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ISSN

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et al.

Publication Date

DOI

Peer reviewed

Physical Activity and Stress Management during COVID-19: A Longitudinal Survey Study

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Word Count: 2,881

Abstract

Objective: Physical activity (PA) during COVID-19 shelter-in-place (SIP) may offset stress. This study examined associations between PA, stress, and stress management strategies during SIP. **Design and Main Outcome Measures:** Participants (N=990) from a cohort of Northern California adults completed surveys during early SIP (3/23/20-4/2/20) and mid-SIP (4/24/20-5/8/20). Participants self-reported past-month PA (meeting vs. not meeting guidelines), changes in stress (decreased/unchanged vs. increased) and use (yes/no) of ten stress management strategies. We tested differences in mid-SIP stress and stress management strategies by PA, and differences in mid-SIP stress by stress management strategies. **Results:** Compared to participants inactive at mid-SIP, active participants reported less stress (AOR=0.60 [0.45,0.81]). Active participants were more likely to manage stress using outdoor PA, indoor PA, yoga/meditation/prayer, gardening, and reading (AORs>1.42), and less likely to sleep (AOR=.65 [.48,.89]) or eat ([AOR=.48 [.35,.66]) more. Managing stress using outdoor PA, indoor PA, or reading was associated with lower stress; managing stress using TV/movies, sleeping, or eating was associated with increased stress ($ps<.05$). **Conclusions:** Meeting PA guidelines during SIP was associated with less stress. Inactive participants reported greater sleeping and eating to cope; active participants used active stress management strategies. Engagement in physically active stress management was associated with lower stress.

Keywords: physical activity; stress; COVID-19; shelter-in-place; stress management

Introduction

Public health measures to contain the spread of COVID-19, the disease caused by the novel coronavirus SARS-CoV-2, have affected billions of people worldwide. In March 2020, approximately 1.7 billion people were under orders to remain at home or shelter-in-place (SIP) (Davidson, 2020). Such orders, which mandate remaining at home except for essential activities and outdoor exercise with social distance (Schwiegershausen, 2020), are crucial to slowing transmission of COVID-19, preserving healthcare systems' capacities, and limiting deaths (Qualls et al., 2017). However, successes in mitigating the spread of COVID-19 are paired with devastating economic, social, and psychological effects (Rajkumar, 2020). Stress management strategies are needed to preserve well-being during this abrupt isolation period.

Physical activity (PA) decreases emotional stress and improves physical and psychological health (Stults-Kolehmainen & Sinha, 2014). Yet, engaging in regular PA can be challenging under even normal circumstances. In 2018, 54.2% of American adults engaged in light or moderate activity for 150+ minutes/week or vigorous activity for 75+ minutes per week (Centers for Disease Control and Prevention & National Center for Health Statistics, 2018). SIP orders may further reduce activity levels (Hall et al., 2020; Pinto et al., 2020) by decreasing incidental daily PA (e.g., walking from place-to-place) and exercise opportunities (e.g., gyms, parks, sports facilities). As such, the World Health Organization issued recommendations for engaging in PA at home (Ricci et al., 2020). Many people face serious challenges to being physically active during SIP. Many neighborhoods may not be conducive to safe, socially distant

outdoor exercise. Moreover, many individuals have increased demands on their time during SIP, such as essential work, caring for family members, and standing in long lines to buy necessities. Vulnerable communities, particularly communities of color, have been disproportionately affected by COVID-19 (National Center for Immunization and Respiratory Disease, 2020). On the other hand, SIP may facilitate greater PA for some individuals. Those who transitioned from commuting to working from home may have more free time for PA. Additionally, individuals and families may spend time outside to combat boredom and stress. Some stress management strategies that may be used during COVID-19 involve physical activity (e.g., outdoor activities, home improvement projects, gardening), while others are mostly sedentary (e.g., reading, watching TV, eating more, sleeping more).

We hypothesized that adults who met PA guidelines during COVID-19 SIP would be less likely to report increased stress during SIP and would be more likely to report use of physically active stress management strategies. We also explored whether increased stress would be associated with PA pattern (e.g., becoming less active during SIP) or associated with use of specific stress management strategies.

Materials and Methods

Participants and procedure

Participants were recruited from the U.S. component of the Stanford WELL for Life initiative (N=5,464), a cohort of adults residing mostly in Northern California. Eligible participants for the WELL for Life cohort (i.e., the parent study) were age 18 or older, residing in the U.S., and able to complete the online survey in English. Participants were recruited through research registries, Stanford listservs, social media, and through existing community partnerships (Chrisinger et al., 2019). WELL for Life cohort participants who had indicated willingness to

participate in other studies (N=4,800) were invited to participate in the present study examining

well-being during COVID-19. Participants completed surveys in early SIP (3/23/20-4/2/20) and

mid-SIP (4/24/20-5/8/20). Participants provided informed consent and the study was approved

by the Stanford University Institutional Review Board.

Study setting

The majority of participants (81.4%) resided in the San Francisco Bay Area, where a

regional SIP order on 17 March 2020 affecting 6 Bay Area counties and the city of Berkeley

mandated closure of indoor and outdoor recreation venues such as gyms, climbing walls,

playgrounds, golf courses, basketball and tennis courts, and pools (City and County of San

Francisco Department of Public Health, 2020a). Additionally, the state of California closed many

state parks and beaches (California Department of Parks and Recreation, 2020) and instructed

residents to stay close to home for recreation (State of California, 2020). Most restrictions

remained in place through the end of May 2020 (California Department of Parks and Recreation,

2020; City and County of San Francisco Department of Public Health, 2020a, 2020b; State of

California, 2020).

Measures

Physical activity

Past-month PA was measured with the Stanford Leisure-Time Activity Categorical Item

(L-Cat), a validated measure with excellent sensitivity to change in PA over time (Kiernan et al.,

2013; Ross et al., 2018). Participants selected one of six descriptions that best matched their past-

month leisure time physical activity. Scoring was based on adherence to the 2007 American

College of Sports Medicine/American Heart Association guideline of: a) 30+ minutes of

moderate-intensity aerobic physical activity 5 days/week, b) 20+ minutes of vigorous-intensity

aerobic physical activity 3 days/week, or c) a combination of the above (Haskell et al., 2007). Responses were categorized as meeting/exceeding or not meeting PA guidelines.

Stress during SIP

In early SIP, participants were asked, "Since the Shelter in Place Order, how stressed do you feel?" (less stressed, no change in stress, more stress). At mid-SIP, participants were asked, "In the last two weeks, how stressed did you feel?" (less stressed, no change in stress, more stress). Responses were categorized as "increase in stress" or "no increase in stress."

Coping strategies

Participants responded to, "What are you currently doing to manage your stress?". In early SIP, the question was open-ended. Participant responses from early SIP informed the 10 response options provided in mid-SIP: outdoor physical activities (e.g., walking, running, hiking), indoor physical activities (e.g., at-home workouts, home improvement projects), yoga/meditation/prayer, calling/video-chatting with friends and family, watching TV/movies at home, reading, listening to music, gardening, sleeping more, and eating more.

Participant characteristics

Participants reported their age, gender, race, education, total combined family income, marital status, employment status, and the number of people living in their household. Participants also reported the number of days they drank alcohol in the past month (0-30) and whether they used cannabis in the past two weeks (yes/no). Current smoking status was derived from two items; participants were considered current smokers if they reported 100+ lifetime cigarettes and currently smoking "some days" or "every day" (vs. not at all).

Statistical analysis

Differences in participant characteristics by mid-SIP PA (not meeting vs. meeting/exceeding guidelines) were tested using independent-samples t-tests and chi-square tests. PA pattern from early SIP to mid-SIP was coded as "remaining inactive" (not meeting guidelines in early or mid-SIP), "remaining active" (meeting guidelines in both early SIP and mid-SIP), "becoming inactive" (meeting guidelines in early SIP but not mid-SIP), or "becoming active" (meeting guidelines in mid-SIP but not early SIP). Logistic regressions examined differences by mid-SIP PA (meeting vs. not meeting guidelines) in likelihood of increased stress at mid-SIP and use of each stress management strategy at mid-SIP, adjusting for age, race, education, income, employment, and past-month alcohol use (any drinking vs. no drinking). Chi-square tests examined the association between mid-SIP stress and PA pattern, and between mid-SIP stress and mid-SIP use of stress management strategies. P-values < 0.05 were considered statistically significant.

Results

The analytic sample (*N*=990) was 79.6% female (*M* age=50.5; *SD*=16.7). The majority of participants identified as White/Caucasian (69.4%) or Asian (21.2%) and were married (59.7%). Most (88.2%) had a college degree or higher and were employed at mid-SIP (70.6%); 43.7% reported $150,000 or more in annual household income. Participant characteristics are shown for active (i.e., those who met PA guidelines during mid-SIP) and less active participants in Table 1.

[*Table 1 near here*]

Physically active participants were significantly older, more likely to be White/Caucasian, had greater educational attainment and higher income, were less likely to be employed (most who were not employed were retired), and were more likely to drink alcohol in the past month (*p*s<.05), compared to less physically active participants. The proportion of active participants

was comparable to the national average (early SIP *n*=527, 54.0%; mid-SIP *n*=583, 58.9%). In

early SIP, a majority of participants reported that their stress had increased since SIP began

(*n*=630, 64.4%), while a minority reported increased stress in mid-SIP (*n*=316; 32.0%).

At mid-SIP, active participants were significantly less likely to report recent increased

stress, compared to less active participants (AOR=0.60, 95% CI [0.45, 0.81], *p*=.001).

Additionally, active participants were approximately four times more likely to report managing

stress using outdoor PA (e.g., walking, running, hiking; AOR=4.03, 95% CI [2.98, 5.45,

p< .001), nearly three times as likely to report indoor PA (e.g., home workouts, home

improvement projects; AOR=2.84, 95% CI [2.14, 3.77], *p*< .001), and approximately 1.5 times

to nearly twice as likely to report use of yoga, meditation, or prayer (AOR=1.92, 95% CI [1.42,

2.60], *p*< .001), gardening (AOR=1.68, 95% CI [1.22, 2.29], *p*=.001), and reading (AOR=1.43,

95% CI [1.08, 1.88], *p*=.011), compared to less active participants. Active participants were

approximately half as likely as less active participants to cope with stress by sleeping more

(AOR=0.65, 95% CI [0.48, 0.89], *p*=.007) or eating more (AOR=0.48, 95% CI [0.35, 0.66],

p<.001). Use of the other coping strategies (calling/video-chatting with friends and family,

watching TV/movies at home, and listening to music) was not associated with PA (*p*s>.05).

Results are presented in Table 2.

[*Table 2 near here*]

PA pattern from early SIP to mid-SIP was associated with mid-SIP stress (*p*=.002),

adjusting for age, race, education, income, employment, and alcohol use. Planned contrasts

showed that compared to participants who remained active, those who remained less active were

nearly twice as likely to report increased stress (AOR=1.90, 95% CI [1.37, 2.64], *p*<.001).

Participants who became active (AOR=1.32, 95% CI [.84, 2.06], *p*=.225) or became less active

(AOR=1.56, 95% CI [.94, 2.62], *p*=.089) did not significantly differ in stress from those who remained active.

During mid-SIP, the likelihood of reporting increased stress was lower among participants who coped with stress using outdoor PA (χ^2=11.90, *p*=.001), indoor PA (χ^2=7.39, *p*=.007), and reading (χ^2=8.64, *p*=.003). Likelihood of recent increase in stress was higher among those who managed stress by watching TV/movies (χ^2=4.30, *p*=.038), sleeping more (χ^2=6.77, *p*=.009), and eating more (χ^2=32.96, *p*<.001). Increases in stress did not differ by use of yoga/meditation/prayer, calling/video-chatting family/friends, listening to music, or gardening (*p*s>.05).

All analyses were repeated excluding participants who did not report residing in the Bay Area during April 2020 (*n*=184, 18.6%) and hence may not have been subject to the same shelter-in-place orders. The pattern of results was unchanged, except that the association between increased stress and managing stress by watching TV/movies was attenuated (χ^2=2.61, *p*=.106).

Discussion

Managing stress while complying with the uniquely disruptive COVID-19 SIP restrictions may require a variety of stress management strategies. In a sample of adults mostly residing in Northern California, we examined relationships between stress, physical activity, and other stress management strategies during SIP. Participants who were physically active (i.e., met PA guidelines) during SIP were less likely to feel increased stress during SIP and were more likely to report use of physically active stress management strategies. Additionally, physically active participants were less likely to report managing stress by sleeping more or eating more. Participants who reported managing stress using outdoor PA, indoor PA, and reading were less

likely to feel increased stress during SIP. Those who managed stress by watching TV/movies, sleeping more, and eating more were more likely to feel increased stress.

The association between greater PA and lower stress was consistent with hypotheses and with the extensive literature on the positive effects of PA on stress reduction in non-COVID contexts (Stults-Kolehmainen & Sinha, 2014). Engaging in PA may have significantly reduced stress incurred by COVID-19. Alternatively, participants with fewer stressors may have found it easier to be physically active. In this study, participants meeting PA guidelines were older, more likely to be White and to drink alcohol, had greater educational attainment and higher household income, and were less likely to be employed (most participants without jobs were retired; see Table 1). These participants may represent a subset of adults with greater resources and fewer demands on their time during SIP, leading to lower stress and increased ability to engage in PA. Nonetheless, the association between PA and stress remained statistically significant after accounting for age, race, past-month alcohol use, education, household income, and employment status. Participants reported relative stress during SIP compared to their own previous stress level. Engaging in PA may have contributed to stress management, even for participants who already had many advantages. This study suggests that the well-documented positive effects of PA (Stults-Kolehmainen & Sinha, 2014) on stress management persist even in the highly unusual circumstances of SIP.

Active and less active participants also differed in the stress management strategies they employed. A majority of active participants reported that they used PA—especially outdoor PA — to manage stress. Active participants were four times more likely than less active participants to report managing stress using outdoor PA than inactive participants. Active participants were also more likely to report use of indoor PA, yoga, meditation, or prayer, gardening, and reading.

Most of these activities involve a physical activity component. Additionally, physically active participants were less likely to cope with stress by eating more or sleeping more. Disruptions in diet are common during stressful times. Similar to the present study, a study of Belgian university students found students with more stress and less physical activity were at greatest risk for increased snacking during a stressful final exam period (Michels et al., 2020). COVID-19 SIP is a more widespread, disruptive, long-term stressful circumstance than a final exam period, yet similar results were found. Sleep disruptions have also been linked to stress during COVID-19 self-isolation (Xiao et al., 2020). Indeed, in the current study, participants who managed stress by eating more, sleeping more, or watching TV/movies were more likely to report increased stress. Eating, sleeping, and watching TV/movies may have been used to manage stress by participants who were already experiencing a great deal of stress. These activities require less energy to initiate than the more active strategies and may have felt more manageable. Concurrently, these less active strategies may have been less effective than strategies involving physical activity. Participants who coped with stress using PA or reading were less likely to report increased stress. Making PA—especially outdoor PA— more accessible during COVID-19 SIP may help ease stress. Recent changes in SIP policies in the San Francisco Bay Area have opened up local parks and activity areas (e.g., playgrounds, tennis courts).

Overall level of PA during SIP, rather than change in PA, was associated with stress. Specifically, participants who became active or became less active during SIP did not significantly differ in likelihood of increased stress from those who were active throughout SIP. On the other hand, those who were less active both before and during SIP were more likely to experience increased stress. Low physical activity may be associated with other risk factors for stress, such as long work hours, that persisted during SIP. The study period was short

(approximately one month) and may not have been sufficient to show long-term associations. Other research has found that improvement in stress management over time is associated with increases in PA (Lipschitz et al., 2015). As people adjust to COVID-19 and its associated restrictions, stress management and PA may improve. Although PA remained fairly consistent over the one-month study period (54% met guidelines in early SIP; 59% met guidelines in mid-SIP), the proportion of participants reporting increased stress during SIP decreased substantially (64% in early SIP; 32% in mid-SIP). Engaging in PA throughout SIP may further decrease stress. Stress management is crucial during COVID-19, as stress can increase susceptibility to viral infection (Cohen et al., 1991).

Limitations and future directions

This study was observational and precludes causal conclusions about the role of PA in reducing stress. Analyses adjusted for numerous potential confounding factors; however, analyses were correlational. Generalizability of results is limited due to the non-representative sample. Most participants resided in Northern California, where the weather is generally conducive to outdoor PA year-round. The sample was predominantly middle-aged, female, White or Asian, and highly educated, with high household incomes. Although PA has near-universal benefits, disparities in the ability to engage in PA during COVID-19 are likely. To our knowledge, such disparities have not yet been studied. Future research is needed to examine the role of PA in COVID-19 stress management among more socio-demographically and geographically diverse populations. Participants were surveyed at the beginning of SIP and one month into SIP. Longer follow-up may show different patterns of results. The measure of stress used in this study was designed to capture changes in stress specific to SIP in a single item, with

high face validity. Validated measures of stress, while less specific to SIP, should be used in future longitudinal research to expand upon the present study.

Conclusions

Meeting PA guidelines during COVID-19 SIP was associated with lower likelihood of experiencing increased stress during SIP and with greater use of active stress management strategies. Prior research has demonstrated consistent benefits of PA on mitigating stress (Stults-Kolehmainen & Sinha, 2014). The current findings, though correlational, suggest that engaging in PA may reduce stress during COVID-19 SIP. Further research is needed to examine and address potential disparities in stress and PA during COVID-19 SIP. Public health interventions should emphasize the importance of engaging in PA consistently and safely during SIP, and should facilitate accessible opportunities to safely engage in PA.

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Declaration of Interest Statement

No authors have conflicts of interest to disclose.

Data Access Statement

The data that support the findings of this study are available from the corresponding author, EAV, under reasonable request.

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Table 1. *Differences in participant characteristics by physical activity (PA) level during COVID-19 shelter-in-place (SIP) order (N=990)*

	Meeting PA guidelines during mid-SIP (*n*=583)	Not meeting PA guidelines during mid-SIP (*n*=407)	*p*	Full analytic sample (*N*=990)
Age (M/SD)[a]	51.7 (16.6)	48.7 (16.8)	**.006**	50.5 (16.7)
Gender (N/%)[b]			.243	
Male/man	122 (21.0%)	73 (18.0%)		195 (19.8%)
Female/woman	458 (78.7%)	328 (81.0%)		786 (79.6%)
Gender minority	2 (0.3%)	4 (1.0%)		6 (0.6%)
Race (N/%)[b]			**.001**	
White/Caucasian	425 (73.8%)	252 (63.0%)		677 (69.4%)
Asian	99 (17.2%)	108 (27.0%)		207 (21.2%)
Other or multiple race(s)	52 (9.0%)	40 (10.0%)		92 (9.4%)
Education (N/%)[b]			**.001**	
Less than college degree	51 (8.8%)	65 (16.0%)		116 (11.8%)
College degree or higher	527 (91.2%)	340 (84.0%)		867 (88.2%)
Household income (U.S. $) (N/%)[b]			**.001**	
Less than $50,000	42 (7.5%)	49 (12.4%)		91 (9.5%)
$50,000 - $99,999	130 (23.1%)	105 (26.6%)		235 (24.6%)
$100,000-$149,999	117 (20.8%)	95 (24.1%)		212 (22.2%)
$150,000 or more	273 (48.6%)	145 (36.8%)		418 (43.7%)
Marital status (N/%)[b]			.066	
Married	363 (62.3%)	228 (56.0%)		591 (59.7%)

Single	94 (16.1%)	92 (22.6%)		186 (18.8%)
Divorced, separated, or widowed	68 (11.7%)	50 (12.3%)		118 (11.9%)
Living with partner	58 (9.9%)	37 (9.1%)		95 (9.6%)
Employment status[c]				
Working full-time or part-time	395 (67.9%)	303 (74.4%)	**.022**	698 (70.6%)
Retired	127 (21.8%)	62 (15.2%)		189 (19.1%)
Unemployed or temporarily laid off	22 (3.8%)	9 (2.2%)		31 (3.1%)
Other	38 (6.5%)	33 (8.1%)		71 (7.2%)
People living in household (M/SD)[a]	2.7 (1.3)	2.8 (1.7)	.190	2.7 (1.5)
Past-month drinking (N/% yes)[a]	402 (69.6%)	237 (59.5%)	**.001**	639 (65.5%)
Past-month drinking days among those who drank (M/SD)[a]	10.2 (8.7)	9.1 (8.8)		9.8 (8.8)
Past-month drinking days including non-drinkers (M/SD)[a]	7.1 (8.7)	5.4 (8.2)		6.4 (8.5)
Used cannabis in the past 2 weeks (N/% yes)[c]	49 (8.4%)	44 (10.8%)	.205	93 (9.4%)
Current smoking (N/% yes)[a]	2 (0.3%)	7 (1.8%)	.058	9 (0.9%)

Note: The analytic sample consisted of participants who provided physical activity data during mid-SIP.
[a]Measured in early SIP.
[b]Measured prior to COVID as part of the parent study
[c]Measured in mid-SIP.

Table 2. *Likelihood of reporting increased stress and use of stress management strategies during COVID-19 shelter-in-place orders (4/24/20 – 5/8/20) by physical activity (meeting vs. not meeting guidelines)*

	Prevalence of stress and stress management (N/% yes) by physical activity			Unadjusted associations with physical activity		Adjusted associations with physical activity[a]	
	Meeting guidelines (*n*=583)	Not meeting guidelines (ref.; *n*=407)	Total (N=990)	OR	p	AOR	p
Increased stress during SIP	151 (26.0%)	165 (40.5%)	316 (32.0%)	**.52 (.39, .68)**	**<.001**	**.60 (.45, .81)**	**.001**
Stress management strategies							
Outdoor physical activity	474 (81.3%)	198 (48.6%)	672 (67.9%)	**4.59 (3.45, 6.10)**	**<.001**	**4.03 (2.98, 5.45)**	**<.001**
Indoor physical activity	373 (64.0%)	156 (38.3%)	529 (53.4%)	**2.86 (2.20, 3.71)**	**<.001**	**2.84 (2.14, 3.77)**	**<.001**
Yoga, meditation, prayer	230 (39.5%)	105 (25.8%)	335 (33.8%)	**1.87 (1.42, 2.47)**	**<.001**	**1.92 (1.42, 2.60)**	**<.001**
Gardening	203 (34.8%)	95 (23.3%)	298 (30.1%)	**1.75 (1.32, 2.34)**	**<.001**	**1.68 (1.22, 2.29)**	**.001**
Reading	296 (50.8%)	162 (39.8%)	458 (46.3%)	**1.56 (1.21, 2.02)**	**.001**	**1.43 (1.08, 1.88)**	**.011**
Sleeping more	130 (22.3%)	136 (33.4%)	266 (26.9%)	**0.57 (.43, .76)**	**<.001**	**.65 (.48, .89)**	**.007**
Eating more	106 (18.2%)	129 (31.7%)	235 (23.7%)	**0.48 (.36, .64)**	**<.001**	**.48 (.35, .66)**	**<.001**
Watching TV or movies	356 (61.1%)	265 (65.1%)	621 (62.7%)	.84 (.65, 1.09)	.195	.96 (.72, 1.27)	.751
Listening to music	246 (42.2%)	166 (40.8%)	412 (41.6%)	1.06 (.82, 1.37)	.658	1.18 (.89, 1.56)	.246
Calling/video-chatting friends/family	340 (58.3%)	226 (55.5%)	566 (57.2%)	1.12 (.87, 1.45)	.383	1.07 (.81, 1.40)	.657

Note: "Not meeting guidelines" is the reference group. Odds ratios (ORs) and adjusted odds ratios (AORs) greater than 1 indicate that participants who met PA guidelines were *more* likely to endorse the item than participants who did not

meet PA guidelines. Bold text indicates p<.05.

[a]Adjusted for age, race, education, income, employment status, and past-month alcohol use.