**Sedentary behavior and depression among community-dwelling adults aged ≥50 years: results from the Irish Longitudinal Study on Ageing**

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**Abstract**

*Background:* Sedentary behavior (SB) may be a risk factor for depression in middle- and old age adults. The aim of this study was to examine cross-sectional and longitudinal relationships between SB and depression in a large national sample of Irish people aged 50 and older taking into account a wide range of previously identified influential factors.

*Methods:* Data from the Irish Longitudinal Study on Ageing survey were analyzed (wave 1: 2009-2011, wave 2: 2012-2013). Depression was assessed with the Center for Epidemiologic Studies Depression scale. Total weekday SB and control variables were self-reported. Multivariable logistic regression and mediation analysis were conducted to assess the associations.

*Results:* The final sample consisted of 6903 individuals aged ≥50 years (63.6±9.2years; 52.1% female). After full adjustment for age, gender, social class, current smoking, physical activity, mobility, pain, cognition, chronic physical conditions, disability, anxiety, loneliness, and social network, the association between SB and depression was not statistically significant (OR=1.06; 95%CI=0.60-1.89). Mediation analysis showed that the association is explained by social network (mediated percentage 23.1%), physical activity (20.3%), loneliness (13.2%), chronic physical conditions (11.1%), and disability (7.9%). Cross-sectional analysis showed that SB is significantly associated with depression even after full adjustment.

Limitations: SB was self-reported.

*Conclusions:*Factors closely linked with SB such as social isolation, loneliness, physical inactivity, chronic physical conditions, and disability may play a major role in depression among middle-aged and older people. Lifestyle interventions focusing on reductions in depression in this population need to consider these factors.

**Keywords:** depression; sitting; physical activity; loneliness; social isolation

**Introduction**

Depression is one of the leading causes of years lived with disability worldwide (Whiteford et al., 2015). It is associated with an increased risk for suicide (Hawton et al., 2013) and cardio-metabolic diseases (Stubbs et al., 2017; Vancampfort et al., 2016; Vancampfort et al., 2015), which are the leading causes of premature death in this vulnerable population (Correll et al., 2017), in particular in middle- and old age people. For example, a recent meta-analysis demonstrated that depression later in life is associated with increased risk of all-cause (risk ratio = 1.34; 95%CI = 1.27 to 1.42) and cardiovascular mortality (risk ratio = 1.31; 95% CI = 1.20 to 1.43) (Wei et al., 2019).

The current focus of treatment for depression consists of antidepressants and psychotherapy. While antidepressants are more efficacious than placebo (Cipriani et al., 2018), only about half of those treated achieve a clinically relevant response, i.e. a decrease of 50% or more on depressive symptoms (Pigott, 2015). Psychotherapy, such as cognitive behavioral therapy, has a small-to-moderate effect on depressive symptoms (Cuijpers et al., 2010), but the impact of psychotherapy on the physical co-morbidity is unknown. Thus, there is a need for improved understanding of risk factors associated with depression onset and its physical co-morbidity so that more efficacious treatment strategies can be developed and therapeutic outcomes optimized (Firth et al., 2019a). To this end, there is growing recognition that lifestyle behaviors, such as physical inactivity (i.e. not complying with international physical activity recommendations) partially contribute to the risk of developing depression (Mammen and Faulkner, 2013; Stubbs et al., 2016b). Being physically active, in its turn, can be an effective strategy for preventing (Schuch et al., 2018) and treating depression (Stubbs et al., 2018a, Schuch et al., 2016) and its physical co-morbidity (Knapen et al., 2014).

More recently, interest has grown in sedentary behavior as an independent risk factor for depression. Sedentary behavior refers to any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture (Sedentary Behaviour Research, 2012; Tremblay et al., 2017). A meta-analysis in adults demonstrated that the relative risk of depression for the highest versus non-occasional/occasional sedentary behavior was 1.31 (95% CI 1.16 to 1.48) when pooling 13 cross-sectional studies and 1.14 (95% CI = 1.06 to 1.21) when pooling 11 longitudinal studies (Zhai et al., 2014). Meta-analytical data specifically in middle-aged (50-64 years) as well as older people (≥65 years) are however missing. Being sedentary is increasingly being recognized as an important health risk factor in this age group and this is mainly due to declining physical capacities (Mañas et al., 2017). A previous multi-national cross-sectional study in middle- and old-age people demonstrated that being sedentary for 8 or more hours was associated with a 1.72 (95% confidence interval = 1.21 to 2.45) times higher odds for depression compared to those being sedentary less than 8 hours per day (Stubbs et al., 2018b). This multinational study also demonstrated that exploring associations between sedentary time and depression in middle-aged and older people is important since cognition and anxiety were important mediators only in this age group, while mobility and pain/discomfort explained 50% of the association (Stubbs et al., 2018b). However, since data were cross-sectional, the directionality of the relationships could not be deduced with certainty in the study.

Focusing on middle-aged and older adults is also important because populations are ageing worldwide and physical activity levels naturally decline with age (Sallis et al., 2016). It is now well established that extended sedentary time has a stronger detrimental effect in those who are less physically active (Ekelund et al., 2016; Patterson et al., 2018).

Thus, the aim of this study was to examine cross-sectional and longitudinal relationships of the time spent sedentary and depression in a large national sample of Irish people aged 50 and older, taking into account a wide range of previously identified confounders, including chronic physical conditions and disability (Stubbs et al., 2018c). Exploring these associations in the Irish population is of high relevance since previous research using data from the Irish Longitudinal Study on Ageing (TILDA) indicated that depression is a major problem in people aged ≥50 years with a prevalence of 12% (Briggs et al., 2018). Previous research using the TILDA survey also already demonstrated that meeting recommended levels of moderate to vigorous physical activity and walking were associated with significantly lower odds of concurrent depression, and non-significantly reduced odds of the development of depression over two years (McDowell et al., 2018a). We hypothesized that higher levels of sedentary behavior will be cross-sectionally and longitudinally associated with a higher odds for depression.

**Methods**

***The survey***

We analyzed data from two consecutive waves of the TILDA survey. Full details of the survey including its sampling methods have been described in detail elsewhere (Barrett et al., 2011; Kenny et al., 2010; Nolan et al., 2014). Briefly, this was a community-based survey of older adults residing in Ireland conducted by Trinity College Dublin. The first wave (W1) or the baseline survey was conducted between October 2009 and February 2011, and the second wave (W2) was undertaken between April 2012 and January 2013. The target sample consisted of all individuals living in private households aged 50 and over in Ireland. Clustered random sampling was used to obtain nationally representative samples. The first wave excluded institutionalized individuals, anyone with known dementia or anyone unable to personally provide written informed consent to participate due to severe cognitive impairment. Trained personnel conducted interviews with the use of Computer Assisted Personal Interviewing (CAPI). For sensitive questions, participants were asked to fill in a self-completion questionnaire (SCQ), which was returned after the interview. The response rate of W1 was 62%, and of those who participated in W1, 84% returned the SCQ (Kearney et al., 2011; Whelan and Savva, 2013). Sampling weights were generated with respect to age, sex and educational attainment to the Quarterly National Household Survey 2010. Ethical approval for TILDA was obtained by the Faculty of Health Sciences Ethics Committee of Trinity College Dublin. Written informed consent was obtained from all participants.

***Sedentary behavior***

In order to assess sedentary behavior, participants were asked the sitting time question of the widely validated International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003): “During the last 7 days, how much time (per day) did you spend sitting on a week day?”. This included time spent at work, at home, while doing course work during leisure time, and commuting, and could have included time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television. This variable was used as a continuous variable (hours per day) and also as a categorical (0≤4h, 4≤8h, ≥8h) variable. The cut-offs for the categorical variable were selected based on past literature (Ekelund et al., 2016). Previous research in older adults from the UK (Cleland et al., 2018) shows good convergent validity of the IPAQ sitting time item with sedentary time measured with an Actigraph GT3X+ on weekdays (r = 0.70) and fair levels of validity (r = 0.26) on weekend days.

***Depressive symptoms***

The same method of assessment for depression at W1 and W2 were employed. The scale used for depressive symptoms was the 20-item Center for Epidemiologic Studies Depression (CES-D) (Radloff, 1977), which assesses symptoms experienced in the seven days preceding the survey. The 20 items were scored on scales from 0 (rarely or none of the time, less than one day in the week) to 3 (most or all of the time, five to seven days in the week) with four items reverse coded (recoded so that all items were based on the same scale). Scores were summed to create a scale that ranged from 0 to 60, with higher scores indicating more depressive symptoms. The validity of the CES-D scale as a measure of depression in community-dwelling older adults has been well-documented in older populations (Cosco et al., 2019). A positive screen for depression was defined as a cut-off score ≥16. This cut-off point has been associated with 100% sensitivity and 88% specificity for major depression in community-dwelling older adults (Beekman et al., 1997).

***Control variables***

The selection of control variables was based on past literature (Stubbs et al., 2018a). All control variables were assessed at W1. Sociodemographic characteristics included sex, age, and social class. The European Socioeconomic Classification scheme was used to classify participants into 7 categories of social class (Rose and Harrison, 2007). Specifically, the categories included professional workers, managerial and technical, non-manual, skilled manual, semi-skilled, unskilled, and farmers. Those who were not in paid employment were categorized as “not working”.

Other control variables included smoking, physical activity, mobility, pain, cognitive function, chronic physical conditions, disability, anxiety, loneliness, and social network. Smoking status was categorized as current smoking or not (i.e., quit or never). Physical activity was measured with the IPAQ-SF. Participants were classified as having low levels of physical activity if they did not meet the WHO physical activity guidelines (i.e., at least 150 min/week of moderate physical activity or 75 min/week of vigorous physical activity or 600 metabolic equivalents (MET) min of weekly moderate-to-vigorous physical activity) (McDowell et al., 2018b). Mobility was assessed with the Timed Up-and-Go (TUG) test, a well-established mobility test (Donoghue et al., 2018). Participants stood up, walked 3 meters at normal pace to a line on the floor, turned around, walked back to the chair and sat down, and the time it took for the participant to perform these series of action was timed with a stopwatch. Those who answered affirmatively to the question “are you often troubled with pain” were considered to have pain. Cognitive function was assessed with the Mini-Mental State Examination (MMSE) (Folstein et al., 1975). This scale ranges from 0-30 with higher scores indicating higher cognitive function. Chronic medical conditions were assessed by the question “Has a doctor ever told you that you have any of the conditions on this card?” The total number of the following 14 conditions were summed: chronic lung disease (chronic bronchitis or emphysema), asthma, arthritis, osteoporosis, cancer, stomach ulcer, varicose ulcer, cirrhosis, hypertension, diabetes, high cholesterol, cerebrovascular disease (stroke or transient ischemic attack), heart disease (angina, heart attack, congestive heart failure, heart murmur, abnormal heart rhythm, or other heart disease), eye disease (cataracts, glaucoma, age-related macular degeneration, or other eye disease). Difficulties with six types of activities of daily living (ADL) (dressing, walking, bathing, eating, getting in or out of bed, and using the toilet) were assessed by asking participants to indicate whether they had difficulty performing these activities. ADL disability was defined as having difficulty with at least one of these ADLs. Anxiety symptoms were assessed with the anxiety subscale of the Hospital Anxiety and Depression Scale (HADS-A) (Zigmond and Snaith, 1983). A positive screen for generalized anxiety disorder was defined as a score of ≥8. This cut-off point has been associated with 89% sensitivity and 75% specificity for the screening of generalized anxiety disorder (Bjelland et al., 2002; Olssøn et al., 2005).The short form of the University of California, Los Angeles (UCLA) Loneliness Scale (Russell et al., 1980) was used to assess feelings of loneliness, and this was a scale ranging from 3-9 with higher scores representing higher levels of loneliness. In accordance with a recent study, a score of 4–9 was categorized as feeling lonely while a score of 3 (i.e., replying ‘hardly ever’ to all of the questions) was classified as not feeling lonely (Stickley et al., 2017). Social networks were assessed with the Berkman-Syme Social Network Index (SNI) (Berkman and Syme, 1979), which assesses a person's degree of social integration by: marital/partnership status (married/ with partner versus not), sociability (number and frequency of contact with children, close relatives, and close friends), and church group membership or membership in community organizations. Participants were categorized as ‘most isolated’, ‘moderately isolated’, ‘moderately integrated’, and ‘most integrated’.

***Statistical analysis***

A total of 8163 people aged ≥50 years participated in W1. Of these individuals, 6903 returned the SCQ. We restricted our analysis to those who returned the SCQ as some information used in the current analysis were obtained via this mode (e.g., financial strain, loneliness). Thus, the total sample size for the cross-sectional analysis was 6903. Of these individuals, 6098 were followed up at W2. Among these individuals, 533 had depression at W1 and 82 had missing information on depression at W1. These individuals were deleted from the longitudinal analysis to obtain a sample that was free of depression at baseline. Thus, the sample for the longitudinal analysis consisted of 5483 individuals.

The analysis was done with Stata version 14.1 (Stata Corp LP, College Station, Texas). First, using data only from W1 (cross-sectional analysis), we conducted multivariable logistic regression analysis to assess the association between sedentary behavior (exposure) and depression (outcome). Next, we conducted longitudinal analysis among those who were free of depression at baseline. This consisted of conducting a multivariable logistic regression analysis with depression at W2 as the outcome with baseline (W1) time spent in sedentary behavior being the exposure variable among those who were free of depression at baseline. For these analyses, we used both the continuous and categorical sedentary behavior variables. Two models were constructed: Model 1 - adjusted for sex and age; Model 2 adjusted for sex, age, social class, smoking, physical activity, mobility, pain, cognitive function, number of chronic physical conditions, disability, anxiety, loneliness, and social network.

We also conducted mediation analysis to assess the degree to which social class, smoking, physical activity, mobility, pain, cognitive function, chronic physical conditions, disability, anxiety, loneliness, social network influence the association between sedentary behavior and incident depression longitudinally. We only conducted this analysis using longitudinal data as mediation analysis is more meaningful with longitudinal than cross-sectional data (Maxwell and Cole, 2007). The stata *khb* (Karlson Holm Breen) command in Stata was used for the mediation analysis (Breen et al., 2013). This method can be applied in logistic regression models and decomposes the total effect of a variable into direct and indirect effects. Using this method, the percentage of the main association explained by the mediator can also be calculated (mediated percentage). We used the continuous sedentary behavior variable (i.e., hours/day of sedentary behavior) for this analysis. Each mediator was included in the model individually. The mediation analysis controlled for sex and age.

All variables were assessed at W1 with the exception of depression at W2 and were included in the models as categorical variables apart from mobility, cognitive function, and number of chronic physical conditions. (continuous variables). Complete case analysis was done. The sample weighting and the complex study design including clustering within households were taken into account to obtain nationally representative estimates using the Stata *svy* command. Using the ado-command svylogitgof that allows to account for the complex survey design, model fit was evaluated with the F-adjusted mean residual test, and this test suggested that final models were a good fit for the data. Results are expressed as odds ratios (ORs) and 95% confidence intervals (95%CIs). A *p*-value <0.05 was considered to be statistically significant.

**Results**

The baseline characteristics are provided in **Table 1** (n=6903). The mean (SD) age was 63.6 (9.2) years and 52.1% were females. The prevalence of depression at W1 was 10.0%. The mean (SD) time spent in sedentary behavior was 4.9 (2.6) hours/day, and 34.0%, 51.3%, and 14.7% spent 0-<4 hours/day, 4-<8 hours/day, and ≥8 hours/day in sedentary behavior. The prevalence of male sex, older age, higher social class, smoking, low physical activity, pain, disability, anxiety, loneliness, and low levels of social network tended to be higher in those who spent greater time in sedentary behavior. Furthermore, those who engage in greater time sedentary were more likely to have mobility limitations and greater number of chronic physical conditions. The baseline characteristics by depression status at baseline are shown in Table S1 of the supplementary material. People with depression were more likely to engage in unhealthy behavior (e.g., smoking), while indicators of mental and physical health were also worse. The prevalence of depression increased linearly with increasing time spent in sedentary behavior regardless of sex and age (**Figure 1**). Overall, the prevalence of depression was 7.8%, 10.4%, and 13.1% for 0-<4h/day, 4-<8h/day, and ≥8h/day of sedentary behavior, respectively. The prevalence of incident depression at two-year follow up also increased with increasing time spent in sedentary behavior at baseline (**Figure 2**). Overall, the prevalence of incident depression was 4.5%, 5.1%, and 6.3% for 0-<4 h/day, 4-<8h/day, and ≥8h/day of sedentary behavior.

The cross-sectional association between sedentary behavior and depression estimated by multivariable logistic regression is shown in **Table 2**. In the model only adjusted for sex and age (Model 1), compared to 0-<4 hours/day of sedentary behavior, 4-<8h/day and ≥8h/day were associated with 1.51 (95%CI=1.25-1.82) and 2.17 (95%CI=1.72-2.75) times higher odds for depression, respectively. There was only a slight attenuation in the ORs after full adjustment (Model 2) with the corresponding OR (95%CI) being 1.50 (1.13-2.00) and 1.88 (1.27-2.78), respectively. Furthermore, in Model 1, a one-hour increase/day in sedentary behavior was associated with a 1.10 (95%CI=1.07-1.13) times higher odds for depression, and this also remained significant after full adjustment (Model 2) (OR=1.08; 95%CI=1.04-1.13).

When the outcome was incident depression (longitudinal analysis), in Model 1, compared to 0-<4h/day of sedentary behavior, ≥8h/day was associated with a significant 1.46 (95%CI=1.01-2.10) times higher risk for incident depression. This became non-significant after full adjustment (OR=1.06; 95%CI=0.60-1.89). This loss of significance after full adjustment was also observed for a one-hour increase in sedentary behavior, where the OR (95%CI) was 1.08 (95%CI=1.03-1.13) and 1.05 (95%CI=0.97-1.13) in Model 1 and 2, respectively.

The results of the mediation analysis are shown in **Table 3**. Social network (mediated percentage 23.1%), physical activity (20.3%), loneliness (13.2%) and chronic physical conditions (11.1%) explained more than 10% of the association between baseline time spent in sedentary behavior and incident depression. Disability, pain, and smoking were also significant mediators but to a lesser extent.

**Discussion**

*General findings*

To the best of our knowledge, the current study is the first to examine cross-sectional and longitudinal relationships of the time spent sedentary and depression in a large national sample of people aged 50 and older. We found that sedentary behavior is associated with higher prevalence of depression cross-sectionally, and this association was significant even after adjustment for a variety of factors that have been reported to be associated with both sedentary behavior and depression. However, longitudinally, while baseline sedentary behavior was a significant predictor of depression onset after two years based on the sex- and age-adjusted analysis, this was no longer significant after full adjustment. Mediation analysis showed that factors such as social network, physical activity, loneliness, chronic physical conditions, and disability may play a role in the longitudinal association. The significant and strong association found in the cross-sectional study even after full adjustment may be indicative of reverse causality where depressed individuals may be more likely to be sedentary due to factors such as lack of energy and fatigue.

Longitudinal associations between depression, social isolation, loneliness, physical inactivity and sedentary behavior and chronic physical conditions are increasingly being recognized in middle-and old age adults. One of the reasons is that this age group is at a higher risk for social isolation (Nicholson, 2012), feeling lonely (Ong et al., 2016), being physically inactive and sedentary (Sallis et al., 2016), and at a high risk for chronic conditions and disability (Courtin et al., 2017). In the English Longitudinal Study of Ageing, among 3,392 men and women aged ≥52 years, social isolation, but not loneliness, was related to physical inactivity over a 10 year time period (Kobayashi and Steptoe, 2018). Social isolation, particularly in depressed middle-aged and old age people, may reduce or remove any direct sense of obligation to stay well for loved ones, may exempt one from broader group-based social norms that promote health, and could result in a lack of instrumental or emotional social support that can help promote healthy behaviors (Kobayashi and Steptoe, 2018). For older adults who were lonely, social connections may still be in place despite the unpleasant affective experience of feeling alone (Kobayashi and Steptoe, 2018). A recent trial involving mostly middle-aged adults also demonstrated that baseline levels of social support predicted treatment response to depression, regardless of the type of treatment (Hallgren et al., 2017).

Social isolation and physical inactivity are in middle-aged and old age people often due to the presence of chronic physical conditions and disability (Rico-Uribe et al., 2016; Squires, 2015), which in turn is associated with feelings of depression (Stubbs et al., 2017). For example, compared to those with no depression, those with subsyndromal depression, brief depressive episode and depressive episode are significantly associated with 2.62, 2.14 and 3.44 times higher odds for multimorbidity, respectively (Stubbs et al., 2017). Vice versa, a previous meta-analysis demonstrated that the risk for depressive disorder is twice as high for people with multimorbidity compared to those without multimorbidity (RR=2.13; 95%CI=1.62-2.80; p<0.001) and three times greater for people with multimorbidity compared to those without any chronic physical condition (RR=2.97; 95%CI=2.06-4.27; p<0.001) (Read et al., 2017).

Our findings indicate that in order to prevent and treat the health risks associated with sedentary behavior and depression in middle and old age people, a multidisciplinary approach is needed. For example, campaigns should be designed to raise awareness about the growing problem of clustered sedentary behavior, physical inactivity, depression, social isolation and chronic physical conditions, and disability in middle-aged and old aged people. Public campaigns could raise awareness about the multidimensional problem, but these campaigns represent only a first step. Effective public health interventions are also needed. Four primary types of intervention programs have been tested to address for example social isolation and / or sedentary behavior: (a) those that increase opportunities for social contact (e.g., facilitating social recreation), (b) those that enhance social support (e.g., through buddy programs, e.g. going for a walk with a buddy), (c) those that focus on skills-building (e.g., enhancing non-verbal communication skills), and (d) those that address maladaptive social cognitions (e.g., cognitive behavioral therapy) (Cacioppo et al., 2015). With regards to the importance of considering chronic physical conditions, and disability in the relationship between sedentary behavior and depression, efforts are needed to improve the care of sedentary people with chronic diseases. Since older adults often wish to have one professional to take continuing responsibility for their overall care, and to consider their personal situation and preferences when advising about treatment decisions (Bayliss et al., 2008), primary health care professionals should regularly assess the presence of feelings of depression in particular in sedentary people with chronic diseases. Future research should explore the mental, physical and social outcomes of, for example, prescribing group-based physical activity in sedentary middle-aged and old age people with chronic diseases who also present with symptoms of depression.

Also other mechanisms could explain detrimental relationships of sedentary behavior and depression. For example, sedentary behaviors could displace time spent in moderate-to-vigorous physical activity, which is shown to reduce depressive symptoms and enhance mood. A review of 25 interventions found that acute bouts of uninterrupted sedentary behavior results in moderate and deleterious changes in insulin sensitivity, glucose tolerance, and plasma triglyceride levels, which could indirectly affect mood and well-being (Saunders et al., 2012). As sedentary behavior increasingly involves the use of screen-based devices, these activities could also contribute to sleep and mood disorders (Firth et al., 2019b). Moreover, because sedentary behavior predominantly occurs indoors, away from direct sunlight, there is the possibility that it might reduce vitamin D exposure. This in turn, may increase the likelihood of developing depression in later life (Briggs et al., 2019).

*Limitations*

The current findings should be interpreted in light of some limitations. First, sedentary behavior was assessed with a self-report measure, the accuracy of which has been questioned before (Soundy et al., 2014; Stubbs et al., 2016a). Objective measures (accelerometers-inclinometers) enable a more valid and reliable assessment of sedentary behavior (Grant et al, 2006). Second, we have not investigated context specific sedentary behaviors (e.g. TV viewing) which may provide important insights into the underlying relationships we observed. A longitudinal study in 40,569 Swedish adults (Hallgren et al., 2019) found a significant negative association between mentally-active sedentary behaviors such as reading and office work and reduced risk of incident major depressive disorder over a time span of 13 years (hazard ratio=0.74, 95% CI=0.58-0.94, p=0.018), while there was a non-significant positive relationship with passive sedentary behaviors such as watching television (hazard ratio=1.20, 95% CI=0.96-1.52, p=0.106). Future research should explore whether differential associations of passive and mentally-active sedentary behavior with depression are also observed in middle-aged and old age adults. Third, those who were lost to follow-up for the longitudinal analysis differed in some aspects from those who were followed (details are provided in Table S2 of the supplementary material). For example, those who were not followed were older and more likely to engage in unhealthy behaviors (e.g., smoking, low physical activity), and have worse health status (e.g., disability). Thus, some level of bias may have been introduced due to loss to follow-up. Finally, although the chronic physical conditions assessed in the TILDA were diverse and included many diseases that commonly occur in older age, there were other diseases that were not assessed. Thus, this should be taken into account when interpreting the results.

*Conclusion*

While sedentary individuals may be more likely to have (or to develop) depression, other factors that are closely linked with being sedentary and depressed such as social isolation, loneliness, physical inactivity, chronic physical conditions, and disability may play a major role in the longitudinal association.

**References**

Barrett, A., Savva, G., Timonen, V., Kenny, R., 2011. Fifty Plus in Ireland 2011: First results from the

Irish Longitudinal Study on Ageing (TILDA). Dublin: The Irish Longitudinal Study on Ageing.

Bayliss, E.A., Edwards, A.E., Steiner, J.F., Main, D.S., 2008. Processes of care desired by elderly

patients with multimorbidities. Family Practice 25, 287-293.

Beekman, A.T., Deeg, D.J., Van Limbeek, J., Braam, A.W., De Vries, M.Z., Van Tilburg, W., 1997.

Criterion validity of the Center for Epidemiologic Studies Depression scale (CES-D): results from a community-based sample of older subjects in The Netherlands. Psychological Medicine 27, 231-235.

Berkman, L.F., Syme, S.L., 1979. Social networks, host resistance, and mortality: a nine-year follow-up

study of Alameda County residents. American Journal of Epidemiology 109, 186-204.

Bjelland, I., Dahl, A.A., Haug, T.T., Neckelmann, D., 2002. The validity of the Hospital Anxiety and

Depression Scale: an updated literature review. Journal of Psychosomatic Research 52, 69-77.

Breen, R., Karlson, K.B., Holm, A., 2013. Total, direct, and indirect effects in logit and probit models.

Sociological Methods & Research 42, 164-191.

Briggs, R., McCarroll, K., O'Halloran, A., Healy, M., Kenny, R.A., Laird, E.J., 2019. Vitamin D deficiency is associated with an increased likelihood of incident depression in community-dwelling older

adults. Journal of the American Medical Directors Association 20, 517-523.

Briggs, R., Tobin, K., Kenny, R.A., Kennelly, S.P., 2018. What is the prevalence of untreated

depression and death ideation in older people? Data from the Irish Longitudinal Study on Aging.

International Psychogeratrics 30, 1393-1401.

Cacioppo, S., Grippo, A.J., London, S., Goossens, L., Cacioppo, J.T., 2015. Loneliness: Clinical import

and interventions. Perspectives on Psychological Science 10, 238-249.

Cipriani, A., Furukawa, T.A., Salanti, G., Chaimani, A., Atkinson, L.Z., Ogawa, Y., Leucht, S., Ruhe,

H.G., Turner, E.H., Higgins, J.P., 2018. Comparative efficacy and acceptability of 21 antidepressant drugs for the acute treatment of adults with major depressive disorder: a systematic review and network meta-analysis. The Lancet 16, 420-429.

Cleland, C., Ferguson, S., Ellis, G., Hunter, R.F., 2018. Validity of the International Physical Activity

Questionnaire (IPAQ) for assessing moderate-to-vigorous physical activity and sedentary behaviour of older adults in the United Kingdom. BMC Medical Research Methodology 18, 176.

Correll, C.U., Solmi, M., Veronese, N., Bortolato, B., Rosson, S., Santonastaso, P., Thapa-Chhetri, N.,

Fornaro, M., Gallicchio, D., Collantoni, E., Pigato, G., Favaro, A., Monaco, F., Kohler, C., Vancampfort, D., Ward, P.B., Gaughran, F., Carvalho, A.F., Stubbs, B., 2017. Prevalence, incidence and mortality from cardiovascular disease in patients with pooled and specific severe mental illness: a large-scale meta-analysis of 3,211,768 patients and 113,383,368 controls. World Psychiatry 16, 163-180.

Cosco, T.D., Lachance, C.C., Blodgett, J.M., Stubbs, B., Co, M., Veronese, N., Wu, Y.-T., Prina, A.M.,

2019. Latent structure of the Centre for Epidemiologic Studies Depression Scale (CES-D) in older adult populations: a systematic review. Ageing & Mental Health 1-5.

Courtin, E., Knapp, M., 2017. Social isolation, loneliness and health in old age: a scoping review. Health

and Social Care in the Community 25, 799-812.

Craig, C., Marshall, A., Sjostrom, M., Bauman, A., Booth, M., Ainsworth, B., Pratt, M., Ekelund, U.,

Yngve, A., Sallis, J., Oja, P., 2003. International physical activity questionnaire: 12-country reliability and validity. Medicine & Science in Sports & Exercise 35, 1381-1395.

Cuijpers, P., van Straten, A., Bohlmeijer, E., Hollon, S., Andersson, G., 2010. The effects of

psychotherapy for adult depression are overestimated: a meta-analysis of study quality and effect size. Psychological Medicine 40, 211 - 223.

Donoghue, O., Feeney, J., O'Leary, N., Kenny, R.A., 2018. Baseline mobility is not associated with

decline in cognitive function in healthy community-dwelling older adults: findings from The Irish Longitudinal Study on Ageing (TILDA). American Journal of Geriatric Psychiatry 26, 438-448.

Ekelund, U., Steene-Johannessen, J., Brown, W.J., Fagerland, M.W., Owen, N., Powell, K.E., Bauman,

A., Lee, I.-M., 2016. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. The Lancet 388, 1302-1310.

Firth, J., Siddiqi, N., Koyanagi, A., Siskind, D., Rosenbaum, S., Galletly, C., Allan, S., Caneo, C.,

Carney, R., Carvalho, A.F., et al, 2019a. The Lancet Psychiatry Commission: a blueprint for protecting physical health in people with mental illness. The Lancet Psychiatry 6, 675-712.

Firth, J., Torous, J., Stubbs, B., Firth, J.A., Steiner, G.Z., Smith, L., Alvarez‐Jimenez, M., Gleeson, J.,

Vancampfort, D., Armitage, C.J.., 2019b. The “online brain”: how the Internet may be changing our cognition. World Psychiatry 18, 119-129.

Folstein, M.F., Folstein, S.E., McHugh, P.R., 1975. “Mini-mental state”: a practical method for grading

the cognitive state of patients for the clinician. Journal of Psychiatric Research 12, 189-198.

Hallgren, M., Lundin, A., Tee, F.Y., Burström, B., Forsell, Y., 2017. Somebody to lean on: Social

relationships predict post-treatment depression severity in adults. Psychiatry Research 249, 261-267.

Hallgren, M., Owen, N., Stubbs, B., Vancampfort, D., Lundin, A., Dunstan, D., Bellocco, R., Lagerros,

Y.T, 2019. Cross-sectional and prospective relationships of passive and mentally active sedentary behaviours and physical activity with depression. British Journal of Psychiatry 1-7.

Hawton, K., Casanas, I.C.C., Haw, C., Saunders, K., 2013. Risk factors for suicide in individuals with

depression: a systematic review. Journal of Affective Disorders 147, 17-28.

Kenny, R., Whelan, B., Cronin, H., Kamiya , Y., Kearney , P., O’Regan, C., Ziegel, M., 2010. The Design

of the Irish Longitudinal Study on Ageing. Dublin: Trinity College Dublin.

Knapen, J., Vancampfort, D., Moriën, Y., Marchal, Y., 2014. Exercise therapy improves both mental

and physical health in patients with major depression. Disability & Rehabilitation, 1-6.

Kobayashi, L.C., Steptoe, A., 2018. Social isolation, loneliness, and health behaviors at older ages:

longitudinal cohort study. Annals of Behavioral Medicine 52, 582-593.

Mammen, G., Faulkner, G., 2013. Physical activity and the prevention of depression: a systematic

review of prospective studies. American Journal of Preventive Medicine 45, 649-657.

Mañas, A., del Pozo-Cruz, B., García-García, F.J., Guadalupe-Grau, A., Ara, I., 2017. Role of

objectively measured sedentary behaviour in physical performance, frailty and mortality among older adults: A short systematic review. European Journal of Sports Science 17, 940-953.

Maxwell, S.E., Cole, D.A., 2007. Bias in cross-sectional analyses of longitudinal mediation.

Psychological Methods 12, 23.

McDowell, C., Dishman, R., Hallgren, M., MacDonncha, C., Herring, M.J.E.g., 2018a. Associations of

physical activity and depression: Results from the Irish Longitudinal Study on Ageing. Experimental Gerontology 112, 68-75.

McDowell, C.P., Dishman, R.K., Vancampfort, D., Hallgren, M., Stubbs, B., MacDonncha, C., Herring,

M.P., 2018b. Physical activity and generalized anxiety disorder: results from The Irish Longitudinal Study on Ageing (TILDA). International Journal of Epidemiology 47, 1443-1453.

Nicholson, N.R., 2012. A review of social isolation: an important but underassessed condition in older

adults. Journal of Primary Prevention 33, 137-152.

Nolan , A., O’Regan, C., Dooley, C., Wallace, D., Hever, A., Cronin, H., Hudson, E., Kenny, R., 2014.

The over 50s in a changing Ireland: Economic circumstances, health and well-Being. Dublin:

The Irish Longitudinal Study on Ageing.

Olssøn, I., Mykletun, A., Dahl, A.A., 2005. The Hospital Anxiety and Depression Rating Scale: a cross-

sectional study of psychometrics and case finding abilities in general practice. BMC Psychiatry 5, 46.

Ong, A.D., Uchino, B.N., Wethington, E., 2016. Loneliness and health in older adults: A mini-review and

synthesis. Gerontology 62, 443-449.

Patterson, R., McNamara, E., Tainio, M., de Sá, T.H., Smith, A.D., Sharp, S.J., Edwards, P., Woodcock,

J., Brage, S., Wijndaele, K., 2018. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. European Journal of Epidemiology. 33(9), 811-829

Pigott, H.E., 2015. The STAR\* D trial: It is time to reexamine the clinical beliefs that guide the treatment

of major depression. Canadian Journal of Psychiatry 60, 9-13.

Radloff, L.S., 1977. The CES-D Scale:A Self-Report Depression Scale for Research in the General

Population. Applied Psychological Measurement 1, 385-401.

Read, J.R., Sharpe, L., Modini, M., Dear, B.F., 2017. Multimorbidity and depression: a systematic

review and meta-analysis. Journal of Affective Disorders 221, 36-46.

Rico-Uribe, L.A., Caballero, F.F., Olaya, B., Tobiasz-Adamczyk, B., Koskinen, S., Leonardi, M., Haro,

J.M., Chatterji, S., Ayuso-Mateos, J.L., Miret, M., 2016. Loneliness, social networks, and health: a cross-sectional study in three countries. PLoS One 11, e0145264.

Rose, D., Harrison, E., 2007. The European socio-economic classification: a new social class schema

for comparative European research. European Societies 9, 459-490.

Russell, D., Peplau, L.A., Cutrona, C.E., 1980. The revised UCLA Loneliness Scale: concurrent and

discriminant validity evidence. Journal of Personality and Social Psychology 39, 472-480.

Sallis, J.F., Bull, F., Guthold, R., Heath, G.W., Inoue, S., Kelly, P., Oyeyemi, A.L., Perez, L.G., Richards,

J., Hallal, P.C., 2016. Progress in physical activity over the Olympic quadrennium. The Lancet 388, 1325-1336.

Saunders, T.J., Larouche, R., Colley, R.C., Tremblay, M.S. 2012. Acute sedentary behaviour and

markers of cardiometabolic risk: a systematic review of intervention studies. Journal of Nutrition & Metabolism, 712435

Schuch, F.B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P.B., Silva, E.S., Hallgren, M., Leon,

A.P.D., Dunn, A.L., Deslandes, A.C., Fleck, M.P., Carvalho, A.F., Stubbs, B., 2018. Physical activity and incident depression: A meta-analysis of prospective cohort studies. American Journal of Psychiatry , 175(7), 631-648.

Schuch, F.B., Vancampfort, D., Richards, J., Rosenbaum, S., Ward, P.B., Stubbs, B., 2016. Exercise

as a treatment for depression: A meta-analysis adjusting for publication bias. Journal of Psychiatric Research 77, 42-51.

Sedentary Behaviour Research, 2012. Letter to the Editor: Standardized use of the terms 'sedentary'

and 'sedentary behaviours'. Applied Physiology, Nutrition & Metabolism 37, 540-542.

Soundy, A., Roskell, C., Stubbs, B., Vancampfort, D., 2014. Selection, use and psychometric properties

of physical activity measures to assess individuals with severe mental illness: a narrative synthesis. Archives of Psychiatric Nursing 28, 135-151.

Squires, S.E., 2015. To a deeper understanding of loneliness amongst older Irish adults.

Collegium Anthropologicum 39, 289-295.

Stickley, A., Santini, Z.I., Koyanagi, A., 2017. Urinary incontinence, mental health and loneliness among

community-dwelling older adults in Ireland. BMC Urology 17, 29.

Stubbs, B., Firth, J., Berry, A., Schuch, F.B., Rosenbaum, S., Gaughran, F., Veronesse, N., Williams,

J., Craig, T., Yung, A.R., Vancampfort, D., 2016a. How much physical activity do people with schizophrenia engage in? A systematic review, comparative meta-analysis and meta-regression. Schizophrenia Research 176(2-3), 431-440.

Stubbs, B., Koyanagi, A., Schuch, F.B., Firth, J., Rosenbaum, S., Veronese, N., Solmi, M., Mugisha, J.,

Vancampfort, D., 2016b. Physical activity and depression: a large cross-sectional, population-based study across 36 low- and middle-income countries. Acta Psychiatrica Scandinavica 134, 546-556.

Stubbs, S., Vancampfort, D., Hallgren, M., Firth, J., Veronese, N., Solmi, M., Brand, S., Cordes, J.,

Malchow, B., Gerber, M., 2018c. EPA guidance on physical activity as a treatment for severe mental illness: a meta-review of the evidence and Position Statement from the European Psychiatric Association (EPA), supported by the International Organization of Physical Therapists in Mental Health (IOPTMH). European Psychiatry 54, 124-144.

Stubbs, B., Vancampfort, D., Firth, J., Schuch, F.B., Hallgren, M., Smith, L., Gardner, B., Kahl, K.G.,

Veronese, N., Solmi, M., Carvalho, A.F., Koyanagi, A., 2018b. Relationship between sedentary behavior and depression: A mediation analysis of influential factors across the lifespan among 42,469 people in low- and middle-income countries. Journal of Affective Disorders 229, 231-238.

Stubbs, B., Vancampfort, D., Firth, J., Schuch, F.B., Hallgren, M., Smith, L., Gardner, B., Kahl, K.G.,

Veronese, N., Solmi, M., Carvalho, A.F., Koyanagi, A., 2018b. Relationship between sedentary behavior and depression: a mediation analysis of influential cactors across the lifespan among 42,469 people in low- and middle-income countries. Psychological Medicine 229, 231-238.

Stubbs, B., Vancampfort, D., Veronese, N., Kahl, K.G., Mitchell, A.J., Lin, P.Y., Tseng, P.T., Mugisha,

J., Solmi, M., Carvalho, A.F., Koyanagi, A., 2017. Depression and physical health

multimorbidity: primary data and country-wide meta-analysis of population data from 190 593 people across 43 low- and middle-income countries. Psychological Medicine, 47(12), 2107-2117.

Tremblay, M.S., Aubert, S., Barnes, J.D., Saunders, T.J., Carson, V., Latimer-Cheung, A.E., Chastin,

S.F.M., Altenburg, T.M., Chinapaw, M.J.M., 2017. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. International Journal of Behavioral Nutrition and Physical Activity 14, 75.

Vancampfort, D., Stubbs, B., Mitchell, A.J., De Hert, M., Wampers, M., Ward, P.B., Rosenbaum, S.,

Correll, C.U., 2015. Risk of metabolic syndrome and its components in people with schizophrenia and related psychotic disorders, bipolar disorder and major depressive disorder: a systematic review and meta-analysis. World Psychiatry 14, 339-347.

Vancampfort, D., Correll, C.U., Galling, B., Probst, M., De Hert, M., Ward, P.B., Rosenbaum, S.,

Gaughran, F., Lally, J., Stubbs, B., 2016. Diabetes mellitus in people with schizophrenia, bipolar disorder and major depressive disorder: a systematic review and large scale meta-analysis. World Psychiatry 15, 166-174.

Wei, J., Hou, R., Zhang, X., Xu, H., Xie, L., Chandrasekar, E.K., Ying, M., Goodman, M. 2019. The

association of late-life depression with all-cause and cardiovascular mortality among community-dwelling older adults: systematic review and meta-analysis. British Journal of Psychiatry, 215(2), 449-455.

Whiteford, H.A., Ferrari, A.J., Degenhardt, L., Feigin, V., Vos, T., 2015. The global burden of mental,

neurological and substance use disorders: an analysis from the Global Burden of Disease Study 2010. PLoS One 10, e0116820.

Zhai, L., Zhang, Y., Zhang, D., 2015. Sedentary behaviour and the risk of depression: a meta-analysis.

British Journal of Sports Medicine 9(11), 709.

Zigmond, A.S., Snaith, R.P., 1983. The Hospital Anxiety and Depression Ccale. Acta psychiatrica

Scandinavica 67, 361-370.

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| --- | --- | --- | --- | --- | --- |
| **Table 1** Baseline characteristics of people aged ≥50 years from the Irish Longitudinal Study on Ageing (TILDA) survey (n=8163) | | | | | |
|  |  |  | Sedentary time/day | | |
| Characteristic | Category | Overall | 0-<4 h | 4-<8 h | ≥8 h |
| Sex | Female | 52.1 | 55.6 | 51.2 | 47.0 |
|  | Male | 47.9 | 44.4 | 48.8 | 53.0 |
| Age (years) | 50-59 | 40.5 | 47.5 | 35.3 | 42.0 |
|  | 60-69 | 30.7 | 32.6 | 31.8 | 23.6 |
|  | 70-79 | 20.0 | 15.1 | 23.2 | 19.5 |
|  | ≥80 | 8.8 | 4.8 | 9.7 | 14.9 |
| Social class | Professional workers | 2.5 | 1.7 | 2.5 | 4.4 |
|  | Managerial and technical | 16.4 | 15.3 | 16.7 | 17.7 |
|  | Non-Manual | 12.1 | 10.5 | 12.1 | 15.9 |
|  | Skilled manual | 10.9 | 10.1 | 11.2 | 11.9 |
|  | Semi-skilled | 11.1 | 11.7 | 10.8 | 11.7 |
|  | Unskilled | 4.5 | 3.8 | 4.7 | 4.8 |
|  | Farmers | 8.1 | 10.8 | 7.2 | 5.5 |
|  | Not working | 34.3 | 36.2 | 35.0 | 28.1 |
| Smoking | No | 80.7 | 81.8 | 80.8 | 77.1 |
|  | Yes | 19.3 | 18.2 | 19.2 | 22.9 |
| Low physical activity | No | 45.6 | 58.5 | 43.3 | 24.6 |
|  | Yes | 54.4 | 41.5 | 56.7 | 75.4 |
| Mobilitya | Mean (SD) | 9.3 (3.9) | 8.7 (2.8) | 9.4 (3.6) | 10.6 (6.1) |
| Pain | No | 63.8 | 66.5 | 63.5 | 58.4 |
|  | Yes | 36.2 | 33.5 | 36.5 | 41.6 |
| Cognitive functionb | Mean (SD) | 28.1 (2.2) | 28.3 (1.9) | 28.0 (2.3) | 28.0 (2.7) |
| No. of chronic physical conditions | Mean (SD) | 1.9 (1.5) | 1.7 (1.4) | 2.0 (1.6) | 2.2 (1.7) |
| Disability | No | 90.9 | 94.6 | 91.3 | 80.9 |
|  | Yes | 9.1 | 5.4 | 8.7 | 19.1 |
| Anxiety | No | 75.2 | 74.5 | 76.1 | 73.8 |
|  | Yes | 24.8 | 25.5 | 23.9 | 26.2 |
| Loneliness | No | 51.0 | 54.6 | 50.0 | 45.7 |
|  | Yes | 49.0 | 45.4 | 50.0 | 54.3 |
| Social network | Most isolated | 7.5 | 5.8 | 7.0 | 12.5 |
|  | Moderately isolated | 28.8 | 24.9 | 28.8 | 37.5 |
|  | Moderately integrated | 41.0 | 41.8 | 42.6 | 34.1 |
|  | Most integrated | 22.7 | 27.5 | 21.6 | 15.9 |

Abbreviation: SD Standard deviation

Data are percentage unless otherwise stated.

a Mobility was assessed with the Timed Up-and Go (TUG) test and referred to the time in seconds that it took for the participant to complete the task

b Cognitive function was assessed with the Mini-Mental State Examination (MMSE). This scale ranges from 0-30 with higher scores indicating higher cognitive function.

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| **Table 2** Cross-sectional and longitudinal associations between time spent in sedentary behavior and depression estimated by multivariable logistic regression in people aged ≥50 years from the Irish Longitudinal Study on Ageing (TILDA) survey | | | | | |
|  |  | Cross-sectional analysisa (n=6903) | | Longitudinal analysisb  (n=5483) | |
| SB variable |  | Model 1 | Model 2 | Model 1 | Model 2 |
| Categorical | 0-<4 hours/day | 1.00 | 1.00 | 1.00 | 1.00 |
|  | 4-<8 hours/day | 1.51\*\*\* | 1.50\*\* | 1.14 | 0.94 |
|  |  | [1.25,1.82] | [1.13,2.00] | [0.87,1.49] | [0.66,1.35] |
|  | ≥8 hours/day | 2.17\*\*\* | 1.88\*\* | 1.46\* | 1.06 |
|  |  | [1.72,2.75] | [1.27,2.78] | [1.01,2.10] | [0.60,1.89] |
| Continuous | per one hour increase/day | 1.10\*\*\* | 1.08\*\*\* | 1.08\*\* | 1.05 |
|  |  | [1.07,1.13] | [1.04,1.13] | [1.03,1.13] | [0.97,1.13] |

Abbreviation: SB Sedentary behavior

Data are odds ratio [95% confidence interval].

a Estimates are based only on data from Wave 1.

b Exposure is time spent in sedentary behavior at baseline (Wave 1) and outcome is incident depression (depression at Wave 2). Sample is restricted to those who did not have depression at Wave 1.

Model 1 - Adjusted for sex and age.

Model 2 - Adjusted for sex, age, social class, current smoking, physical activity, mobility, pain, cognition, chronic physical conditions, disability, anxiety, loneliness, and social network.

\* p<0.05, \*\* p<0.01, \*\*\* p<0.001

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 3** Mediators in the association between baseline time spent in sedentary behavior (hours/day) and incident depression in people aged ≥50 years from the Irish Longitudinal Study on Ageing (TILDA) survey | | | | | | | |
|  | Total effect |  | Direct effect |  | Indirect effect |  |  |
| Mediator | OR [95%CI] | P-value | OR [95%CI] | P-value | OR [95%CI] | P-value | Mediated %a |
| Social class | 1.090 [1.032,1.151] | 0.002 | 1.086 [1.029,1.148] | 0.003 | 1.003 [0.990,1.016] | 0.640 | NA |
| Smoking | 1.084 [1.029,1.141] | 0.002 | 1.081 [1.026,1.138] | 0.003 | 1.003 [1.000,1.006] | 0.041 | 3.8 |
| Physical activity | 1.085 [1.031,1.143] | 0.002 | 1.068 [1.012,1.126] | 0.016 | 1.017 [1.005,1.028] | 0.004 | 20.3 |
| Mobility | 1.071 [1.011,1.134] | 0.019 | 1.066 [1.006,1.129] | 0.031 | 1.005 [1.000,1.010] | 0.058 | NA |
| Pain | 1.086 [1.031,1.145] | 0.002 | 1.081 [1.026,1.140] | 0.004 | 1.004 [1.000,1.009] | 0.049 | 5.4 |
| Cognitive function | 1.076 [1.017,1.139] | 0.011 | 1.080 [1.020,1.142] | 0.008 | 0.997 [0.994,1.000] | 0.092 | NA |
| Chronic physical conditions | 1.084 [1.030,1.142] | 0.002 | 1.075 [1.020,1.132] | 0.007 | 1.009 [1.004,1.014] | 0.001 | 11.1 |
| Disability | 1.082 [1.028,1.139] | 0.002 | 1.076 [1.022,1.132] | 0.005 | 1.006 [1.002,1.010] | 0.004 | 7.9 |
| Anxiety | 1.076 [1.021,1.134] | 0.007 | 1.077 [1.022,1.135] | 0.006 | 0.999 [0.991,1.007] | 0.819 | NA |
| Loneliness | 1.076 [1.019,1.135] | 0.008 | 1.065 [1.009,1.125] | 0.023 | 1.010 [1.002,1.017] | 0.013 | 13.2 |
| Social network | 1.085 [1.030,1.144] | 0.002 | 1.065 [1.010,1.123] | 0.020 | 1.019 [1.011,1.027] | <0.001 | 23.1 |

Models are adjusted for age and sex.

Sample is restricted to those who did not have depression at Wave 1.

Outcome is depression at Wave 2.

Time spent in sedentary behavior and the mediators were assessed at Wave 1.

a Mediated % was only calculated when the indirect effect was significant (P<0.05).

**Figure 1** Prevalence of depression at Wave 1 by time spent in sedentary behavior at Wave 1

**Figure 2** Prevalence of incident depression at Wave 2 by time spent in sedentary behavior at Wave 1

Analysis is restricted to those who did not have depression at Wave 1.