Relationships between media use, body fatness and physical activity

in children and youth: a meta-analysis.

Simon J. Marshall[1]

Stuart J.H. Biddle[2]

Trish Gorely[2]

Noel Cameron[3]

Ian Murdey[3]

[1] Department of Exercise & Nutritional Sciences, San Diego State University, San Diego, CA, 92182, USA, [2] British Heart Foundation National Centre for Physical Activity and Health, School of Sport & Exercise Sciences, [3] Department of Human Sciences, Loughborough University, Loughborough LE11 3TU, UK.

Running Head: sedentary behavior, television viewing, body fatness, youth, meta-analysis

Address for correspondence:
Simon J. Marshall, Ph.D.
Department of Exercise & Nutritional Sciences
San Diego State University
5500 Campanile Drive
San Diego, CA 92182-7251
E-mail: smarshal@mail.sdsu.edu
Tel: (+001) 619 594 7272
Fax: (+001) 619 594 6553

1   Abstract
2   Objective: To review the empirical evidence of associations between television (TV) viewing,
3   video/computer game use and: a) body fatness, and b) physical activity.
4   Design: Meta-analysis.
5   Method: Published English-language studies were located from computerised literature
6   searches, bibliographies of primary studies and narrative reviews, and manual searches of
7   personal archives. Included studies presented at least one empirical association between TV
8   viewing, video/computer game use and body fatness or physical activity among samples of
9   children and youth aged 3-18 years.
10 Main outcome measure: Mean sample-weighted corrected effect size (Pearson r).
11 Results: Based on data from 52 independent samples, the mean sample-weighted effect size
12 between TV viewing and body fatness was 0.066 (95% CI = 0.056 to 0.078; total N = 44,707).
13 The sample-weighted fully corrected effect size was 0.084. Based on data from 6 independent
14 samples, the mean sample-weighted effect size between video/computer game use and body
15 fatness was 0.070 (95% CI = -0.048 to 0.188; total N = 1722). The sample-weighted fully
16 corrected effect size was 0.128. Based on data from 39 independent samples, the mean sample-
17 weighted effect size between TV viewing and physical activity was -0.096 (95% CI = -0.080 to -
18 0.112; total N = 141,505). The sample-weighted fully corrected effect size was -0.129. Based
19 on data from 10 independent samples, the mean sample-weighted effect size between
20 video/computer game use and physical activity was -0.104 (95% CI = -0.080 to -0.128; total N =
21 119,942). The sample-weighted fully corrected effect size was -0.141.
22 Conclusion: A statistically significant relationship exists between TV viewing and body fatness
23 among children and youth although it is likely to be too small to be of substantial clinical
24 relevance. The relationship between TV viewing and physical activity is small but negative.
25 The strength of these relationships remain virtually unchanged even after correcting for common
26 sources of bias known to impact study outcomes. While the total amount of time per day
27 engaged in sedentary behavior is inevitably prohibitive of physical activity, media-based
28 inactivity may be unfairly implicated in recent epidemiologic trends of overweight and obesity
29 among children and youth. Relationships between sedentary behavior and health are unlikely to
30 be explained using single markers of inactivity such as TV viewing or video/computer game use.
31
32
33 KEYWORDS: television, media use, fatness, children and youth, meta-analysis

1 <u>Introduction</u>

2   The World Health Organisation now considers obesity to be a global epidemic[1].

3 Increases in the prevalence and severity of obesity among children and adolescents have been

4 attributed largely to behavioral and environmental factors[2]. A consistent referent in the academic

5 and lay reporting of secular trends in overweight and obesity among children and youth is that

6 decreases in physical activity and increases in sedentary behavior, particularly TV viewing and

7 video/computer game use, are partly to blame[3-5]. A recent expert panel convened by the

8 American College of Sports Medicine (ACSM)[6] stated unequivocally that "obesity is directly

9 related to the number of hours spent watching television" (p4). Despite these claims, adequate

10 empirical evidence is rarely presented to support these conclusions. The lack of an empirical

11 synthesis of available data concerning these relationships represents a considerable gap in the

12 literature. This paper presents two meta-analytic reviews of literature. The first review examines

13 evidence of a relationship between television viewing, video/computer game use and body

14 fatness among children and youth. The second review examines evidence that these prevalent

15 sedentary behaviors 'displace' physical activity. The displacement of physical activity is one

16 mechanism widely hypothesised to explain possible relationships between sedentary behavior

17 and body fatness.

18 <u>Methods</u>

19 <u>Search procedures and inclusion criteria</u>. For both reviews, relevant literature was located from

20 three sources. Firstly, the computerised databases PsychInfo, SportDiscus, MedLine (PubMed),

21 and Ingenta were searched. The following keyword combinations were used: Physical Activity

22 and Sedentary Behavior, Inactivity, Television, Computer, Video, Body Composition, Fatness,

23 Obesity, Overweight, Youth and Adolescence. For the sedentary behavior and body fatness

24 review, all computerised searches were restricted to studies published on or after 1985. This was

1   the date of publication of Dietz and Gortmaker's[4] original study, widely acknowledged as the

2   first empirical examination of these relationships. For the sedentary behavior and physical

3   activity review, a cut-off publication date was not set. However, the maiden date for each

4   computerised search engine was 1887, 1949, 1996 and 1988 (PsychInfo, SportsDiscus, PubMed

5   and Ingenta, respectively). Secondly, reference sections of narrative reviews and primary studies

6   located from the previous two sources were examined. Finally, a manual search was conducted

7   of reprint files (1980-2002) held by the Sedentary Behavior Research Group at Loughborough

8   University.

9   Only studies with participants less than 18 years of age and published in English as

10   papers or abstracts in peer-reviewed journals were included. While including only English

11   language studies is acknowledged as a limitation of the reviews, it is important to note that 29%

12   and 16% of TV/body fatness and TV/physical activity effects sizes, respectively, were based on

13   samples in which English was not the first language. An independent sample was used as the

14   unit of analysis.

15   <u>Data extraction</u>. Data were extracted by one reviewer (SJM) using a structured form and were

16   checked for accuracy by a second reviewer (IM). All disagreements were resolved by consensus.

17   <u>Calculation of effect size</u>. All analyses were conducted using the Pearson correlation coefficient

18   (*r*) effect size with the adjustment computations proposed by Hunter and Schmidt[7]. Hunter and

19   Schmidt's procedures draw on psychometric theory and are designed to correct for

20   methodological artifacts in primary studies such as sampling error and measurement error.

21   These techniques were preferred over other meta-analytic methods because instruments designed

22   to measure TV viewing, body fatness and physical activity are prone to variance produced by

1   artifacts. These procedures fit random-effects models to the data that are consistent with

2   assumptions about sources of variability in this research domain.

3   Where data other than Pearson coefficients were presented in primary studies (e.g.,

4   Cohen *d* values, Odds Ratios, t-values, etc.) standard transformations[8] were applied to estimate

5   the Pearson correlation. Where primary studies presented only p-values and sample sizes, the

6   maximum possible Pearson correlation was computed. While this method is likely to

7   overestimate the true effect size, it reduces the likelihood of making Type II errors[7]. Pearson *r*

8   values of 0.1, 0.3 and 0.5 represent small, medium and large effects, respectively[9]. All

9   calculations were performed using syntax macros written by SJM using SPSS v11.0 for

10   Windows.

11   Correcting for artifactual variance. The present study corrected for four main study artifacts:

12   sampling error, measurement error in the independent variable, measurement error in the

13   dependent variable and dichotomization of a continuous dependent variable (body fatness).

14   These artifacts attenuate the population correlation and artificially inflate its variance[7]. It was

15   particularly important to correct for dichotomization of body fatness variables because primary

16   studies often report effect sizes comparing obese and non-obese samples on measures of TV

17   viewing and physical activity. Each study correlation was weighted by its sample size. The

18   variance of the mean of these sample-weighted correlations was then corrected for sampling

19   error because sampling error also adds to the variance of correlations across studies[7].

20   Dichotomization of the body fatness variables was corrected at the individual study level. A

21   meta-analysis was then performed on these partially corrected correlations. The mean effect size

22   (and variance) from this analysis was then further corrected for measurement unreliability in the

23   independent and dependent variables. These corrections were based on the distribution of

1   reliability coefficients in other studies that used the same measures. Artifact distributions were

2   used because not all primary studies reported reliability coefficients for their measures. This

3   technique is referred to as artifact distribution meta-analysis and has been written about

4   extensively elsewhere[7]. Because effect sizes were corrected both at the individual level and at

5   the group level, corrected effect sizes cannot be reported at the individual study level (e.g., forest

6   plots).

7   <u>Credibility and confidence intervals</u>.   For each sample-weighted and corrected mean correlation,

8   95% credibility and confidence intervals were computed. Credibility and confidence intervals

9   are often used and interpreted incorrectly in the meta-analytic literature[10]. Credibility intervals

10 provide information about validity generalization, or the extent to which moderators may be

11 influencing the effect estimate. Confidence intervals are used to estimate the accuracy of the

12 corrected effect size in representing the true population parameter.

13 <u>Omnibus tests for homogeneity of effects.</u> The homogeneity of mean corrected effect sizes were

14 examined to determine if the variability in outcomes was greater than expected from sampling

15 error and measurement artifacts. In addition to credibility intervals, homogeneity of effects was

16 examined using the Q-statistic and the '75% rule'[7]. The Q-statistic (within-group goodness-of-

17 fit) has an approximate chi-square distribution with k – 1 degrees of freedom (k = number of

18 effect sizes). A significant Q-statistic indicates heterogeneity of effects. The 75% rule posits

19 that 'in any data set in which known and correctable artifacts account for 75% of the variance in

20 study correlations [outcomes], it is likely that the remaining 25% is due to uncontrolled artifacts'

21 (p.68)[7]. Thus, the value represents the percent variance accounted for by corrected study

22 artifacts. However, it should also be noted that because the number of studies in each subgroup

23 was small, there exists the possibility of second-order sampling error--the extent to which

1   outcomes of available studies vary randomly about the mean. Where assumptions of

2   homogeneity were rejected, effects were computed separately by hypothesised moderators.

3   These included effects by age and gender, types of measure used for independent and dependent

4   variables, as well as study design factors.

5   Results

6   Page restrictions prevent a full presentation of individual sample characteristics and

7   forest plots of effect sizes (four mixed meta-analyses were conducted, yielding 107 separate

8   effects)[*].

9   TV viewing, video/computer game use and body fatness. A total of 39 studies[4 5 11-47] were

10   located that presented empirical data on TV viewing, video/computer use and body fatness

11   among children and youth. Of these, nine were not included in the review because they involved

12   experimental manipulations of sedentary behavior and physical activity[40], involved interventions

13   targeting additional sedentary behaviors[41-43], were single-subject case studies[44 45], measured only

14   body mass[46], or presented data previously published [47]. From the remaining 30 studies, data

15   were available on 52 independent samples. Effect sizes are reported separately by body fatness

16   and TV viewing (k = 52) and body fatness and video/computer game use (k = 6). Of the 30

17   published studies only one (3%) was published prior to 1990, eight 27% were published between

18   1990 and 1995, and the remaining 21 (70%) were published after 1995.

19   Sample characteristics. A total of 44,707 young people were studied (median = 294;

20   range = 22 to 7,299). Samples were from the USA (k = 25), Canada (k = 17), Belgium, Japan

21   (both k = 2), Australia, China, France, Germany, Mexico and the United Kingdom (all k = 1).

22   Forty-six percent of samples were 7-12 years of age, with the remainder being under 7 yr (8%),

---

[*] these results can be obtained from the lead author upon request

1   13-18 yr (23%), or a combination (23%). The majority of samples were single-sex (42% girl-

2   only, 29% boy-only), with 29% including both boys and girls.

3   Table 1 presents the results of the meta-analysis between TV viewing and body fatness

4   and video/computer game use and body fatness. Ninety-six percent of effect sizes were in the

5   predicted direction (positive). Table 2 presents the results of the moderator analysis for TV

6   viewing and body fatness. A moderator analysis of the relationship between video/computer

7   game use and body fatness was not performed because second-order sampling error is likely to

8   confound results when the initial number of effects is small[7].

9

10   [Insert Tables 1 & 2 about here]

11

12   <u>TV viewing, video/computer game use and physical activity.</u> Thirty-three studies[11-13 17 18 21 25 30-

13   32 36 38 39 46 48-66] were located that presented a measure of association between physical activity

14   and TV viewing, playing video games or computer use. Nine studies were excluded from

15   analyses either because they had serious design limitations[46 50 51], presented insufficient data for

16   meta-analytic synthesis[11 12 54], presented data on composite measures of sedentary behavior[49 52]

17   or reported on special populations[36]. The remaining 24 studies presented data on 41 independent

18   samples (the unit of analysis) and were included in the final analyses. Fifteen studies presented

19   data on one sample, seven studies presented data on two samples and two studies presented data

20   on six samples. Effect sizes are reported separately by physical activity and TV viewing (k = 39)

21   and physical activity and video/computer game use (k = 10). Of the 24 published papers, none

22   were published prior to 1990, 42% (k = 10) were published between 1990 and 1995 and 58% (k

23   = 14) were published after 1995.

1   Sample characteristics. A total of 143,235 young people were studied (median = 527;

2   range = 36 to 20,766), although one study[62] (six samples) was a pan-European collaborative

3   survey of 118,173 youth. Excluding this study, the median sample size was 448 (n range = 36

4   to 5650). Samples were from the USA (k = 19), Canada (k = 7), pan-Europe (k = 6), Belgium,

5   Hong Kong (both k = 2), Germany, Iceland, Norway, South Africa and Spain (all k = 1). Thirty-

6   nine percent of samples (k = 16) were 13-18 years of age, with the remainder being 7-12 yr

7   (22%), under 7 yr (7%), or a combination (32%). The majority of samples were single-sex (41%

8   girl-only, 32% boy-only), with 27% including both boys and girls.

9   Table 3 presents the results of the meta-analysis between TV viewing and physical

10 activity and video/computer game use and physical activity. Table 4 presents the results of the

11 moderator analysis for TV viewing and physical activity. Again, a moderator analysis of the

12 relationship between video/computer game use and physical activity was not performed because

13 of the likelihood of second-order sampling error.

14

15   [Insert Tables 3 & 4 about here]

16

17 Discussion – TV viewing, video/computer game use and body fatness

18   The sample-weighted effect size (Pearson *r*) between TV viewing and body fatness was

19 0.066 (95% CI = 0.056 to 0.078). The sample-weighted fully corrected effect size was 0.084.

20 While this relationship is statistically significant (p<.05), the fact that 99% of the variance in

21 body fatness may be explained by factors other than TV viewing calls into question the clinical

22 relevance of the TV viewing and body fatness relationship. This conclusion is in contrast to

23 many statements in the literature. For example, Bar-Or and colleagues[6] make it clear that current

1   data support a strong and clinically significant relationship between TV viewing and body

2   fatness yet draw their conclusion from only two[4][5] of the samples included in our review, one of

3   which yields an effect size that is a statistical outlier (r = 0.324)[5] to the extant literature. A more

4   balanced appraisal than Bar-Or et al's is made by Caspersen, Nixon and DuRant[67]. They cite

5   four studies showing mixed results. While there is biologic plausibility for a causal relationship[4]

6   and the available evidence is consistent (96% of the effect sizes are positive), relationships are

7   small, dose-response data are lacking, important confounders (e.g., diet) are rarely accounted for

8   and temporal precedence has not been established. This is largely due to the high proportion

9   (83%) of samples that rely on a cross-sectional design. The one randomized controlled trial[12]

10   revealed that an intervention to reduce TV viewing and video game use among 8-9 yr old

11   children attenuated the maturation-related increase in body fatness across a 6-month period. The

12   experimental trials of Gortmaker at al[68] and Epstein and colleagues[42] are also noteworthy

13   because similar decreases in pediatric obesity have been reported when TV viewing was reduced.

14   However, because these studies also targeted other sedentary behaviors[42] or increases in physical

15   activity[68], it is difficult to isolate the effects of TV viewing on changes in body fatness. There is

16   a definite need for more experimental research to evaluate the effects of TV viewing on body

17   fatness during childhood.

18   Because the current analysis adjusted for four common artifacts known to bias the mean

19   effect size, plausible explanations of findings are that additional artifacts (e.g., imperfect

20   construct validity of measures) confound true relationships or that body fatness is largely

21   independent of TV viewing.

22   Although few studies have examined relationships between TV viewing and fatness in

23   very young children (0-6 yr), our meta-analytic evidence suggests that effects are greater in this

1   age group than during adolescence (13-18 yr). The reason for this finding is uncertain but it may

2   have implications for interventions designed to reduce or prevent pediatric overweight and

3   obesity. The mean effect size also appears invariant with regard to gender.

4   The sample-weighted effect size between video/computer game use and body fatness was

5   0.070 (95% CI = -0.048 to 0.188). The sample-weighted fully corrected effect size was 0.128.

6   The 95% CI for the sample-weighted effect size suggests that the relationship in the population is

7   probably zero. However, this should be interpreted with caution because the mean effect size is

8   based on only six primary effect sizes, suggesting the possibility of second-order sampling

9   error[7].

10   Discussion – TV viewing, video/computer game use and physical activity

11   The sample-weighted effect size (Pearson *r*) between TV viewing and physical activity

12   was -0.096 (95% CI = -0.080 to -0.112). The sample-weighted fully corrected effect size was -

13   0.129. A statistically significant negative effect provides possible evidence for a displacement

14   hypothesis. A recent review[69] of correlates of physical activity of children and adolescents

15   concluded the relationship between TV/video games and physical activity to be indeterminate

16   among 4-12 yr olds and zero among 13-18 year olds. The current review examined these studies

17   more closely, located additional evidence and concluded that the relationship among 0-6 year

18   olds is zero (CI's include zero) and 'small' among 7-18 year olds. There was no significant

19   difference between the size of effect among 7-12 year olds and 13-18 year olds. Again, the mean

20   effect size appeared invariant by gender.

21   From the moderator analysis, it was evident that the effect size differed by physical

22   activity intensity, with only vigorous activity being significantly and inversely associated with

23   TV viewing. A possible explanation is that TV viewing displaces only vigorous physical

1   activity. However, because vigorous physical activity appears more easily recalled than moderate

2   physical activity[70], the observed effect size between TV viewing and MVPA may be biased.

3   Indeed, even after correcting for known artifacts, there remained uncorrected variance in these

4   estimates. This suggests that additional unmeasured variables may be confounding possible

5   relationships. Interestingly, when a TV composite variable was used (e.g., TV viewing,

6   watching videos and playing computer games) the effect disappeared, suggesting possible

7   mechanisms are specific to TV viewing.

8   The sample-weighted effect size between video/computer game use and physical activity

9   was -0.104 (95% CI = -0.080 to -0.128). The sample-weighted fully corrected effect size was

10   0.141. This suggests that the relationship is best described as 'small.' Again, this should be

11   interpreted with caution because the mean effect size is based on only 10 primary effects and

12   second-order sampling error may be present[7].

13   <u>General issues - Research designs and measurement</u>

14   In the review of TV viewing and body fatness, 83% of samples were studied using cross-

15   sectional designs (k = 43), eight samples were longitudinal[4 15 18 19 24 32], and one was a

16   randomized controlled trial (RCT)[12]. The difference between the mean effect size from

17   longitudinal and cross-sectional samples was not statistically significant. In the review of TV

18   viewing and physical activity, 90% of samples were studied using cross-sectional designs (k =

19   35) and only four were longitudinal[18 32 61 66]. It is important note that no data were available from

20   controlled trials that manipulated only TV viewing. Cross-sectional studies provide "Category

21   C" level evidence[71] (with 4 Categories, A, B, C, & D) of possible relationships. Evidence is

22   considered Category C when data supporting the conclusion are from uncontrolled or non-

23   randomized trials, cross-sectional or prospective observational studies. The overwhelming

1   reliance on cross-sectional data severely restricts the conclusions that can be drawn from the

2   current evidence.

3   <u>Assessment of TV viewing, video game playing and computer use</u>. Across all reviews (k = 107

4   effects), 79% involved self-reported measures of sedentary behavior. Eleven effects (10.3%)

5   were derived from parental reports of child behavior. Six effects[4 5 14 24] were derived from child

6   and parent reports of child behavior, although correlations between child and parent estimates

7   were generally poor (Spearman rho ~ 0.3). Levels of agreement improved when estimating only

8   the number of days per week each behavior occurred[21]. In only two studies was TV viewing

9   observed directly[18 19]. There was considerable variability in the criteria used for the assessment

10 of TV viewing and video/computer game use. One third of all measures used a single self-report

11 item, with the majority having categorical response formats (e.g., 0-2 hr, 2-3 hrs, etc.). The units

12 of estimation also varied greatly with samples self-reporting in hours (59%), minutes (28%),

13 programs (5%), days in which viewing occurred (4%), or separate bouts of viewing (4%). The

14 sampling frame of TV viewing and video/computer game use also varied, with studies relying on

15 recalls of one week (39%), two to six days (21%), one day (34%) or part-day (e.g., after school)

16 (6%) to estimate habitual behavior. Reliability or validity data were presented in only 23% of

17 samples reviewed. Twenty-six effects (29%) were derived using behavioral composites of TV

18 viewing (e.g., TV viewing plus watching videos and playing computer games), making it

19 difficult to isolate the strength of association between single behaviors and body fatness or

20 physical activity.

21 <u>Assessment of body fatness</u>. It is important to note that all primary studies have utilised proxy

22 measures of body fatness such as subcutaneous fat thickness (i.e., skinfolds) or height-to-weight

23 ratios (i.e., BMI) to estimate fat mass. While these measures have been validated previously

1   (e.g., Goran et al.[72]) this is an important limitation to conclusions drawn from this review. Body

2   fatness was usually assessed using skinfold thickness (60%) or BMI (37%) derived from direct

3   observation of height and weight. Four samples[15 20 38] relied on self-reported height and weight to

4   compute BMI. Only one sample used dual-energy x-ray absorptiometry (DXA)[35] which is

5   considered a 'gold standard' technique for assessing fat mass in children[72]. Although the mean

6   effect size between TV viewing and fatness measured by skinfold thickness and fatness

7   measured by BMI were not statistically different, all of the artifactual variance in the effect size

8   was accounted for when using skinfolds. This suggests that the mean effect size is likely to be

9   similar to the population effect size. When BMI is used as a proxy for body fatness, over 80% of

10 the artifactual variance remains unaccounted for. This suggests either than these samples

11 comprise a heterogeneous population or that uncorrected artifacts are contributing to the variance

12 of the mean effect size.

13   Few studies reported whether they controlled body fatness measures for sexual maturity

14 or age, variables which are known to confound interpretation[73]. Classifications of 'overweight'

15 and 'obese' also differed across studies. For example, Bernard and colleagues[16] classified

16 children as 'overweight' if they were above the 90th percentile whereas Dietz and Gortmaker[4]

17 used the 85th percentile for 'obesity' and the 95th for 'superobesity'. A recent report[74] of

18 international standards proposed for child overweight and obesity recommended using age- and

19 sex-dependent centile curves defined to pass through cut-off points for BMI of 25 kg/m^2 and 30

20 kg/m^2 at age 18 yr. To date, no studies have adopted these definitions when studying the

21 relationship between TV viewing and body fatness.

22 Assessment of physical activity. Forty-two effect sizes (86%) were derived from studies using

23 self-reported measures of physical activity of which 91% were child reports and 8% were parent

1   reports of child behavior. No study-specific validity or reliability data was reported for the

2   physical activity measure in one-third of samples. Only three of the self-reported measures

3   utilised cognitive recall techniques administered via interview. Of the seven effect sizes derived

4   using 'objective' measures of physical activity, four were based on accelerometry from a single

5   study[60], two were derived from direct observation[18 59], and one from indirect calorimetry[39]. The

6   mean effect size between objectively measured physical activity and TV viewing was not

7   statistically different from self-reported physical activity and TV viewing.

8   <u>Conclusions</u>

9   It is concluded that a statistically small relationship exists between TV viewing and body

10   fatness among children and youth although the magnitude of the relationship suggests we should

11   be cautious about the clinical relevance of this finding. The strength of this relationship remains

12   virtually unchanged even after correcting for common sources of bias[7] known to impact study

13   outcomes. This finding is in contrast to many reports[6 75 76] which claim the relationship to be

14   strong and conclusive. Possible mechanisms lack supporting evidence and claims that TV

15   viewing, playing video games or using computers displace physical activity receive very limited

16   empirical support. Possible relationships may be confounded by other factors such as the

17   consumption of energy-dense snacks that may accompany these behaviors. Additional sources

18   of error may also confound true relationships because most studies used cross-sectional designs

19   which have detached and statistically aggregated time-use patterns across a day or week (e.g.,

20   hours of TV viewing per day). Because the temporal and environmental context of each

21   behavior is lost, trends of association within sampling periods may be masked or cancelled out. It

22   should be noted that the one randomized controlled trial[12] does provide evidence that reductions

23   in TV viewing can attenuate the age-related increases in body fatness. More experimental

1   research is needed to replicate these findings and explore possible mechanisms. However, based

2   on the entire spectrum of current evidence, it is uncertain whether reductions in TV viewing or

3   video/computer game use will elicit clinically relevant decreases in subcutaneous fat thickness or

4   body mass index. While the total amount of time per day engaged in sedentary behavior is

5   inevitably prohibitive of physical activity and the cumulative effect of multiple sedentary

6   behaviors reduces total daily energy expenditure, relationships between sedentary behavior and

7   health are unlikely to be explained using single markers of inactivity such as TV viewing or

8   video/computer game use.

9

10

References

1. World Health Organisation. Obesity: Preventing and managing the global epidemic. Rep. WHO Consult. Geneva: World Health Organisation, 1998.

2. Hill JO, Melanson EL. Overview of the determinants of overweight and obesity: current evidence and research issues. *Medicine & Science in Sports and Exercise* 1999;31(11 Suppl):S515-521.

3. British Heart Foundation. *Couch kids: The growing epidemic*. London: The British Heart Foundation, 2000.

4. Dietz WH, Gortmaker SL. Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. *Pediatrics* 1985;75(5):807-812.

5. Gortmaker SL, Must A, Sobol AM, Peterson K, Colditz GA, Dietz WH. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Pediatr Adolesc Med* 1996;150:356-362.

6. Bar-Or O, Foreyt J, Bouchard C, Brownell KD, Dietz WH, Ravussin E, et al. Physical activity, genetic and nutritional considerations in childhood weight management. *Med Sci Sports Exerc* 1998;30:2-10.

7. Hunter JE, Schmidt FL. *Methods of meta-analysis. Correcting error and bias in research findings*. Newbury Park, CA: Sage Publications Inc., 1990.

8. Lipsey MW, Wilson DB. *Practical meta-analysis*. Newbury Park, CA: Sage Publications, Inc., 2000.

9. Cohen J. *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum, 1988.

10. Whitener EM. Confusion of confidence intervals and credibility intervals in meta-analysis. *J Appl Psychol* 1990;75(3):315-321.

11. Obarzanek E, Schreiber GB, Crawford PB, Goldman SR, Barrier PM, Frederick MM, et al. Energy intake and physical activity in relation to indexes of body fat: the National Heart, Lung, and Blood Institute Growth and Health Study. *Am J Clin Nutr* 1994;60:15-22.

12. Robinson TN. Reducing children's television viewing to prevent obesity. *JAMA* 1999;282(16):1561-1567.

13. Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M. Relationship of physical activity and television watching with body weight and level of fatness among children. *JAMA* 1998;279(12):938-942.

14. Armstrong CA, Sallis JF, Alcaraz JE, Kolody B, McKenzie TL, Hovell MF. Children's television viewing, body fat, and physical fitness. *Am J Health Promot* 1998;12(6):363-368.

15. Berkey CS, Rockett HRH, Field AE, Gillman MW, Frazier AL, Camargo CA, et al. Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. *Pediatrics* 2000;105(4):1-9.

16. Bernard L, Lavallée C, Gray-Donald K, Delisle H. Overweight in Cree schoolchildren and adolescents associated with diet, low physical activity, and high television viewing. *J Am Diet Assoc* 1995;95(5):800-803.

17. Calderon LL, Johnston PK, Lee JW, Haddad EH. Risk factors for obesity in Mexican-American girls: Dietary factors, anthropometric factors, and physical activity. *J Am Diet Assoc* 1996;96(11):1177-1179.

18. DuRant RH, Baranowski T, Johnson M, Thompson WO. The relationship among television watching, physical activity, and body composition of young children. *Pediatrics* 1994;94(4):449-455.
19. DuRant RH, Thompson WO, Johnson M, Baranowski T. The relationship among television watching, physical activity, and body composition of 5- or 6-year-old children. *Pediatr Exerc Sci* 1996;8:15-26.
20. Gracey D, Stanley N, Burke V, Corti B, Beilin LJ. Nutritional knowledge, beliefs and behaviors in teenage school students. *Health Educ Res* 1996;11(2):187-204.
21. Guillaume M, Lapidus L, Bjorntorp P, Lambert A. Physical activity, obesity, and cardiovascular risk factors in children. The Belgian Luxembourg Child Study II. *Obes Res* 1997;5(6):549-556.
22. Hanley AJG, Harris SB, Gittlesohn J, Wolever TMS, Saksvig B, Zinman B. Overweight among children and adolescents in a native Canadian community: prevalence and associated factors. *Am J Clin Nutr* 2000;71:693-700.
23. Hernandez B, Gortmaker SL, Colditz GA, Peterson KE, Laird NM, Parra-Cabrera S. Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico City. *Int J Obes* 1999;23:845-854.
24. Horn OK, Paradis G, Potvin L, Macaulay AC, Desrosiers S. Correlates and predictors of adiposity among Mohawk children. *Prev Med* 2001;33:274-281.
25. Katzmarzyk PT, Malina RM, Song TMK, Bouchard C. Television viewing, physical activity, and health-related fitness of youth in the Québec Family Study. *J Adolesc Health* 1998;23(5):318-325.
26. Katzmarzyk PT, Malina RM, Song TMK, Bouchard C. Physical activity and health-related fitness in youth: a multivariate analysis. *Med Sci Sports Exerc* 1998;30(5):709-714.
27. Kimm SYS, Obarzanek E, Barton BA, Aston CE, Similo SL, Morrison JA, et al. Race, socioeconomic status, and obesity in 9- to 10-year-old girls: The NHLBI growth and health study. *Ann Epidemiol* 1996;6(4):266-275.
28. Locard E, Mamelle N, Billette A, Miginiac M, Munoz F, Rey S. Risk factors of obesity in a five year old population. Parental versus environmental factors. *Int J Obes* 1992;16:721-729.
29. Muller MJ, Koertringer I, Mast M, Langnase K, Grund A. Physical activity and diet in 5 to 7 years old children. *Pub Health Nutr* 1999;2(3a):443-444.
30. Myers L, Strikmiller PK, Webber LS, Berenson GS. Physical and sedentary activity in school children grades 5-8: the Bogalusa Heart Study. *Med Sci Sports Exerc* 1996;28(7):852-859.
31. Robinson TN, Killen JD. Ethnic and gender differences in the relationships between television viewing and obesity, physical activity, and dietary fat intake. *J Health Educ* 1995;26(2 (Supplement)):S91-S98.
32. Robinson TN, Hammer LD, Killen JD, Kraemer HC, Wilson DM, Hayward C, et al. Does television viewing increase obesity and reduce physical activity? cross-sectional and longitudinal analyses among adolescent girls. *Pediatrics* 1993;91(2):273-280.
33. Sekine M, Yamagami T, Handa K, Saito T, Nanri S, Kawaminami K, et al. A dose-response relationship between short sleeping hours and childhood obesity: results of the Toyama Birth Cohort Study. *Child Care Health Dev* 2002;28(2):163-170.
34. Shannon B, Peacock J, Brown MJ. Body fatness, television viewing and calorie-intake of a sample of Pennsylvania sixth grade children. *J Nutr Educ* 1991;23(6):262-268.

35. Stafford M, Wells JCK, Fewtrell M. Letter to the editor: Television watching and fatness in children. *JAMA* 1998;280(14):1231.

36. Tanasescu M, Ferris AM, Himmelgreen DA, Rodriguez N, Perez-Escamilla R. Biobehavioral factors are associated with obesity in Puerto Rican children. *J Nutr* 2000;130:1734-1742.

37. Waller CW, Popkin BM. Television viewing, video games and studying are not associated with overweight in Chinese children. *Experimental Biology* 2002:A1020.

38. Wolf AM, Gortmaker SL, Cheung L, Gray HM, Herzog DB, Colditz GA. Activity, inactivity, and obesity: racial, ethnic, and age differences among schoolgirls. *Am J Public Health* 1993;83(11):1625-1627.

39. Grund A, Krause H, Siewers M, Rieckert H, Muller MJ. Is TV viewing an index of physical activity and fitness in overweight and normal weight children? *Pub Health Nutr* 2001;4(6):1245-1251.

40. Faith MS, Berman N, Heo M, Pietrobelli A, Gallagher D, Epstein LH, et al. Effects of contingent television on physical activity and television viewing in obese children. *Pediatrics* 2001;107(5):1043-1048.

41. Epstein LH, Saelens BE, Myers MD, D.Vito. Effects of decreasing sedentary behaviors on activity choice in obese children. *Health Psychol* 1997;16(2):107-113.

42. Epstein LH, Paluch RA, Gordy CC, Dorn J. Decreasing sedentary behaviors in treating pediatric obesity. *Arch Pediatr Adolesc Med* 2000;154:220-226.

43. Epstein LH, Saelens BE, O'Brien JG. Effects of reinforcing increases in active behavior versus decreases in sedentary behavior for obese children. *Int J Behav Med* 1995;2(1):41-50.

44. Jason LA, Johnson SZ. Reducing excessive television viewing while increasing physical activity. *Child Fam Behav Ther* 1995;17(2):35-45.

45. Jason LA, Brackshaw E. Access to TV contingent on physical activity: effects on reducing TV-viewing and body-weight. *J Behav Ther Exp Psychiatry* 1999;30:145-151.

46. Gupta RK, Saini DP, Acharya U, Miglani N. Impact of television on children. *Indian J Pediatr* 1994;61(2):153-159.

47. Schmitt HJ. Does television viewing increase obesity and reduce physical activity? Cross-sectional and longitudinal analyses among adolescent girls. *Eur J Pediatr* 1993;152:619-620.

48. Ho SMY, Lee TMC. Computer usage and its relationship with adolescent lifestyle in Hong Kong. *J Adolesc Health* 2001;29:258-266.

49. Kerner MS, Kalinski M, Kurrant AB, Small E, Spatz E, Gropack S. Leisure-time internet use does not correlate with physical activity or physical fitness level of ninth grade African-American girls. *Pediatr Exerc Sci* 2001;13:402-412.

50. Taras HL, Sallis JF, Patterson TL, Nader PR, Nelson JA. Television's influence on children's diet and physical activity. *J Dev Behav Pediatr* 1989;10(4):176-180.

51. Katzmarzyk PT, Malina RM. Contribution of organized sports participation to estimated daily energy expenditure in youth. *Pediatr Exerc Sci* 1998;10:378-386.

52. Garcia AW, Broda MN, Frenn M, Coviak C, Pender NJ, Ronis DL. Gender and developmental differences in exercise beliefs among youth and prediction of their exercise behavior. *J Sch Health* 1995;65(6):213-219.

53. Lindquist CH, Reynolds KD, Goran MI. Sociocultural determinants of physical activity among children. *Prev Med* 1999;29:305-312.

54. Murray JP, Kippax S. Children's social behavior in three towns with differing television experience. *J Communication* 1978:19-29.
55. Zakarian JM, Hovell MF, Hofstetter CR, Sallis JF, Keating KJ. Correlates of vigorous exercise in a predominantly low SES and minority High School population. *Prev Med* 1994;23:314-321.
56. Bungum TJ, Vincent ML. Determinants of physical activity among female adolescents. *Am J Prev Med* 1997;13(2):115-122.
57. Vilhjalmsson R, Thorlindsson T. Factors related to physical activity: a study of adolescents. *Soc Sci Med* 1998;47(5):665-675.
58. Trost SG, Pate RR, Dowda M, Saunders R, Ward DS, Felton G. Gender differences in physical activity and determinants of physical activity in rural fifth grade children. *J Sch Health* 1996;66(4):145-150.
59. Sallis JF, Nader PR, Broyles SL, Berry CC, Elder JP, McKenzie TL, et al. Correlates of physical activity at home in Mexican-American and Anglo-American preschool children. *Health Psychol* 1993;12(5):390-398.
60. Janz KF, Mahoney LT. Maturation, gender, and video game playing are related to physical activity intensity in adolescents: The Muscatine Study. *Pediatr Exerc Sci* 1997;9:353-363.
61. Huston AC, Wright JC, Marquis J, Green SB. How young children spend their time: television and other activities. *Dev Psychol* 1999;35(4):912-925.
62. World Health Organisation. Health and health randomized among young people. WHO Policy Series: policy for children and adolescents issue 1, 2000.
63. Lasheras L, Aznar S, Merino B, Lopez E. Factors associated with physical activity among Spanish youth through the National Health Survey. *Prev Med* 2001;32:455-464.
64. Stephens T, Craig C. The well-being of Canadians: Highlights of the 1988 Campbell's survey. Ottawa: Canadian Fitness and Lifestyle Research Institute, 1990.
65. Sjolie AN, Thuen F. School journeys and leisure activities in rural and urban adolescents in Norway. *Health Promot Internation* 2002;17(1):21-30.
66. Mutz DC, Roberts DF, Vuuren DP. Reconsidering the displacement hypothesis. Television's influence on children's time use. *Communication Res* 1993;20(1):51-75.
67. Caspersen CJ, Nixon PA, DuRant RH. Physical activity epidemiology applied to children and adolescents. *Exerc Sport Sci Rev* 1998;26(341-403).
68. Gortmaker SL, K. P, Wiecha J, Sobol AM, Dixit S, Fox MK, et al. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Archives of Pediatric Adolescent Medicine* 1999;153(4):409-418.
69. Sallis J, Prochaska J, Taylor W. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc* 2000;32(5):963-975.
70. Welk GJ, Corbin CB, Dale D. Measurement issues in the assessment of physical activity in children. *Res Q Exerc Sport* 2000;71(2):59-73.
71. National Institutes of Health and National Heart LaBI, ,. Clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults: the evidence report. *Obes Res* 1998;6(Supplement 2):51-209.
72. Goran MI, Driscoll P, Johnson R, Nagy TR, Hunter G. Cross-calibration of body composition techniques against dual-energy x-ray absorptiometry in youth young children. *Am J Clin Nutr* 1996;63:299-305.

73. Flegal KM. Defining obesity in children and adolescents: epidemiological approaches. *Crit Rev Food Sci Nutr* 1993;33:307-312.

74. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for childhood overweight and obesity worldwide: International Survey. *British Medical Journal* 2000;320:1240.

75. Dietz WH, Strasburger VC. Children, adolescents, and television. *Curr Probl Pediatr* 1991:8-31.

76. Gortmaker SL, Dietz WH, Cheung LWY. Inactivity, diet, and the fattening of America. *J Am Diet Assoc* 1990;90:1247-1252, 1255.

Table 1. Results of the meta-analysis between TV viewing and body fatness and video/computer game use and body fatness.

	k	n	$\overline{r_o}$	$\overline{r_c}$	sd	Var.	75%	Q	95% Cr Int.	95% CI
TV viewing and Body Fatness	52	44707	0.066	0.084	0.084	0.007	33%	165.3[**]	0.060 to 0.108	0.056 to 0.078
Video/computer game use and Body Fatness	6	1722	0.070	0.128	0.181	0.033	31%	19.6[**]	-0.017 to 0.273	-0.048 to 0.188

Notes:

k = number of independent samples; n = total sample size; $\overline{r_o}$ = uncorrected sample-weighted mean effect size; $\overline{r_c}$ = fully corrected sample-weighted mean effect size; sd = standard deviation of fully corrected mean effect size; Var. = variance of fully corrected mean effect size; 75% = 75% rule; Q = within-group goodness of fit (approximates chi-square distribution with k-1 degrees of freedom); 95% Cr Int. = 95% credibility interval; 95% CI = 95% confidence interval.

* = p<.05; ** = p<.01.

Table 2. Meta-analysis results for the moderator analysis between TV viewing and body fatness.

Moderator variable	k	n	$\bar{r_o}$	$\bar{r_c}$	sd	Var.	75%	Q	95% Cr Int.	95% CI
Body Fatness measure										
BMI	19	29382	0.068	0.087	0.094	0.009	19%	98.8[**]	0.048 to 0.132	0.040 to 0.096
Skinfold	31	14073	0.050	0.066	0.000	0.000	100%	24.3	0.066 to 0.066	0.033 to 0.067
Other[a]	2	1252	0.175	0.253	0.101	0.010	95%	2.1	0.113 to 0.393	0.086 to 0.264
TV measure										
Self report	36	29431	0.043	0.054	0.000	0.000	100%	24.8	0.054 to 0.054	0.041 to 0.045
Parent report	6	10151	0.114	0.219	0.084	0.007	42%	14.4[*]	0.152 to 0.286	0.054 to 0.174
Direct observation	2	215	0.094	0.167	0.000	0.000	100%	1.2	0.167 to 0.167	0.094 to 0.094
TV only	33	21701	0.088	0.125	0.113	0.013	31%	106.3[**]	0.086 to 0.164	0.056 to 0.120
TV composite	19	23006	0.043	0.054	0.017	0.000	97%	16.6	0.046 to 0.062	0.051 to 0.066
Study Design										
Cross-sectional	43	28718	0.081	0.111	0.101	0.012	35%	118.5[**]	0.095 to 0.127	0.043 to 0.063
Longitudinal	8	15797	0.041	0.053	0.030	0.001	61%	13.1	0.042 to 0.064	0.030 to 0.052
RCT[b]	1	192	0.262	0.263	n/a	n/a	n/a	n/a	n/a	n/a
Gender										
Boys	15	14949	0.047	0.062	0.000	0.000	100%	7.3	0.062 to 0.062	0.047 to 0.047
Girls	22	21662	0.063	0.075	0.081	0.007	31%	65.0[**]	0.040 to 0.110	0.034 to 0.092
Mixed	15	8096	0.112	0.173	0.132	0.017	29%	48.0[**]	0.104 to 0.242	0.055 to 0.169
Age (yr)										
0-6	4	2047	0.146	0.190	0.046	0.002	100%	2.5	0.145 to 0.235	0.089 to 0.203
7-12	24	18788	0.076	0.127	0.081	0.007	93%	22.7	0.093 to 0.161	0.049 to 0.103
13-18	12	3196	0.057	0.069	0.000	0.000	100%	2.9	0.069 to 0.069	0.037 to 0.077

Table 2 Contd.

Notes:

k = number of independent samples; n = total sample size; $\bar{r_o}$ = uncorrected sample-weighted mean effect size; $\bar{r_c}$ = fully corrected sample-weighted mean effect size; sd = standard deviation of fully corrected mean effect size; Var. = variance of fully corrected mean effect size; 75% = 75% rule; Q = within-group goodness of fit (approximates chi-square distribution with k-1 degrees of freedom); 95% Cr Int. = 95% credibility interval; 95% CI = 95% confidence interval.

[a] fat mass (g) from dual-energy x-ray absorptiometry (k = 1), >2 SD (z) from Sempe's weight/height/sex reference charts (k = 1).

[b] RCT = randomized controlled trial

* = p<.05; ** = p<.01.

Table 3. Results of the meta-analysis between TV viewing and physical activity and video/computer game use and physical activity.

	k	n	$\bar{r}_o$	$\bar{r}_c$	sd	Var.	75%	Q	95% Cr Int.	95% CI
TV viewing and Physical Activity	39	141505	-0.096	-0.129	0.062	0.004	27%	140.8[**]	-0.110 to -0.148	-0.080 to -0.112
Video/computer game use and Physical Activity	10	119942	-0.104	-0.141	0.045	0.002	39%	28.3[**]	-0.173 to -0.119	-0.080 to -0.128

Notes:

k = number of independent samples; n = total sample size; $\bar{r}_o$ = uncorrected sample-weighted mean effect size; $\bar{r}_c$ = fully corrected sample-weighted mean effect size; sd = standard deviation of fully corrected mean effect size; Var. = variance of fully corrected mean effect size; 75% = 75% rule; Q = within-group goodness of fit (approximates chi-square distribution with k-1 degrees of freedom); 95% Cr Int. = 95% credibility interval; 95% CI = 95% confidence interval.

* = p<.05; ** = p<.01.

Table 4. Meta-analysis results for the moderator analysis between TV viewing and physical activity.

Moderator variable	k	n	$\overline{r_o}$	$\overline{r_c}$	sd	Var.	75%	Q	95% Cr Int.	95% CI
PA measure										
Self report	34	140887	-0.096	-0.132	0.062	0.004	28%	119.6[**]	-0.111 to -0.153	-0.079 to -0.113
Objective[a]	5	618	-0.118	-0.155	0.094	0.009	47%	10.7[*]	-0.073 to -0.237	-0.052 to -0.184
PA intensity										
Combined	12	9229	-0.066	-0.089	0.039	0.002	63%	17.4	-0.066 to -0.112	-0.046 to -0.085
MVPA[b]	11	1847	0.062	0.084	0.216	0.047	19%	56.7[**]	-0.044 to 0.211	-0.033 to 0.157
Vigorous	13	126046	-0.104	-0.140	0.040	0.002	44%	29.5[**]	-0.119 to -0.162	-0.083 to -0.125
Sports	3	9122	-0.066	-0.089	0.075	0.006	23%	13.1[**]	-0.004 to -0.174	0.000 to -0.131
TV measure										
Self report	33	139349	-0.097	-0.132	0.058	0.003	29%	112.2[**]	-0.112 to -0.151	-0.081 to -0.114
Parent report	5	2043	0.042	0.057	0.186	0.035	10%	39.3[**]	-0.126 to 0.239	-0.094 to 0.178
TV only	31	138005	-0.098	-0.132	0.050	0.003	35%	88.5[**]	-0.115 to -0.150	-0.083 to -0.113
TV composite	7	3393	-0.002	-0.002	0.232	0.054	7%	107.1[**]	-0.174 to 0.170	-0.129 to 0.126
Study Design										
Cross-sectional	35	139047	-0.097	-0.131	0.059	0.004	28%	119.6[**]	-0.112 to -0.151	-0.081 to -0.114
Longitudinal	4	2458	-0.007	-0.009	0.140	0.020	13%	30.3[**]	-0.146 to 0.128	-0.108 to 0.095
Gender										
Boys	12	63085	-0.085	-0.115	0.029	0.001	56%	21.3[*]	-0.099 to -0.131	-0.069 to -0.102
Girls	16	67136	-0.115	-0.156	0.072	0.005	26%	62.7[**]	-0.120 to -0.191	-0.086 to -0.144
Mixed	11	11284	-0.038	-0.051	0.109	0.012	13%	76.9[**]	-0.119 to 0.016	-0.088 to 0.012

Table 4 Contd.

Age (yr)

0-6	3	631	-0.046	-0.063	0.127	0.016	36%	8.4**	-0.206 to 0.081	-0.153 to 0.060
7-12	9	84347	-0.090	-0.122	0.000	0.000	100%	5.0**	-0.122 to -0.122	-0.082 to -0.098
13-18	16	14630	-0.113	-0.152	0.053	0.003	37%	43.4**	-0.127 to -0.178	-0.090 to -0.136

Notes:

k = number of independent samples; n = total sample size; $\bar{r}_o$ = uncorrected sample-weighted mean effect size; $\bar{r}_c$ = fully corrected sample-weighted mean effect size; sd = standard deviation of fully corrected mean effect size; Var. = variance of fully corrected mean effect size; 75% = 75% rule; Q = within-group goodness of fit (approximates chi-square distribution with k-1 degrees of freedom); 95% Cr Int. = 95% credibility interval; 95% CI = 95% confidence interval.

[a] accelerometry (k = 2); direct observation (k = 2); indirect calorimetry (k = 1).

[b] moderate-to-vigorous physical activity

* = p<.05; ** = p<.01.