Comparison of physical activity level between overweight/obese and normal weight individuals: A systematic review
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Citation

Abstract
Context: The relationship between activity levels and body fat is unclear, despite large number of studies. This issue is clouded by the wide methods used to measure body fatness and activity levels.

Objective: To review published prospective observational studies evaluating the associations between body fatness and physical activity, with emphasis on methodological issues.

Data sources: Published English-Language studies were located from PubMed and bibliographies of primary studies.

Data extraction: Sample size, population studied, measures of activity and body fatness, statistic approach, and main findings were extracted, summarized, and key methodological issues highlighted.

Results: In total, 58 studies were identified and reviewed. Results were mixed, with most studies showing an inverse association of physical activity with fatness. The effects identified were generally of small magnitude. Imprecise measurement of activity and small sample sizes likely weakens the observed relationships. On balance, combinations of methods of activity measures tend to produce a better result. Consistently documented high effect sizes were found for all studies that used 18-Oxygen for assessing body fatness and doubly labelled water for activity measure.

Conclusions: This review suggests that there is small to moderate inverse relationship body fatness and activity. The association is in favour of male and younger subjects. It is important to note, however, that there is a need more research on uniform ways of activity and fatness measures.

INTRODUCTION
Obesity is a serious public health problems with immense health, social and economic implications. It has been estimated that, unless effective action is taken, about one-third of adults and one-fifth of children aged 2-10 years will be obese by 2010. Obesity is fast approaching cigarette smoking as the major preventable cause of mortality. Modifiable physical activity and sedentary and diet behaviours are associated with morbidity and mortality, and improving these behaviours in all populations, including among adolescents, is a national health priority. Expert groups have recommended 60 minutes per day of moderate to vigorous physical activity for youth, yet data based on objective measures suggest that only 30% of teenagers meet this guideline. Television watching is the dominant sedentary behaviour in adolescents, and it is estimated that 57% adolescents view television for less than two hours a day. Physical exertion has almost disappeared from our lives particularly in the developed world, and fast becoming a trait of the past even in developing countries.

Despite extensive evidence, questions remain about the relations between physical activity and adiposity during adolescence, a critical time when risk for obesity increases and amount of habitual activity drops greatly. It is not clear whether obese children and adolescents are less physically active than their non-obese peers. The aim of this study was to review the empirical evidence of
associations between body fatness and physical activity and undertake a critical review of quality of these studies, addressing the sample size, method of assessing body composition, and physical activity levels.

METHODS
DATA SOURCES AND SEARCH STRATEGY
A comprehensive, unbiased search strategy was developed to identify all relevant studies published in English language regardless of the age, gender, and country in PubMed from inception (1966) to February 2007. Broad search terms were used so as not to miss any potentially relevant articles during the search procedure. Detailed search strategies can be seen in Figure 1. In addition, we searched references of all retrieved articles and systematic review to ensure that all eligible studies had been identified.

Figure 1
Figure 1: Review question, eligibility criteria and search strategy

CRITERIA FOR CONSIDERING STUDIES
The selection criteria for inclusion were:

- Observational or cross-sectional studies evaluating associations between body composition and physical activity levels;
- Measure of habitual physical activity was included;
- Measure of body fat/relative weight was included;
- Measure of activity did not follow an intervention which might alters habitual daily activity; and
- Measures of fat and activity were taken at the same time. We excluded validation studies, review articles, and qualitative studies.

SELECTION OF STUDIES
Abstracts were scanned by the two of authors independently to exclude those out of scope. Discrepancies were discussed until consensus was reached. The full text of each remaining paper was then viewed and papers were again excluded with the consensus of both authors. Finally, the reference lists of all remaining papers were scanned. The selection of studies from the reference lists followed the same steps as outlined above.

DATA EXTRACTION AND PROCESSING
Data were extracted by the first author using a specially designed electronic data extraction form and create a database using Epi-Info\textsuperscript{9}, and were checked for accuracy by a second author. All disagreements were resolved by consensus and discussion. Information entered into the database included: study citation, year of publication, study settings, methods of body composition assessment, and main findings. The data extraction form had a semi-structured format. Each variable was allotted one field of the data extraction form, and the field expanded as needed to accommodate the text.

DATA ANALYSIS AND MAPPING
Data are presented as figures, numbers and simple frequencies processed with Stata 9.0 software\textsuperscript{10} (Stata Corporation). Descriptive statistics and qualitative information are presented when appropriate. A tabular evidence profile was prepared for all the eligible studies. For study location, we recorded the geographic coordinates for each study and used Stata\textsuperscript{10} s map thematic mapping package to plot the position of each study.

RESULTS
LITERATURE SEARCH
The literature searches yielded 2474 titles of potentially relevant articles (Figure 2). After scanning titles and abstracts, 75 potentially relevant articles were identified. Three studies\textsuperscript{11,12,13} could not be retrieved. The reference lists of the remaining 72 selected articles were scanned, which resulted in another four publications for inclusion. Eighteen articles were excluded because they were either review articles (n=4), qualitative (n=2), fitness test (n=6) or validation studies (n=6). Fifty eight articles met inclusion criteria and included in this review (Table 1). These papers and their findings are described below.
Figure 2

Figure 2: Literature flow

- Citations identified by PubMed (n=3474)
- Rejected on title, abstract, and keywords (n=2359)
- Included on basis of title or abstract (n=75)
- Reports unavailable (n=3)
- Full report obtained (n=72)

Studies excluded (n=18):
- Review articles (n=4)
- Qualitative studies (n=2)
- Fitness test (n=5)
- Validation studies (n=5)

Studies included from cross-references (n=4)

Studies included in the review (n=54)
Table 1: Summary of studies included in the review

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<tr>
<th>Study author</th>
<th>Country</th>
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<th>Activity measure</th>
<th>Feature measured</th>
<th>Gender</th>
<th>Age</th>
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Comparison of physical activity level between overweight/obese and normal weight individuals: A systematic review


CHARACTERISTICS OF INCLUDED STUDIES

Our search identified 58 studies evaluating the association between body fatness and level of physical activity. All studies had cross-sectional design. Of the 58 published papers, 74% (n=43) were published after 2001, 19% (n=11) were published between 1996 and 2000; only 7% (n=4) were published before 1995. We found one study that was published in 1968. Seventeen had sample size of less than 100 participants, 16 had 100 - 500 subjects, six had 500-999 subjects, 14 had 1000-4999 participants, and only five had more than 5000 participants. The sample size ranges from 24 to 137, 593, 7 with mean of 3,888 participants. In total 33% (n=19) of samples were preteen (less than 10y), another 33% (n=19) were adolescents (10-19y), with the remainder being between 19 - 70y (28% [n=16]), or a combination 33-36,58-62 (7% [n=4]).

Most studies 32% (n=19) were carried out in the USA, The rest were either from UK, Australia, Sweden, France, Portugal, Belgium, Canada, Switzerland, Germany, Iran, Japan, Mexico, Slovenia, South Africa, Spain. (all n=1).

MEASURES OF ACTIVITY

About half (41% [n=24]) of the 58 studies reviewed used objective measures of physical activity. The others relied on self-reported measures, either by the physical activity questionnaire alone (52% [n=30]) or in combination with objective measures (n = 3). Duration of pedometer and accelerometer usage differed across studies. For example accelerometer was worn for three days, six days, and seven days; and while pedometer was worn for three days and seven days.

MEASURES OF BODY FATNESS

Most of the studies reviewed rely on body mass index (BMI=weight in kg/square of height in meters), or on a measure that is based on BMI, to reflect weight status or adiposity. Three of the 58 studies reviewed here use more direct and precise measures of adiposity, such as dual-energy X-ray absorptiometry or percent body fat by bioelectrical impedance analysis alone. Of the 58 studies, six (10.34%) relied on self-reported height and weight for measurement of body fatness. Classifications of 'overweight' and 'obese' also differed across studies. More than half (55% [n=32]) of the studies reviewed reported the classification of body composition used. Half (16 of 32) studies used CDC cut-off point for Age- and sex-specific BMI percentile and another 14 of the 32 studies classified participant as ‘overweight if they were above BMI of 25 kg/m2 and 'obesity' if there BMI were greater than 30 kg/m2. Kagamimori et al used the Kaup index (see equation 1) used for evaluating the degree of obesity at three, obese children were those for whom Kaup's index was 18 or more; and Garraulet et al used BMI; Queletet index of 23 or above for overweight and obese.
Kaup index = weight (g) / (height (cm) x height (cm)) x 10

MEASURES OF ASSOCIATION

Most of the studies controlled for one or more confounders (74.14% [n=43]). Gender (63.79% [n=37]), age (32.76% [n=19]), and race/ethnicity (10.34% [n=6]) were the most common confounders adjusted for during analysis. Most of the studies (88% [n=51]) reviewed in this study found a statistical significant correlation between body composition and level of physical activity. Only 24% (n=14) studies reported the effect size of the association as negative correlation coefficient (r), with values from -0.5 to -0.16 (see Figure 4 and 5). Two studied assessed physical activity in form of sedentary behaviours. Deheeger M et al. found that TV watching was positively correlated with BMI (r=-0.27, p= 0.01) and Trueith MS et al. found that fat mass and percentage fat was positively correlated to time spent in sedentary activity (r=0.47, p<0.001) in girls.

DISCUSSION

MAIN FINDINGS

We performed a systematic review of literature on the association between body composition and physical activity level, using 58 studies primarily from the last 40 years incorporating over 225,500 subjects.

In our review of these studies, we found, like others, that most cross-sectional studies reported that overweight subjects had lower physical activity levels than their non-overweight peers. Null findings are not uncommon. Some of the studies, however, illustrate the variety of findings: body mass index was negatively associated with physical activity in females, but not males, whereas fat mass was negatively associated with physical activity in males, but not females.

The studies reviewed reported relatively moderate to weak (r=-0.5 to r=-0.16), but statistical significant associations between body fatness and physical activity levels. Physical activity explained only 2.5 to 25 percent shared variation in body composition in the subjects. Interpreting the size of a correlation coefficient has always caused difficulty. Several authors have attempted to provide a practical guideline; the most commonly quoted are those advocated by Cohen. However, as Rosenthal and colleagues state in their excellent discussion of this issue, "mechanical labelling … [correlation coefficient] … automatically as 'small', 'medium' and 'large' can lead to a later difficulties, even 'small' effects can turn out to be practically important".
physical activity is associated with a lower percentage body mass, males on the other hand, as expected, a higher level of physical activity when they adopt a higher level of physical activity. The results are that females probably does not lose much fat responsive to exercise interventions. Females, and abdominal fat has been shown to be more responsive to exercise interventions. Males tend to compensate less for an increase in energy expenditure. Males are probably based on a difference in the ability to compensate for an increase in energy expenditure. Males tend to compensate less for an increase in energy expenditure when body fat stores permit. Thus, exercise is not an effective modality to reduce body fat in females unless accompanied by restriction of energy intake.

Other possible explanations for this gender dimorphism could be related to gender differences in body fat distribution. Males tend to have more abdominal fat than females, and abdominal fat has been shown to be more responsive to exercise interventions. The implications of the results are that female probably does not lose much fat when they adopt a higher level of physical activity. In males on the other hand, as expected, a higher level of physical activity is associated with a lower percentage body fat.

In this review we found that studies that used preteen (<10y) and adolescents (10 - 19y) consistently reports high effect sizes. Nielsen et al. was the only one that used adult subjects and reported effect size (r=-0.16, n=783, p<0.05); which is the weakest correlation of all the reviewed studies.

### COMPARISON BETWEEN MEASURES OF BODY FATNESS

It is important to note that most primary studies have used proxy measures of body fatness such as subcutaneous fat thickness (i.e., skin folds) or height-to-weight ratios (i.e., BMI) to estimate fat mass. While these measures have been validated previously, this is an important limitation to conclusions drawn from this review. Only eight studies used dual-energy X-ray absorptiometry (DXA), which is considered a 'gold standard' technique for assessing fat mass in children. The use of objective measure of body fatness resulted in variety of findings. In this review, we found as expected that objective measures were able to detect higher effect sizes compared to self-reported activity measures. For example, Davies et al. was able to explain 25% variation between the two factors with the use of doubly labelled water. Another important finding is that combination of methods tends to produce a better result.

### COMPARISON WITH OTHER REVIEWS

By searching several PubMed database and the studies’ reference lists, we located four other reviews on the association between body composition and physical activity. These reviews differed from ours in terms of focus of the review, search methods, and choice of synthesis of the studies.

Three of these reviews used meta-analysis, while one used narrative syntheses like our review. Three of these reviews focused specially on youth; while Westerterp et al. re-analyzed existing data including 290 healthy subjects, aged 18-49y, 146 females and 144 males, from 22 different studies. Must et al. was the most directly comparable review, being most recent and with a specific focus on relationship between adiposity and physical activity. Must et al. in their review reviewed 20 published prospective observational studies of the relationship of PA and sedentary behaviour with the development of overweight and adiposity, with an emphasis on methodological issues. A 2000 meta-analysis encompassed...
In summary, with the data available, it can be concluded that

CONCLUSIONS

50 studies, 42 were published as journal articles, four as chapters in books, three as abstracts and one was unpublished. Thirty-two studies assessed activity by questionnaire, eight by heart rate, ten by motion counters and six by observational. A recent 2004 meta-analysis reviewed the empirical evidence of association between television (TV) viewing, video/computer game use and body fatness, and physical activity using 52 independent samples.

Nevertheless, our review has yielded broadly similar results to previous work. Westerterp et al. found that in males, there is a significant inverse cross-sectional relationship between activity energy expenditure and percent body fat, whereas no such relationship was apparent in females. Marshall et al. found a statistically significant relationship between TV viewing and body fatness among children and youth although it is likely to be too small to be of substantial clinical evidence. Also, Rowland et al. reported that there is a small to moderate relationship between body fat and activity in children.

STUDY LIMITATIONS

As with any other review, this study suffers from noteworthy limitations. There are appreciable amounts of missing data in the association analysis. Undoubtedly, these missing effect sizes weakened our discussion on the actual strength of the association. Self-reported activity measures and self-reported height and weight may not be accurate and is subject to subject recall bias, as it requires participants to remember an event or series of events that occur in the past. In addition, obese subjects may tend to over report their activity level. The search strategies did not locate 'grey literature' (e.g. unpublished studies, local reports, PhD and Masters abstracts). It was, however, reasoned that problem with including grey literature (poor study quality owing to lack of peer review and the time and costs involved in identifying and retrieving grey literature outweighed the possible advantage of preventing our results from the influence of publication bias. A thorough search of conference proceedings might also be useful. Although recent research has shown that conference abstracts might not accurately summarize subsequently full reports, the fact that about half the research reported at conference does not accurately summarize subsequently full reports makes such abstracts a useful source of studies.

CONCLUSIONS

In summary, with the data available, it can be concluded that there is a significant weak to moderate inverse cross-sectional relationship between physical activity and body fatness. Moreover, this review provides evidence that the association is strongest among male and younger subjects. Data from the current review provide compelling evidence that doubly labelled water is the gold standard for activity measure. Consistently documented high effect sizes were found for all studies that used 18-Oxygen for assessing body fatness.

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