Journal of Behavioral Health
www.scopemed.org
DOI: 10.5455/jbh.20160310105222

Short Communication

The association of changes in screen-time sedentary behavior with changes in depression symptomology: Prospective pilot study

Paul D. Loprinzi, Eveleen Sng

Department of Health, Exercise Science, and Recreation Management, The University of Mississippi, Mississippi 38677, United States

Address for correspondence:
Paul D. Loprinzi, Department of Health, Exercise Science, and Recreation Management, School of Applied Sciences, The University of Mississippi, 229 Turner Center University, Mississippi 38677, United States. Phone: 662-915-5521, Fax: 662-915-5525, E-mail: pdloprin@olemiss.edu

Received: February 05, 2016
Accepted: March 02, 2016
Published: April 09, 2016

ABSTRACT

Objective: It is well established that physical activity is inversely associated with depression symptoms. Emerging work demonstrates that independent of physical activity, sedentary behavior is associated with mental health outcomes. However, limited research has examined the influences of changes in sedentary behavior on changes in depression symptoms, which was the purpose of this pilot study. **Methods:** In this prospective pilot study, 29 adults ($Age_{mean} = 36.8$; 79% female) completed a survey at baseline and again approximately 2-months later. Sedentary behavior (TV and computer use) and depression (PHQ-9), along with potential confounders (e.g. physical activity, anxiety), were subjectively assessed. **Results:** In a series of nested, sequential multivariable regression models, increases in screen-time sedentary behavior over the follow-up period was associated with increased depression symptomology ($\beta_{adjusted} = 0.65$; 95% confidence interval CI: 0.06-1.23; $P = 0.03$). There was no evidence to suggest a bi-directional relationship, in that changes in depression symptoms was not associated with follow-up screen-time sedentary behavior ($\beta = 0.31$; 95% CI: –0.08-71; $P = 0.11$). **Conclusion:** Increases in screen-time sedentary behavior were associated with increased depression symptomology. Future replicative work is needed.

KEY WORDS: Inactivity, mental health, physical activity, psychological functioning

INTRODUCTION

There is an established inverse relationship between physical activity behavior and depression symptomology [1-6]. Emerging research demonstrates that independent of physical activity, prolonged sedentary behavior is unfavorably associated with various cardiometabolic parameters [7-12]. Cross-sectional work also suggests that sedentary behavior is independently and positively associated with depression symptoms [13-15]. Less research, however, has evaluated the prospective associations of sedentary behavior on depression [16]. Among 1,511 women aged 18-45 years, Teychenne *et al.* [16]. demonstrated that sedentary behavior at baseline was not associated with follow-up depression symptomology, but baseline depression was associated with greater sedentary behavior at follow-up. Given the limited work on this topic, the purpose of this study was to evaluate the association between changes in screen-time sedentary behavior and changes in depression symptomology, written here as a brief report.

METHODS

Study Design and Participants

A random sample of 900 faculty/staff at the authors' institution were sent an e-mail asking if they wanted to participate in an on-line survey; 73 completed the baseline survey in early September, 2015. At an approximate 2 months follow-up (mean, 66.7 days; standard deviation [SD], 11.4, range, 55-90 months), 29 of these participants recompleted the same survey for follow-up assessment. Notably, there were no significant differences in the study variables between those included in the analysis and those lost to follow-up. These 29 participants constitute the analytic sample of this pilot study. Inclusion criteria included being at least 18 years of age and exclusion criteria included being pregnant or having an infant within the last 6 months ($n = 1$). All procedures were approved by the authors' institutional review board, with participant consent obtained.

Depression

At baseline and follow-up, participants completed the Patient Health Questionnaire-9 (PHQ-9) [17]. The PHQ-9 is the 9-item depression module from the full Patient Health Questionnaire, which is a 3-page self-administered questionnaire that assesses 8 diagnoses. The PHQ-9 depression scale consists of the actual 9 criteria on which the diagnosis of DSM-IV depressive disorders is based. Sample items include, "over the last 2 weeks, how often have you been bothered by": "Feeling down, depressed or hopeless," "feeling tired or having little energy," and "trouble concentrating on things, such as reading the newspaper or watching television." For each question, participants responded using a 4-point Likert scale, with responses including not at all (0), several days (1), more than half the days (2), and nearly every day (3). Items were summed, with higher scores indicating greater severity of depression. As a measure of severity, the PHQ-9 can range from 0 to 27 since each of the 9 items can be scored from 0 (not at all) to 3 (nearly every day). Typically, depression severity via the PHQ-9 is defined by the following established cut-points from the total PHQ-9 score: No depression (0-4), mild depression (5-9), moderate-depression (10-14), moderately-severe depression (15-19), and severe depression (20-27) [17]. For the analyses presented herein, we modeled depression symptoms as a continuous variable, as only 8 out of the 29 participants had a baseline PHQ-9 score of 5 or greater, with 6 out of 29 (20.7%) having a baseline PHQ-9 score of 10 or higher. Notably, this 20.7% is higher than the national average (7.5%) for adults in the general population [In this CDC reference [18]].

In addition, a change score for depression symptoms was calculated by subtracting the baseline PHQ-9 score from the follow-up PHQ-9 (i.e., $\text{PHQ-9}_{\text{follow-up}}$ - $\text{PHQ-9}_{\text{base}}$). Thus, a positive (+) change score would indicate an increase in depression symptomology over the follow-up period.

The PHQ-9 has demonstrated evidence of reliability and validity, with Cronbach's alpha ranging from 0.86 to 0.89 and a 48 h test-retest correlation coefficient of 0.84 [17]. In the present sample, the internal consistency of this questionnaire, as measured by Cronbach's alpha, was excellent at both time periods; baseline $\alpha = 0.92$, follow-up $\alpha = 0.90$.

Sedentary Behavior

As part of the Adult Sedentary Behavior Questionnaire [19], participants completed items related to their time spent watching TV and on the computer/videos. Specifically, (1) In a typical weekday/weekend day over the last week, how much time did you spend watching TV (including videos on VCR/DVD)? And (2) In a typical weekday/weekend over the last week, how much time did you spend on the computer or videos? Participants were asked to answer these questions for the weekday and weekend, with response options of: none (coded as "0"), 15 minutes or less (0.25), 30 min (0.5), 1 h (1), 2 h (2), 3 h (3), 4 h (4), 5 h (5), or 6+ h (6). Responses were re-calculated to be expressed per week (i.e., 5 × weekdays + 2 × weekends). These items have previously demonstrated evidence of test-retest reliability among adults [19]. For the TV item, the ICC for weekdays and weekend days, respectively, has been shown to be 0.857 and 0.828. For the computer/videos item, the ICC for weekdays and weekend days, respectively, has been shown to be 0.829 and 0.801 [19].

An overall baseline screen-time sedentary behavior score was calculated by summing the responses for the TV and computer/video items for the weekday and weekend. In addition, a change score for screen-time sedentary behavior was calculated by subtracting the baseline screen-time sedentary behavior score from the follow-up screen-time sedentary behavior score (i.e., $\text{Sedentary}_{\text{follow-up}}$ - $\text{Sedentary}_{\text{base}}$). Thus, a positive (+) change score would indicate an increase in screen-time sedentary behavior over the follow-up period.

Covariates

Based on other research [1-6] covariates included age, gender, change score for moderate-to-vigorous physical activity (MVPA), change score for body mass index (BMI), change score for sleep duration, change score for anxiety, baseline smoking status, baseline perceived general health status, and duration of follow-up.

With regard to the change score in MVPA, this was calculated using the same formula as above and determined from weekly MVPA engagement from the short-form International Physical Activity Questionnaire (IPAQ) [20]. With regard to BMI, participants self-reported their height and weight, with BMI calculated as kg/m^2. A change score for sleep duration was adopted from the National Health and Nutrition Examination Survey (NHANES) by asking participants, "On average, how many hours of sleep do you get each night?" For anxiety, participants completed the OASIS (5-item) anxiety survey [21], with the internal consistency for this item being 0.89 and 0.90, respectively, for the baseline and follow-up assessments. Smoking status was self-reported as current smoker versus not. General perceived health status was assessed using the item from the NHANES: "Would you say your health in general is: Excellent, very good, good, fair or poor." Finally, duration of follow-up was calculated as the length (in days) between the baseline and follow-up assessment.

Statistical Analysis

Analyzes computed in Stata (v.12). Various nested linear regression models were computed given the small sample size. Statistical significance was established as $P < 0.05$.

1. The first series of nested models evaluated the association between the screen-time sedentary behavior change score (independent variable) and the depression symptoms change score (outcome variable).
   a. Model 1 was an unadjusted model.
   b. Model 2 added age and gender as covariates.
   c. Model 3 included age, gender, and the MVPA change score.

d. Model 4 included age, gender, MVPA change, and BMI change.
e. Model 5 included age, gender, MVPA change, BMI change, and sleep change.
f. Model 6 included age, gender, MVPA change, BMI change, sleep change, and anxiety change score.
g. Model 7 included age, gender, MVPA change, BMI change, sleep change, anxiety change, follow-up duration, smoking status, and general health status.

These nested and sequential models were evaluated given the small sample size of this pilot study. That is, reliance on the results of only model 7 would be inappropriate as this model is likely over adjusted (i.e., 12 IVs for a sample size of 29). However, if the results are similar across all the models, then this would suggest some degree of robustness for the observed association between screen-time sedentary behavior and depression symptoms.

2. The next main regression analysis evaluated the association between the screen-time sedentary behavior change score (IV) on the follow-up (not change) depression symptoms score (DV), while controlling for baseline depression level, age, gender, MVPA change, BMI change, sleep change, anxiety change, follow-up duration, smoking status, and general health status.
3. The last regression analysis was similar to this second regression model, but instead examined the association between the depression symptoms change score (IV) on follow-up (not change) screen-time sedentary behavior (DV), while controlling for baseline screen-time sedentary behavior, age, gender, MVPA change, BMI change, sleep change, anxiety change, follow-up duration, smoking status, and general health status.

Notably, the second main analysis (labeled here as #2) was used to confirm analysis 1, with analysis 3 used to examine the potential bi-directional association between screen-time sedentary behavior and depression symptoms.

RESULTS

Characteristics of the study variables are shown in Table 1. On average, participants were approximately 37-years-old; the majority of participants were female (79%) and white (90%).

The first series of nested models [Table 2] evaluated the association between the screen-time sedentary behavior change score (independent variable) and the depression symptoms change score (outcome variable).

As shown in Table 2, changes in screen-time were associated with changes in depression symptomology. This result was consistent across all the models shown in Table 2. As an example, and as shown in Model 7 of Table 2, a unit (h/week) increase in screen-time was associated with a 0.65 unit (PHQ-9 score) increase in depression symptomology. Notably, Model 7 explained the most variance (60%) of changes in depression symptomology, whereas Model 6 had the lowest Akaike information criterion. However, the purpose of these nested models was not to identify which model best explained changes in depression symptomology, but rather to demonstrate that increases in screen-time sedentary behavior were associated with increases in depression symptomology across multiple scenarios that considered various covariates.

Table 1: Characteristics of the study variables (*n*=29)

Variable	Mean/proportion	SD	Range
Age, mean years	36.8	15.3	18-67
Female, %	79.3		
Race-ethnicity, %			
Non-Hispanic white	89.7		
Non-Hispanic black	3.4		
Other	6.9		
Smoking status, %			
Non-smoker	89.7		
Smokes some days	3.4		
Smokes every day	6.9		
Perceived health status, %			
Excellent	20.7		
Very good	55.2		
Good	13.8		
Fair	6.9		
Poor	3.4		
BMI at baseline, mean kg/m^2	25.6	5.8	18.1-43.2
BMI at follow-up, mean kg/m^2	25.8	5.9	18.9-43.6
BMI change score	0.09	0.7	–1.1-2.7
MVPA at baseline, mean min/week	156.5	157.5	0-532
MVPA at follow-up, mean min/week	126.8	146.9	0-600
MVPA change score	–29.7	179.9	–270-535
TV/computer at baseline, mean h/week	9.3	5.0	2.25-20
TV/computer at follow-up, mean h/week	11.4	4.5	2.25-22
TV/Computer change score†	2.1	3.8	–6-12
Sleep at baseline, mean h/night	6.5	1.1	4-8
Sleep at follow-up, mean h/night	6.3	1.2	4-9
Sleep change score	–0.17	0.6	–2-1
Anxiety at baseline, mean	3.3	3.4	0-14
Anxiety at follow-up, mean	3.3	3.6	0-13
Anxiety change score	–0.03	2.9	–9-8
Depression symptoms at baseline, mean PHQ-9	4.7	5.7	0-22
Depression symptoms at follow-up, mean PHQ-9	5.4	5.4	0-22
Depression symptoms change score‡	0.7	5.1	–13-11
Follow-up period, mean days	66.7	11.4	55-90

BMI: Body mass index, MVPA: Moderate-to-vigorous physical activity, PHQ-9: Patient health questionnaire-9, TV: Television, †Based on a paired-samples *t*-test, baseline screen-time was significantly different than follow-up screen time (P=0.007), ‡Based on a paired-samples *t*-test, baseline depression was not significantly different than follow-up depression (P=0.47)

In this extended adjusted model (i.e., Model 7), there was no evidence of multicollinearity: Mean VIF, 1.77; highest individual VIF, 2.62; and lowest individual tolerance statistic, 0.38. Notably, race-ethnicity was not included as a covariate given that nearly all of participants (90%) were white; however, when race-ethnicity was included in the model, results were unchanged (data not shown).

Table 2: Prospective association between changes in screen-time and changes in depression symptomology (outcome variable)

Models	Covariates	β for changes in screen-time	95% CI	*P* value	R^2	AIC
Model 1	Unadjusted	0.59	0.13-1.05	0.01	0.20	173.3
Model 2	Age, gender	0.66	0.12-1.19	0.01	0.22	176.8
Model 3	Age, gender MVPA change	0.75	0.20-1.30	0.009	0.27	176.7
Model 4	Age, gender, MVPA change, BMI change	0.79	0.28-1.31	0.004	0.38	173.9
Model 5	Age, gender, MVPA change, BMI change, sleep change	0.78	0.32-1.24	0.002	0.53	167.6
Model 6	Age, gender, MVPA change, BMI change, sleep change, anxiety change score	0.62	0.09-1.14	0.02	0.57	167.5
Model 7	Age, gender, MVPA change, BMI change, sleep change, anxiety change, follow-up duration, smoking status, general health status	0.65	0.06-1.23	0.03	0.60	171.8

BMI: Body mass index, MVPA: Moderate-to-vigorous physical activity, AIC: Akaike information criterion, CI: Confidence interval

The next main regression analysis evaluated the association between the screen-time sedentary behavior change score (IV) on the follow-up (not change) depression symptoms score (DV), while controlling for baseline depression level, age, gender, MVPA change, BMI change, sleep change, anxiety change, follow-up duration, smoking status, and general health status.

As shown in Table 3, in this adjusted model, changes in screen-time sedentary behavior was positively associated with follow-up depression symptoms ($\beta = 0.57$; 95% CI: 0.08-1.05; $P = 0.02$). Notably, a unit (h/week) increase in screen-time was associated with a 0.57 unit (PHQ-9 score) increase in depression symptomology at the follow-up period.

The last regression analysis was similar to this second regression model, but instead examined the association between the depression change score (IV) on follow-up (not change) screen-time sedentary behavior (DV), while controlling for baseline screen-time sedentary behavior, age, gender, MVPA change, BMI change, sleep change, anxiety change, follow-up duration, smoking status, and general health status.

As shown in Table 4, in this adjusted model, changes in depression symptoms was not associated with follow-up screen-time sedentary behavior ($\beta = 0.31$; 95% CI: –0.08-71; $P = 0.11$). Notably, a unit (1 PHQ-9 score increase) increase in depression symptomology was associated with a non-significantly 0.31 unit (h/week) increase in screen-time at the follow-up period.

Table 3: Prospective association between changes in screen-time with follow-up depression symptomology (outcome variable), while controlling for baseline depression symptomology and other covariates†

β for changes in screen-time	95% CI	*P* value	R^2	AIC
0.57	0.08-1.05	0.02	0.76	161.3

†Covariates included baseline depression symptomology, age, gender, MVPA change, BMI change, sleep change, anxiety change, follow-up duration, smoking status and general health status, BMI: Body mass index, MVPA: Moderate-to-vigorous physical activity, AIC: Akaike information criterion, CI: Confidence interval

Table 4: Prospective association between changes in depression symptomology on follow-up screen-time (outcome variable), while controlling for baseline screen-time and other covariates†

β for changes in depression symptomology	95% CI	*P* value	R^2	AIC
0.31	–0.08-0.71	0.11	0.72	156.4

†Covariates included baseline screen-time sedentary behavior, age, gender, MVPA change, BMI change, sleep change, anxiety change, follow-up duration, smoking status, and general health status, BMI: Body mass index, MVPA: Moderate-to-vigorous physical activity, AIC: Akaike information criterion, CI: Confidence interval

DISCUSSION

In this brief-report pilot study, we aimed to examine whether increases in screen-time sedentary behavior, independent of MVPA and other potential confounders, was associated with increases in depression symptomology. This topic has not been extensively evaluated in prospective studies [16]. Here, we observed a prospective association between changes in sedentary behavior and changes in depression symptoms. The potential link between screen-time sedentary behavior and depression symptoms may, in part, be a result of cardiometabolic changes linked with prolonged sedentary behavior. For example, increased sedentary behavior has been shown to inhibit lipoprotein lipase enzyme activity, which plays an important role in triglyceride and cholesterol metabolism [22]. Recently, hypercholesterolemia has been shown to trigger brain chemical alterations involved in depression disorders [23]. The present study was not able to empirically support this assertion as cardiometabolic parameters were not evaluated in this pilot study.

Although there is some biological plausibility to explain the association between increased sedentary behavior and increased depression symptoms, it is well established that symptoms of depression include physical inactivity. Thus, it is possible that a bi-directional relationship exists between sedentary behavior and depression symptoms, which are in support of other work [16]. Our analysis 3, however, did not support an association between changes in depression symptoms (independent variable) and follow-up sedentary behavior. Of course, though, the sample size of this pilot study was very low, which may have rendered too low of statistical power to detect this likely relationship.

CONCLUSION

The main findings of this pilot study suggest the possibility that increases in screen-time sedentary behavior may increase depression symptoms. Of course, our observations should be interpreted with caution given the very small sample size, low response rate, the subjective assessment of all the evaluated parameters, utilization of only TV/computer time as a proxy for sedentary behavior, lack of assessment of potential underlying mechanisms (e.g., cardiometabolic parameters), homogeneity with regard to various demographic characteristics (e.g., gender and race-ethnicity), and the relatively short follow-up period. This study is not without strengths, however, in that we used a prospective study design and included a comprehensive assessment of various potential confounders. At minimum, we feel these findings should spawn the development of future replicative work on this topic.

REFERENCES

1. Dunn AL, Trivedi MH, O'Neal HA. Physical activity dose-response effects on outcomes of depression and anxiety. Med Sci Sports Exerc 2001;336 Suppl: S587-97.
2. Loprinzi PD. Objectively measured light and moderate-to-vigorous physical activity is associated with lower depression levels among older US adults. Aging Ment Health 2013;17:801-5.
3. Loprinzi PD, Cardinal BJ. Interrelationships among physical activity, depression, homocysteine, and metabolic syndrome with special considerations by sex. Prev Med 2012;54:388-92.
4. Loprinzi PD, Fitzgerald EM, Cardinal BJ. Physical activity and depression symptoms among pregnant women from the. National Health and Nutrition Examination Survey 2005-2006. J Obstet Gynecol Neonatal Nurs 2012;41:227-35.
5. Loprinzi PD, Mahoney S. Concurrent occurrence of multiple positive lifestyle behaviors and depression among adults in the United States. J Affect Disord 2014;165:126-30.
6. Loprinzi PD, Walker JF, Kane C, Cardinal BJ. Physical activity moderates the association between nicotine dependence and depression among U.S. smokers. Am J Health Promot 2014;29:37-42.
7. Loprinzi PD. Sedentary behavior and predicted 10-yr risk for a first atherosclerotic cardiovascular disease (ASCVD) event using the pooled cohort risk equations among US adults. Int J Cardiol 2015;203:443-4.
8. Loprinzi PD. Sedentary behavior and medical multimorbidity. Physiol Behav 2015;151:395-7.
9. Loprinzi PD. Leisure-time screen-based sedentary behavior and leukocyte telomere length: Implications for a new leisure-time screen-based sedentary behavior mechanism. Mayo Clin Proc 2015;90:786-90.
10. Loprinzi PD. Sedentary behavior and predicted 10-yr risk for a first atherosclerotic cardiovascular disease (ASCVD) event using the pooled cohort risk equations among US adults. Int J Cardiol 2016;203:443-4.
11. Loprinzi PD, Cardinal BJ, Lee H, Tudor-Locke C. Markers of adiposity among children and adolescents: Implications of the isotemporal substitution paradigm with sedentary behavior and physical activity patterns. J Diabetes Metab Disord 2015;27:14-46.
12. Loprinzi PD, Ford ES. The association between objectively measured sedentary behavior and red blood cell distribution width in a national sample of US adults. Am J Epidemiol 2015;181:357-9.
13. Hamer M, Stamatakis E. Prospective study of sedentary behavior, risk of depression, and cognitive impairment. Med Sci Sports Exerc 2014;46:718-23.
14. Teychenne M, Ball K, Salmon J. Physical activity, sedentary behavior and depression among disadvantaged women. Health Educ Res 2010;25:632-44.
15. Teychenne M, Costigan SA, Parker K. The association between sedentary behaviour and risk of anxiety: A systematic review. BMC Public Health 2015;15:513.
16. Teychenne M, Abbott G, Ball K, Salmon J. Prospective associations between sedentary behaviour and risk of depression in socio-economically disadvantaged women. Prev Med 2014;65:82-6.
17. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: Validity of a brief depression severity measure. J Gen Intern Med 2001;16:606-13.
18. Centers for Disease Control and Prevention. 2009-2012 National Health and Nutrition Examination Survey. Depression in the U.S. Household Population, 2009-2012. Available from: http://www.cdc.gov/nchs/data/databriefs/db172.htm. [Last accessed on 2016 Feb 03].
19. Rosenberg DE, Norman GJ, Wagner N, Patrick K, Calfas KJ, Sallis JF. Reliability and validity of the Sedentary Behavior Questionnaire (SBQ) for adults. J Phys Act Health 2010;7:697-705.
20. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, *et al*. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003;35:1381-95.
21. Norman SB, Cissell SH, Means-Christensen AJ, Stein MB. Development and validation of an Overall Anxiety Severity And Impairment Scale (OASIS). Depress Anxiety 2006;23:245-9.
22. Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N. Physiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab 2010;35:725-40.
23. De Bem AF, Engel D, de Oliveira J, Moreira EL, Neis VB, Santos DB, *et al*. Hypercholesterolemia as a risk factor for depressive disorder?. Free Radic Biol Med 2014;75 Suppl 1:S28.

Source of Support: Nil, Conflict of Interest: None declared.