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Original research

Exchanging screen for non-screen sitting time or physical activity might attenuate depression and anxiety: A cross-sectional isotemporal analysis during early pandemics in South America

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ABSTRACT

Objectives: To examine the theoretical substitutions of screen exposure, non-screen sitting time, moderate and vigorous physical activity with depressive and anxiety symptoms in South American adults during the COVID-19 pandemic.
Design: A cross-sectional study during the first months of the COVID-19 pandemic with data from 1981 adults from Chile, Argentina, and Brazil.
Methods: Depressive and anxiety symptoms were assessed using the Beck Depression and Anxiety Inventories. Participants also reported physical activity, sitting time, screen exposure, sociodemographic, and tobacco use data. Isotemporal substitution models were created using multivariable linear regression methods.
Results: Vigorous physical activity, moderate physical activity, and screen exposure were independently associated with depression and anxiety symptoms. In adjusted isotemporal substitution models, replacing 10 min/day of either screen exposure or non-screen sitting time with any intensity of physical activity was associated with lower levels of depressive symptoms. Improvements in anxiety symptoms were found when reallocating either screen exposure or non-screen sitting time to moderate physical activity. Furthermore, replacing 10 min/day of screen exposure with

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non-screen sitting time was beneficially associated with anxiety (B = −0.033; 95 % CI = −0.059, −0.006) and depression (B = −0.026; 95 % CI = −0.050, −0.002).

Conclusions: Replacement of screen exposure with any intensity of physical activity or non-screen sitting time could improve mental health symptoms. Strategies aiming to reduce depressive and anxiety symptoms highlight physical activity promotion. However, future interventions should explore specific sedentary behaviors as some will relate positively while others negatively.

Practical implications

- Replacing time spent either sitting with screen exposure or non-screen sitting time with time in any intensity of physical activity was beneficial for depression.
- Replacing time spent either sitting with screen exposure or non-screen sitting time with time in only moderate physical activity was beneficial with anxiety.
- Importantly, changing screen exposure to non-screen sitting time was beneficial for both depression and anxiety.
- These findings suggest important potential applications of transitioning screen-based sedentary activities for other sedentary activities (e.g., reading) to improve mental health.
- While transitioning from seated activities to physical activity is clearly helpful, subtler substitutions between sedentary activity types might also have important effects on mental health.

1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic resulted in a global public health emergency. Government measures aimed at slowing the spread of the virus forced millions of people to stay in social isolation with limited social and physical contact, in addition to closures and restrictions of facilities outside their households.[1] While social isolation reduces the infection rate,[1] it drastically alters people's daily lifestyle, and is associated with negative mental health.[2] Regrettably, mental health disorders are associated with high healthcare costs, and the COVID-19 pandemic increased the overall pooled prevalence of depression to 31.4 % and anxiety to 31.9 %, which will likely have significant long-term societal and financial ramifications.[3]

Evidence demonstrates that regular participation in physical activity (PA) is associated with lower symptoms of depression and anxiety, which may represent a particularly valuable treatment option given current poor adherence and limited effectiveness of traditional treatment for mood disorders.[4,5] Unfortunately, PA levels during the pandemic decreased worldwide.[6] However, staying physically active has been demonstrated to mitigate the negative mental health effects of the pandemic.[7] A recent systematic review found that those reporting a higher total time spent being physically active had 12–32 % and 15–34 % lower odds of high depressive and anxiety symptoms, respectively.[7] In addition, higher sedentary behavior or sitting time (ST) is also associated with mental health disorders,[8] regardless of PA participation. Moreover, within time spent seated, high screen exposure seems to be particularly associated with poorer mental health.[9] Screen exposure increased drastically during lockdown, as a way to stay connected socially, emotionally, educationally, and/or at work. However, other behaviors not using screens while seated such as reading, doing crosswords or writing (considered as mentally-active SB) may not have detrimental effects on mental health,[5] indicating that what a person does during sitting time may be important for its mental health correlates. The COVID-19 era, when opportunities for PA were largely reduced and opportunities for indoor ST and screen exposure increased,[10] is a potentially informative moment to study how PA and different types of SB are associated with mental health outcomes.

As the day has a fixed length (24 h), people distribute time understanding that engaging in one activity requires one to refrain from doing others.[11] People distribute their time each day across sleep, PA of different intensities, and ST. It has been observed that the amount of time spent on each of these behaviors has a different impact on one's health. Within this framework, statistical methods, such as the isotemporal substitution model (ISM), allow for modeling of the potential health benefits of substitution of time spent in one time-use behavior with time in another.[12] The ISM approach has recently been applied to health research, observing the relationship between these behaviors and indicators of morbidity and mortality,[13] and with depression and anxiety prior the pandemic.[8,14] The present moment provides us with a unique opportunity to evaluate ISMs within the context of the pandemic and its known effects on mental health and behavior to learn about the interrelationships among these health outcomes and behaviors.

Given the continuous influence of the COVID-19 crisis on depressive and anxiety symptoms and the potential protective or harmful effects of these time-use behaviors, summed with limited studies assessing different types of SB, it is essential to understand their relationship. Especially, in South America countries, where studies are underrepresented regarding global health, and COVID-19 consequences are unequally distributed.[15] Taking this into account, the aims of this study were (i) to examine the independent association of screen exposure, non-screen sitting time, moderate PA, and vigorous PA with depressive and anxiety symptoms and (ii) to examine how reallocating time among these time-use behaviors is associated with depressive and anxiety symptoms in the South American population during the early COVID-19 pandemic.

2. Methods

This cross-sectional study involved 2273 adult participants, of which 575 were residing in Argentina and 968 were in Brazil. Of the remaining 730 participants in Chile, 438 and 379 had information on depressive and anxiety symptoms, resulting in a final sample of 1981. A Spanish and Portuguese online questionnaire collected information from the 4th to 26th April 2020 for Chile, from the 24th of April to 27th July 2020 for Argentina, and from the 5th of April to 11th of May for Brazil. Brazil identified their first case of COVID-19 on February 25th, while Chile and Argentina did so on March 3rd. Mandatory quarantine was introduced at the end of March (Chile 26th, Argentina 20th and Brazil 24th March). Brazil and Argentina experienced heterogenous measures across regions/provinces during the compilation process. Non-probability sampling using social media posts and mass emails reached students, colleagues, and researchers' network for diffusion. Only adult participants with ≥7 days in lockdown and living in Chile or Argentina or Brazil were invited to participate.

The study in Chile was approved by the faculty of medicine at the University Diego Portales (number 02-220; 27th March), in Argentina by the Universidad the Flores (number 09/2020; 22th April) and in Brazil by the Federal University of Santa Maria (number [CONEP] 30,244,620.1.0000.5346; 10th April). Informed consent was obtained for all participants.

The objective of the questionnaire was to assess the influence of lockdown on health and wellbeing. A total of eight core variables were included in the survey.[10] For this study, sociodemographic, mental health (depressive and anxiety symptoms) and lifestyle factor variables (PA, ST, screen exposure and tobacco use) were included.

Validated versions of the Beck Depression Inventory (BDI) were used for Brazil (original), Chile (version IA) and Argentina (version II). All versions are composed of 21 symptoms and attitudes with a score range from 0 to 63 with higher scores indicative of higher symptom severity. One of the main differences between versions IA and II is that version II adds on sleep change and appetite, however, all versions have high internal consistency.[16]

The Beck Anxiety Inventory (BAI) was used to assess severity of anxiety symptoms over the previous week. This instrument includes 21 items summing a total score ranging from 0 to 63.[17] Higher scores are indicative of higher symptom severity.

Daily hours and minutes in PA, ST and screen exposure during lockdown were registered. For PA, daily minutes engaged in moderate (small increase in heart rate or breathing) and vigorous (large increase in heart rate or breathing) intensities were reported separately. However, participants who reported >960 min/day on vigorous PA and/or moderate PA, or >1440 min/day on screen exposure and/or ST, were excluded. Screen exposure and ST were calculated with the following questions: "Now that you are isolated: How much time each day do you spend in front of a screen/tablet/social media?" and "how much time do you spend sitting daily?", respectively. Non-screen sitting time was derived by subtracting screen exposure from ST, corresponding to activities not using screens while seated, truncating negative values into 0.

Finally, sex, age (18–24, 25–34, 35–44, 45–64 and ≥65 years), area of residence (North, Center, and South or Patagonian for Chile/Brazil and Argentina, respectively) and marital status (single, married/civil union/living with a partner, divorced/separated and widow) were reported. Tobacco use was reported as yes or no.

Frequency and percentages are reported for categorical variables. Means and standard deviations are reported for continuous variables. Chi-squared, and the one-way analysis of variance (Bartlett post-hoc) tests assessed for differences between countries.

Multiple linear regression models (single activity, partitioned and ISM) assessed the magnitude of the associations between 10 min of screen exposure, non-screen sitting time, moderate PA or vigorous PA, and each mental health outcome separately (depressive and anxiety symptoms).

The single activity model estimated each time-use behavior independently with depressive and anxiety symptoms, not including the other behaviors.

Partitioned models examined the "exclusive association" of each time-use behavior with depressive and anxiety symptoms. Briefly, each time-use behavior was included simultaneously in the model.

The ISM predicted the effect of replacing a time-use behavior with another time-use behavior for the same period, while holding total activity (screen exposure + non-screen sitting time + moderate PA + vigorous PA) constant. For example, to estimate the effects of replacing 10 min of screen exposure (behavior of interest) with vigorous PA, screen exposure is replaced in the model by a total time variable while retaining each of the other time-use variables. Then, the coefficients of the time-use behaviors (moderate PA, vigorous PA, and non-screen sitting time) then represent the consequence of substituting 10 min of that behavior in place of 10 min of screen exposure while holding other time-use behaviors constant.[12]

All models were adjusted for age, sex, country of residence, area of residence, marital status and tobacco consumption.

There were missing values for depressive (n = 292) and anxiety symptoms (n = 351) in Chile. Therefore, we conducted multiple imputations using auxiliary variables, considering the assumption of missing at random, with the number of imputations set at ten. After the multiple imputation procedures, we conducted the ISM as a sensitivity analysis.

All analyses were performed using Stata v.15 (StataCorp LP, College Station, TX, USA), with unstandardized regression coefficients. Statistical significance level was set at alpha = 0.05.

3. Results

Sample characteristics of the 1981 adult participants are outlined in Table 1. Of the total sample, 76.0 % were women, 28.4 % were between 25 and 34 years of age, 44.0 % were married/living with

Table 1
Descriptive characteristics of the participants by country.

Variable	Category	Chile n = 438	Argentina n = 575	Brazil n = 968	Total n = 1981	p
		Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Sex	Female	350 (79.9)	456 (79.3)	699 (72.2)	1505 (76.0)	0.001
Age (years)	18–24	91 (20.8)	36 (6.3)	136 (14.1)	263 (13.3)	<0.001
	25–34	77 (17.6)	111 (19.3)	375 (38.7)	563 (28.4)	
	35–44	112 (25.6)	128 (22.3)	242 (25.0)	482 (24.3)	
	45–54	76 (17.4)	95 (16.5)	118 (12.2)	289 (14.6)	
	55–64	64 (14.6)	121 (21.0)	80 (8.3)	265 (13.4)	
	≥ 65	18 (4.1)	84 (14.6)	17 (1.8)	119 (6.0)	
Area of residence	North	20 (4.6)	26 (4.5)	108 (11.2)	154 (7.7)	<0.001
	Center	382 (87.2)	481 (83.7)	30 (3.1)	893 (45.1)	
	South or Patagonian	36 (8.2)	68 (11.8)	830 (85.7)	934 (47.2)	
Marital status	Single	201 (45.9)	165 (28.7)	480 (49.6)	846 (42.7)	<0.001
	Married/living with partner	170 (38.8)	286 (49.7)	415 (42.9)	871 (44.0)	
	Divorced/separated	62 (14.2)	94 (16.4)	70 (7.2)	226 (11.4)	
	Widowed	5 (1.1)	30 (5.2)	3 (0.3)	38 (1.9)	
Smoking/tobacco use	Yes	124 (28.3)	95 (16.5)	51 (5.3)	270 (13.6)	<0.001

Variable	Category	Chile n = 438	Argentina n = 575	Brazil n = 968	Total n = 1981	p
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Moderate physical activity	min/day	53.2 (95.2)	55.7 (86.8)	34.0 (52.7)	44.5 (75.1)	<0.001
Vigorous physical activity	min/day	20.8 (44.3)	16.2 (38.4)	15.0 (30.1)	16.6 (36.2)	<0.02
Non-screen sitting time	min/day	79.40 (132.2)	108.6 (154.2)	102.1 (164.9)	98.98 (155.4)	0.009
Screen exposure	min/day	466.0 (236.6)	489.2 (223.6)	534.6 (243.3)	506.2 (237.9)	<0.001
Depression symptoms		14.7 (10.4)	10.4 (9.0)	9.9 (7.5)	11.1 (8.9)	<0.001
Anxiety symptoms		12.2 (10.5)[a]	8.3 (8.9)	8.9 (9.1)	9.4 (9.4)[b]	<0.001

[a] n = 379.
[b] n = 1922.

Table 2
Single and partition models of association of 10-min/day of time-use behaviors with depressive and anxiety symptoms.

Analysis method	Vigorous physical activity β (95 % CI)	Moderate physical activity β (95 % CI)	Non-screen sitting time β (95 % CI)	Screen exposure β (95 % CI)
Depression symptoms				
Single activity models				
Model A	−0.203 (−0.311; −0.096)*	−0.102 (−0.154; −0.050)*	−0.015 (−0.040; 0.010)	0.058 (0.042; 0.074)*
Model B	−0.227 (−0.328; −0.126)*	−0.112 (−0.162; −0.063)*	−0.004 (−0.028; 0.019)	0.051 (0.035; 0.067)*
Partition models				
Model A	−0.122 (−0.240; −0.004)**	−0.045 (−0.102; 0.013)	0.021 (−0.006; 0.049)	0.060 (0.042; 0.078)*
Model B	−0.134 (−0.246;-0.023)**	−0.060 (−0.114; −0.005)**	0.029 (0.003; 0.055)**	0.055 (0.037; 0.073)*
Anxiety symptoms[a]				
Single activity models				
Model A	−0.104 (−0.220; 0.012)	−0.093 (−0.153; −0.033)**	−0.023 (−0.050; 0.004)	0.054 (0.037; 0.072)*
Model B	−0.113 (−0.224; −0.001)**	−0.088 (−0.146; −0.029)**	−0.015 (−0.040; 0.011)	0.045 (0.027; 0.063)*
Partition models				
Model A	−0.015 (−0.144; 0.115)	−0.058 (−0.126; 0.010)	0.011 (−0.019; 0.040)	0.054 (0.034; 0.074)*
Model B	−0.028 (−0.154; 0.097)	−0.058 (−0.125; 0.008)	0.013 (−0.016; 0.042)	0.046 (0.026; 0.066)*

Model A Crude.
Model B Adjusted for age, sex, country and area of residence, marital status and smoking.
[a] n = 1922.
* $p < 0.001$.
** $p < 0.05$.

partner/civil union, and 45.1 % resided in central areas. Brazil had a younger population, with lower tobacco consumption than Chile and Argentina ($p < 0.001$).

Single activity and partition models for depressive and anxiety symptoms are represented in Table 2. In the single models, every 10 min of vigorous PA was associated with lower depression (B = −0.227; 95 % CI [−0.328, −0.126]) and anxiety (B = −0.113; 95 % CI [−0.224, −0.001]) symptoms. On the other hand, screen exposure was positively associated with both mental health outcomes. In the partition models, vigorous PA and moderate PA remained favorably associated with depression, while non-screen sitting time and screen exposure negatively associated. Screen exposure was also associated with higher anxiety symptoms (B = 0.046; 95 % CI [0.026, 0.066]). Regarding sociodemographics, females experienced higher depressive (β 3.26) and anxiety symptoms (β 3.41) than males. Also, those participants between 18 and 24 years had higher depressive and anxiety symptom scores than their older counterparts (BDI ranging β −1.80 to −3.27; BAI ranging β −2.24 to −4.14), with those aged 65 and older having lower scores (n = 119).

The ISM depicts that replacing 10 min/day in any PA intensity for the same amount of time in non-screen sitting time or screen exposure is significantly associated with greater depressive symptoms, while holding total activity constant (Table 3). Similar results for anxiety symptoms were observed when 10 min/day of moderate PA was substituted with non-screen sitting time (B = 0.072; 95 % CI [0.002, 0.142]) or screen exposure (B = 0.104; 95 % CI [0.037, 0.171]). Lastly, replacing 10 min/day of screen exposure with non-screen sitting time was favorably associated with both mental health outcomes.

Moreover, when conducting multiple imputation analysis, no significant differences were shown with the observed associations (Table S.1).

Lastly, an ISM sensitivity analysis was conducted separately for moderate-to-vigorous PA (MVPA), non-screen sitting time, and screen exposure (Table S.2). The magnitude and direction of the observed associations were very similar to moderate PA in the main analysis (Table 3); for example, when replacing 10 min/day of MVPA for non-screen sitting time or screen exposure, depression scores were 0.092 (95 % [CI 0.055, 0.129]) and 0.118 (95 % CI [0.086, 0.150]), respectively. However, coefficients for anxiety symptoms were similar to those for VPA but significant when replacing 10 min/day of MVPA for non-screen sitting time (B = 0.049; 95 % CI [0.008, 0.091]) or screen exposure (B = 0.082; 95 % CI [0.046, 0.118]).

4. Discussion

This cross-sectional study including 1981 adult participants from Chile, Argentina and Brazil aimed to investigate the independent association of screen exposure, non-screen sitting time and PA intensities, and the effect of replacing these time-use behaviors on depressive and anxiety symptoms during the first lockdown in April–July 2020. The present findings suggest a significant decrease in depressive and anxiety symptoms when 10 min/day of screen exposure or non-screen sitting time was replaced with moderate PA. In addition, replacing 10 min/day of screen exposure or non-screen sitting time with vigorous PA was associated with improved depressive symptoms. Finally, switching from screen-based sedentary activities (i.e., screen exposure) to non-screen based sedentary activities (i.e., non-screen sitting time) was associated with both better anxiety and depressive symptoms. Overall, this suggests that both alterations to increase physical activity and/or to modify sedentary activities may have important influences on mental health.

Single and partition models demonstrated that vigorous PA was the largest protective factor for depressive symptoms, while screen exposure was associated with higher depressive and anxiety symptoms. This is congruent with a study conducted in the United States (US) which found that vigorous PA was associated with overall depression score (B = −0.07).[18] On the other hand, studies conducted in the United Kingdom and US also found that screen exposure was higher in younger participants and associated with higher depressive and anxiety symptoms.[19,20] It is noteworthy that both previous studies had similar age distributions, used the same instruments, and were conducted during the early phases of the initial wave of the pandemic, indicating these results corroborate the extant literature.

Studies prior the pandemic, have demonstrated that replacing ST for PA, specifically MVPA, is associated with a lower risk of depression and anxiety. Previous research found that reallocating 60 min/day of SB with vigorous PA was associated with a reduction of −1.215 points (95 % CI [−2.250, −0.180]) in depression symptoms.[21] Further, past research has also shown that replacing 30 min/day of watching TV/listening to music/sitting in the bathtub with MVPA was associated with 19 % lower odds (OR 0.81; 95 % CI [0.73, 0.90]) for high depressive symptoms.[22] Lastly, another recent study found that replacing 60 min/day of SB with MVPA resulted in 13 % and 7 % lower depression and anxiety symptom scores, respectively.[8] While somewhat incongruent with past findings, the present results showed no association between replacing non-screen sitting time or screen exposure with vigorous PA and anxiety

Table 3
Isotemporal substitution of activities, per 10-min/day increase and depression and anxiety symptoms among South American participants.

Analysis method	VPA[a] β (95 % CI)	MPA[b] β (95 % CI)	Non-screen sitting time β (95 % CI)	Screen exposure β (95 % CI)
Depression symptoms				
Substitution of time-use behavior to replace VPA[a]	Dropped			
Model A		0.077 (−0.073; 0.228)	0.144 (0.023; 0.264)**	0.182 (0.063; 0.300)**
Model B		0.075 (−0.069; 0.218)	0.163 (0.049; 0.277)**	0.189 (0.077; 0.301)*
Substitution of time-use behavior to replace MPA[b]		Dropped		
Model A	−0.077 (−0.228; 0.073)		0.066 (0.005; 0.127)**	0.104 (0.047; 0.162)*
Model B	−0.075 (−0.218; 0.069)		0.088 (0.030; 0.147)**	0.114 (0.059; 0.170)*
Substitution of time-use behavior to replace non-screen sitting time			Dropped	
Model A	−0.144 (−0.264; −0.023)**	−0.066 (− 0.127; −0.005)**		0.038 (0.013; 0.064)**
Model B	−0.163 (−0.277; −0.049)**	−0.088 (−0.147; −0.030)**		0.026 (0.002; 0.050)**
Substitution of time-use behavior to replace screen exposure				Dropped
Model A	−0.182 (−0.300; −0.063)**	−0.104 (−0.162; −0.047)*	−0.038 (−0.064; −0.013)**	
Model B	−0.189 (−0.301; −0.077)*	−0.114 (− 0.170; −0.059)*	−0.026 (−0.050; −0.002)**	
Anxiety symptoms[c]				
Substitution of time-use behavior to replace VPA[a]	Dropped			
Model A		−0.043 (−0.214; 0.128)	0.025 (−0.107; 0.158)	0.069 (−0.061; 0.200)
Model B		−0.030 (−0.197; 0.137)	0.042 (−0.087; 0.170)	0.074 (−0.052; 0.201)
Substitution of time-use behavior to replace MPA[b]		Dropped		
Model A	0.043 (−0.128; 0.214)		0.068 (−0.003; 0.140)	0.112 (0.044; 0.180)*
Model B	0.030 (−0.137; 0.197)		0.072 (0.002; 0.142)**	0.104 (0.037; 0.171)*
Substitution of time-use behavior to replace non-screen sitting time			Dropped	
Model A	−0.025 (−0.158; 0.107)	−0.068 (−0.140; 0.003)		0.044 (0.016; 0.071)**
Model B	−0.042 (−0.170; 0.087)	−0.072 (−0.142; −0.002)**		0.033 (0.006; 0.059)**
Substitution of time-use behavior to replace screen exposure				Dropped
Model A	−0.069 (−0.200; 0.061)	−0.112 (−0.180; −0.044)*	−0.044 (−0.071; −0.016)**	
Model B	−0.074 (−0.201; 0.052)	−0.104 (−0.171; −0.037)*	−0.033 (−0.059; −0.006)**	

Model A Crude.
Model B Adjusted for age, sex, country and area of residence, marital status and smoking.
[a] VPA = vigorous physical activity.
[b] MPA = moderate physical activity.
[c] n = 1922.
* $p < 0.001$.
** $p < 0.05$.

symptoms. This could be due to the context in which vigorous PA occurs (e.g., indoor/domestic), vigorous PA generating greater displeasure and heightening existing emotions similar to anxiety symptoms (e.g., shortness of breath, increased heart rate, sweating), or aspects of the COVID pandemic that limited how much vigorous PA was possible, any of which could partially explain why lower intensities such as moderate PA may be associated with lower anxiety in the present study and more generally.[23]

Social isolation during COVID-19 negatively impacted mental health, PA levels and ST. In the present data, depression and anxiety symptoms were 42.9 % and 46.7 % higher, respectively, in Chile than in their neighboring countries (results not shown). Possible reasons are the greater percentage of younger participants aged 18–24 and the number of social measures applied to contain the movement across and within countries, in Chile compared to the other countries.[24] Also, according to a recent systematic review and meta-analysis, ST increased by 126.9 ± 42.2 min/day during the pandemic, with SE accounting for 57.2 % of the total increase in sitting time with the other 42.8 % being non-screen sitting time.[25] Increases in both screen exposure and mental health might be explained by the high level of scientific uncertainty and rapid virus dissemination during the early phase, summed with information overload which was ambiguous and inaccurate.[26] Moreover, recreational screen-time while sitting (e.g., Netflix, YouTube, social media) has been negatively associated with mental health, and may generate collateral harm to vision health, eating habits and sleeping patterns, in addition to encouraging social isolation, and potentially compulsive or addictive technology use.[9,27] On the other hand, PA levels during social isolation have declined,[6] with those performing lower levels of PA reporting higher depressive and anxiety symptoms.[7] Present findings among inactive participants (<150 min/week of moderate-to-vigorous PA; or <75 min/week of vigorous PA; or an equivalent combination) suggest that replacing 10 min/day of moderate PA for the same amount of time in non-screen sitting time or screen exposure is significantly associated with greater depressive symptoms. However, among active participants, a significant association with greater depressive symptoms was only observed when substituting 10 min/day of non-screen sitting time for the same amount of time in screen exposure. Regarding anxiety symptoms, associations were only observed when replacing 10 min/day of non-screen sitting time for screen exposure among inactive participants only (Tables S.3 and S.4). Mechanisms that have been postulated to underlie the protective effects of PA in preventing and treating mental health disorders include regulation of the hypothalamic–pituitary–adrenal axis and neurogenesis through secretion of β-endorphins, vascular endothelial growth factor and serotonin, and expression of brain-derived neurotrophic factor.[28] However, the PA–mental health association appears to be bidirectional, as people experiencing high mental health symptoms tend to also be more isolated, or may have lower energy levels or apathy to engage in PA, thus, spending more time in passive behaviors.[29]

With some quickly spreading respiratory viruses, such as Middle East Respiratory Syndrome (MERS) or the Severe Acute Respiratory Syndrome (SARS), people who isolated or quarantined have reported

long term mental health conditions.[2] As such, there is a possible bidirectionality where the COVID-19 pandemic might lead to increases in mental health disorders while simultaneously people with these disorders also appear to be at a higher risk for infection.[30] In both of these situations, the healthcare system will suffer an additional burden of mental health disorders, affecting mostly those with limited access to healthcare systems, financial resources and social minorities, widening the existing social and health inequality gap.[15]However, we may now have the opportunity to globally reinforce the promotion and prevention of negative psychosocial wellbeing among vulnerable populations in these countries, informing decision-makers about the urgent need for tackling the underfunded mental health service, which until now only receives approximately a median of 1.60 % to 3.80 % of the domestic general government health expenditure.[15] Strategies to improve wellbeing should include a cross-cutting perspective where optimal distributions of time-use behaviors are incorporated in daily life, focusing on less screen exposure, sitting less, and moving more. This would likely be particularly influential as people with depression currently experience an 8–10 year premature mortality gap in comparison with the general population, and that 30 min/day of MVPA is associated with 16.9 % reduction in the number of annual deaths.[31,32] Yet, the pandemic has also forced a substantial shift to screen-based communication via ubiquitous virtual platforms that have been used to maintain educational, economic, and health-care sectors, many of which may be here to stay. However, our results suggest that variation of sedentary activities on its own could be psychologically important, as different types of SBs may have distinct associations with mental health. For example, mentally-active behaviors characterized by cognitive effort or improved cognitive performance capacities such as knitting, sewing, reading, or office work were favorably associated with lower risks for depressive disorders, whereas mentally-passive behaviors (watching TV or listening to music) associated with higher risks for depressive disorders.[5] Further, the past research has suggested that replacing 30 min/day of passive SB with active SB was associated with 5 % reduction in depression,[22] which is similar to our current results that show replacing screen exposure with non-screen siting was associated with significant reductions in both depressive and anxiety symptoms. Possible explanations for these effects might include the context in which the behavior occurs (environment), cognitive effort, and happiness and satisfaction when a positive behavior is performed.[5] In our study, screen exposure also had a stronger overall effect on mental health than non-screen sitting time. Therefore, strategies such as public campaigns to encourage practicing healthy digital habits are imperative. Examples might include having active audio calls or voice notes to beat screen fatigue, or using mobile health applications that allow for intentionally noticing and interrupting ST.

The findings of this study should be considered in the context of their strengths and limitations. Limitations include precluding inference of causality and potential reverse causality, a non-representative sample, residual confounding such as social support and body mass index, and information bias due to the use of self-reported questionnaires. Moreover, non-screen sitting time has not been validated and could incur bias, as participants could have been exposed to the screen while performing light PA. Lastly, information about the accumulation of SB types was not available, ignoring differential responses depending on whether the activities were mentally active or mentally inactive. However, PA, ST and mental health outcomes were derived from validated instruments. On the other hand, strengths include an identical survey used in different countries, and data of samples from low to middle-income countries that are usually less frequently investigated compared to high-income countries.

5. Conclusion

To our knowledge this is the first study identifying novel associations between substitutions of time-use behaviors and mental health outcomes in the early stages of the COVID-19 pandemic. Low-cost and attainable strategies such as promoting PA and limiting screen exposure and ST could support population mental health. Future emergency responses that permit exercising outdoors may be important to protect mental health during challenging periods.[29] However, longitudinal research incorporating objective devices studying various components of SB and PA using ISM is encouraged, particularly given the current lack of research investigating the potentially distinct health effects of various types of SB.

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Confirmation of ethical compliance

The study in Chile was approved by the faculty of medicine at the University Diego Portales (number 02-220; 27th March), in Argentina by the Universidad the Flores (number 09/2020; 22th April) and in Brazil by the Federal University of Santa Maria (number [CONEP] 30,244,620.1.0000.5346; 10th April). Inform consent was obtained for all participants.

CRediT authorship contribution statement

KPS involved in Conceptualization; KPS, FBS, GDR and PL were involved in Investigation; KPS, DMG and JM were involved in Methodology; KPS, FBS, RC and PL were involved in Data curation; KPS involved in Formal analysis; KPS, FBS, DMG, AOW and JM were involved in Validation; KPS, FBS, DMG and JM were involved in Visualization; KPS, FBS, DMG, AOW and JM were involved in Supervision; KPS involved in Roles/Writing – original draft; KPS, FBS, GDR, DMG, RC, PL, CCM, AOW, HA, GF, AI, DRS, AVO, TSM, IG and JM were involved in Writing – review & editing. All authors review critically several drafts of the manuscript and approved the final version before. The corresponding author has full access to all the data in the study and is responsible for the decision to submit for publication.

Declaration of interest statement

The authors report no conflicts of interest in this work.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsams.2023.04.007.

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