

Physical Activity, Sitting Time, and Feelings of Energy and Fatigue During the Early Stages of the COVID-19 Pandemic: Does Grit Make a Difference?

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Abstract

Grit has been associated with feelings of energy when measured as the opposite end of fatigue. During the COVID-19 pandemic, grit has been linked to positive health-related behaviors, which are known to influence feelings of energy and fatigue. The objective of this study was to identify the association between grit, time spent sitting, physical activity (PA), and feelings of mental and physical energy (ME, PE) and fatigue (MF, PF) during the early stages of the COVID-19 pandemic in the United States. Participants ($n = 859$) completed surveys once. Using a series of multivariate regression models, we assessed the association between grit, time spent sitting, PA and ME, MF, PE, and PF. When accounting for all factors, performing vigorous PA was associated positively with PE and ME and negatively with PF and MF, whereas sitting was related negatively with PE and ME and positively with PF and MF. Grit was not associated with the four moods. Study findings underscore the need to adopt healthy lifestyle behavior to improve feelings of energy and fatigue in the face of a pandemic. During this ongoing global health crisis, these findings present novel and important evidence with possible immediate applications for health behavior, such as informing already-established health behavior theories to, ultimately, design COVID-19-specific interventions.

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The novel coronavirus disease (COVID-19) was first diagnosed in December 2019 in China (Wang et al., 2020). Non-pharmaceutical interventions (NPIs) requiring physical and social distancing were implemented to slow the spread of the virus, which helped reduce infection rates (Bedford et al., 2020). However, their unintended consequences have been linked to mental health (MH) problems (Galea et al., 2020; Li et al., 2020), such as depression and anxiety (Pappa et al., 2020; Twenge & Joiner, 2020) and fatigue (Michie et al., 2020).

Fatigue is an MH consequence most often tied to COVID-19 as an unintended consequence of physical distancing policies implemented during the early stages of the pandemic (Michie et al., 2020). Although Michie and colleagues (Michie et al., 2020) describe fatigue as an impairment in the ability to perform a mental or physical task as a result of depleted mental or physical resources, the definition used in this study is based on the work of Loy and colleagues (Loy et al., 2018). In their work, they define fatigue as the “persistent sense of physical, emotional, and/or cognitive tiredness or

exhaustion”, while energy is defined as “an individual’s potential to perform mental and physical activity” (Loy et al., 2018, p. 47).

Evidence supports the assertion that trait-level energy and fatigue influence state-level fatigue (Boolani, Fuller, et al., 2022; Fuller et al., 2021; Manierre et al., 2020). Further, literature also exists on the effects of the Big Five personality traits on state-level feelings of fatigue (De Vries & Van Heck, 2002; Khodarahimi & Rasti, 2015). However, there is scant evidence about the effects of grit, another personality trait measuring perseverance and passion for long-term goals, on feelings of fatigue (Sharkey et al., 2017).

Sharkey et al. (2017) reported that college students who report higher levels of grit also report higher feelings of energy, when measured as the opposite of fatigue. Nevertheless, multiple recent studies have reported that energy and fatigue are biologically two distinct unipolar moods (Boolani et al., 2019; Boolani, Gallivan, et al., 2022; Dupree et al., 2019; Loy et al., 2018) with their own mental and physical components (Boolani, Gallivan, et al., 2022; Boolani & Manierre, 2019; Manierre et al., 2020). Thus, this study examines mental and physical energy and fatigue as four separate unipolar constructs. Further, in the context of the COVID-19 pandemic, this study seeks to understand whether grit is associated with MH through feelings of mental or physical energy or fatigue.

Evidence suggests that gritty individuals are more self-controlled and will maintain a positive attitude over time despite adversity (Duckworth et al., 2007). Grit has also been associated with mental well-being (Kannangara et al., 2018), emotional stability during stressful or negative life events (Blalock et al., 2015), and the ability to cope with stress (Kannangara et al., 2018). Additionally, findings exist to infer that individuals who are gritty participate in

healthier lifestyle behaviors even during a global pandemic (Totosy de Zepetnek et al., 2021). Healthy lifestyle behaviors, such as decreased sedentary behavior (Boolani et al., 2019; Boolani et al., 2021) and increased physical activity (PA) (O'Connor & Puetz, 2005; Puetz et al., 2006), are associated with feelings of mental and physical energy and fatigue.

PA is defined as “any bodily movement produced by the contraction of skeletal muscles that results in an increase in caloric requirements over resting energy expenditure” (Caspersen et al., 1985; p.126). Regardless of the method used to estimate PA (e.g., oxygen uptake reserve, heart rate reserve, volume of oxygen consumed per minute, heart rate, metabolic equivalents), intensity matters. Higher intensity activities (i.e., moderate-to-vigorous PA; MVPA) are preferred (American College of Sports Medicine, 2022a), and recommended PA durations are inversely related to intensity levels. We used to believe that the relationship between sedentary behavior (most often operationalized as sitting time) and health outcomes was not dependent on time spent in MVPA (Biswas et al., 2015). The latest guidelines, however, recommend a minimum of 150 weekly minutes of moderate intensity or 75 weekly minutes of vigorous intensity aerobic physical activity, or an equivalent combination of MVPA (American College of Sports Medicine, 2022a).

While healthy lifestyle behaviors (e.g., PA) and grit have been shown to influence feelings of energy and fatigue (Boolani et al., 2021), little is known about how a global pandemic may have modified the interactions between them (Totosy de Zepetnek et al., 2021). Therefore, the purpose of this study was to identify the interaction between PA, time spent sitting, feelings of mental energy (ME) and fatigue (MF) and physical energy (PE) and fatigue (PF), and grit during the early stages of the COVID-19 pandemic.

Because the vast majority of the aforementioned studies were conducted prior to the COVID-19 pandemic, which has been shown to disrupt PA and other healthy behaviors (e.g., Bhutani et al., 2021), this study is unique in that it examined these relationships in the context of the earliest stages of the pandemic. Based on previous literature, we hypothesized that PA and time spent sitting would be associated with ME, MF, PE, and PF and that these direct associations would be modified by the participants' level of grit.

Method

Participants

A total of 1,459 participants started the survey during the early stages of the COVID-19 health crisis. After removal of outliers and participants who either did not complete the survey or chose not to allow geo-tracking, 859 (males = 233, female = 625, non-binary = 1, age = 34.37 ± 13.95 , 31.3% ever diagnosed with COVID-19) participants remained in our analysis. Participants were eligible for this study if they were over the age of 18 and could read and comprehend the English language. Participant characteristics are reported in Table 1.

Study Design

This study was cross-sectional. Data were collected between April 13, 2020 and May 3, 2020 as part of a larger study conducted in the United States (US) to understand the health behavior and mood changes of adults during the pandemic (e.g., Toczko et al., 2022). Using a snowball recruitment method, participants were recruited via social media and by invitations distributed by the study investigators to their professional networks. All participants voluntarily completed the

baseline questionnaire using Qualtrics software (Qualtrics, XM, Provo, UT). All study procedures were approved by the Institutional Review Boards at Clarkson University (approval #20.5.1) and George Mason University (approval #15922393-1).

Outcome Variables

The State-Trait Mental and Physical Energy and Fatigue survey was used to measure the state aspect of ME, MF, PF, and PF (O'Connor, 2006). The 12-item scale uses a Visual Analog Scale with responses ranging from 0 (no feelings) to 100 (highest imaginable feelings) in reference to how the participant had felt over the last seven days. Cronbach's α for the current study ranged from .867 to .940 (PE = .867, PF = .927, ME = .868 and MF = .940).

Predictor Variables

The eight-item Grit-Short Scale was used (Duckworth et al., 2007; Duckworth & Quinn, 2009) to measure trait-level perseverance and consistency of interest. Each item was scored on a 5-point Likert scale ranging from 1 (not at all like me) to 5 (very much like me). The responses were scored according to previously published literature (Duckworth et al., 2007; Duckworth & Quinn, 2009), and the calculated Cronbach's α for the current study was .80.

The International Physical Activity Questionnaire-Short Form (IPAQ-SF) was used to assess PA levels over the last seven days (Craig et al., 2003). Participants were asked about the duration, intensity, and frequency of PA and time spent sitting over the last seven days. The number of minutes of light, moderate, and intense PA, and sitting time per week, were calculated similarly to previous studies (Craig et al., 2003).

Table 1

Participant Characteristics (n = 859)

Variable	Mean ± SD	Self-reported COVID positive	Self-reported COVID negative
		Demographics ^a	
Age (years)	34.39 ± 13.97	33.27 ± 13.33	35.04 ± 14.39*
Sex			
Male	27.1%	23.8%	28.7%
Female	72.8%	75.9%	71.3%
Non-binary	0.1%	0.3%	0%
		Education ^a	
Some High School	.9%	0.7%	1.0%*
High School Diploma/GED	2.6%	1.0%	3.2%
Education Beyond High School	13.9%	8.7%	16.4%
Associates Degree	5.5%	4.5%	5.7%
Bachelor's Degree	36.9%	38.1%	36.3%
Master's Degree	27.3%	34.6%	23.9%
Doctorate Degree	13.0%	12.2%	13.5%
		Relationship Status ^a	
Committed Relationship	59.6%	57.0%	61.0%
Not Committed Relationship	40.4%	43.0%	39.0%
		Employment ^a	
Yes	60.7%	63.6%	59.4%
No	39.3%	36.4%	40.6%
		Student ^a	
Yes	20.6%	19.6%	21.0%
No	79.4%	80.4%	79.0%
		Urbanicity ^a	
Major City	13.9%	18.9%	12.6%
Small City	20.3%	20.6%	20.5%
Suburb	21.8%	19.6%	22.5%
Small Town	25.7%	23.4%	26.3%
Rural Area	18.3%	17.5%	18.2%

Table 1

Participant Characteristics (n = 859)

Variable	Mean ± SD	Self-reported COVID positive	Self-reported COVID negative
		Chronic Medical Conditions ^a	
Yes	31.6%	31.1%	31.8%
No	68.4%	68.9%	68.2%
		COVID-associated Variables ^a	
COVID-19 diagnosis			
Yes	31.3%	N/A ^b	N/A ^b
No	68.7%	N/A ^b	N/A ^b
7-Day Infection Rate	75.53 ± 178.01	94.14 ± 202.85	67.73 ± 166.63**
Currently Living with Someone			
Yes	85.6%	84.6%	86.1%
No	14.4%	15.4%	13.9%
Having Children (< 18 ys.) Living at Home			
Yes	26.8%	25.2%	27.5%
No	73.2%	74.8%	72.5%
		Working Location ^a	
Working From Home	66.8%	64.3%	68.0%
Physically Going to Work	33.2%	35.7%	32.0%
		Smoking ^a	
Yes	6.7%	5.9%	7.2%
No	93.3%	94.1%	92.8%
		Eating Habits ^a	
REAP-S Score ^c	30.43 ± 4.07	30.30 ± 3.97	30.47 ± 4.12
		Intensity of Mental Workload ^a	
Work/School Days	91.15 ± 85.20	98.13 ± 86.01	86.01 ± 83.63
Non-Work/School Days	23.06 ± 44.73	23.03 ± 49.72	23.80 ± 43.00

Table 1

Participant Characteristics (n = 859)

Variable	Mean ± SD	Self-reported COVID positive	Self-reported COVID negative
Average Sleep Duration (Hours/Day)	7.22 ± 2.22	Sleep ^a 7.06 ± 1.30	7.28 ± 2.46
PSQI Sleep Latency Component ^d			
0	32.4%	33.2%	32.0%
1	26.9%	25.2%	28.2%
2	26.7%	23.8%	27.7%
3	13.9%	17.8%	12.1%
PSQI Sleep Disturbance Component ^d			
0	1.9%	1.4%	2.2%
1	65.7%	63.3%	66.7%
2	31.3%	33.6%	30.3%
3	1.1%	1.7%	0.8%
PSQI Use of Sleep Medication Component ^d			
0	70.5%	65.4%	72.9%
1	10.9%	12.9%	10.0%
2	7.1%	7.3%	7.2%
3	11.5%	14.3%	9.9%
PSQI Daytime Dysfunction Component ^d			
0	20.9%	18.9%	21.8%
1	45.1%	47.6%	44.1%
2	29.8%	29.0%	30.3%
3	4.1%	4.5%	3.8%
Vigorous Physical Activity (Minutes/Week)	255.37 ± 489.01	Physical Activity ^e 284.43 ± 596.75	242.79 ± 419.07*
Moderate Physical Activity (Minutes/Week)	257.24 ± 628.97	298.53 ± 596.45	233.58 ± 502.94*
Light Physical Activity (Minutes/Week)	387.07 ± 632.80	414.52 ± 670.17	380.87 ± 633.54
Total Time Spent Sitting (Minutes/Week)	3040.55 ± 1668.99	Sedentary Behavior ^e 3028.97 ± 1730.05	3012.49 ± 1608.11
Grit	3.46 ± .63	Grit ^c 3.46 ± .61	3.45 ± .63

Table 1

Participant Characteristics (n = 859)

Variable	Mean ± SD	Self-reported COVID positive	Self-reported COVID negative
		State Mental and Physical Energy and Fatigue ^f	
State Physical Energy	121.41 ± 70.99	119.52 ± 72.04	125.57 ± 68.59
State Physical Fatigue	112.94 ± 83.15	119.08 ± 70.71	115.64 ± 85.00*
State Mental Energy	115.82 ± 69.96	114.34 ± 69.63	119.08 ± 70.71
State Mental Fatigue	124.04 ± 87.56	125.87 ± 87.67	123.21 ± 87.57

Note. PSQI: The Pittsburgh Sleep Quality Index (Buysse et al., 1989); REAP-S: The Rapid Eating and Activity Assessment for Patients (short version) (Segal-Issacson et al., 2004). ^aControl Variables; ^bN/A = Non-applicable; ^cHigher scores represent better quality diet; ^dHigher categories indicate worse sleep or higher use of sleep medications; ^ePredictor Variables; ^fOutcomes Variable. * $p < 0.05$; ** $p < 0.01$

Control Variables

Control variables in statistical analyses included demographic variables (self-reported sex, age, education status, employment status, student status, and urbanicity), self-reported health status (smoking, physical and psychiatric illness), COVID-19-related variables (COVID-19 diagnosis, 7-day infection rate, essential worker status, and whether they were providing care for someone during the lockdown period), sleep (PSQI scores), diet (REAP-S scores), and intensity of mental work on working and non-working days.

Data Analyses

Data were downloaded from Qualtrics into Microsoft Excel and scored. Using geo-tracking data, 7-day infection rates were added into the file using data from the Johns Hopkins University COVID-19 website. If participants refused geo-tracking when taking the survey, their data were not included in these analyses. Using the latitude and longitude captured by Qualtrics, the ggmap library in R (R Core Team, 2020) was used to find the ZIP Codes of where each participant took the survey. The ggmap library was then used to classify these ZIP Codes into counties. Two researchers independently checked for 7-day infection rates using the Johns Hopkins University COVID-19 website. The 7-day infection rate was determined for the 7 days prior to the participant completing the survey (Boolani et al., 2021). Data were uploaded into SPSS v26.0 (IBM Corp.) and analyzed for normality using a combination of data visualization techniques and the Shapiro-Wilks test. Participants with missing data, or data ≥ 3 standard deviations (SD) away from the mean, were omitted from analyses. Descriptive statistics were performed and were compared by whether or not the

participant ever tested positive for COVID-19. Then, a series of multivariate linear regression models were fitted to assess relationships between lifestyle behaviors, mental and physical energy, and fatigue and grit. G*Power (version 3.1.9.2) was used to calculate power for each model.

Results

Our analysis used baseline data collected during the early stages of the COVID-19 pandemic to quickly address this contemporary, fast-moving topic. Table 2 reports the results by outcome variable.

State Physical Energy (PE)

Our model predicted 14.7% (Adjusted $R^2 = .173$, $F(26, 832) = 6.703$, $p < .001$) of variance in the dependent variable. State PE was associated with vigorous PA ($\beta = .229$, $t(26, 832) = 6.166$, $p < .001$) and total time spent sitting ($\beta = -.183$, $t(26, 832) = -5.510$, $p < .001$). Grit was not significantly associated with state PE ($p = .075$).

State Physical Fatigue (PF)

Our model predicted 7.8% (Adjusted $R^2 = .106$, $F(26, 832) = 3.804$, $p < .001$) of variance in the dependent variable. State PF was associated with vigorous PA ($\beta = -.106$, $t(26, 832) = -2.604$, $p = .009$) and total time spent sitting ($\beta = .164$, $t(26, 832) = 4.760$, $p < .001$). Grit was not significantly associated with state PF ($p = .209$).

State Mental Energy (ME)

Our model explained 6.6% of variance (Adjusted $R^2 = .095$, $F(26, 832) = 3.343$, $p < .001$) in the dependent variable. State ME was associated with vigorous PA ($\beta = .091$, $t(26, 832) = 2.301$, $p = .022$) and time spent sitting ($\beta = -.139$, $t(26, 832) = -4.015$,

Table 2

Factors Associated with Mental and Physical Energy and Fatigue

Variable	State Physical Energy		State Physical Fatigue		State Mental Energy		State Mental Fatigue	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Lifestyle Behavior								
Vigorous Physical Activity	.229***	.022, .044	-.102**	-.031, -.004	.091*	.002, .024	-.097*	-.031, -.004
Moderate Physical Activity	-.027	-.011, .005	.033	-.006, .015	-.001	-.009, .009	.044	-.005, .017
Light Physical Activity	.065	.000, .015	-.015	-.011, .007	.007	-.007, .008	.012	-.008, .011
Total Time Spent Sitting	-.183***	-.010, -.005	.164***	.005, .012	-.139***	-.009, -.003	.193***	.007, .014
Grit	-.063	-14.989, .733	.049	-3.124, 16.232	-.033	-11.770, 4.429	-.010	-11.603, 8.688

Note. Model accounts for 7-day infection rates, age, sex, education, relationship status (ref: committed), employment status (ref: employed), student status (ref: student), living status (ref: living with someone), diagnosis of COVID (ref: yes), chronic medical condition (ref: yes), and diet habits (REAP-S). * $p < 0.05$. ** $p < 0.01$. *** $p < .001$

$p < .001$). Grit was not associated with state ME ($p = .310$).

State Mental Fatigue (MF)

Our model explained 7.9% of variance (Adjusted $R^2 = .107$, $F(26, 832) = 3.830$, $p < .001$) in the dependent variable. State MF was associated with vigorous PA ($\beta = -.097$, $t(26, 832) = -2.472$, $p = .014$) and total time spent sitting ($\beta = .193$, $t(26, 832) = 5.601$, $p < .001$). Grit was not associated with state MF ($p = .310$).

Discussion

This study attempted to advance the science of health behavior research during the early stages of the COVID-19 pandemic in the United States. In more detail, we examined the interaction between PA, time spent sitting, grit, and state ME, MF, PE, and PF. As expected and aligned with previous literature, all four moods were associated in the expected direction with vigorous PA (Puetz et al., 2006) and sitting time (Ellingson et al., 2014). While multiple studies examine the association between health-related behaviors and the four moods, evidence has been scarce during the COVID-19 pandemic (e.g., Carter et al., 2022). Contrary to the study hypothesis and previous evidence from Sharkey and colleagues (2017), grit did not influence these moods in any of the four regression models; therefore, there was no evidence to support that higher levels of grit modify the relationship between PA, sitting time, and feelings of ME, PE, MF, and PF.

In the bivariate analyses, the current study found that participants who reported a positive diagnosis of COVID-19 also reported being significantly more physically fatigued. This is consistent with previous literature in that more fatigue was experienced by those who had a COVID-19

diagnosis (Arnold et., 2021). However, this significant relationship did not remain when examined in multivariate analyses. There may be several explanations for these quizzical findings stemming from the specifics about the temporality, severity, and symptomology related to the COVID-19 diagnosis not being collected. For instance, it was unknown whether or not participants actively had COVID-19 when completing the questionnaire or if they had recovered from COVID-19 or had long-haul COVID-19 symptomology. This may have influenced the associations observed with the current study.

There are several limitations to this study that must be acknowledged. First, this was a cross-sectional survey design reliant on participants' self-reported data. As a result, it was impossible to examine the temporality of COVID-19 diagnoses and associated post-COVID fatigue (and other possible related symptomology) among participants. Second, this study sample was highly educated adults in the United States and was recruited from a snowballing convenience sample consisting of social media and the investigators' professional networks. As such, findings may not be generalizable to larger populations across the United States and/or from other countries. Third, this study did not collect data about the lockdowns, stay-at-home orders, and social restrictions experienced by participants, whether self-imposed or imposed by the participants' municipality, which may have been helpful to interpret and contextualize findings. However, ZIP Codes were used to identify the 7-day COVID-19 infection rates for participants, which may serve as a proxy for environmental risk for this sample. Finally, the current study examined grit (a dispositional concept applied to individuals pursuing a singular objective) as a primary variable of interest in this particular period of time, but did not include other positive psychology constructs

similar to grit, such as mental toughness (a state-like concept, crucial when pursuing multiple goals) (Dorvily et al., 2021; Giuliani et al., 2021) or resilience (a largely reactive concept applied to a range of systems) (Verdolini et al., 2021). Future studies should attempt to diversify the measures included in community surveys and consider utilizing qualitative methods to contextualize findings and disentangle non-intuitive and contradicting associations.

Implications for Health Behavior Theory

Drawing from the interdisciplinary model of psychophysiology, this study assessed the association between grit, PA, time spent sitting, and state ME, MF, PE, and PF during the early stages of the COVID-19 pandemic. After controlling for several demographic, lifestyle, and COVID-19-related variables, these analyses suggest that grit was not significantly associated with state ME, MF, PE, and PF during a broadly changing event, such as a pandemic. However, lifestyle behaviors of vigorous PA and sitting time were associated with these four moods in the same period of time. This work constitutes a novel and important evidence-based source when working in the field of health behavior since its findings could lead to immediate applications for translation of the theoretical framework to practice to improve health behaviors.

Researchers, practitioners, and policy makers need to recognize that the most successful public health initiatives are based on an understanding of both the theoretical model to be used and the context in which they will take place (Glanz & Bishop, 2010). For instance, to use theories of behavior efficiently in the COVID-19 era, researchers should consider concepts of perceived barriers/susceptibility, self-efficacy, and stage of change drawn from the health belief model (HBM), transtheoretical model

(TTM), and social cognitive theory (SCT). However, in a broader context as framed by the social ecological model (SEM), interpersonal, environmental, and community factors should be considered in addition to individual factors, which may influence engagement in PA and sedentary behaviors.

It is evident from our work that NPIs had an effect on individual lifestyle factors in the early stages of this global health crisis of COVID-19. Our participants exhibited an uncommon combination of behaviors with more than seven hours of sitting per day but also with more than 250 minutes of vigorous intensity PA per week. The US Department of Health and Human Services recommends that adults should participate in 75 to 150 minutes of vigorous intensity PA per week and sit for fewer than four hours per day (American College of Sports Medicine, 2022a). Recent evidence (Ekelund et al., 2016) demonstrated that high levels of moderate- to high-intensity PA seem to decrease the mortality risk associated with high levels of sedentary behavior. Further, there is strong evidence to support that regular PA can have great benefits for an individual's physical, metabolic, and mental health (American College of Sports Medicine, 2022b) whereas higher-intensity PA has more MH benefits (e.g., anxiety, depression) (American College of Sports Medicine, 2022a). Lately, the role of positive psychology in MH during the COVID-19 outbreak has been investigated (Waters et al., 2022; Yamaguchi et al., 2020).

In terms of positive psychology and if not looking for a similar-to-grit construct, we should most likely turn our focus toward investigating self-efficacy (Bandura, 1997). Self-efficacy is an important component of PA and MH (American College of Sports Medicine, 2022b) and a key construct of several health behavior models (i.e., HBM, TTM, SCT).

Discussion Questions

1. Our findings indicate a need to not include grit in models that outline, clarify, and/or predict health behavior outcomes (i.e., PE, ME, PF, and MF) during the COVID-19 crisis. Which positive psychology constructs should be included instead?
2. We reported that performing vigorous PA was associated positively with PE and ME and negatively with PF and MF. When compared with moderate and light intensity, vigorous PA is associated with increased risk of musculoskeletal injuries, sudden cardiac death, and acute myocardial infarction. Which assessments should exercise professionals complete as part of a preparticipation health screening before prescribing vigorous intensity?
3. Sitting was found to be related negatively with PE and ME and positively with PF and MF. However, sitting is not the only factor attributed to leading a sedentary lifestyle. Describe how you could use other behaviors to investigate if sedentary lifestyle is associated with the four moods during this global health crisis.

Acknowledgments

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References

- American College of Sports Medicine. (2022a). *ACSM'S Guidelines for exercise testing and prescription* (11th ed.). Wolters Kluwer.
- American College of Sports Medicine. (2022b). *ACSM'S resources for the exercise physiologist: A practical guide for the health fitness professional* (3rd ed.). Wolters Kluwer.
- Arnold, D. T., Hamilton, F. W., Milne, A., Morley, A. J., Viner, J., Attwood, M., Noel, A., Gunning, S., Hatrick, J., Hamilton, S., Elvers, K. T., Hyams, C., Bibby, A., Moran, E., Adamali, H. I., Dodd, J. W., Maskell, N. A., & Barratt, S. L. (2021). Patient outcomes after hospitalisation with COVID-19 and implications for follow-up: Results from a prospective UK cohort. *Thorax*, 76(4), 399-401. <https://doi.org/10.1136/thoraxjnl-2020-216086>
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. Freeman.
- Bedford, J., Enria, D., Giesecke, J., Heymann, D. L., Ihekweazu, C., Kobinger, G., Lane, H. C., Memish, Z., Oh, M. -D., Sall, A. A., Schuchat, A., Ungchusak, K., & Wieler, L. H. (2020). COVID-19: Towards controlling of a pandemic. *The Lancet*, 395(10229), 1015-1018. [https://doi.org/10.1016/S0140-6736\(20\)30673-5](https://doi.org/10.1016/S0140-6736(20)30673-5)
- Bhutani, S., vanDellen, M. R., & Cooper, J. A. (2021). Longitudinal weight gain and related risk behaviors during the COVID-19 pandemic in adults in the US. *Nutrients*, 13(2), 671. <https://doi.org/10.3390/nu13020671>
- Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., & Alter, D. A. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: A systematic review and meta-analysis.

- Annals of Internal Medicine*, 162(2), 123-132. <https://doi.org/10.7326/M14-1651>
- Blalock, D. V., Young, K. C., & Kleiman, E. M. (2015). Stability amidst turmoil: Grit buffers the effects of negative life events on suicidal ideation. *Psychiatry Research*, 228(3), 781-784. <https://doi.org/10.1016/j.psychres.2015.04.041>
- Boolani, A., Bahr, B., Milani, I., Caswell, S., Cortes, N., Smith, M. L., & Martin, J. (2021). Physical activity is not associated with feelings of mental energy and fatigue after being sedentary for 8 hours or more. *Mental Health and Physical Activity*, 21, Article 100418. <https://doi.org/10.1016/j.mhpa.2021.100418>
- Boolani, A., Fuller, D., Mondal, S., & Gumprich, E. (2022). Trait energy and fatigue modify acute ingestion of an adaptogenic-rich beverage on neurocognitive performance. *Applied Sciences*, 12(9), Article 4466. <https://doi.org/10.3390/app12094466>
- Boolani, A., Gallivan, K. M., Ondrak, K. S., Christopher, C. J., Castro, H. F., Campagna, S. R., Taylor, C. M., Luo, M., Dowd, S. E., Smith, M. L., & Byerley, L. O. (2022). Trait energy and fatigue may be connected to gut bacteria among young physically active adults: An exploratory study. *Nutrients*, 14(3), Article 466. <https://doi.org/10.3390/nu14030466>
- Boolani, A., & Manierre, M. (2019). An exploratory multivariate study examining correlates of trait mental and physical fatigue and energy. *Fatigue: Biomedicine, Health & Behavior*, 7(1), 29-40. <https://doi.org/10.1080/21641846.2019.1573790>
- Boolani, A., O'Connor, P. J., Reid, J., Ma, S., & Mondal, S. (2019). Predictors of feelings of energy differ from predictors of fatigue. *Fatigue: Biomedicine, Health & Behavior*, 7(1), 12-28. <https://doi.org/10.1080/21641846.2018.1558733>
- Buysse, D. J., Reynolds, C. F. III, Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193-213. [https://doi.org/10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4)
- Carter, M., Adams, J., Martin, J. Smith, M. L., Milani, I., Caswell, S. V., Cortes, N., Boolani, A., Stamatis, A., & Papadakis, Z. (2022). The limited role of grit in the associations between lifestyle behavior and feelings of energy and fatigue during the early stages of the COVID-19 pandemic. *International Journal of Exercise Science*, 2(14), Article 10.
- Caspersen, C. J., Powell, K. E., Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports*, 100(2), 126-131.
- Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*, 35(8), 1381-1395.
- De Vries, J., & Van Heck, G. L. (2002). Fatigue: Relationships with basic personality and temperament dimensions.

- Personality and Individual Differences*, 33(8), 1311-1324.
[https://doi.org/10.1016/S0191-8869\(02\)00015-6](https://doi.org/10.1016/S0191-8869(02)00015-6)
- Dorvily, M., Etchebaster, M., Stamatis, A., Forsse, J. S., Amasay, T., & Papadakis, Z. (2021). COVID-19 adherence to physical activity guidelines moderates the mental health/toughness relationship on black/Hispanic females. *Medicine and Science in Sports and Exercise*, 53(8S), 323-323.
<https://doi.org/10.1249/01.mss.00007629.36.11226.72>
- Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and passion for long-term goals. *Journal of Personality and Social Psychology*, 92(6), 1087-1101.
<https://doi.org/10.1037/0022-3514.92.6.1087>
- Duckworth, A. L., & Quinn, P. D. (2009). Development and validation of the Short Grit Scale (GRIT-S). *Journal of Personality Assessment*, 91(2), 166-174.
<https://doi.org/10.1080/00223890802634290>
- Dupree, E. J., Goodwin, A., Darie, C. C., & Boolani, A. (2019). A pilot exploratory proteomics investigation of mental fatigue and mental energy. In A. G. Woods & C. C. Darie (Eds.), *Advancements of mass spectrometry in biomedical research* (2nd ed.). *Advances in experimental medicine and biology* (Vol. 1140). Springer.
https://doi.org/10.1007/978-3-030-15950-4_36
- Ekelund, U., Steene-Johannessen, J., Brown, W. J., Fagerland, M. W., Owen, N., Powell, K. E., Bauman, A., & Lee, I.-M. (2016). Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *The Lancet*, 388(10051), 1302-1310.
[https://doi.org/10.1016/S0140-6736\(16\)30370-1](https://doi.org/10.1016/S0140-6736(16)30370-1)
- Ellingson, L. D., Kuffel, A. E., Vack, N. J., & Cook, D. B. (2014). Active and sedentary behaviors influence feelings of energy and fatigue in women. *Medicine and Science in Sports and Exercise*, 46(1), 192-200.
<https://doi.org/10.1249/MSS.0b013e3182a036ab>
- Fuller, D. T., Smith, M. L., & Boolani, A. (2021). Trait energy and fatigue modify the effects of caffeine on mood, cognitive and fine-motor task performance: A post-hoc study. *Nutrients*, 13(2), 412-426.
<https://doi.org/10.3390/nu13020412>
- Galea, S., Merchant, R. M., & Lurie, N. (2020). The mental health consequences of COVID-19 and physical distancing: The need for prevention and early intervention. *JAMA Internal Medicine*, 180(6), 817-818.
<https://doi.org/10.1001/jamainternmed.2020.1562>
- Giuliani, M., Morgan, G., Cowden, R. G., Forsse, J. S., & Stamatis, A. (2021). Enhancing mental toughness in student-athletes during the COVID-19 pandemic via educational-based psychological skills training: Preliminary results of a pilot study. *International Journal of Exercise Science*, 2(13), Article 91.
- Glanz, K., & Bishop, D. B. (2010). The role of behavioral science theory in development and implementation of public

- health interventions. *Annual Review of Public Health*, 31(1), 399-418.
<https://doi.org/10.1146/annurev.publhealth.012809.103604>
- Kannangara, C. S., Allen, R. E., Waugh, G., Nahar, N., Khan, S. Z. N., Rogerson, S., & Carson, J. (2018). All that glitters is not grit: Three studies of grit in university students. *Frontiers in Psychology*, 9, 1539.
<https://doi.org/10.3389/fpsyg.2018.01539>
- Khodarahimi, S., & Rasti, A. (2015). The roles of fatigue, depression, and Big Five Personality traits in males with and without multiple sclerosis disease. *Clínica y Salud*, 26(2), 91-96.
<https://doi.org/10.1016/j.clysa.2015.03.002>
- Li, S., Wang, Y., Xue, J., Zhao, N., & Zhu, T. (2020). The impact of COVID-19 epidemic declaration on psychological consequences: A study on active Weibo users. *International Journal of Environmental Research and Public Health*, 17(6), 2032.
<https://doi.org/10.3390/ijerph17062032>
- Loy, B. D., Cameron, M. H., & O'Connor, P. J. (2018). Perceived fatigue and energy are independent unipolar states: Supporting evidence. *Medical Hypotheses*, 113, 46-51.
<https://doi.org/10.1016/j.mehy.2018.02.014>
- Manierre, M., Jansen, E., & Boolani, A. (2020). Sleep quality and sex modify the relationships between trait energy and fatigue on state energy and fatigue. *PLoS ONE*, 15(1), Article e0227511.
<https://doi.org/10.1371/journal.pone.0227511>
- Michie, S., West, R., & Harvey, N. (2020). The concept of “fatigue” in tackling COVID-19. *BMJ*, 371, Article m4171.
<https://doi.org/10.1136/bmj.m4171>
- O'Connor, P. J. (2006). *Mental and physical state and trait energy and fatigue scales*. University of Georgia.
- O'Connor, P. J., & Puetz, T. W. (2005). Chronic physical activity and feelings of energy and fatigue. *Medicine and Science in Sports and Exercise*, 37(2), 299-305.
<https://doi.org/10.1249/01.mss.0000152802.89770.cf>
- Pappa, S., Ntella, V., Giannakas, T., Giannakoulis, V. G., Papoutsis, E., & Katsaounou, P. (2020). Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. *Brain, Behavior, and Immunity*, 88, 901-907.
<https://doi.org/10.1016/j.bbi.2020.05.026>
- Puetz, T. W., O'Connor, P. J., & Dishman, R. K. (2006). Effects of chronic exercise on feelings of energy and fatigue: A quantitative synthesis. *Psychological Bulletin*, 132(6), 866-876.
<https://doi.org/10.1037/0033-2909.132.6.866>
- R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>
- Segal-Isaacson, C. J., Wylie-Rosett, J., & Gans, K. M. (2004). Validation of a short dietary assessment questionnaire: The Rapid Eating and Activity Assessment for

- Participants short version (REAP-S). *The Diabetes Educator*, 30(5), 774-781.
<https://doi.org/10.1177/014572170403000512>
- Sharkey, C. M., Bakula, D. M., Gamwell, K. L., Mullins, A. J., Chaney, J. M., & Mullins, L. L. (2017). The role of grit in college student health care management skills and health-related quality of life. *Journal of Pediatric Psychology*, 42(9), 952-961.
<https://doi.org/10.1093/jpepsy/jsx073>
- Toczko, M., Merrigan, J., Boolani, A., Guempel, B., Milani, I., & Martin, J. (2022). Influence of grit and healthy lifestyle behaviors on anxiety and depression in U.S. adults at the beginning of the COVID-19 pandemic: Cross-sectional study. *Health Promotion Perspectives*, 12(1), 77-84.
<https://doi.org/10.34172/hpp.2022.10>
- Totosy de Zepetnek, J. O., Martin, J., Cortes, N., Caswell, S., & Boolani, A. (2021). Influence of grit on lifestyle factors during the COVID-19 pandemic in a sample of adults in the United States. *Personality and Individual Differences*, Article 110705.
<https://doi.org/10.1016/j.paid.2021.110705>
- Twenge, J. M., & Joiner, T. E. (2020). US Census Bureau-assessed prevalence of anxiety and depressive symptoms in 2019 and during the 2020 COVID-19 pandemic. *Depression and Anxiety*, 37(10), 954-956.
<https://doi.org/10.1002/da.23077>
- Verdolini, N., Amoretti, S., Montejo, L., García-Rizo, C., Hogg, B., Mezquida, G., Rabelo-da-Ponte, F. D., Vallespir, C., Radua, J., Martinez-Aran, A., Pacchiarotti, I., Rosa, A. R., Bernardo, M., Vieta, E., Torrent, C., & Solé, B. (2021). Resilience and mental health during the COVID-19 pandemic. *Journal of Affective Disorders*, 283, 156-164.
<https://doi.org/10.1016/j.jad.2021.01.055>
- Wang, C., Horby, P. W., Hayden, F. G., & Gao, G. F. (2020). A novel coronavirus outbreak of global health concern. *The Lancet*, 395(10223), 470-473.
[https://doi.org/10.1016/S0140-6736\(20\)30185-9](https://doi.org/10.1016/S0140-6736(20)30185-9)
- Waters, L., Algoe, S. B., Dutton, J., Emmons, R., Fredrickson, B. L., Heaphy, E., Moskowitz, J. T., Neff, K., Niemiec, R., Pury, C., & Steger, M. (2022). Positive psychology in a pandemic: Buffering, bolstering, and building mental health. *The Journal of Positive Psychology*, 17(3), 303-323.
<https://doi.org/10.1080/17439760.2021.1871945>
- Yamaguchi, K., Takebayashi, Y., Miyamae, M., Komazawa, A., Yokoyama, C., & Ito, M. (2020). Role of focusing on the positive side during COVID-19 outbreak: Mental health perspective from positive psychology. *Psychological Trauma: Theory, Research, Practice, and Policy*, 12(S1), S49-S50.
<https://doi.org/10.1037/tra0000807>