International Journal of EXERCISE SCIENCE

Original Research

Physical Activity Independently Predicts Perceived Stress During the COVID-19 Pandemic in Private University Students

CURTIS W. BROWNELL*, AUGUSTO X. RODRIGUEZ‡, CASSANDRA S. DIEP‡, AMANDA M. PERKINS-BALL‡, HEIDI Y. PERKINS‡, LAURA S. KABIRI‡

Sports Medicine & Exercise Physiology, Department of Kinesiology, Rice University, Houston, TX, USA

*Denotes undergraduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 15(7): 1680-1691, 2022. Physical activity has significantly declined during the COVID-19 pandemic. Declines in physical activity have correlated with increased levels of perceived stress, though studies examining physical activity and stress have failed to account for critical confounds. The present study aims to determine whether physical activity independently predicts perceived stress in students attending private four-year universities. Physical activity, socioeconomic status, resilience, gender, and perceived stress data were collected from 85 students and used in a multiple linear regression analysis. The regression model accounted for 43.5% of the variance in perceived stress ($R2 = .462$, $p < .001$). Total physical activity significantly and inversely predicted perceived stress ($\beta = -.229$, $p = .007$) in students irrespective of other covariates. Socioeconomic status, resilience, and gender also independently and significantly predicted perceived stress. Findings should be leveraged by university staff to promote psychological well-being and wholistic health initiatives incorporating physical activity as a primary and modifiable component.

KEY WORDS: Coronavirus, disparities, mental health, resilience, socioeconomic status, undergraduate

INTRODUCTION

Population levels of physical activity (PA) have significantly declined during the pandemic (12, 31, 40). Declines in PA during the COVID-19 pandemic have been associated with decreased psychological well-being and increased perceptions of stress (31, 40). High perceptions of stress correlate with depression, anxiety, poor sleep quality, fatigue, illness symptoms, and poor health (4, 20, 26). Additionally, duration and intensity of stress perceptions are associated with summary physiological dysregulation scores, indicating that perceived stress is related to multisystem physiological dysregulation (18). The implementation of measures that combat perceived stress and its adverse psychological and physiological consequences requires a thorough understanding of the predictors of perceived stress during the COVID-19 pandemic.

Regular PA has frequently been investigated as a means of attenuating stress perception and its physiological repercussions. In correlational studies, high levels of PA, especially vigorous PA, have been found to correlate with low levels of perceived stress (14, 33). Other studies have found that regular exercisers are less likely to experience negative emotional consequences of stress or to develop mental health problems despite moderate to high perceptions of stress (3, 14, 15). However, the exact mechanism by which PA is associated with lower levels of perceived stress remains unknown. One prevailing hypothesis posits that behavioral changes impacting sleep quality, self-regulation, or coping strategies mediate the relationship between PA and mental health (27). Researchers aptly call this the behavioral mechanisms hypothesis (27). Cross-sectional research has supported this hypothesis by demonstrating that physically active adolescents are more likely to employ problem-focused or "shift-persist" coping strategies and less likely to employ emotion-focused coping strategies, when compared to inactive peers (8). PA is also intimately related to physiological stress responses and induces acute disturbances to the hypothalamic-pituitary-adrenal axis (HPAA) that may resemble those induced by psychosocial stressors (28). Low levels of PA correlate with increased HPAA reactivity in response to stress and slower stress recovery (16, 29). Chronic PA also results in adaptations to the HPAA such that submaximal psychosocial stressors elicit responses of lower magnitude (16, 36). Overall, PA is associated with a tempered experience of stress. Highly active individuals generally experience lower perceptions of stress, in addition to reduced emotional and physiological consequences of stress.

In addition to PA, socioeconomic status (SES), resilience, and gender have all been identified as correlates with perceived stress. Research has identified a consistent social gradient in perceived stress among adolescents regardless of the measure used to assess SES. This effect is at least partially mediated by varying levels of optimism across SES strata (10). SES in university students resembles SES in adolescents because it is determined by both available parental resources and students' individual statuses (17). Interestingly, subjective SES, or one's self-perception of social rank based on financial, educational, or occupational prestige, has significantly predicted perceived stress in models where income and other objective measures of SES did not significantly predict perceived stress (19). These findings emphasize how the subjective relationship between an individual and the social environment cannot be separated from stress perception (19).

Resilience, a construct often defined as the ability to recover from stress or adversity, can act as a resource to reduce perceptions of stress (1, 25). Resilience has significantly predicted perceived stress in undergraduate students (13). Gender is also significantly associated with perceived stress, with females generally reporting more stress than males (24, 30). In comparison to males, females report more chronic stress and daily stressors and rate life events as more negative and uncontrollable (30). Significant differences exist in the types of stressful life events reported by each gender. Females report more stressful life events pertaining to family and health, whereas men report more stressful events related to work, finances, and romantic relationships (30). Differences in coping also exist, with females more frequently employing emotion-focused or avoidance coping styles (10, 30). Students' propensities to bounce back from and cope with

pandemic-related adversities are intimately connected to their experience of stress, necessitating consideration of resilience and gender in a predictive model of perceived stress.

Clearly, PA, SES, resilience, and gender are related to perceived stress. Though past studies have established a relationship between PA, SES, resilience, gender, and perceived stress, they have failed to determine whether PA continues to uniquely predict perceived stress during the COVID-19 pandemic. It remains unknown if social isolation, separation from university support systems, changes to the classroom environment, or other stressors associated with the COVID-19 pandemic disrupt the known relationship between PA and perceived stress. Given that PA is easily measured and modified, knowledge of the unique contribution of PA in a predictive model of stress is essential to the design of future PA interventions intended to minimize stress. Therefore, the purpose of the present study is to determine whether PA is an independent predictor of perceived stress in university students during the COVID-19 pandemic while accounting for the known influence of SES, resilience, and gender in the overall model. We hypothesize that PA will independently predict perceived stress when accounting for the effects of SES, resilience, and gender.

METHODS

Participants

This study received Institutional Review Board approval from the primary investigator's university prior to any recruitment, enrollment, or data collection. Furthermore, this research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (32).

The present study examined data collected as part of the larger COVID-19 Stress, Physical Activity, and Nutrition Effects on Students (CSPANES) research project, which collected data across four domains: (1) perceived stress, (2) PA, (3) nutrition, and (4) resilience. The CSPANES project used university email, social media, and chain referral sampling in November of 2020 to recruit adults ages 18-25 years old who were enrolled in a college or university in the Greater Houston area. Participants provided informed consent prior to online survey access and were allowed to skip questions or end the survey at any time. For their participation, participants could enter a drawing for a $20 gift card. The present study examined three of the four CSPANES domains and restricted participants to only students attending a private four-year university. An a priori power analysis indicated a sample size of 85 to achieve statistical power ≥ 0.80 at alpha level ≤ 0.05 and an effect size of f2 = 0.15 with four predictor variables.

Protocol

The online survey asked participants about personal and household characteristics and demographic information, including self-reported age, gender, type of university attended, and perceived SES as "poor," "working class," "middle class," or "affluent" following standard practice (9). Perceived stress was measured using the 10-item Perceived Stress Scale (PSS-10) (4, 6). The PSS-10 is the most widely used assessment of perceived stress and exhibits good internal

(Cronbach's α > .70) and test-retest (> .70) reliability (26). The PSS-10 explicitly captures the appraisal of stress and is distinct from measures of related constructs such as depression (6). Pertinent to the present investigation, the PSS-10 has also been validated in samples of people living with life altering, yet uncontrollable stressors such as lupus (37). It is assumed that these low control stressors may resemble those associated with the COVID-19 pandemic, given that many decisions regarding social distancing, academic accommodations, and other pandemic responses are outside of students' direct control.

PA was assessed using the International Physical Activity Questionnaire – Short Form with seven-day recall (IPAQ-SF) (7). The IPAQ-SF is an accepted standard recall tool for PA with excellent repeatability (Spearman's ρ = 0.8) and good convergent validity with other self-report measures (ESρ = .53) (7, 23). With COVID-19 restrictions limiting the ability to collect data in-person, self-reported measures such as the IPAQ-SF have appealed to researchers and have been used successfully in other activity assessments during the COVID-19 pandemic (2). The IPAQ-SF contains seven questions that gauge time spent in sedentary behavior or each of three PA intensities: walking (WPA), moderate PA (MPA), or vigorous PA (VPA). The IPAQ-SF calculates PA as weekly MET-minutes spent in each of the three intensities, as well as participants' total weekly MET-minutes. Despite earlier cautions against using the IPAQ-SF to derive continuous measures of PA, meta-analyses have concluded that continuous measures derived from the IPAQ-SF have corrected mean effect sizes equal to or greater than those derived from the IPAQ-Long Form and support the utilization of the IPAQ-SF as a means of obtaining continuous data (23). The IPAQ-SF uses a published algorithm to further categorize participants as inactive, minimally active, or health-enhancing PA (HEPA) active according to time spent in WPA, MPA, and VPA (22).

Resilience was measured using the Brief Resilience Scale (BRS). The BRS is a six-item self-report tool (35). While other resilience scales primarily assess the availability of factors that protect against psychopathology, the BRS is designed to explicitly capture a person's ability to bounce back or recover from stress. In a recent review of resilience measures, the BRS received the maximum score for construct validity and was ranked highest in overall quality (39). It correlates well with both the Connor-Davidson Resilience Scale (r = .59, p < .01) and Ego Resiliency Scale (r = .51, p < .01) and has been studied and validated in diverse populations (35).

Statistical Analysis

Statistical analyses included descriptive statistics for all variables reported as frequency and mean/percentage ± standard deviation. The authors cleaned IPAQ-SF data prior to analysis in accordance with published guidelines, which included recoding cases with PA durations < 10 minutes to zero minutes of PA and zero days for the corresponding intensity (22). Weekly MET-minutes, as well as MET-minute subtotals for WPA, MPA, and VPA, were calculated. IPAQ-SF activity classification was also reported.

The authors ran multiple linear regression to determine the effect of four predictor variables (MET-minutes, SES, BRS score, and gender) on the dependent variable (PSS score). A normal

predicted probability (P-P) plot of the regression residuals for the dependent variable was generated and visually inspected to confirm a normal distribution of the dependent variable. The assumption of homoscedasticity was verified by scatterplot. The authors conducted all other statistical analyses using SPSS (version 27, Chicago, IL, USA), with statistical significance set at an alpha value of ≤ .05. A faculty statistician reviewed and verified all statistical tests.

RESULTS

In all, 181 participants responded to the CSPANES study, with 162 completing the survey. This resulted in an overall completion rate of 89.5%. After removing any respondent who did not attend a private four-year university (n = 18), the sample was reduced to 144. Removal of participants who failed to complete required survey sections (PSS (n = 27), BRS (n = 1), or IPAQ-SF (n = 31)) yielded a final sample of 85, thus meeting the a priori power analysis requirement.

Descriptive statistics for the sample are presented in Table 1. Participants were primarily female (74.1%) and overwhelmingly identified as Asian (42.4%) or white (32.9%). Over half of the sample identified as middle class (57.6%), and almost two thirds were classified by the IPAQ-SF as minimally active or HEPA active (62.3%).

For analysis, the "poor" and "working class" categories were combined into one "poor or working class" category for SES. Overall, the regression model accounted for 43.5% of the variance in PSS scores (R2 = .462, R2 adj = .435, F(4,80) = 17.164, p < .001). Consistent with the authors' hypothesis, MET-minutes were a significant predictor of perceived stress (β = –.229, p = .007). Similarly, SES and resilience significantly, independently, and inversely predicted perceived stress. Gender also significantly and independently predicted perceived stress, with female gender predicting higher perceived stress than male gender. Table 2 presents regression coefficients and significance levels for the four predictor variables.

Table 1. Descriptive characteristics of the sample.

Characteristic or Demographic	Frequency (n)	Mean ± SD or %
Age (years)	85	19.8 ± 1.25
Gender		
Male	21	24.7%
Female	63	74.1%
Gender nonconforming, other	1	1.2%
Race/Ethnicity		
White	28	32.9%
Asian	36	42.4%
Black	5	5.9%
Hispanic or Latino	2	2.4%
Middle Eastern	3	3.5%
Multi-racial	10	11.8%
Prefer not to answer	1	1.2%
Socioeconomic Status (SES)		

Poor	1	1.2%
Working class	14	16.5%
Middle class	49	57.6%
Affluent	21	24.7%
Perceived Stress		
PSS Score	85	23.5 ± 6.06
Resilience		
BRS Score	85	3.2 ± 0.72
Weekly MET-Minutes	85	1954.7 ± 2133.20
WPA MET-minutes	85	562.6 ± 742.89
MPA MET-minutes	85	271.5 ± 406.66
VPA MET-minutes	85	1120.6 ± 1424.66
IPAQ-SF Categorization		
Inactive	32	37.6%
Minimally Active	20	23.5%
HEPA active	33	38.8%

Table 2. Coefficients of multiple regression analysis predicting PSS Score from MET-minutes, SES, BRS Score, and gender.

	B	β	*t*	*p*
Constant	45.690		15.786	< .001***
MET-minutes	–.001	–.229	–2.784	.007**
SES	–2.808	–.301	–3.630	< .001***
BRS Score	–4.575	–.540	–6.458	< .001***
Gender	–2.214	–.173	–2.048	.044*

Note: ‡$p \leq .1$, *$p \leq .05$, **$p \leq .01$, ***$p < .001$

DISCUSSION

Our findings indicate that PA significantly and independently predicts perceived stress in students attending four-year private universities during the COVID-19 pandemic. Consistent with our original hypothesis, this predictive association persists despite statistically controlling for the collective influence of SES, resilience, and gender. Higher volumes of weekly activity predict lower perceptions of stress regardless of these covariates. SES and gender also significantly and independently predict perceived stress, though not as effectively as resilience, which eclipsed all other variables as the single best predictor of perceived stress.

While previous studies have demonstrated that PA predicts perceived stress in undergraduate students, our study is the first to do so during the COVID-19 pandemic while also controlling for multiple widely accepted confounds. A past study of university students controlled for confounds such as SES, gender, and ethnicity but found no significant association between PA and perceived stress (34). However, that study employed the Godin Leisure-Time Exercise Questionnaire to assess PA, which assesses PA frequency but does not assess the total duration for which activity occurred in each intensity-specific domain and does not accurately measure

total PA volume. Hence, previous failures to identify PA as an independent predictor of stress may be attributable to the incomplete assessment of PA volume. In contrast, the IPAQ-SF more completely assesses the influence of PA volume on perceived stress and likely explains the significance of PA as a predictor of stress in the present study.

Notably, the mean perceived stress score for participants in the present study was markedly higher than normative scores for age-matched peers (5). Cohen & Janicki-Deverts reported perceived stress data from three survey periods in 1983, 2006, and 2009, with each survey involving at least 2,000 adults in the United States. In no survey period did any demographic average more than 20.21 points on the PSS-10 (5). The present mean of 23.5 is significantly greater than the mean score for adults ages 18-25 in 2006 (18.64) or 2009 (16.78). The educational demographics of the present sample may partially account for the high stress scores observed. Nguyen–Michel et al. determined that students attending either public or private four-year universities reported greater perceived stress relative to students attending community colleges (34). However, pandemic-related stressors likely contributed most significantly to elevated perceptions of stress in our sample. Policies designed to suppress the spread of COVID-19 have had the unfortunate side effect of closing schools and businesses, hindering academic and professional pursuits, and separating university students from friends and other traditional providers of social support, such as university faculty and staff. Therefore, it seems reasonable to presume that social isolation and other low-control, pandemic-related stressors contributed to the high levels of perceived stress observed, especially when considering that the PSS-10 was designed to reflect, in part, the sense of control that individuals have over their lives (6). The presumed absence of students' control over policies implemented by their universities or local governments in response to the pandemic may have contributed to the high PSS-10 scores.

Considering the social withdrawal that has accompanied the COVID-19 pandemic, socializing deserves special attention as a mediator of the relationship between PA and perceived stress. VanKim & Nelson examined the associations between VPA, mental health, perceived stress, and socializing in university students. They concluded that at least some of the positive influence of VPA on perceived stress occurs through a pathway mediated by the size of a person's friend group and the frequency with which they socialize (38). In the present study, where normal social patterns among participants were presumedly disrupted, the socializing mediation pathway may have exerted a stronger than usual effect. It is possible that PA provided opportunities to socialize with friends, family, or community members that would not have otherwise existed. Though the present study did not assess the environment(s) in which PA occurred, it is assumed that PA during the survey period occurred primarily in the home (e.g., home gym) or neighborhood (e.g., walking, jogging, bicycling) environments given the closure of fitness centers due to pandemic restrictions. In comparison to commercial environments, these environments may have augmented the socializing mediation pathway by facilitating conversation.

Furthermore, our model supports previous findings that SES inversely predicts perceived stress (10, 17, 19). Different measures of SES relate to stress in different ways, and selecting an

appropriate measure of SES for university students is especially difficult (17, 34). A student's subjective relationship with his social environment may be influenced by his parents' education, family income, tuition assistance, personal income, and other factors that existing objective assessments of SES cannot capture (17, 34). The present study attempted to capture the collective influence of these factors through the assessment of self-reported subjective SES, which has been shown to significantly predict perceived stress in populations with multifactorial SES (19). As expected, students with lower subjective SES reported more stress. SES-dependent levels of pessimism and optimism may mediate this effect, given that low SES is associated with more pessimistic attitudes, and pessimistic attitudes are associated with higher perceived stress (10). Students of low SES in the present sample may have maintained more pessimistic attitudes regarding their ability to endure challenges associated with the pandemic. It is also possible that low-SES students were more frequently exposed to environments with a high risk of COVID-19 transmission, and that higher perceived stress accompanied these exposures.

Of all the predictors, our study found that resilience exerted the strongest effect on perceived stress. The effect size exerted by resilience is approximately triple that of gender and more than double that of PA. This result is consistent with other research demonstrating that resilience is moderately to strongly associated with perceived stress in university students (13). It is possible that the BRS partially accounts for the strong association between resilience and perceived stress. Though resilience has been defined in several different terms, the developers of the BRS designed it to specifically capture an individual's ability to bounce back or recover from stress (1, 35). Therefore, individuals who score lower on the BRS may not recover as quickly from stress and are more likely to remain in a condition where they are conscious of, and thus affected by, a given stressor. Resilient participants in the present study may have perceived less stress due to "shedding" or recovering from stressors at a faster rate. Accordingly, had another resilience measure been employed, we assume a weaker association between resilience and perceived stress would have been observed, as such measures assess constructs more tangentially related to the ability to recover from stress (35). Nonetheless, the BRS remains the principal measure of resilience as the capacity to bounce back from stress and was appropriately employed in the present study to assess participants' resilience.

The findings that gender significantly predicts perceived stress and that female gender predicts higher stress are consistent with previous cross-sectional research (24). These effects likely arise in part from the gender differences in stress perceptions across various types of life events. Females are more likely than males to perceive stress from life events involving family concerns or the health issues of those around them (30). Hence, the social consequences of the pandemic could have differentially affected male and female participants. Immersion in the home environment could have facilitated the development of stressful family events, while fears of the coronavirus could have increased concerns for the health and well-being of family members. Female participants may have been more susceptible to both stressors, thus resulting in higher PSS scores. Gender differences in coping may also contribute to the significance of gender as a predictor of stress. Though males and females employ similar total amounts of coping behaviors, females more frequently rely on avoidant (disengagement) coping (10, 30). Low-

control pandemic-related stressors may have biased participants towards avoidant coping (11). It is possible that pandemic-related changes in coping behaviors may have disproportionately affected female students and contributed to the significance of gender as a predictor of stress.

Though the present study adds to a growing body of evidence that PA independently predicts stress, research has yet to conclusively determine whether different intensities of activity differ in their association with stress. Existing studies have attempted to stratify participants by their attainment of various activity guidelines to judge the association between PA intensity and perceived stress. However, these studies have been limited by the categorical measures employed. For example, in a 2014 study, Gerber et al. divided participants into groups that did or did not meet the VPA recommendation of the American College of Sports Medicine for at least 20 minutes of VPA 3 times per week (14). However, all participants in both groups satisfied the recommendation for MPA by the American College of Sports Medicine, making it impossible to compare the effects of MPA versus VPA on stress. The same procedure was employed by Gerber et al. in a 2017 study and the same limitation was encountered (16). In contrast, Ng & Jeffery employed the Godin Leisure-Time Questionnaire to derive a continuous measure of activity and examine intensity-specific effects (33). As mentioned, this instrument measures only the number of days in which participants engaged in activity of various intensities, not the total duration of these activities. Nonetheless, analyses determined that days of WPA, MPA, and VPA exerted similar effect sizes on perceived stress, though the effect exerted by walking was only marginally statistically significant. Further research is warranted to determine whether there exists a minimum exercise intensity for minimizing stress.

A strength of this study was the assessment of PA as a continuous rather than categorical variable. The use of MET-minutes rather than categorical IPAQ-SF classification allows the present study to more precisely gauge participants' activity, increasing the sensitivity of the present study to account for differences in individuals' activity. Additionally, MET-minutes allow the present study to more accurately reflect associations between activity and perceived stress. A second strength of this study was its robust sample size, which met the a priori power analysis sample requirements and conferred strong statistical power.

Results of this study should be viewed in the context of several limitations. First, the study sample consisted exclusively of students attending private four-year universities. Participants also largely self-identified as female and Asian or white, so generalizability may be limited. However, the relationship between PA and stress is consistent across groups of university students stratified by age, gender, ethnicity, parental education (SES), and type of university attended (34). Therefore, we are optimistic that our results may be extended to the general undergraduate university population. Second, we employed a non-probability sampling method, so responses are subject to non-response bias. Non-responders may have differed in how PA independently predicted their perceptions of stress. However, alternative sampling methods were limited given the pandemic-related distancing measures in place at the time of sampling. Third, as a self-report tool, the IPAQ-SF is subject to recall bias. Participants may have overreported PA, especially VPA, resulting in overestimates of PA that would not have occurred

with objective PA assessments (23). However, in a systematic review of PA questionnaires, the IPAQ-SF was found to be one of only four questionnaires to exhibit good validity and reliability, and it remains a widely accepted measure for assessing PA (21). Fourth, although subjective SES allows for a more wholistic representation of a participant's perceived social status than available objective measures, some variability is assumed in how participants interpreted the available levels of SES. For example, one participant may have self-identified as "middle class" despite a participant of equal objective SES identifying as "affluent." Finally, due to its cross-sectional nature, our study cannot claim that PA causally reduces perceived stress.

In conclusion, PA predicted perceived stress in students attending private four-year universities during the COVID-19 pandemic independently of SES, resilience, or gender. SES, resilience, and gender also independently predicted perceived stress, with resilience being the strongest predictor. The present findings augment current knowledge that physically active students enjoy better physical and immunological health by illustrating the predictive value of PA on perceived stress. Knowledge of this relationship should be leveraged by university faculty and staff in the development and promotion of wholistic well-being programs that emphasize PA, such as designing lesson plans that incorporate PA, organizing campus-wide fitness events, promoting student involvement in recreational clubs, or offering subsidies for access to off-campus recreation centers. Future studies are needed to assess how the inverse relationship between PA and stress varies for different intensities of activity.

REFERENCES

1. Aburn G, Gott M, Hoare K. What is resilience? An integrative review of the empirical literature. Journal of Advanced Nursing 72(5): 980–1000, 2016.

2. Barkley JE, Lepp A, Glickman E, Farnell G, Wiet R, Dowdell B. The acute effects of the COVID-19 pandemic on physical activity and sedentary behavior in university students and employees. International Journal of Exercise Science 13(4): 1326–39, 2020.

3. Childs E, de Wit H. Regular exercise is associated with emotional resilience to acute stress in healthy adults. Front Physiol 5: Article 161, 2014.

4. Cohen S. Perceived stress in a probability sample of the United States. In: The social psychology of health. Thousand Oaks, CA, US: Sage Publications, Inc, 1988.

5. Cohen S, Janicki-Deverts D. Who's stressed? Distributions of psychological stress in the United States in probability samples from 1983, 2006, and 2009. Journal of Applied Social Psychology 42(6): 1320–34, 2012.

6. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. Journal of Health and Social Behavior 24(4): 385–96, 1983.

7. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International Physical Activity Questionnaire: 12-country reliability and validity. Medicine & Science in Sports & Exercise 35(8): 1381–95, 2003.

8. Dahlstrand J, Friberg P, Fridolfsson J, Börjesson M, Arvidsson D, Ekblom Ö, et al. The use of coping strategies "shift-persist" mediates associations between physical activity and mental health problems in adolescents: a cross-sectional study. BMC Public Health 21(1): Article 1104, 2021.

9. Diemer MA, Mistry RS, Wadsworth ME, López I, Reimers F. Best practices in conceptualizing and measuring social class in psychological research. Analyses of Social Issues and Public Policy 13(1): 77–113, 2013.

10. Finkelstein DM, Kubzansky LD, Capitman J, Goodman E. Socioeconomic differences in adolescent stress: the role of psychological resources. Journal of Adolescent Health 40(2): 127–34, 2007.

11. Frazier PA, Mortensen H, Steward J. Coping strategies as mediators of the relations among perceived control and distress in sexual assault survivors. Journal of Counseling Psychology 52(3): 267–78, 2005.

12. Gallè F, Sabella EA, Ferracuti S, De Giglio O, Caggiano G, Protano C, et al. Sedentary behaviors and physical activity of Italian undergraduate students during lockdown at the time of CoViD-19 pandemic. International Journal of Environmental Research and Public Health 17(17): Article 6171, 2020.

13. García-León MÁ, Pérez-Mármol JM, Gonzalez-Pérez R, García-Ríos M del C, Peralta-Ramírez MI. Relationship between resilience and stress: perceived stress, stressful life events, HPA axis response during a stressful task and hair cortisol. Physiology & Behavior 202: 87–93, 2019.

14. Gerber M, Brand S, Herrmann C, Colledge F, Holsboer-Trachsler E, Pühse U. Increased objectively assessed vigorous-intensity exercise is associated with reduced stress, increased mental health and good objective and subjective sleep in young adults. Physiology & Behavior 135: 17–24, 2014.

15. Gerber M, Jonsdottir IH, Lindwall M, Ahlborg G. Physical activity in employees with differing occupational stress and mental health profiles: a latent profile analysis. Psychology of Sport and Exercise 15(6): 649–58, 2014.

16. Gerber M, Ludyga S, Mücke M, Colledge F, Brand S, Pühse U. Low vigorous physical activity is associated with increased adrenocortical reactivity to psychosocial stress in students with high stress perceptions. Psychoneuroendocrinology 80: 104–13, 2017.

17. Glasscock DJ, Andersen JH, Labriola M, Rasmussen K, Hansen CD. Can negative life events and coping style help explain socioeconomic differences in perceived stress among adolescents? A cross-sectional study based on the West Jutland cohort study. BMC Public Health 13: Article 532, 2013.

18. Goldman N, Glei DA, Seplaki C, Liu I-W, Weinstein M. Perceived stress and physiological dysregulation in older adults. Stress: The International Journal on the Biology of Stress 8(2): 95–105, 2005.

19. Goodman E, McEwen BS, Dolan LM, Schafer-Kalkhoff T, Adler NE. Social disadvantage and adolescent stress. Journal of Adolescent Health 37(6): 484–92, 2005.

20. Hand GA, Phillips KD, Dudgeon WD. Perceived stress in HIV-infected individuals: Physiological and psychological correlates. AIDS Care 18(8): 1011–7, 2006.

21. Helmerhorst HHJ, Brage S, Warren J, Besson H, Ekelund U. A systematic review of reliability and objective criterion-related validity of physical activity questionnaires. Int J Behav Nutr Phys Act 9: Article 103, 2012.

22. International Physical Activity Questionnaire. IPAQ scoring protocol. Retrieved from: https://sites.google.com/site/theipaq/scoring-protocol.

23. Kim Y, Park I, Kang M. Convergent validity of the International Physical Activity Questionnaire (IPAQ): meta-analysis. Public Health Nutrition 16(3): 440–52, 2013.

24. Klein EM, Brahler E, Dreier M, Reinecke L, Muller KW, Schmutzer G, et al. The German version of the Perceived Stress Scale - psychometric characteristics in a representative German community sample. BMC Psychiatry 16: Article 159, 2016.

25. Lazarus RS. Stress, appraisal, and coping [Internet]. New York : Springer Pub. Co., 1984 [cited 2021 Jun 29].

26. Lee E-H. Review of the psychometric evidence of the Perceived Stress Scale. Asian Nursing Research 6(4): 121–7, 2012.

27. Lubans D, Richards J, Hillman C, Faulkner G, Beauchamp M, Nilsson M, et al. Physical activity for cognitive and mental health in youth: a systematic review of mechanisms. Pediatrics 138(3): e20161642, 2016.

28. Luger A, Deuster PA, Kyle SB, Gallucci WT, Montgomery LC, Gold PW, et al. Acute hypothalamic-pituitary-adrenal responses to the stress of treadmill exercise. Physiologic adaptations to physical training. The New England Journal of Medicine 316(21): 1309–15, 1987.

29. Martikainen S, Pesonen A-K, Lahti J, Heinonen K, Feldt K, Pyhälä R, et al. Higher levels of physical activity are associated with lower hypothalamic-pituitaryadrenocortical axis reactivity to psychosocial stress in children. The Journal of Clinical Endocrinology & Metabolism 98(4): E619–27, 2013.

30. Matud MP. Gender differences in stress and coping styles. Personality and Individual Differences 37(7): 1401–15, 2004.

31. Maugeri G, Castrogiovanni P, Battaglia G, Pippi R, D'Agata V, Palma A, et al. The impact of physical activity on psychological health during Covid-19 pandemic in Italy. Heliyon 6(6): Article e04315, 2020.

32. Navalta JW, Stone WJ, Lyons TS. Ethical issues relating to scientific discovery in exercise science. International Journal of Exercise Science 12(1): 1–8, 2019.

33. Ng DM, Jeffery, Robert W. Relationships between perceived stress and health behaviors in a sample of working adults. Health Psychology 22(6): 638–42, 2003.

34. Nguyen-Michel ST, Unger JB, Hamilton J, Spruijt-Metz D. Associations between physical activity and perceived stress/hassles in college students. Stress and Health 22(3): 179–88, 2006.

35. Smith BW, Dalen J, Wiggins K, Tooley E, Christopher P, Bernard J. The Brief Resilience Scale: assessing the ability to bounce back. International Journal of Behavioral Medicine 15(3): 194–200, 2008.

36. Strahler J, Fuchs R, Nater UM, Klaperski S. Impact of physical fitness on salivary stress markers in sedentary to low-active young to middle-aged men. Psychoneuroendocrinology 68: 14–9, 2016.

37. Sun Y, Gao L, Kan Y, Shi B-X. The Perceived Stress Scale-10 (PSS-10) is reliable and has construct validity in Chinese patients with systemic lupus erythematosus. Lupus 28(2): 149–55, 2019.

38. VanKim NA, Nelson TF. Vigorous physical activity, mental health, perceived stress, and socializing among college students. Am J Health Promot 28(1): 7–15, 2013.

39. Windle G, Bennett KM, Noyes J. A methodological review of resilience measurement scales. Health and Quality of Life Outcomes 9: 8–8, 2011.

40. Woodruff SJ, Coyne P, St-Pierre E. Stress, physical activity, and screen-related sedentary behaviour within the first month of the COVID-19 pandemic. Applied Psychology: Health and Well-Being 13(2): 454–68, 2021.