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Review article

Sedentary behaviour and risk of anxiety: A systematic review and meta-analysis

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ABSTRACT

Objective: This research synthesis sought to determine the magnitude of the association between sedentary behaviour (sitting time) and anxiety.
Evidence acquisition: A comprehensive literature search of eight electronic databases (and a manual search) identified 13 observational studies that met inclusion criteria (22 effect sizes; total n = 70,425). Pooled mean effects were computed using inverse-variance weighted random effects meta-analysis and moderation by study and population characteristics were tested using random effects meta-regression.
Evidence synthesis: Sedentary behaviour was associated with an increased risk of anxiety for non-adjusted effect sizes (k = 7, OR = 1.33 [95% CI: 1.14, 1.55]) and effect sizes adjusted for sociodemographic and health-related factors (k = 11, OR = 1.48 [95% CI: 1.25, 1.75]). There was no evidence of publication bias in the results. The regression models showed that effect sizes were not moderated by age or gender. However, there was some evidence of moderation by study quality and measurement of sedentary behaviour and anxiety. Measures of sitting time showed larger associations than measures of screen time, and measures of anxiety symptoms showed larger associations than measures of anxiety disorders.
Conclusion: The research synthesis provides evidence that sedentary behaviour has a small positive association with anxiety, after controlling for sociodemographic and other health-related factors. Study limitations include low statistical power in meta-regression models and heterogeneity in measures of anxiety and sedentary behaviour. Findings might be of interest to health care professionals developing health care initiatives to reduce risk of anxiety.

1. Introduction

Lifestyle is an important and often underestimated risk factor for psychopathologies (Walsh, 2011). Indeed, research syntheses provide compelling evidence that low levels of physical activity, poor diet, and tobacco use are associated with an increased risk of anxiety and depressive disorders (Lai et al., 2013; Liu et al., 2016; Rebar et al., 2015; Schuch et al., 2016; Schuch et al., 2018; Taylor et al., 2014). Until recently, the term *sedentary behaviour* had often been used to describe low levels of physical activity, but is now recognized as a distinct behaviour category that incorporates activities with low energy expenditure. Indeed, many individuals who achieve the recommended minimum levels of physical activity (see World Health Organization, 2010, for guidelines) are also highly sedentary, spending a considerable amount of time sitting when at home or at work (Mansoubi et al., 2014). Sedentary behaviour is defined as "any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Tremblay et al., 2017, p. 9) and includes activities such as television viewing, driving, seated electronic gaming and computer time, reading, and study time.

Time spent in sedentary behaviour is associated with chronic disease and premature death, irrespective of the level of physical activity (Biswas et al., 2015; also see Ekelund et al., 2016). Moreover, excessive sedentary behaviour has been linked to an increased risk of various mental health problems including depression, bipolar disorder and schizophrenia (Vancampfort et al., 2016, 2017; Stubbs et al., 2016, 2018; Zhai et al., 2015). Less is known about how sedentary behaviour might relate to anxiety. Anxiety is an unpleasant emotional state characterised by feelings of fear and distress, and is often accompanied by physiological symptoms (Craske and Stein, 2016). Individuals with anxiety disorders are excessively fearful and avoidant of perceived

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threats (e.g., social situations and unfamiliar locations) and the anxiety response is out of proportion to the actual risk or danger posed (Craske and Stein, 2016). Anxiety is the sixth leading cause of disability in high-income and middle-income countries, accounting for 390 disability-adjusted life years per 100,000 persons in 2010 (Baxter et al., 2014). The global prevalence of anxiety disorders is estimated at 7.3 percent (Baxter et al., 2013), is more common in women than men, and is most prevalent in persons aged 15–34 years (Baxter et al., 2014).

Sedentary behaviour might be expected to relate to anxiety through biological or psychosocial pathways. For example, excessive sedentary time is associated with social isolation, adverse health conditions (including major non-communicable diseases), and sleep disturbance (Hale and Guan, 2015; Lee et al., 2012) that have all been found to relate to an increased risk of anxiety disorders (Chou et al., 2011; Monti and Monti, 2000; Tully et al., 2013). As far as we are aware, only one previous systematic review has been published that attempted to synthesise research findings on sedentary behaviour and anxiety (Teychenne et al., 2015). The review synthesised findings from nine studies and concluded that there was "inconsistent evidence for the relationship between screen time, television viewing, computer use, and anxiety risk" (Teychenne et al., 2015, p. 1). Since the publication of this systematic review, interest has grown in understanding the potential role of sedentary behaviour in anxiety risk, and more research is now available meaning that it is possible, and timely, to synthesise research findings using quantitative techniques (i.e., meta-analysis).

The present meta-analysis sought to explore the association between sedentary behaviour and risk of anxiety (anxiety symptoms or the presence of an anxiety disorder). To best interpret the size of the effect we explore non-adjusted and multivariable-adjusted associations in separate analyses. This is important because sedentary behaviour might be confounded with other sociodemographic or health-related factors. For instance, sedentary behaviour tends to be higher in persons from low socioeconomic backgrounds and low socioeconomic conditions foster a greater risk of anxiety disorders (Gallo and Matthews, 2003). Therefore, any connection between sedentary behaviour and anxiety might be attributable to these other potential confounds. Multivariable-adjusted effect sizes provide a better indication of the independent contributions of the health behaviour of interest and can provide useful indirect information on whether multimodal interventions might be more effective than unimodal interventions (targeting a single lifestyle factor) in reducing risk of anxiety. The present research aimed to investigate these associations through quantitative analysis of published data.

2. Evidence acquisition

This research synthesis was prepared in accordance with the PRISMA statement for the reporting of systematic reviews and meta-analyses (Moher et al., 2009).

2.1. Eligibility criteria

Observational studies assessing an association between sedentary behaviour and anxiety were eligible for inclusion. Included studies needed to report how sedentary behaviour was assessed and include an assessment of sitting time, television time, seated computer time, or total screen time. Behaviours associated with sedentary behaviour (e.g., social media use, internet use) were not included if sedentary time (sitting) could not be separated from non-sedentary time (e.g., smart phone use). Studies using the term "sedentary behaviour" to describe "low physical activity" were also excluded. Included studies needed to assess either the presence of an anxiety disorder or reported anxiety symptoms. General measures of psychological distress and measures combining anxiety with other mental health symptoms (e.g., depression) were not included.

2.2. Search strategy

A systematic search of eight electronic databases covering all dates up to the search date was conducted in February 2018. The databases searched were Web of Science; MEDLINE via Ovid; PsycINFO; SPORTDiscus and CINHAL via EBSCO; PubMed; Science Direct; Scopus; PsycARTICLES; and ProQuest. The search terms used were: sedent* [or "sedent* lifestyle" / or sitt*/ or stationary/ or video gam*/ or gam*/ or console/ or television/ or tv/ or media/ or internet/ or computer*/ or pc/ or Facebook/ or "social media"/ or web/ or online/ or "screen time"/ or "read* time"] AND anxiety [or anxious/ or worry/ or worrie*/ or panic/ or phobia/ or agoraphobi*/ or "generali*ed anxiety disorder"/ or "obsessive compulsive disorder"/ or "post-traumatic stress disorder"/ or social* anx*/ or social* phob*] (see Supplementary File S1 for an example of the full search strategy). A single researcher screened the titles, keywords and abstracts of each study for eligibility. If a study appeared to meet eligibility criteria, or if the relevance of the study was uncertain, the full text was obtained. Introduction sections and reference lists of identified studies were then manually searched for further relevant articles by two researchers (using a snowball search strategy). Full texts of all identified studies were then independently assessed for inclusion by two researchers. Discrepancies were resolved through discussion between the two researchers.

2.3. Data extraction and study quality

Data extraction was performed by two researchers. Information extracted from each study included the sample size, age and sex of participants, the nation where the study was completed, a description of the sample population, the measures used to assess anxiety and sedentary behaviour, effect size estimates, and information used to assess risk of bias (study quality). There were two instances in which the sex of participants was not reported in the published article and this information was sourced from the study cohort website. There was also one instance in which the effect size of interest was not reported in the published article. The corresponding author was contacted via email and provided information on the missing effect size. Study quality was assessed using the AXIS tool (Downes et al., 2016). This scale is designed for non-experimental research and includes 20 items that measure aspects of study quality including justification of sample size, representativeness of the sample, a description of non-responders, use of validated measures, description of statistical methods, discussion of non-response bias, and reporting of funding and conflicts of interest (see Supplementary File S2 for computation table). Each study was assigned a score from 0 to 20 with higher scores reflecting lower risk of bias (higher study quality).

2.4. Data analysis

Calculation of the pooled mean effect size (odds ratio [OR] and 95% confidence interval [CI]) was computed using inverse-variance weighted random effects meta-analysis. The inverse-variance method involves each included effect size being given a weight equal to the inverse of its variance and allows more weight to be given to more precise studies (Borenstein et al., 2009). Effect sizes were taken directly from the published studies and were converted to odds ratios within analyses using standard formulae (Borenstein et al., 2009). Where a study reported standardized regression coefficients (that do not convert using standard formulae), these were first converted to r (correlation coefficient) using the formula: $r = 98\beta + .05\lambda$, where λ is an indicator variable that equals 1 when β is non-negative and 0 when β is negative (Peterson and Brown, 2005). In cases where multiple effect sizes were available (e.g., for TV viewing time and total screen time) effect sizes were extracted and averaged within studies resulting in one effect size per sample. Non-adjusted and multivariable-adjusted estimates (in most instances effect sizes were adjusted for age, gender, education, body