Are physical activity and sedentary behavior related to depression?

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Abstract: Depression is an increasing public health concern with rising prevalence. Nevertheless, far from everyone seeks help or receives adequate treatment. Although psychotherapy and antidepressants still constitute the bulk of treatments offered, recent research suggests that physical activity (PA) can be a powerful adjunct therapy while sedentary behavior (SB) is a definite risk factor for developing depression. The aim of the present study was to investigate the relationship between PA, SB and depressive symptoms in a population (n = 962) of applicants for an online treatment study. This study hypothesised that there will be; (1) a positive relationship between SB and depressive symptoms, and (2) a negative relationship between PA and depressive symptoms. In addition, we investigated whether the combination of a sedentary lifestyle and physical inactivity increased the risk for depressive symptoms. Finally, we also examined whether gender, age, marital status, educational level, or medication affected the relationship between PA, SB, and depressive symptoms. The results showed a positive correlation between SB and depression. There was, however, no statistically significant support for a negative relation between PA and depressive symptoms. Even though no

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PUBLIC INTEREST STATEMENT

Depression is one of the greatest causes of human suffering in the world today and approximately 300 million people worldwide suffer from depression. It is also worth noticing, there are no signs of any reduction in the number of sufferers, but rather an increase. It should also be added that only 50% of those affected are seeking help, which makes the situation even more acute. Apathy and hopelessness, which are common features of depression, are some of the more common explanations for why so few seek help, but also that the help usually offered (antidepressant medicine) comes with relatively high risks of side effects is also a contributing factor. All in all, this shows the urgent need to be able to offer alternative, evidence-based treatments for this group.

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conclusions about causality can be drawn, our results suggest that high SB, being a woman, being young, not being in a stable relationship, and current or previous medication are risk factors for depression. To be able to determine the causal direction, that is, whether high SB increases the risk for depressive symptoms, or if depressive symptoms increase the likelihood of high SB, further research is needed.

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Major depressive disorder (MDD) has become a serious public health threat, with substantial economic consequences in many countries (Johansson, Carlbring, Hedman, Paxling, & Andersson, 2013). From 1990 to 2010, depression moved from fifteenth to eleventh place in the world in terms of contributing to the burden of disease (Lopez, Mathers, Ezzati, Jamison, & Murray, 2006; Murray et al., 2012). MDD is the second greatest cause of disability in the world, with a prevalence that is expected to rise in the coming years (Murray et al., 2012; Vos et al., 2012). Depression is also associated with premature death and medical comorbidity, such as diabetes and asthma (Moussavi et al., 2007).

Research shows that approximately 50% of those who suffer from depression do not seek help, possibly due to the cost and perceived stigma attached to psychotherapy, antidepressants, etc. (Blake, 2012; Mojtahabi, 2009). The fact that some people with MDD do not receive adequate help demonstrates the need for alternative solutions, including the promising option of physical activity (PA). In addition, PA could also lessen the stigma that is reported to accompany more traditional treatments (i.e. psychotherapy and antidepressants), because of its positive effects on an individual’s self-esteem (Lubans et al., 2016). Furthermore, many of the positive aspects of exercise, (e.g. mood improvement, stress reduction and increased energy), are inversely related to the barriers of depression (e.g. loss of energy), which is restricting people from seeking help (Firth et al., 2016).

PA is defined as any physical movement as a result of muscle contractions that leads to increased energy consumption (Garber et al., 2011). There is strong evidence that regular PA reduces the risk of a range of medical conditions, including both physical and mental diseases (e.g. cardiovascular conditions, depression, anxiety; Mammen & Faulkner, 2013; Stubbs et al., 2017; Warburton, Nicol, & Bredin, 2006). Regular PA has also been described as an “intervention” with pharmacological benefits, for depression as well as for anxiety (Stubbs et al., 2017; Vina, Sanchis-Gomer, Martinez-Bello, & Gomez-Cabrera, 2012). A positive correlation between PA and mental health (e.g. depression, anxiety) has been identified, independent of age, gender, marital status, income or educational level (Abu-Omar, Rütten, & Robine, 2004; Stubbs et al., 2017). In contrast, physical inactivity has been found to be responsible for nine percent of premature mortality, i.e. more than five million of the 57 million premature deaths reported in 2008. This is on par with other major risk factors in poor health, such as smoking and obesity (Lee et al., 2012).

PA has been associated with a reduced risk of depression, further suggesting that it can be used for both protect against and as treatment for depression (Cho et al., 2019; Danielsson, Nora, Waern, & Carlsson, 2013; Ku, Steptoe, Liao, Sun, & Chen, 2018). Nevertheless, research remains inconclusive with regards to the environment, type, intensity, frequency and duration of PA that are most effective in preventing and treating depression (Harvey, Hotopf, Overland, & Mykletun, 2010; Nyström, Neely, Hassmen, & Carlbring, 2015; Pickett, Yardley, & Kendrick, 2012).

In addition, sedentary behaviour (SB)—independent of PA level—increases the risk of several common diseases and premature death (Grantved & Hu, 2011; Proper, Singh, van Mechelen, & Chinapaw, 2011). SB is, however, not merely the absence of PA. Even an individual who engages in
more intense physical activity every day may be predominantly sedentary (Schäfer Elinder, Hagströmer, Nyberg, & Ekblom-Bak, 2011) because SB is defined as all activities that do not significantly increase energy expenditure above resting consumption (Pate, O’Neill, & Lobelo, 2008).

Researchers have found that physical inactivity and SB can be independently related to depression (see e.g. Faulkner & Biddle, 2013; Kremer et al., 2014; Ku et al., 2018). Thus, in this study, PA and SB are regarded as two qualitatively different concepts, which, in simple terms, mean that the same person can be high on PA and still be considered to have predominantly SB. Moreover, a combination of a sedentary lifestyle and physical inactivity triples the risk for depressive symptoms (van Uffelen et al., 2013). PA may, however, cushion the impact of SB: low PA in combination with high SB increase the risk of depression, but high PA combined with high SB does not (Ku et al., 2018). Previous studies have reported associations between SB and a variety of psycho-social, physiological, socio-economic and psychological aspects (see Biddle & Faulkner, 2013 for an overview). Because few studies have distinguished between inactivity, SB and depression, more research is needed, particularly studies focusing on depression as a primary outcome measure (Faulkner & Biddle, 2013; Vancampfort, Stubbs, Firth, Van Damme, & Koyanagi, 2018). The aim of the present study was therefore to investigate the relationship between PA, SD and depressive symptoms in a population of applicants for an online treatment study. We hypothesised that there will be (1) a positive relationship between SB and depressive symptoms and (2) a negative relationship between PA and depressive symptoms. In addition, we aimed to investigate whether the combination of a sedentary lifestyle and physical inactivity would increase the risk of depressive symptoms. Finally, we wanted to examine whether gender, age, marital status, educational level or medication affect the relationship between PA, SB and depressive symptoms.

1. Method

1.1. Participants

The participants were applicants for an internet administered treatment study for depression (Nyström et al., 2017), recruited nationally in Sweden through advertisements in printed media (including newspapers) and online (Google.se, Studie.nu, etc.). Information about the study and links were also posted on Facebook and Twitter (see Lindner, Nyström, Hassmén, Andersson, & Carlbring, 2015; for a more detailed description of the advertising for participants). Applications were accepted on the project website between January 2013 and February 2014. All applicants had to be at least 18 years old, have daily access to an Internet connected computer and speak, read and write Swedish. Use of medication was not considered an exclusion criterion per se, but the dose had to have been stable for the last three months. All applicants were also asked to fill out an informed consent form. In total, 979 individuals over 18 years volunteered. For a few applicants, data on the targeted variables were missing and were therefore excluded from further analyses. The variables and number of excluded applicants were: age (n = 12), gender (n = 1) and medication (n = 4), resulting in 962 participants. Their mean age was 42.8 years (SD = 14.9): 72.9% women and 27.1 % men. For more detailed demographic data, see Table 1.

This study is part of the Actua intervention trial, which was pre-registered in the Clinicaltrials.gov registry (NCT01619930) and approved by the Regional Ethical Board in Umeå, Sweden. Actua aims to evaluate the effects on depression of four internet-administered self-help programmes with therapist support (see Carlbring et al., 2013, for more information about the Actua project). In the present study, all individuals taking part in Actua’s pre-tests and who reported full data on the targeted variables were analysed, even those participants who were later excluded from the intervention trial.

1.2. Instruments

The International Physical Activity Questionnaire (IPAQ; Craig et al., 2003) is a self-rating scale used to measure and compare PA and SB over the last seven days. There are two versions of the IPAQ, a long and a short version (Craig et al., 2003). The short version consists of nine statements and measures physical activity in general for all domains; it also contains questions
on sedentary behaviour. The questions regarding sedentary behaviour were developed as distinct indicators and are not part of the summed physical activity score. In this study, the short IPAQ was used, which has been shown to have as good measurement properties as other established self-administered tests (Craig et al., 2003). In a study in 12 countries, reliability estimates were satisfactory: Spearman’s rho = .80, criterion validity $p = .30$ (Craig et al., 2003). Another study showed similar criterion validity ($p = .16$–.35) and a significant correlation ($r = .34$ $p < .001$) between the IPAQ and an objective measure of PA in the form of an accelerometer (Ekelund et al., 2006). Metabolic equivalents of task (MET) minutes/week were calculated for all participants by multiplying the time for the activity with the estimated MET for each type of activity. The level of PA was then categorised according to the IPAQ (2005) guidelines, and the following categorical variables were calculated for the IPAQ: low, moderate and high physical activity. The criterion for “high activity” is that participants are engaged in vigorous-intensity activity on at least three days, achieving a minimum total physical activity of at least 1,500 MET minutes/week, or, have 7 days of any combination of walking, moderate-intensity or vigorous-intensity activities, achieving a minimum of 3000 MET minutes/week. “Moderate activity” is classified as having three or more days of vigorous-intensity activity of at least 20 minutes per day; five or more days of moderate-intensity activity and/or walking for at least 30 minutes per day or five or more days of any combination of walking, moderate-intensity or vigorous-intensity activities, achieving a minimum of 600 MET minutes/week. Participants who did not fulfil any of the abovementioned criteria were characterised as engaging in “low” activity.

For SB, the IPAQ has no established categories. Further, it was not possible to treat MET minutes for SB as a continuous variable due to extreme skewness; neither the transformations, such as log 10, Ln, nor the Sqrt transformations changed this pattern. Thus, we used a similar classification of

| Table 1. Demographic data of the participants (n = 962) |
|-----------------------------------------------|
| **Participants (%)**                          |
| **Gender**                                    |
| Women                                         | 701 (73%) |
| Men                                           | 261 (27%) |
| **Age**                                       |
| 18–24                                         | 107 (11%) |
| 25–34                                         | 225 (23%) |
| 35–44                                         | 208 (22%) |
| 45–54                                         | 191 (20%) |
| 55+                                           | 148 (15%) |
| 65+                                           | 83 (9%)   |
| **Marital status**                            |
| Single/Sole breadwinner                       | 281 (29%) |
| Married/Reg. partner/Partner/Living apart     | 584 (61%) |
| Divorced/Widowed                              | 89 (9%)   |
| Other                                         | 8 (1%)    |
| **Educational level**                         |
| Elementary/junior high school                 | 60 (6%)   |
| High school                                   | 353 (37%) |
| University degree                             | 520 (54%) |
| Postgraduate                                  | 29 (3%)   |
| **Current or past medication for mental illness** |
| Yes                                           | 476 (49%) |
| No                                            | 486 (51%) |
the IPAQ-SB as Rosenberg et al. (2008) and calculated three tertiles based on the number of minutes sitting per week: low (≤330), mid (331–540) and high (≥541) SB.

The Patient Health Questionnaire-9 (PHQ-9; Kroenke, Spitzer, & Williams, 2001), is a self-rating scale for screening major depressive disorders according to the DSM-IV as well as for measuring the current level of symptoms of depression. The test’s first nine statements are based on corresponding criteria in the DSM-IV, while the tenth is a functioning scale. The symptoms experienced by an individual over the last 14 days are scored on a scale from zero to three, where zero corresponds to “not at all” and three to “daily”. These scores are then added to determine a total score. The PHQ-9 has been shown to have good internal consistency, with Cronbach’s alpha ranging from .86 to 0.89 and a test-retest reliability of \( r = .95 \) (Bian, Li, Duan, & Wu, 2011). In a recent study, the test-retest reliability was \( r = .95 \) (Bian, Li, Duan, & Wu, 2011). The scale also has good criterion, construct and external validity (Kroenke et al., 2001; Löwe, 2004; Titov et al., 2011). In the present study, the internal consistency measured with Cronbach’s alpha was .78. The PHQ-9 was then categorised in accordance with the guidelines (Kroenke et al., 2001) into minimal (scores, 0–4), mild (5–9), moderate (10–14), moderately severe (15–19) and severe depressive symptoms (20–27).

The Montgomery-Asberg Depression Rating Scale—Self-report Version (MADRS-S; Svanborg & Åsberg, 2001) is designed to measure depressive symptoms and their severity over the last three days. The scale was created to determine the extent of depression and to make it possible to follow it over time. Questions are broken down into categories, with the perceived severity of symptoms estimated on a six-point scale and a total score ranging from 0 to 54 (Holländare, Andersson, & Engström, 2010). The MADRS-S has shown good internal consistency, with Cronbach’s alpha = .84, and test-retest reliability \( r = .78 \) (Fantino & Moore, 2009; Thorndike et al., 2009). In the present study, the internal consistency measured with Cronbach’s alpha was .77. Answers to the MADRS-S were categorised according to the guidelines (Svanborg & Åsberg, 2001) into untroubled (scores, 0–6), mild depressive (7–19), moderate (20–34) and severe depressive symptoms (35–54).

1.3. Statistical analysis

Binary logistic regression, with depressive symptoms (PHQ-9 or MADRS-S) as the dependent variables, was used to analyse the data. In the analyses, we controlled for confounders known to be related to depressive symptoms, such as age, gender, marital status, educational level and medication (see Table 1). In the first model (Model 1, MADRS-S), untroubled and mild depressive symptoms were combined and then compared with moderate and severe depressive symptoms. In the second model (Model 2, MADRS-S), untroubled, moderate and mild depressive symptoms were combined and then compared with severe depressive symptoms. For the PHQ-9 (Model 3), minimal, mild and moderate depressive symptoms were combined and then compared with moderately severe and severe depressive symptoms. Finally, for the fourth model (Model 4, PHQ-9), minimal, mild, moderate and moderately severe depressive symptoms were combined and then compared with severe depressive symptoms. In every model, we investigated the effects of the levels of PA and SB separately. We also investigated the possible combinations of PA and SB as predictors of depressive symptoms.

2. Results

According to the MADRS-S, 0.4% of the participants displayed no/untroubled depressive symptoms; 26.0% displayed mild depression; the vast majority of the participants, 68.9%, reported moderate depressive symptoms; and 4.7% displayed more severe depressive symptoms. For the PHQ-9, 1.2% displayed no/minimal depressive symptoms, 19.4% mild depression, 32.6% moderate depressive symptoms, 31.6% moderately severe depressive symptoms, and 15.1% displayed more severe depressive symptoms. Responses to the IPAQ showed that 38.0% had low PA; 41.0% had moderate PA; and 21.0% had high PA. The median PA was 1,173 MET minutes per week (IQR = 1897). For SB, split into tertiles, the median for the participants was 450 (IQR = 300). Results from Spearman’s correlation test revealed that the first MADRS-S variable (untroubled—mild/moderate—severe) was significantly related to both the first (minimal—mild—moderate/moderately severe—severe; \( r_s = 42, p < 05 \)) and second (minimal—mild—moderate—moderately severe/severe; \( r_s = .24, p < 05 \)) PHQ-9
variable. The other MADRS-S variable (untroubled—moderate—mild/severe depressive symptoms) was also related to the first ($r_s = .19, p < .05$) and second ($r_s = .35, p < .05$) PHQ-9 variable. However, even if variables were significantly correlated, associations only ranged from weak ($r_s = .20$) to moderate ($r_s = .42$) according to guidelines (Akoglu, 2018), and thus it was justified to analyse MADRS-S and PHQ-9 separately.

The univariate logistical regressions showed that aspects of both PA (high PA used as reference category) and SB (low SB as reference) were related to more depressive symptoms on both the MADRS-S ($p < .05$) and the PHQ-9 ($p < .05$).

In the next step, multivariate logistic regressions were performed for both the PHQ-9 and the MADRS-S in order to determine which variables could best predict depressive symptoms. The models consisted of the following variables: SB or PA, age, gender, marital status and medication. The results showed that no PA category (i.e. low, moderate or high) was associated with depressive symptoms, neither for the PHQ-9 nor the MADRS-S (see Table 2).

For SB, however, more sedentary behaviour was related to higher odds of depressive symptoms in three of the models compared to less sedentary behaviour (see Table 3). For the MADRS-S (Model 2), when untroubled, moderate and mild depressive symptoms were compared with severe depressive symptoms, the odds ratio (OR) was 2.51 (95% CI 1.11–5.65, $p = .027$). For the PHQ-9 in model 3, comparing no, mild and moderate depressive symptoms with moderate and severe depressive symptoms, the OR was 1.41 (95% CI 1.01–1.98, $p = .046$). In model 4 (PHQ-9), when no, mild, moderate and moderately severe depressive symptoms were compared with severe depressive symptoms, the OR was 2.01 (95% CI 1.24–3.25, $p = .005$). In this model, “mid” SB was also associated with increased risk (OR = 1.70, 95% CI 1.05–2.75, $p = .032$).

Finally, different combinations of PA and SB revealed only one significant association, demonstrating that moderate PA and mid SB were associated with a decreased risk (OR = 0.41, 95% CI 0.20–0.87, $p = .019$) of depressive symptoms (MADRS-S, Model 1).

For the demographics included, the results derived from the MADRS-S generally revealed that younger age, being single or divorced and currently or previously being on medication were most strongly related to higher odds of depressive symptoms. The same pattern was found for the PHQ-9, with the addition of gender (being women), which was also related to higher odds of depressive symptoms.

3. Discussion
The main aim of the present study was to examine the relationship between self-reported depressive symptoms, PA and SB. In addition, we also wanted to see if a number of demographic variables affected the proposed relationship in a group of 962 adults who applied to an online treatment study. The results supported the first hypothesis, indicating that individuals reporting more SB had significantly more depressive symptoms than those who reported less SB. The results did not, however, support the second hypothesis, suggesting a negative association between depressive symptoms and a high level of PA. Investigating whether different combinations of SB and PA were associated with an increased or decreased risk of depressive symptoms showed that the combination of moderate PA and mid SB significantly reduced the risk of depressive symptoms (only for the MADRS-S). In addition, the results suggested that current or previous medication for treating mental illness, being a woman (only for the PHQ-9), being younger and not being in a stable relationship were associated with a higher risk of depressive symptoms.

The results from the present study contradict previous research in that it does not support the assumption of a negative relationship between higher levels of PA and depressive symptoms (De Mello et al., 2013; Goodwin, 2003; Harvey et al., 2010; Stubbs et al., 2018). There can, of course, be a variety of reasons for this contradiction, for example, that the sample in the present study
### Table 2. Associations between physical activity and depressive symptoms, presented in Odds Ratio. Models are adjusted for age, sex, marital status, educational level, and medication

|                     | MADRS-S          | PHQ-9            |
|---------------------|------------------|------------------|
|                     | Model 1 | Model 2 | Model 3 | Model 4 | Model 1 | Model 2 | Model 3 | Model 4 |
|                     | B | S.E. | OR | CI (95%) | P | B | S.E. | OR | CI (95%) | P | B | S.E. | OR | CI (95%) | P | B | S.E. | OR | CI (95%) | P |
| High Physical Activity (ref) | .02 | .20  | 0.98 | 0.66-1.44 | .91 | .02 | .45  | 1.02 | 0.42-2.46 | .97 | -.14 | .19  | 0.87 | 0.60-1.25 | .44 | -.12 | .26  | 0.88 | 0.53-1.48 | .63 |
| Moderate Physical Activity | .15 | .27  | 1.18 | 0.63-2.11 | .86 | .15 | .47  | 1.02 | 0.55-1.91 | .90 | .15 | .19  | 0.74 | 0.42-1.34 | .86 | .16 | .26  | 0.87 | 0.54-1.41 | .61 |

- Model 1: Untroubled and mild depressive symptoms compared with moderate and severe depressive symptoms.
- Model 2: Untroubled, mild, and moderate depressive symptoms compared with severe depressive symptoms.
- Model 3: No, mild, and moderate depressive symptoms compared with moderately severe and severe depressive symptoms.
- Model 4: No, mild, moderate, and moderately severe compared with severe depressive symptoms.

Note: B = Unstandardized Regression Weight, S.E. = Standard Error, OR = Odds Ratio, CI = Confidence Intervall.
Table 3. Associations between sedentary behaviour and depressive symptoms, presented in Odds Ratio. Models are adjusted for age, sex, marital status, educational level, and medication.

|         | MADRS-S |         |         |        | PHQ-9 |         |         |        |        |        |
|---------|----------|---------|---------|--------|-------|---------|---------|--------|--------|--------|
|         | Model 1  | Model 2 | Model 3 | Model 4|       | Model 1  | Model 2 | Model 3 | Model 4|       |
| B       | S.E.     | OR      | CI (95%)| P      |       | B       | S.E.     | OR      | CI (95%)| P      |
| Low Sitting Time (ref) | .03  | .18  | 0.96  | 0.68-1.38 | .85 | .28  | .45  | 1.33  | 0.55-3.22 | .52 | .26  | .17  | 1.30  | 0.94-1.80 | .12 | .53  | .25  | 1.70  | 1.05-2.75 | .03 |
| Middle Sitting Time | .04  | .19  | 1.04  | 0.71-1.52 | .82 | .91  | .41  | 2.51  | 1.11-5.65 | .03 | .35  | .17  | 1.41  | 1.01-1.98 | .05 | .70  | .25  | 2.01  | 1.24-3.25 | .01 |

Model 1. Untroubled and mild depressive symptoms compared with moderate and severe depressive symptoms
Model 2. Untroubled, mild, and moderate depressive symptoms compared with severe depressive symptoms
Model 3. No, mild, and moderate depressive symptoms compared with mildly severe and severe depressive symptoms
Model 4. No, mild, moderate, and moderately severe compared with severely depressive symptoms

Note: B = Unstandardized Regression Weight, S.E. = Standard Error, OR = Odds Ratio, CI = Confidence Interval.
cannot be considered to mirror a “normal population”. In our sample, only 0.4 % and 1.2 % reported no, or minimal amounts of depressive symptoms (for the MADRS-S and PHQ-9, respectively). This can be compared to a study conducted in the United States, in which the same instrument was used, and which reported that 75% of the sample displayed no, or minimal amounts of depressive symptoms (Shim, Baltrus, Ye, & Rust, 2011). Therefore, our sample perhaps is better described as a non-healthy population, which in turn could have influenced the impact of PA on depressive symptoms.

The reasons for these somewhat opposing results could perhaps furthered be explained by the positively skewed IPAQ scores, resulting in a rather large low PA group (38%). This could be compared to a study on a Swedish non-clinical sample using the same categorisation guidelines as in the present study, which reported that 15% were categorised as being low in PA (Ekelund et al., 2006). In validating the IPAQ, Craig and colleagues (2003) reported a median of PA at 2,514 MET min/week, which is more than twice as much PA/week as what was reported in the present study (1,173 MET min/week). It is also worth pointing out that several studies have concluded that the short version of the IPAQ, which was used in the present study, tends to overestimate PA time (Ekelund et al., 2006; Lee, Macfarlane, Lam, & Stewart, 2011). This further supports the assumption that the present sample does not mirror a normal population, both when it comes to the extent of depressive symptoms and the level of PA. Hence, it could be that the spread in our sample is less than in a normal population, which could be a contributing factor to our results, i.e. a non-significant negative relationship between PA and depressive symptoms. In this context, it should perhaps also be noted that fewer men (27%) applied for the online treatment compared to women. This was however expected since it is well established that women are more likely to seek help for depression than men (see e.g. Wilhelm, 2009).

Previous research has predominantly used the national public health guidelines (i.e. 150 min of moderate intensity exercise/week) to determine whether a person is sufficiently physically active. It is worth noting that these guidelines are not specifically developed for use on people suffering from depression. Since the present study sample reported more depressive symptoms and less physical activity compared to a normal population, it is difficult to determine the directionality between the factors in our sample (i.e. is it the disorder that causes the decrease in activity, or vice versa?). It may even be that the elevated values of depressive symptoms in our sample are already influenced by physical inactivity, which could be a contributing explanation of the non-effects of PA on depressive symptoms. This interpretation is supported by a recent study, which suggested that the presence of depressive symptoms could be related to a decrease in PA over time (Adamson, Yang, & Motl, 2016).

Regarding the assumption of a positive relationship between SB and depressive symptoms, our results corroborate those of previous research (Kremer et al., 2014; Vancampfort et al., 2018), the high SB group reported significantly more depressive symptoms than the low and mid SB groups. It is important to note that SB was related to more depressive symptoms when measured using both the PHQ-9 and the MADRS-S, even though there were differences between the instruments. For example, the MADRS-S is specifically designed to measure the severity of depression, whereas the PHQ-9 is designed to screen and diagnose depression. The two questionnaires also have different time windows (3 vs. 14 days). The use of two different measures for depression, and yet obtaining similar results (i.e. a positive relation between SB and depressive symptoms), suggests that the relationship is not dependant on the specific instruments used; rather, it might indicate the conceptual relationship between the constructs.

Based on our results, it could be argued that since there was an association between SB and depressive symptoms, but not between PA and depressive symptoms, the two concepts are indeed qualitatively different. Thus, being physically inactive is not synonymous with being sedentary. This is an important notion since there has been ambiguity in the existing literature whereby these concepts have been used both interchangeably and as opposite ends on the same continuum. This
aligns with results presented by Rosenberg and colleagues (2008), who concluded that an individual scoring high on SB is just as likely to score high on PA as an individual who scores low on SB. More recent research has also highlighted that light PA, independently of SD, is associated with reduced risk for developing depression (Ku et al., 2018).

To our knowledge, this is one of the largest studies administered over the internet using depression as a specific outcome measure to distinguish between physical inactivity and SB. Our results contribute to the existing knowledge base regarding the role of SB and PA for depressive symptoms in a non-healthy population by further emphasizing the importance of distinguishing between inactivity and SB, and that it may be more important to focus on SB in both the identification of risk groups and when developing treatments. Furthermore, it is also important to investigate whether the proposed associations between SB, PA and depressive symptoms differs between populations (e.g. individuals who applied for an online study). Since internet administered treatments are a vastly growing alternative to more traditional treatments, it is especially important to understand if the assumptions holds for this growing population.

The question of how much and how intense PA should be in order to have a preventive effect on depressive symptoms is complex, and our results do not offer any insights in this regard. In some previous studies, a certain amount of PA has been suggested to be required for it to decrease the risk for developing depressive symptoms (for a review, see Mammen & Faulkner, 2013). Although not significant, according to our results, the OR’s was higher for the low PA group compared to the high and moderate PA groups, suggesting that there was a tendency for the low PA group to be at higher risk of depressive symptoms, both in terms of the PHQ-9 and the MADRS-S. Thus, the present consensus is that well-controlled RCT studies are needed—in order to answer questions relating to the level of PA frequency and intensity in preventing depressive symptoms. It is possible that no universal level of PA exists that will have a preventive effect on depressive symptoms; most likely, this would be based on the individual.

Since the results from the present study indicate, in line with previous studies, inactivity and passivity to be prominent parts of depression it could be quite misleading to use guidelines developed for non-clinical populations. Importantly, our results suggest that the most important factor is to avoid being sedentary; and hence regular PA could be a simple everyday activity that could reduce many of the risks associated with SB. But, perhaps the frequency, duration and intensity of the PA recommended needs to be adjusted to better suit this population.

In this study, we also tested the relationship between a number of demographic variables and depressive symptoms. We found that age, gender (women), marital status (single or divorced) and medication (currently or previously) were significantly related to depression. That women are at greater risk of developing depression was previously known (De Mello et al., 2013; Kessler et al., 2005; Lopez et al., 2006; Van de Velde, Bracke, & Levecque, 2010; Wang et al., 2011); and a variety of biological, psychological and social explanations have been offered (see Kuehner, 2003, for an overview of theories). Not being in a stable relationship is also a known risk factor in poor mental health, including depression (Ishii, Shibata, & Oka, 2011; Kessler et al., 2005; Van de Velde et al., 2010). Consistent with previous research, we also found that those who were divorced or single were at a significantly higher risk of suffering from depression than those who were married, cohabiting, living apart in a stable relationship or having a registered partner.

In addition to reducing the risk for depression, support and encouragement from family and friends are important for achieving the recommended levels of movement (Harvey et al., 2010; Ishii et al., 2011). Congruently, it has been found that solitude increase the risk of physical inactivity (Hawkley, Thisted, & Cacioppo, 2009). In our study, being younger was also related to a higher prevalence of depressive symptoms, thus confirming previous results (Scarinci, Beech, Naumann, Kovach, & Letha, 2002). The results from the present study suggest that high SB, being a woman, being young, not being in a stable relationship and current or previous medication are risk factors in depression. Thus,
individuals with these factors may benefit most from increasing PA and decreasing SB. In line with previous research (Schuch et al., 2017), one possible explanation to the importance of current or previous medication, for both depressive symptoms and SB, could be side effects of anti-depressants (i.e. increased fatigue, weight gain, loss of interest and motivation) resulting in a more passive life. It is however important to remember that these results only can be used as support for associations, but can not be used for drawing conclusions on causal relationships.

3.1. Limitations
Because of its cross-sectional design and reliance on self-report measures, our study has a number of limitations. First, PA and SB were self-reported, which may have led to socially desirable answers (Carlbring et al., 2002). Alternatively, people may have forgotten or miscalculated their degree of PA and/or SB. Even though the collected data were managed and cleaned according to the IPAQ guidelines, it is possible that some responses were erroneous. Furthermore, the IPAQ short form does not distinguish between various types of PA and SB. It is also important to mention that the short form of IPAQ has been reported to overestimate PA, which could have influenced the results, even though the validity of the IPAQ short form is adequate. I addition, it is also important to consider that the reliability of the IPAQ short form is low for elderly (<65), and approximately 10 percent of the participants were in the age range it could also have had an impact on the results. Furthermore, it would have been good to be able to investigate what kind of PA the participants engage in as well as the sort of SB that were predominantly used, in order for a deeper understanding of the present findings. Unfortunately, we did not have such detailed information in our data set. Previous studies have shown that PA has a greater antidepressant effect during leisure hours than at the workplace (Harvey et al., 2010; Pickett et al., 2012). In hindsight, we should have gathered information about the various forms of PA and when they were performed, preferably also making use of more comprehensive techniques such as accelerometers.

The cross-sectional design and focus on PA, SB and depressive symptoms makes it impossible to determine whether there are one or more factors, such as temperament or personality, that are innate or developed at a young age that affect both how active a person is and their risk of developing mental disorders (Harvey et al., 2010). It is also impossible to determine the causal direction, that is, whether high SB increases the risk for depressive symptoms or whether depressive symptoms increase the likelihood of high SB. Longitudinal studies are clearly needed, perhaps also taking BMI into account (Opel et al., 2015).

4. Conclusions and future research
The results of this study show the importance of recognising PA and SB as two distinct behaviours. Important questions remain, including whether a dose-response relationship exists between SB and depression. These results can be considered to give some support to the notion that the most critical risk factor in depression is being overly sedentary. Future research should differentiate between various types of PA and SB in order to determine whether some of them are more strongly associated with depression. To increase the reliability of the results future research should also consider using more objective measures for PA, in order to avoid socially desirable answers. Another area for further investigation is the role of social factors and how they potentially affect the relationship between PA, SB and depression. There is also a need for more longitudinal RCT studies in order to make causal inferences. The latter may also offer opportunities to test the spiral model, which claims that physical inactivity and depression interact in a vicious cycle of negative thoughts, poorer motivation and greater fatigue (Haase, Taylor, Fox, Thorp, & Lewis, 2010).

Clinical implications of the findings from this study could be that it is important for clinicians to separate between PA and SD. Perhaps, rather focus on getting the patients to identify some activity that they could enjoy and then find ways for them to more frequently engage in those, instead of focusing on surten levels and forms of PA. However, the design of this study prohibits us from drawing any conclusions on causality, future studies should further investigate the directionality of these relations which could lead to more precise and clear directions to clinicians.
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