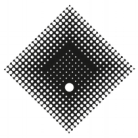

Sedentary behaviour interventions in young people: A meta-analysis

Sedentary Behaviour Interventions in Young People:

A Meta-Analysis

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Abstract

Background. There is increasing concern about the time young people spend in sedentary behaviour ('sitting time'), especially with the development of attractive home-based electronic entertainment. This may have deleterious health effects.

Purpose. To ascertain, through a meta-analytic review, whether interventions targeted at reducing sedentary behaviours in young people are successful.

Method. ERIC, MedLine, PsychInfo, SportDiscus and the Cochrane Library databases were searched up to 2010. Titles and abstracts of identified papers were examined against inclusion criteria. Included papers were coded by three researchers.

Results. 17 papers, including 17 independent samples (N=4976), met the inclusion criteria and were analysed. There was a small but significant effect in favour of sedentary behaviour reduction for intervention groups (Hedges' *g* = - 0.192; SE = 0.056; 95% C.I. = -0.303, -0.082; p = 0.001). Moderator analyses produced no significant between-moderator results for any of the intervention or study characteristics, although trends were evident.

Conclusion. Behaviour change interventions targeting reductions in sedentary behaviour have been shown to be successful, although effects are small. More needs to be known about how best to optimise intervention effects.

Introduction

There is a rapidly growing literature on ‘sedentary behaviour’ in young people and adults as a result of concern about the amount of time people spend sitting. Interest has grown mainly as a result of the rapid developments in technology making home-based entertainment systems and computers highly attractive and available. Moreover, the ubiquitous nature of car travel in place of active forms of transport from previous generations has added to concerns about excessive ‘sitting time’ and health [1-4].

Deleterious health outcomes of high levels of sedentary behaviour are emerging in adults [4-6] but have proved more difficult to demonstrate in young people. Nevertheless, studies with this age group have shown that sedentary behaviour can be associated with higher risk of overweight [1, 7], hypertension [8], adverse metabolic markers [9], and poorer mental health [10].

Despite claims of high levels of sedentary behaviour, there are no definitive population data suggesting where prevalence categories should be drawn. While organisations such as the American Academy of Pediatrics [11] state that they wish to see a restriction of “total media time (with entertainment media) to no more than 1 to 2 hours of quality programming per day” (p. 424), it is unclear whether this is only TV viewing or other screen time, and how such a figure was arrived at. TV viewing of more than 4 h per day is often considered ‘excessive’. New Canadian guidelines [12] state “For health benefits, children (aged 5–11 years) and youth (aged 12–17 years) should minimize the time they spend being sedentary each day” (p. 62). Specifically, they recommend that recreational screen time should be limited to no more than 2 h per day and state that lower levels are associated with additional health benefits. In

addition, “limiting motorized transport, extended sitting time, and time spent indoors throughout the day” is suggested (p. 62).

Evidence exists for greater TV viewing in boys over girls, but girls indulge in more sedentary socialising behaviours. In addition, TV viewing tends to be higher in lower SES groups [13]. A recent review reported moderate levels of tracking of sedentary behaviours, and especially TV viewing [14]. Given the evidence, therefore, that sedentary behaviour (sitting) in young people can have deleterious health consequences, and that the behaviour may persist into adulthood, it is a health priority to successfully limit the sedentary behaviour of young people. Interventions aimed at reducing sedentary behaviour have included a variety of approaches, including education [15] and in the home [16].

Given the likely importance of reducing sedentary behaviour and high prevalence of sitting, it is timely to review how successful interventions have been in reducing sedentary behaviour for young people. Two systematic reviews exist. One has focused on the role of sedentary behaviour interventions specifically in weight management [17], and thus was restricted to studies that assessed body weight or BMI as outcomes measures (K=12). In addition, a meta-analysis by Kamath and colleagues [18] investigated behavioural interventions for physical activity, sedentary behaviour (K=14), and diet. Unfortunately, for the meta-analysis of studies on sedentary behaviour, they also included studies that were specifically designed to increase physical activity, but would have had an assessment of sedentary behaviour as a secondary outcome. We believe this is an erroneous test of sedentary behaviour interventions. As such, in the current review we will specifically analyse interventions that target reductions in sedentary behaviour and consequently include additional studies that were excluded from the previous reviews. The

present review, therefore, aims to identify the interventions targeted at reducing sedentary behaviour in children and adolescents.

Methods

Search Methods

Literature searches were conducted using a combination of methods that included searches of electronic databases, sedentary behaviour review papers, manual searches of references lists, and personal files. Electronic database searches were performed utilising the major databases ERIC, MedLine, PsychInfo, SportDiscus and the Cochrane Library for publications up to 2010, with extraction and data analysis conducted in 2010. Keywords used to guide the search process included “adolescent”, “youth”, “television”, “video games”, “screen-based media”, and “sedentary behaviour”. Initial electronic searches led to the retrieval of 791 papers, of which 676 were excluded on the basis of title or duplication. A review of the remaining 43 abstracts reduced the number of studies to 24. In-out forms were then used to assess each paper. From this, 17 papers met full inclusion criteria.

Inclusion/Exclusion Criteria

Titles and abstracts identified through the search process were reviewed to identify relevant literature which were then included for further assessment if they met the following criteria: (1) the study was an intervention; (2) participants were 18 years of age or younger; (3) an outcome measure of sedentary behaviour was reported; (4) descriptive and/or inferential statistics were included to allow for the calculation of an effect size; (6) published in an English language, peer-reviewed journal.

Data Coding and Extraction

Coding and data extraction forms were developed following procedures recommended by Lipsey and Wilson [19] and Brown, Upchurch, and Acton [20]. Two coders reviewed and evaluated sedentary intervention studies on three primary categories including intervention, participant, and study characteristics. Intervention characteristics provided information on intervention type (clinical, community, counselling, education, or laboratory), intervention design (theory-based or non theory based), intervention time (0-4 months, 5-8 months, 9-12 months, or greater than 12 months), follow-up after intervention (no or yes), intervention focus (sedentary behaviours or combination physical activity and sedentary behaviours), and intervention delivery (weekly, biweekly, monthly, or other). Participant characteristics included sample size (*N*), age (age ranges in years), gender (male and female), ethnicity (race), and socioeconomic status (SES: based on family income). As a result of inconsistent reporting standards and insufficient information, gender, ethnicity, and SES were excluded as moderators. Study characteristics addressed study funding (grant funded or non grant funded), study measures (objective measure – accelerometer; self-report measures – questionnaire; or combination of objective and self-report measures), country in which intervention was conducted (Australia, Canada, France, United Kingdom, or United States), and overall study effect size. Data extraction was conducted by one coder for all sedentary behaviours reported in studies meeting inclusion criteria. After data extraction was complete a random sample of half the studies was drawn and data extraction from the sample was performed independently by a separate coder. All coding was done separately and then discussed and any discrepancies (factual errors or interpretation errors) were discussed and resolved by the third investigator.

Agreement rates and inter-rater reliability coefficients were then calculated and reported for both variable coding and data extraction.

Statistical Methods

Comprehensive Meta-Analysis (CMA) version-2 software [21] was used for all analyses. A random effects model using Hedges' *g* as the effect size index was selected to measure the sedentary intervention differences between control and experimental groups [22, 23]. Hedges' *g* provides a more conservative estimate of effect size as meta-analysis research suggests smaller sample sizes (*k*<20) using Cohen's *d* index over estimate effect sizes [23, 24]. The standard formula for Hedges' *g* used to correct for bias in small samples was:

$$g = (1 - \frac{3}{(4N - 9)})d$$

When descriptive data such as means and standard deviations were not provided in studies, estimates of effect sizes were calculated using *F*, *t*, *r*, or *p*-values [25]. Each study contributed one effect size calculation to the overall analysis. Homogeneity of variance was assessed through observation of the Q_T-statistic which is based on a chi-square (X^2) distribution. Significant Q_T-values indicate a heterogeneous distribution and the need to conduct moderator (or subgroup) analyses to provide a more accurate estimate of study dispersion. Two additional statistics that were used to interpret heterogeneity were tau-squared (τ^2) and I-squared (I^2). The τ^2 statistic is used by CMA to calculate weights and yields an estimate of total variance between studies in a random effects model. Larger τ^2 values reflect the proportion of variance that can be attributed to real differences between studies. The I^2 statistic is the ratio of excess dispersion to total dispersion and can be interpreted as the overlap of confidence intervals explaining the total variance attributed to the covariates [26]. Interpretation of the I^2 statistic indicate low

(25%), moderate (50%), and high (75%) relative variance with higher values requiring techniques (i.e., moderator analysis or meta-regression) to provide explanations [21, 26].

Outlier Analysis and Publication Bias

Analysis of relative residual values of individual studies was performed to examine the presence of outliers. A large residual value was considered to be a standard score (z-score) greater than or equal to a positive or negative value of 1.96. CMA [21] provides a summary interpretation and treatment of relative residuals value through the use of a “one-study removed” procedure. Studies that were identified as outliers are examined in a “one study removed” analysis and set criteria determined that studies would remain within the analysis if they did not substantially impact the effect size *g* and results remained in the 95th confidence interval. Publication bias was analysed by visual inspection of a funnel plot, the Trim and Fill procedure [27], and Fail Safe *N* calculation [28]. Funnel plots provide a visual representation of the symmetrical distribution of data points about the mean effect size. If an asymmetrical funnel plot is present then analysis of Duval and Tweedie’s (2000) Trim and Fill procedure (computed by CMA) allows for the mean effect size to be adjusted accordingly. The classic Fail Safe *N* is a measure of publication bias that determines the number of non-significant missing studies needed to nullify significant results.

RESULTS

Coding Reliability

The review and screening process previously identified found 17 studies to be included in the current research synthesis. Inter-rater reliability ranged from 92% to 100% agreement for coding all intervention categories (92%, r = .985) and data

extraction (100%, r =.1.00). There were a total of 12 factual errors that were corrected and one interpretation error that was not corrected. A third coder evaluated the studies meeting inclusion criteria and value for the category was determined by a simple majority.

Overall Analysis

The primary purpose of the current study was to determine the overall effectiveness of sedentary interventions. There was a total of 17 studies with 17 independent samples that included 4976 participants meeting inclusion criteria. Table 1 displays the coded intervention, participant, and study characteristics as well as each study's overall treatment effect. When interpreting the treatment effects, Cohen's [29] criteria were used for interpretation of standardized mean differences and summarized effect sizes as small (<.49), moderate (.50-.79), and large (≥.79). In the case of sedentary behaviours, negative effect sizes were interpreted as treatment groups (groups receiving sedentary intervention) engaging in less sedentary behaviour than control groups. Conversely, positive treatment effects indicated that the control group had lower sedentary behaviour than intervention groups.

INSERT TABLE 1 ABOUT HERE

The average treatment effect size for all sedentary behaviour intervention studies was small but significant (g = - 0.192; SE = 0.056; 95% C.I. = -0.303, -0.082; p = 0.001) and represented approximately one fifth of a standard deviation advantage for treatment groups over control groups in a reduction of sedentary behaviours. Table 2 presents an overview of the relevant statistics used when evaluating the overall effect. Review of the homogeneity statistics revealed a significant heterogeneous distribution (Q_T=43.48, p < 0.001; I^2 = 63.21) making it

necessary to explain between-study variation through moderator analyses of characteristics coded for studies. In addition, an outlier analysis was conducted through evaluation of residual values and found two studies to be outliers (Epstein, 2002: z = -2.50; Faith et al., 2001: z = -3.45), therefore, a “one study removed” procedure was performed. Both studies were retained as results indicated small changes in the overall effect size (+0.029, g = -0.163) while still remaining within the 95% confidence interval. Evaluation of publication bias suggested a modest influence as a result of a symmetrical funnel plot, no studies being added during the Trim and Fill procedure, and a Fail Safe-N value calculation of 168 studies that would be needed to nullify a significant α-level ($p < .05$).

INSERT TABLES 2 AND 3 ABOUT HERE

Heterogeneity statistics for the random effects model confirmed that there was a heterogeneous (Q_T = 43.48, $p < .05$) distribution and that a moderate level (I^2 = 63.21) of between-study variation existed to justify conducting subgroup analyses for coding characteristics. Tables 2 and 3 provide an overview of the moderator analyses performed on intervention and study characteristics. Results produced no significant moderator differences between treatment effect sizes for each of the moderator characteristics coded, however, there were significant characteristics within specific analyses. Caution should be used when interpreting these moderator analyses as Borenstein et al. [21] suggest that analyses should provide a minimum of five studies to provide a stable estimate of effect size. The purpose for including moderators with fewer than five studies in the analyses was to allow for guidance for future research, including recommendations to be considered for future sedentary behaviour interventions.

Moderator Analyses

Review of the intervention moderator analyses produced no significant between-moderator results for any of the intervention or study characteristics, however, trends were present in the data. Of particular note, community interventions showed a moderate effect (k = 4, g = -0.61, Z = -3.03), while intervention time periods of less than four months (k = 8, g = -0.31, Z = -2.84) and longer than a year (k = 3, g = -0.24, Z = -2.11), and weekly (k = 6, g = -0.22, Z = -2.26) and irregular (k = 9, g = -0.19, Z = -2.33) intervention deliveries produced small treatment effects. All previously mentioned intervention moderators had low between-study variance (τ^2) and explained moderate to large portions of subgroup variance (I^2). Study characteristics also displayed trends in combined (self-report and objective, i.e., questionnaire and accelerometer) outcome measures (k = 6, g = -0.30, Z = -2.86) and for interventions conducted in the United States (k = 11, g = -0.24, Z = -2.96). Similar to findings with intervention characteristics, both study moderators produced low between-study variance and explained moderate portions of variance.

DISCUSSION

Sedentary behaviour research is expanding rapidly and there are calls for more behaviour change interventions, particularly those that might have public health impact [30, 31]. The purpose of this paper, therefore, was to provide a quantitative synthesis of interventions that were designed to reduce sedentary behaviours in young people. A small but significant effect was found, but the effect appears to be robust given the large fail-safe N. Moreover, a small effect, if affecting a large population, which screen time probably does, may have high impact at the level of population health.

The small effect may be due to several factors. First, there may be real difficulties in changing sedentary behaviours that have a strong habitual component. Most of the studies focussed on changing TV or screen-time behaviours. TV viewing is the most prevalent leisure-time behaviour with mean estimates around 2-3 hours per day, and approximately 25% of girls and 30% of boys watching more than 4 hours per day [2]. Although this suggests there is ‘room for change’, it may also reflect strong preferences resistant to change. More pilot work is needed to gather views of what young people feel about their screen time and whether they would be willing to change as well as how they might change.

Second, behaviour change may be difficult due to strong environmental cues. Significant sedentary time is undertaken in activities such as screen time and motorised transport. Screen time is highly attractive, with greater availability of wide screen TV sets, high definition pictures, and wider choice of channels and programmes. The ability of computers to operate several platforms, such as music, films, social networking and internet means that their use will only increase. Such changes, often occurring at a rapid pace, may make behaviour change interventions of this type particularly challenging.

Third, interventions often target one or two sedentary behaviours. It is highly unlikely that any reduction in, say, computer use, will be directly replaced with only light or moderate physical activity. It is probable that some time will allocated to other sedentary behaviours, such as music, talking or sedentary hobbies.

Results of the meta-analysis showed some trends for the effects of moderators. However, the number of studies is very small for this type of analysis and caution must be exercised in their interpretation. Nevertheless, there are two trends worth following up in future. First, community setting interventions had a

higher effect size. This only involved four studies and the community element was not uniform. The recruitment of children via families, and the involvement of parents may be more important than the setting. Second, a higher effect was seen for studies assessing sedentary behaviour through a combination of objective and self-report methods. Objective methods, such as accelerometers, will provide more robust estimates of total sedentary time than self-report. However, the latter will provide important behaviour-specific estimates of sedentary time, such as sedentary socialising and technologically-oriented sedentary behaviours. Combining the two may be the optimal solution.

The evidence presented in this meta-analysis suggests that sedentary behaviour change is possible. However, studies did not report intervention fidelity (how well the intervention was delivered) and process evaluations were lacking. These factors make it quite difficult to ascertain exactly what was done and what might need to change in future interventions. Such approaches would have been very helpful in making better sense of why moderation effects were largely unclear.

Limitations of this meta-analysis include the small numbers of studies, with some excluded due to lack of suitable data for the calculation of effect sizes. Moreover, the studies included were often small (nine had sample sizes less than 100), and all but two were targeted exclusively at children rather than adolescents. Only four studies had follow-up data.

In conclusion, this meta-analysis shows that interventions produce a small but significant reduction in sedentary behaviour – mainly screen-based behaviours – in children, with preliminary data showing that community-based interventions and those assessing sedentary behaviour with a combination of objective and self-report methods being suggestive of larger effects. Future interventions need to build on

pilot work that takes into account the views of young people and families, that involves process evaluation and assessment of intervention fidelity, and has longer follow up with larger samples.

Conflict of Interest Statement: The authors have no conflict of interest to disclose.

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Table 1. Study Characteristics meeting Inclusion Criteria

			Intervention				Participant			Study		
Study	**Type**	**Design**	**Time (Months)**	**Follow-Up**	**Focus**	**Delivery**	***N***	**Age (Years)**	**Funding**	**Measure**	**Country**	**Effect (*g*)**
Dennison et al, 2004	Education	TB	3	No	C	Weekly	163	3-5	Yes	SR	US	-0.23
Epstein et al., 1999	Community	NTB	2	Yes	C	Weekly	76	8-12	Yes	SR	US	-0.11
Epstein et al. 2002	Community	NTB	1	No	C	Other	13	8-12	NR	C	US	-1.12
Epstein et al. 2008	Clinical	NTB	4	No	C	Monthly	70	4-7	Yes	O	US	0.08
Faith et al., 2001	Community	TB	1	No	C	Other	10	8-12	Yes	O	US	-3.74
Ford et al., 2002	Counseling	TB	1	Yes	S	Other	28	7-12	Yes	C	US	-0.21
Goldfield et al., 2006	Community	NTB	1	No	C	Bi-weekly	30	8-12	Yes	C	Canada	-0.55
Gortmaker et al., 1999	Education	TB	4	No	C	Other	1295	12-14	Yes	SR	US	-0.28
Kipping et al., 2008	Education	TB	2	No	C	Other	604	9-10	Yes	SR	UK	-0.07
Lubans et al., 2008	Education	TB	1	Yes	C	Weekly	116	14-15	NR	C	Australia	-0.28
Robinson et al., 1999	Education	TB	2	No	C	Other	92	8.9	Yes	C	US	-0.27
Robinson et al., 2003	Education	TB	1	No	C	Other	61	8-10	Yes	C	US	-0.45
Saelens et al., 1998	Lab	NTB	1	No	C	Other	14	8-12	Yes	O	US	-0.05
Sahota et al., 2002	Education	NTB	3	No	C	Other	636	7-11	Yes	SR	UK	0.00
Salmon et al., 2008	Education	NTB	3	Yes	C	Weekly	311	10.8	Yes	C	Australia	-0.04
Simon et al., 2004	Clinical	NTB	4	No	C	Weekly	954	11.7	Yes	SR	France	-0.30
Spurijt-Metz et al., 2008	Education	TB	1	Yes	C	Other	666	12.5	Yes	SR	US	-0.01

Note: Design: NTB = Non-Theory Based; TB = Theory-Based. Time: 1= 0-4 months; 2= 5-8 months; 3= 9-12 months; 4= greater than 12 months. Focus: S = Sedentary Behaviours; C= Combined (Sedentary, Physical Activity, and/or Nutrition). Funding: NR = Not Reported. Measure: SR = Self Report (Child and/or Parent); O = Objective Measure; C = Combined Self Report and Objective Measure.

Table 2. Sedentary Intervention Moderator Statistics

		Effect Size Descriptive Statistics				Null Test	Heterogeneity Statistics		
	k	***g***	***SE***	s^2	**95% *C.I.***	***Z***	***Q***	τ^2	I^2
Random Effects Model[A]	**17**	**-0.192**	**0.056**	**0.003**	**(-.303,-.082)**	**-3.404***	**43.48***	**0.025**	**63.21**
Intervention Characteristics[B]									
Intervention Type							5.000		
Clinical	2	-0.198	0.151	0.023	(-.494,.098)	-1.311		0.044	59.30
Community	4	-0.612	0.202	0.041	(-1.01, -.216)	-3.029*		0.605	81.78
Counseling	1	-0.220	0.419	0.175	(-.1.04,.600)	-0.526		0.000	0.000
Education	9	-0.141	0.075	0.006	(-.288, 0.06)	-1.885		0.010	50.31
Lab	1	-0.055	0.405	0.164	(-.848,.739)	-0.135		0.000	0.000
Intervention Design							0.006		
Non-Theory Based	7	-0.203	0.100	0.010	(-.400,-.007)	-2.025*		0.046	68.14
Theory Based	10	-0.194	0.076	0.006	(-.342,-.045)	-2.557*		0.024	63.40
Intervention Time (Months)							2.762		
0-4	8	-0.314	0.110	0.012	(-.530,-.097)	-2.843*		0.002	72.19
5-8	3	-0.143	0.123	0.015	(-.384,.099)	-1.158		0.167	0.000
9-12	3	-0.069	0.111	0.012	(-.286,.148)	-0.624		0.000	0.000
>12	3	-0.235	0.111	0.012	(-.453.-.017)	-2.110*		0.000	18.69
Intervention Follow-up							1.481		
No	12	-0.235	0.066	0.004	(-.365,-.105)	-3.549*		0.032	69.79
Yes	5	-0.087	0.102	0.010	(-.287, .112)	-0.856		0.000	0.000
Delivery							1.662		
Weekly	6	-0.215	0.095	0.009	(-.402,-.028)	-2.258*		0.013	44.72
Biweekly	1	-0.547	0.413	0.170	(-1.36,.262)	-1.325		0.000	0.000
Monthly	1	0.082	0.294	0.087	(-.495,.660)	0.280		0.000	0.000
Other	9	-0.191	0.082	0.007	(-.351,-.030)	-2.328*		0.043	75.98

Note. A=Total Q-value used to determine heterogeneity; B=Between Q-value used to determine significant differences between moderators. *k* = number of effect sizes. *g* = Effect size (Hedges' *g*). *SE* = Standard Error. S*2* = variance. 95% *C.I.*= Confidence Intervals (lower limit, upper limit). Z = test of the null hypothesis. τ^2 = Between study variance in Random Effects Model. I^2 = Total variance explained by moderators. *p $\leq$ .05

Table 3. Sedentary Study Moderator Statistics

		Effect Size Descriptive Statistics				Null Test	Heterogeneity Statistics		
	K	***g***	***SE***	s^2	**95% *C.I.***	***Z***	***Q***	τ^2	I^2
Random Effects Model[A]	**17**	**-0.192**	**0.056**	**0.003**	**(-.303,-.082)**	**-3.404***	**43.48***	**0.025**	**63.21**
Study Characteristics[B]									
Outcome measure							1.491		
Combination	7	-0.303	0.106	0.011	(-.510,-.096)	-2.864*		0.045	54.18
Objective	3	-0.144	0.223	0.050	(-.581,.292)	-0.611		0.803	85.04
Self-Report	7	-0.146	0.077	0.006	(-.297,.004)	-1.902		0.013	64.20
Country							2.783		
Australia	2	-0.120	0.156	0.024	(-.425, .186)	-0.768		0.005	18.16
Canada	1	-0.547	0.412	0.170	(-1.35, .260)	-1.329		0.000	0.000
France	1	-0.303	0.184	0.034	(-.664, .058)	-1.647		0.000	0.000
United Kingdom	2	-0.034	0.134	0.018	(-.298, .229)	-0.256		0.000	0.000
United States	11	-0.242	0.082	0.007	(-.402,-.082)	-2.958*		0.046	63.21

Note. A=Total Q-value used to determine heterogeneity; B=Between Q-value used to determine significant differences between moderators. *k* = number of effect sizes. *g* = Effect size (Hedges' *g*). *SE* = Standard Error. S*2* = variance. 95% *C.I.*= Confidence Intervals (lower limit, upper limit). *Z* = test of the null hypothesis. τ^2 = Between study variance in Random Effects Model. I^2 = Total variance explained by moderator. *p $\leq$ .05