinburn (11) found that low levels of spontaneous physical activity in Pima Indians correlated highly with body weight ($r = 0.69$, $p < 0.001$).

In Japanese men physically active groups showed lower triceps, scapula and iliac subcutaneous fat thickness and waist-to-height ratios compared with the sedentary group (12).

In young and middle-aged American female athletes Davy et al. (13) found that body composition and fat distribution did not change signifi-

TABLE 1

Cross-sectional data of the association between physical activity and adiposity

Subjects	number	age	population	PA parameter	adiposity parameter	corr.	reference.
Adults							
M + F	2452	adult	Pima Indians	PA TV watching	BMI	– +	(10)
F	4576	middle aged	The Netherlands	leisure time PA	BMI, waist,	–	(15)
M + F	29855	18 – 74 y	Canada	PA	BMI	–	(9)
M	3331	adults	Japan	PA	skinfold waist/ height	–	(12)
F athletes	30	young + middle-aged	USA	PA	% body fat fat-distribution	–	(13)
M	144	18 – 49 y	The	EE-DLW	% body fat	–	(14)
F	146		Netherlands		% body fat	non	
146							
Children							
M + F	2358	9 – 24 y	Finland	PA	% body fat	–	(16)
M + F	86	10 y	France	PA	fat mass fat free mass BMI	– + non	(17)
M + F	101	school-age	USA	PA during playing	fat free mass	+	(18)
M + F	93	1.5 – 4.5 y	UK	EE-DLW	% body fat	–	(19)

M = male
F = female
+ = positive correlation
– = negative correlation
PA = physical activity
EE-DLW = total energy expenditure assessed with Doubly Labeled Water

TABLE 2

Longitudinal data of the association between prevalence of overweight or weight gain

Subjects	number	age	population	duration follow up	PA parameter	adiposity parameter	corr.	reference
Adults								
M + F	1317 – 1429	adults	Finland	10 y	occupational PA	prevalence of overweight	–	(21)
M	2564	workingadults	Finland	10 y	leisure time PA	major weight gain	–	(22)
F	2695							
M	19478	middle-aged	USA	4 y	Vigorous PA	prevalence of obesity	–	(23)
M	3515	adult	USA	10 y	High PA level	major weight gain	–	(4)
F	5810							
M	525	adults	Japan	20 y	Moderate to higher PA	obesity staying obese	–	(25)
M	5220	adults	Norway	7 y	Leisure-time PA	BMI	–	(26)
F	5869							
M + F	3552	adults	USA	2 y	Walking or High intensity PA	body weight	–	(24)
F	121.700	adults stopped smoking	USA	2 y	More PA	weight gain	–	(27)
Children								
M + F	97	children 3-5y	USA	3 y	More PA	skinfold thickness	–	(28)
M + F	75	pre-adolescent	USA	4 y	EE-DLW	gain in fat mass	no	(29)

M = male
F = female
+ = positive correlation
– = negative correlation
PA = physical activity
EE-DLW = total energy expenditure assessed with Doubly Labeled Water

cantly with age. They concluded that the age related increase in adiposity and decrease in fat free mass in the general population can be counteracted by being physically active.

Stronger evidence for men arises from a study of Westerterp and Goran (14), analyzing 22 existing data sets using the doubly labeled water method to measure average daily energy expenditure and including 146 females and 144 males. To analyze the data average daily metabolic rate was adjusted for basal metabolic rate. They found a significant inverse relationship between activity related energy expenditure and percentage body fat in males (partial $r = .35$, $p < 0.001$), but not in females. They describe 2 possible reasons for this difference between the sexes. First, male tend to compensate more by changing energy intake when energy expenditure rises. A second explanation could be that men usually have more abdominal fat, which is more responsive for physical activity.

In a population of 4576 Dutch middle aged women BMI and waist circumference showed an inverse relation with time spent in leisure time activities, such as cycling, gardening, do-it-your-self activities, and sports (15).

In children

In a cohort of children and young adults in Finland, Raitakari et al. (16) found that in both males and females physical activity was inversely associated with obesity and a significant dose-related relationship was observed.

In a group of 10 year old French children, Deheeger et al. (17) found that increased physical activity was significantly associated with improved body composition, reflected in a higher proportion of fat free mass (defined as body mass minus fat mass) and a lower fat mass, although BMI was similar between different activity levels. This difference in body composition however was associated with higher energy intake accounted for by carbohydrate, but relatively less fat consumption.

Goran et al. (18), in a cross sectional study in school children, assessed total daily energy expenditure using the doubly labeled water technique and differentiated recreational activities using questionnaires. They found that physical activity related energy expenditure was significantly correlated with fat free mass and body weight. After adjusting for fat free mass, age and gender approximately 10% of de variance in body fat mass was explained by time spent in recreational activities such as playing.

A similar study was performed by Davies et al. (19) using the doubly labeled water technique in pre-school children. They did find a correlation coefficient of –0.51 ($p < 0.001$) between the physical activity level (defined as total energy expenditure divided by basal metabolic rate) and percentage body fat.

Evidence from longitudinal studies

In adults

Using large secular trend survey studies in the USA Heini and Weinsier (20) found that fat and calorie intake decreased, and the use of low-calorie foods became more frequent. However this phenomenon was associated with a paradoxical increase in the prevalence of obesity. The authors conclude that this could only be explained by a dramatic drop in physical activity related energy expenditure.

A similar study was performed in Finland by Folgelholm et al. (21) Reported daily energy intake was decreased in 1992 compared to 1982. Energy expenditure during work and moving to and from work also decreased, and this was not completely counterbalanced by the slight increase in leisure-time exercise. Moreover, the prevalence of overweight increased from 39 to 43% in men and from 33 to 34% in women. When accounted for underreporting in energy intake the decrease in daily physical activity must have led tot the increased prevalence of overweight.

This was confirmed by Haapanen et al. (22) in a 10 year follow-up study to determine whether habitual leisure time physical activity and body mass change of working-aged Finnish men ($n = 2564$) and women ($n = 2695$) was associated. They found that increased leisure time activity was associated with only small body mass gains. Physical inactivity and especially decreasing activity was associated with larger weight gains. Men and women with no regular weekly activity at the end of the follow-up had an odds ratio for a body mass gain of at least 5 kg of 2.59 and 2.76 respectively, compared to the most active groups.

A 4 year follow up study in 19478 middle aged American men showed weight loss among those who performed vigorous activity. Furthermore the prevalence of obesity was less compared to those who where relatively sedentary (23).

French et al. (24) followed a cohort of 3552 men and women working in companies participating in a worksite intervention program for weight control for 2 years. Increased exercise, either in walking or high intensity activity was associated with decreases in body weight in both genders.

Williamson et al. (4) used self reported recreational physical activity and weight change data of 3515 men and 5810 women (25-74 y) from the NAHNES-I follow-up study to examine the relationship between physical activity level (low, medium, high) and measured weight change after ten years. When reporting a low activity level at follow-up, the relative risk for major weight gain (more than 13 kg) was 3.1 in men and 3.8 in women, compared to those reporting a high activity level.

In a 20 year follow up study including 199 obese and 326 non-obese university students in Japan, intensity of daily physical activity assessed by questionnaires was correlated with being obese at the start. Obesity in this study was defined as a Broca-index > 120%. The Broca-index is 100% if weight in kg equals body length in cm minus 100. After 20 years only 10% of the obese group stated being moderate to more intensive active compared to 24.4% in the non-obese group. Moreover in the group with continued obesity (obese 20 years ago and still obese now) only 11.8% did moderate to more intensive activity compared to 45.5% in the improved obesity group (obese 20 years ago and less obese now) (25).

In a population based cohort study including 5220 men and 5869 women aged 20-49 years of age there was a dose-response relationship between BMI and levels of physical activity. When assessed 7 years later, differences in BMI between the sedentary group and the still exercising group were even more pronounced, when compared to baseline. This effect was most obvious in the oldest age group (26).

In a 2 year follow-up study of 121.700 US women, smoking cessation was followed by an average of a weight gain of 2.4 kg. A modest increase in physical activity however was able to minimize this phenomenon (27).

In children

In the Framingham Children's Study more active young children aged 3-5 years (n = 97) had gained less subcutaneous fat than did less active children, when entering first grade. Active girls gained 1.0 mm in their triceps skinfold, while the inactive gained 1.75 mm. Active boys lost 0.75 mm while inactive boys gained 0.25 mm. When age, TV-viewing,

energy intake, baseline triceps skinfold, and parents BMI was controlled for, inactive children where 3.8 times more likely to increase their triceps skinfold (rather than stabilize or decrease) (28).

In at least 1 study using the doubly labeled water however, the authors concluded that childhood obesity was related to parents fatness, rather than to physical activity. In a 4 year follow up study of 75 preadolescent children with two annual measurements of physical activity related energy expenditure by doubly labeled water, Goran(29) found that the major determinants of increase in fat mass was initial fat mass and parental fat mass, not energy expenditure. The methodology of this study however has been criticized by Dietz (30).

Conclusion

Dietary habits and low resting energy expenditure are not the only reasons for weight gain and obesity (31). In the recent literature more and more data from cross-sectional and longitudinal studies become available showing the importance of a higher physical activity level in preventing overweight and obesity. Epidemiological and longitudinal studies already suggested a linear dose response effect between physical activity, health, and functional effects. Therefore it is not necessary to recommend vigorous physical activity (16, 26, 32). This recommendation is applicable to obesity prevention in a similar way. In men it might even be more important to improve cardiorespiratory fitness, rather than BMI, to decrease all-cause and CVD mortality (33).

Furthermore, high levels of physical activity may be associated with improvement of other life style characteristics such as fat and carbohydrate intake patterns (17, 34).

While employment physical activity is very low in our developed societies, one should increase leisure time physical activity moderately on an individual basis. This can be done by increasing habitual daily activities, such as cycling or walking in stead of driving, taking stairs in stead of elevators, etc., and by engaging in recreational activities such as sports, dancing, gardening, etc. But in order to reach a large part of the population community based physical activity promotion programs should get initiated.

This is a relevant option to hold off a further dramatic extension of the obesity epidemic.

Samenvatting

Over het algemeen vertonen de graad van fysieke activiteit en het vetpercentage een omgekeerde relatie. De meeste gegevens hierover kwamen uit cross-sectioneel onderzoek. Recent werden echter meer cross-sectionele en follow up studies uitgevoerd. Er werden daarbij grotere populaties onderzocht en/of meer precieze methoden gebruikt. Deze investigaties hebben opnieuw het belang van dagelijkse fysieke activiteit en regelmatige sportbeoefening beklemtoond. In dit artikel wordt een overzicht van deze recente studies gegeven.

Résumé

En général le niveau de l'activité physique est inversément lié à l'adiposité. En grande partie, cette association négative est basée sur des analyses transversales. Récemment, le nombre d'études transversales et longitudinales effectuées à ce sujet a augmenté. Ces études considèrent de plus larges populations et/ou utilisent des méthodes plus précises pour estimer l'activité physique. Les résultats accentuent à nouveau l'importance de l'activité physique habituelle, ainsi que la pratique régulière des sports. L'article suivant résume les analyses les plus récentes.

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