

Article

Influence of Grit on Physical Activity, Sitting Time and Dietary Behaviors: A Multi-Study Analysis

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Abstract: Engaging in physical activity (PA), minimizing sitting time and consuming a healthy diet are behaviors associated with health and wellness across the lifespan. The present multi-study analysis examined the relationship between grit and PA, sitting time and dietary behaviors in several populations that included US adults, active-duty military personnel, veterans, college students and performing artists. The four research laboratories administered an internet-based survey between spring and summer of 2020. The common questionnaires on the surveys were the Grit Scale Short Form, International Physical Activity Questionnaire Short Form and the Rapid Eating Assessment for Participants Short Form. Multiple regression analyses were conducted to examine the association between grit, PA, sitting time and dietary behaviors. PA was associated with grit for US adults, civilians and college students but not for performing artists or active-duty military populations. Sitting time was associated with grit for US adults and active-duty military personnel. US adults, college students and performing artists were found to have a positive association between healthy dietary behaviors and grit. Overall, the findings indicate that grit has a positive influence on PA, sitting time and dietary behaviors across the unique populations; however, the relationships indicate some nuanced differences between the populations.

Keywords: mental resilience; exercise; nutrition; military; performing artists; college students



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1. Introduction

The modifiable lifestyle behaviors of physical activity (PA) and diet are of particular importance to combat numerous health issues experienced across the lifespan [1]. Significant evidence exists on the positive relationship between these healthy lifestyle behaviors (PA, diet, and sitting time) and physical [2–4] and mental health [5,6]. However, not everyone adheres to positive health-related behaviors (e.g., meeting PA guidelines, healthy eating) and reduces/eliminates negative behaviors (e.g., sitting time). While various reasons for these behaviors have been proposed, there exists a large body of literature that reports the role of various personality traits in explaining the inter-individual differences in the lifestyle behaviors of PA and diet [7–9]. Recently, a meta-synthesis of 36 meta-analyses, including over 500,000 participants, concluded that personality predicts overall health and well-being [10]. These findings suggest that some of the inter-individual differences in healthy lifestyle behavior can be explained by personality differences.

Living a healthy lifestyle requires persistence, as there are numerous barriers that exist when trying to consistently remain physically active, eat well and obtain good quality sleep.

The personality trait of grit has been defined as passion and sustained persistence toward long-term achievements [11]. Grit encompasses the personality traits of resilience, ambition, conscientiousness, endurance and self-control [11]. In the context of living a healthy lifestyle, individuals who are ‘gritty’ would, in theory, be more likely to maintain a positive attitude over time despite setbacks and plateaus in progress. Thus, with an increased emphasis on being physically active, eating healthy and sleeping well, there is a growing body of literature examining the influence of grit on healthy lifestyle behaviors [12].

Recently, Totosy and colleagues [12] reported that grit was associated with healthy lifestyle behaviors; specifically, grittier individuals performed more vigorous PA, reported less time spent sitting and consumed a higher quality diet during the early months of the COVID-19 pandemic in a sample of United States (US) adults. Totosy and colleagues [12] attributed their findings to the two components of grit, conscientiousness and consistency of interest [11]. Totosy and colleagues [12] considered the “invest-and-accrue” model [13], which suggests that conscientious individuals invest in their physical health by eating more vegetables, walking and flossing [14], to play a partial role in their findings. The authors suggested that individuals who are consistently interested in healthy lifestyle behaviors such as exercise (e.g., vigorous PA) and a healthy diet would continue to adhere to these behaviors even during the COVID-19 pandemic [12]. While the above findings may be relevant for the general population, the findings may not necessarily be the same for other populations.

Despite CDC recommendations that adults take part in 150 min per week of moderate intensity PA, 75 min per week of vigorous intensity PA, or a combination of moderate and vigorous intensity PA, the typical US adult has no formal requirements to meet these guidelines [15]. Additionally, the typical US adult has the freedom to choose what foods they consume and does not have body composition or aesthetic expectations with which they need to concern themselves. Although many US adults may work in occupations that require working at a computer station for 40 hours per week, standing desks are commonly offered by employers to reduce sitting time [16]. Thus, the purpose of this multi-study analysis was to examine whether grit would be associated with PA, sitting time and dietary behavior in other unique populations. Overall, based on the hypotheses and findings of Totosy and colleagues [12], we may hypothesize that when examining all individuals, those who are grittier will adopt healthier lifestyle behaviors. To test our hypotheses, we examined studies from four different laboratories (labs) to examine whether grit explained inter-individual differences in physical activity, sedentary behavior, and diet among multiple unique populations, some of whom must be physically active and/or eat healthy diets for their occupations.

2. Materials and Methods

2.1. General Study Methods

2.1.1. Survey Instrument Details

The surveys for all 4 studies were collected via electronic surveys at various points during the COVID-19 pandemic. An online platform (Qualtrics, XM, Provo, UT) was used that was accessible on any device with an internet connection. The data selected for the present 4 studies included sections on: demographics, the Grit Scale Short Form (Grit-S), the International Physical Activity Questionnaire Short Form (IPAQ-SF), and the Rapid Eating Assessment for Participants Short Form (REAP-S). Information about participants’ age, sex, education, employment status (employed vs. unemployed), smoking status, and whether they had any chronic illnesses were asked. Participants were also asked about their mental workload on work and non-work days.

Grit-S: The 8-point Grit-S was used to measure trait-level perseverance and consistency of interest [11,13,14,17]. Participants responded to the eight items on a 5-point Likert scale (1 = Not at all like me, 5 = Very much like me). Representative statements included “Setbacks (delays and obstacles) do not discourage me” and “I am a hard worker”. The total scores for all statements were added and then divided by 8 to obtain a grit score. Scores

range from 1 (not at all gritty) to 5 (extremely gritty). The Grit-S scale has been shown to have a Cronbach's alpha range of 0.73 to 0.83 [17]. The Cronbach's alpha in our studies ranged from 0.80 to 0.84 (study 1 = 0.82, study 2 = 0.80, study 3 = 0.84, study 4 = 0.81).

Physical activity: The International Physical Activity Questionnaire-Short Form (IPAQ-SF) is a scale used to determine physical activity levels [18]. Participants are asked to self-report the frequency (exercise sessions per week), duration (minutes per session), and intensity of sessions (light, moderate, and vigorous) and sedentary time (hours and minutes) over a 7-day period. The time participants reported taking part in light physical activity was labeled Light PA. The times participants reported taking part in moderate and vigorous activity were combined into a single variable called Moderate to Vigorous Physical Activity (MVPA) [19].

Diet: The Rapid Activity Assessment for Participants Short Form (REAP-S) was used to assess dietary choices [20]. The questionnaire is divided into 2 parts, the first 13 items target the frequency of food choices (i.e., In an average week how often do you: eat less than 2 servings of whole grain products or high-fiber starches a day?) and are scored from 1 to 3 (1 = usually/often, 2 = sometimes, 3 = rarely/never). Items answered as "does not apply to me" or "rarely eat . . ." were scored as a rarely/never. Higher total scores of the first 13-items were indicative of healthier diets. Red flags indicated participants who reported a score of 1 (usually/often) on an item. Reporting fewer than 5 red flags was classified as having a good diet and 5 or more red flags was classified as having a poor diet. The second part of the REAP-S consisted of 3 items and measured the will of the participants to establish dietary changes, but this was not reported in our analysis.

2.1.2. Statistical Analyses

All data were downloaded from Qualtrics and scored in Microsoft Excel. The data were then uploaded to SPSS v26.0 (IBM Corp. Released 2016, IBM SPSS Statistics for Windows, Armonk, NY, USA). If there were any missing data points for any of the variables measured in the study, the participant's entire data were removed from analyses. All variables were evaluated for the normality of their distribution using a combination of histograms and the Shapiro–Wilk test for normality. In most cases, the variables were non-normally distributed. Common transformations were attempted (i.e., exponential, power, arcsine, and logarithmic); however, none of the transformations resulted in normally distributed data. Given the sample sizes in all 4 studies, the large sample theory was employed to justify the use of parametric tests [21,22].

In all studies, descriptive statistics were computed to describe the participants and measures. Linear regression models were used to examine the associations between healthy lifestyle behaviors and grit. Finally, 1-way ANOVAs were used to assess whether differences in grit, MVPA, sitting time and diet differed between studies. Tukey's post hoc tests were used to identify between-study differences when main effects were observed. All analyses were completed using SPSS v26.0 (IBM Corp. Released 2016, IBM SPSS Statistics for Windows: Armonk, NY, USA), with a level of significance of $p < 0.05$.

3. Study 1

3.1. Participants

Data were added to the data already presented by Totosy and colleagues [12]. Data were obtained from 14th April–31st August 2020. The target population for the study were male and female adults aged 18 or older living in the US. Participants were recruited by researchers I.M. (lab 1), A.B. (lab 1) and J.M. (lab 2) using a snowball method via their personal social media pages (Twitter, Facebook, LinkedIn), emails to friends and colleagues, media publications and promotions by the two institutions of the researchers and word-of-mouth. Followers on social media, friends and colleagues were encouraged to share the survey. The study procedures were approved by the Institutional Review Boards at Clarkson University (approval #20.54.2) and George Mason University (approval #1592393-1).

3.2. Results

The majority of the participants ($n = 1388$) were female (>70%; Table 1) and self-reported grit scores of 3.20 ± 1.00 . Overall, the sample was physically active, with a majority exceeding the recommended PA guidelines of 150 min of MVPA per week (>65%). Most of the participants self-reported healthy eating behaviors with an average total score of 30.29 ± 4.09 , and over 87% were classified as having good diets.

Table 1. Participant characteristics: general population of US adults ($n = 1388$).

	Mean \pm SD
Grit	3.20 \pm 1.00
Male:Female	28.30%:71.70%
Age (yrs)	33.93 \pm 13.92
Non-Smokers:Smokers	90.9%:9.1%
Chronic medical condition Yes:No	33.8%:66.2%
MVPA (min/week)	481.54 \pm 785.99
0 min MVPA	20.80%
0–150 min MVPA	13.40%
151–300 min MVPA	13.40%
301+ minutes MVPA	52.40%
Light PA (min/week)	355.40 \pm 1059.42
Sitting time (min/week)	3098.27 \pm 1728.99
0–4 h sitting time/day	17.20%
4–6 h sitting time/day	21.60%
6–8 h sitting time/day	16.90%
8+ h sitting time/day	44.30%
REAP-S scores	30.29 \pm 4.09
REAP-S good diet:poor diet	87.8%:12.2%

The multiple linear regression model with the lifestyle behavior predictors (Light PA, MVPA, Sitting, and diet) of grit accounted for 16.2% of the adjusted variance ($R^2 = 0.162$, $F(12,1379) = 23.22$, $p = 0.001$; Table 2). MVPA ($p < 0.05$), total time spent sitting ($p < 0.01$), and self-reported diet ($p < 0.001$) were found to be significant predictors of grit ($p = 0.04$). However, LPA ($p = 0.06$) was not a predictor of grit in the sample.

Table 2. Linear regression results for general population of US adults.

Predictors	Grit	
	β	95% CI
MVPA	0.093 *	0.000, 0.000
Light PA	0.039	0.000, 0.000
Sitting time	−0.063 **	0.000, 0.000
REAP-S	0.340 ***	0.023, 0.031
R^2	0.162 ***	
ΔR	0.061 ***	

* $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

4. Study 2

4.1. Participants

Members of the military have to perform physical training (PT) and are expected to maintain minimum fitness standards [23], which means they have to consistently be physically active. However, it may be argued that members of the military do not always perform just the bare minimum amount of PA dictated by military standards. Therefore, we were interested in whether inter-individual differences in the amount of PA engaged in

by military personnel was dictated by how gritty they are. Interestingly, while the military has weight standards, they do not have aesthetic or body composition standards, thus suggesting that there may be varied responses in terms of dietary behavior and that, if the hypotheses presented by Totosy and colleagues [12] holds true, grittier members of the military are more likely to eat healthier as they are more likely to invest in their health.

The target population for the study were male and female adults aged 18 or older living in the United States who were currently serving in the armed forces, veterans of the armed forces or civilians. Participants ($n = 810$) were recruited by S.K. (lab 3) using a snowball method via social media, email, colleagues, media publications and word-of-mouth. Data were obtained from 29th May–25th June 2020. The study procedures were approved by the Institutional Review Board at The American Public University System (approval #2020-061).

4.2. Results

The military ($n = 253$) and veteran ($n = 169$) populations of this study were predominantly male, with about 65% of participants being male and about 35% being female (Table 3). However, the civilian ($n = 388$) population was predominantly female (73%). The military population were from multiple branches of the military (10.8% Marines, 37.4% Army, 10% Navy, 37% Air Force and 4.4% Coast Guard) and comprised a combination of active-duty service members (81%) and reservists (19%). The grit scores were 3.70 ± 0.57 , 3.62 ± 0.62 and 3.62 ± 0.64 for the military, veteran and civilian populations, respectively. Most of the military (81%), veteran (66%) and civilian (58%) populations met or exceed the PA standards. Concerning the sitting time of the populations, those with more than 8 h of sedentary activity a day represented about 17% of the military, 22.5% of the veteran and 26% of the civilian population. Post hoc analyses found that the military population reported less sitting time than the civilian population. Across all three populations, at least 80% reported consuming a good diet.

Table 3. Participant characteristics: military, veteran and civilian ($n = 810$).

	Military ($n = 253$)	Veteran ($n = 169$)	Civilian ($n = 388$)	F-Value	p -Value	Post-Hoc
Grit	3.70 ± 0.57	3.62 ± 0.62	3.62 ± 0.64	1.63	0.19	
Male:Female	65.6%:34.4%	65.1%:34.9%	26.8%:73.2%	121.37	<0.001	
Age (yrs)	33.37 ± 7.29	42.63 ± 9.88	39.18 ± 12.13	44.65	<0.001	
Non-Smokers:Smokers	92.9%:7.1%	87%:13%	89.1%:10.9%	4.31	0.12	
Chronic medical condition Yes:No	19%:81%	42.6%:57.4%	39.1%:60.9%	35.71	<0.001	
MVPA (min/week)	790.0 ± 995.1	749.5 ± 1288.3	684.9 ± 1280.6	0.61	0.54	
MVPA						
0 min	11.90%	22.50%	29.80%	43.03	<0.001	
0–150 min	6.70%	11.20%	12.20%			
151–300 min	11.50%	12.40%	12.40%			
301+ min	70.00%	53.80%	45.60%			
Light PA (min/week)	455.9 ± 646.9	488.2 ± 810.5	479.8 ± 858.7			
Sitting time (min/week)	2117.6 ± 1541.0	2533.5 ± 1922.9	2635.2 ± 2089.0	5.18	<0.001	M < C
Sitting time/day						
0–4 h	36.20%	32.20%	31.20%	14.01	0.03	
4–6 h	26.20%	21.70%	16.90%			
6–8 h	18.80%	21.10%	22.30%			
8+ h	18.80%	25.00%	29.70%			
REAP-S scores	31.40 ± 4.87	31.43 ± 4.38	31.35 ± 4.41	0.02	0.98	
REAP-S good diet: poor diet	80.9%:19.1%	83.0%:17.0%	83.6%:16.3%	0.71	0.51	

The linear regression of grit for the civilian population accounted for 11.4% of the variance ($R^2 = 0.152$, $F(12, 264) = 3.954$, $p < 0.001$; Table 4). MVPA was associated with an increase in grit score ($p < 0.001$). None of the other variables (light PA, sitting time, or dietary behaviors) were significant predictors of grit in the civilian population. None of the health-related behaviors were associated with grit in the military or veteran populations (i.e., the regression models were not significant).

Table 4. Linear regression results for military, veteran and civilian populations.

Predictors	Military		Veteran		Civilian	
	β	95% CI	β	95% CI	β	95% CI
MVPA	−0.097	0.000, 0.000	0.147	0.000, 0.000	0.252 ***	0.000, 0.000
Light PA	−0.084	0.000, 0.000	−0.036	0.000, 0.000	0.039	0.000, 0.000
Sitting time	−0.181 *	0.000, 0.000	−0.010	0.000, 0.000	−0.010	0.000, 0.000
REAP-S	0.038	−0.014, 0.023	0.130	−0.007, 0.044	0.080	−0.005, 0.029
R^2	0.029		0.011		0.114 ***	
ΔR	0.044 †		0.035		0.075 ***	

† $p < 0.1$, * $p < 0.05$, and *** $p < 0.001$.

5. Study 3

5.1. Participants

During the COVID-19 pandemic, multiple studies reported that younger individuals (18–34 years) self-reported less PA and greater sedentary behavior than their older counterparts. [24,25]. While this younger population (18–34 years) was more sedentary than those ages 35–64 years or 65+ years, a recent systematic review reported that in nine studies,

cross-sectional data suggest that there was a slight decline in PA levels [26]. Based on previous findings on younger people reporting lower levels of grit [27], we hypothesized that there would be a decline in PA in college students because they have lower grit scores. Therefore, if this hypothesis holds true, grit will be positively associated with PA levels in a group of college students.

Participants ($n = 144$) were recruited from a small science, technology, engineering and mathematics (STEM)-focused institution in Northern New York by researchers N.B. (lab 1) and A.B. (lab 1). To be eligible for the study, participants had to be (1) 18 to 22 years of age, (2) full-time students in spring of 2020 and planned to register for the fall 2022 semester. Participants were recruited using the university's announcement page and by email, which included a link to screen those who were eligible for the study. The study procedures were approved by the Institutional Review Board at Clarkson University (approval #20.61.1).

5.2. Results

Of the 144 undergraduate college students, 46.1% were male and 53.9% were female (Table 5). The mean grit scores of the sample was 3.40 ± 0.70 . The participants reported being physically active, with over 70% meeting or exceeding the PA standards. However, 17% of the population did not complete any moderate-to-vigorous PA (MVPA), and 26.4% reported sitting for more than 8 h per day. In addition, 83% of the students reported having a good diet.

Table 5. Participant characteristics: college students ($n = 144$).

	Mean \pm SD
Grit	3.40 \pm 0.70
Male:Female	46.1%:53.9%
Age (yrs)	19.49 \pm 0.92
Non-Smokers:Smokers	95.7%:4.3%
Chronic medical condition Yes:No	10.6%:89.4%
MVPA (min/week)	876.44 \pm 1176.80
0 min MVPA	17.4%
0–150 min MVPA	8.3%
151–300 min MVPA	10.4%
301+ min MVPA	63.9%
Light PA (min/week)	559.42 \pm 1281.46
Sitting time (min/week)	2757.44 \pm 1478.33
0–4 h sitting time/day	31.3%
4–6 h sitting time/day	23.6%
6–8 h sitting time/day	18.7%
8+ h sitting time/day	26.4%
REAP-S scores	30.72 \pm 4.22
REAP-S good diet:poor diet	83.3%:16.7%

The results of the linear regression explained 8.0% of the variance in grit ($R^2 = 0.080$, $F(0.651, 0.324) = 2.011, 0.028$). MVPA ($p = 0.049$) and eating a healthy diet ($p = 0.019$) were associated with higher levels of grit. Light PA and sitting time were not found to be significant predictors of grit (Table 6).

Table 6. Linear regression results for population of college students.

Predictors	Grit	
	β	95% CI
MVPA	0.185 *	0.000, 0.000
Light PA	−0.060	0.000, 0.000
Sitting time	0.002	0.000, 0.001
REAP-S	0.202 *	0.004, 0.040
R ²	0.159 *	
ΔR	0.089 *	

* $p < 0.05$.

6. Study 4

6.1. Participants

Performing artists, like athletes, have to invest in their personal wellness with a focus on eating healthy diets and exercising [28]. Unlike athletes, most performing artists have few resources to hold them to PA and dietary standards [28]. Additionally, unlike members of the military, performing artists do not have fitness standards they have to meet for their job, even if their jobs can be quite physically taxing. However, unlike the general population, performing artists rely on their bodies to earn a living, and thus have a built-in motivation to be physically active and eat a healthy diet.

The current study utilized cross-sectional data that were collected from 23 May to 25 July 2020. A sample of performing artists aged 19 to 69 years were recruited through snowball sampling, mass emails, social media (Twitter, Facebook) and media publications. The data presented in this manuscript were obtained from performing artists by researchers J.A. (lab 4) and N.D. (lab 4) via cross-sectional questionnaires as part of a larger investigation into the relationships between lifestyle behaviors and moods during the COVID-19 pandemic. The first portion of the questionnaire focused on qualitative data (i.e., dreams and aspirations), while the second half emphasized quantitative data (i.e., grit, traits and lifestyle behaviors). On average, each participant spent 69.3 min on the questionnaire. Due to the lengthy time commitment, only 71% completed the first half of the survey, and only 52% completed the entire questionnaire. The final sample included 77 performing artists. The study procedures were approved by the Institutional Review Board at George Mason University (approval #1607616-1).

6.2. Results

Our sample of performing artists ($n = 77$) was predominantly female (79.2%) and had an average self-reported grit score of 3.6 ± 0.62 (Table 7). Overall, the performing artists adhered to healthy lifestyle behaviors. Sixty-two percent met or exceeded the physical activity guidelines, and only thirteen percent reported sitting for more than 8 h per day. Ninety-two percent reported consuming a good diet.

Table 7. Participant characteristics: performing artists ($n = 77$).

	Mean \pm SD
Grit	3.60 \pm 0.70
Male:Female	20.8%:79.2%
Age (yrs)	36.10 \pm 12.70
Non-Smokers:Smokers	3.9%:96.1%
Chronic medical condition Yes:No	24.7%:75.3%
MVPA (min/week)	736.00 \pm 915.00
0 min MVPA	13%
0–150 min MVPA	25%
151–300 min MVPA	16%
301+ min MVPA	46%
Light PA (min/week)	345.30 \pm 553.20
Sitting time (min/week)	2367.73 \pm 1391.34
0–4 h sitting time/day	35%
4–6 h sitting time/day	39%
6–8 h sitting time/day	13%
8+ h sitting time/day	13%
REAP-S scores	31.32 \pm 4.19
REAP-S good diet: poor diet	92%:8%

The multiple linear regression model accounted for an additional 29.7% of the adjusted variance ($R^2 = 0.297$, $F(12,64) = 2.25$, $p = 0.02$). Eating a healthy diet was found to be significantly associated with grit among performing artists ($p = 0.04$). However, MVPA ($p = 0.80$), LPA ($p = 0.78$) and total time spent sitting ($p = 0.89$) were not associated with grit (Table 8).

Table 8. Linear regression results for population of performing artists.

Predictors	Grit	
	β	95% CI
MVPA	−0.21 [†]	[0.00, 0.00]
Light PA	−0.32	[0.00, 0.00]
Sitting time	−0.17	[0.00, 0.00]
REAP-S	0.25 *	[0.001, 0.077]
R^2	0.297 *	
ΔR	0.102	

[†] $p < 0.1$, * $p < 0.05$.

7. Study Comparison

The one-way ANOVAs used to assess differences between studies revealed significant differences in terms of grit ($p < 0.001$), MVPA ($p < 0.001$), sitting ($p < 0.001$) and diet ($p < 0.001$). Tukey's post hoc test for grit and diet found that the sample in study 1 had significantly lower grit and dietary behavior quality than the sample in study 2. The post hoc test for MVPA revealed that sample in study 1 engaged in significantly less MVPA compared to the samples in studies 2 and 3. The post hoc test for total time spent sitting found that the sample in study 1 spent significantly more time sitting compared to the samples in studies 2 and 4.

8. Discussion

The purpose of our multi-study analysis was to compare the association between the personality trait of grit and PA, sedentary and dietary behaviors in unique populations. We hypothesized that all populations would demonstrate a positive influence of grit on PA, sedentary and dietary behaviors. Our findings did not fully support our hypothesis. MVPA

was associated with grit for the populations of US adults (study 1), civilians (study 2) and college students (study 3); however, neither performing artists (study 4) nor active-duty members of the military or veterans (study 2) were not found to have the same relationship. Sitting time was associated with grit only for US adults (study 1) and active-duty members of the military (study 2). Lastly, healthy dietary behaviors were associated with grit for US adults (study 1), college students (study 3) and performing artists (study 4).

MVPA is associated with numerous health benefits [29] and current recommendations are to complete 150 min/week of moderate PA, 75 min/week of vigorous PA or a combination of the two intensities [30]. For many individuals, meeting these guidelines is a challenge, and approximately 75% of US adults are unable to complete the recommended amounts of PA [31]. However, some populations are required to be physically active for occupational reasons (i.e., military or firefighters), and others participate in recreational activities (i.e., sport and dance) that promote high levels of PA. Interestingly, the populations included in this multi-study analysis that are not required to be physically active all demonstrated a significant relationship between MVPA and grit. The exception to this statement would be veterans; however, this population has been reported to engage in increased levels of moderate PA compared to non-veteran peers, which suggests that the PA behaviors instilled while actively serving in the military might carry over to post-military life [32]. Our data support this assertion, as the veteran population in study 2 (Table 2) was much more active than the population of US adults in study 1 (481.54 ± 785.99 vs. 737.77 ± 1186.49 min/week of MVPA, respectively). Thus, we postulate that the finding that US adult, civilian and college student populations (but not military, veteran or performing artists populations) demonstrating significant relationships between MVPA and grit is due to differences in occupational requirements related to PA. This finding highlights the importance of grit for those not required to be physically active and supports prior literature reporting a positive relationship between grit and physical activity in populations not required to engage in PA for occupational reasons or for competitive sport [12].

Sitting time is a lifestyle behavior independent of PA that is associated with numerous health-related issues [33]. An increase in sedentary behaviors [34] and negative health consequences has caused many countries to begin to adopt guidelines to promote a decrease in activities that involve sitting for prolonged periods of time [35]. The finding that sitting time was significantly associated with grit for US adults and military populations but not college students or performing artists is curious. Interestingly, the US adults (study 1) had the lowest (3.2 ± 1.0) and active-duty military personnel (study 2) and performing artists (study 4) had the highest (3.6 ± 0.6 and 3.6 ± 0.7 , respectively) grit scores. Potential reasons for the lack of consistent findings regarding sitting time include numerous factors (i.e., occupational or educational demands, COVID-19 social distancing policies) that were not accounted for in our models that may also contribute to time spent sitting. Furthermore, it must be acknowledged that the data from our study were collected during the early stages (spring to summer 2020) of the COVID-19 pandemic. During this time period, there was an increase in sitting time due to remote work and learning [36]. These circumstances potentially lessened the role of grit on sitting time as pandemic-related changes to lifestyles had a stronger influence on sedentary behaviors than individual differences in grit. Future research should examine the role of grit in sedentary behaviors now that social distancing restrictions are no longer in place.

Consuming a healthy diet is another modifiable lifestyle behavior that is necessary for good health and wellness across the lifespan [37,38]. Grit was positively associated with better dietary behaviors in US adults (study 1), college students (study 3) and performing artists (study 4). For these three populations, grit was a stronger predictor, based on standardized betas, in the multiple regression models as compared to MVPA and sitting time. Unexpectedly, we did not find a significant association between grit and dietary behaviors for any of the populations (Table 4; active-duty military, veterans or civilians) in study 2. Grit and REAP-S responses were only found to be significantly different for study 2 participants as compared to study 1 (Table 9). No obvious reason is apparent to

explain the differences in study 2 compared to the other studies. A number of other studies have supported the benefits of the personality traits encompassed in grit for consuming a healthy diet [12,39,40]. Eating a healthy diet consists of eating a similar quantity and quality of foods over a long period of time. Thus, there is a clear connection between traits encompassed in ‘grit’—consistency of interest and perseverance of effort—and adopting consistent eating behaviors to achieve long-term health goals. Furthermore, common barriers to consuming a healthy diet, such as willpower and time constraints [41], would suggest that those with higher levels of grit would report eating healthier.

Table 9. Comparison of grit and healthy lifestyle behaviors between studies.

Variable	Study 1 (n = 1388)	Study 2 (n = 810)	Study 3 (n = 144)	Study 4 (n = 77)	F	Post-Hoc
Grit	3.2 ± 1.00	3.6 ± 0.60	3.4 ± 0.70	3.6 ± 0.70	27.60 ***	S1 < S2
MVPA	481.54 ± 785.99	737.77 ± 1186.49	876.44 ± 1176.80	736.00 ± 915.00	7.09 ***	S1 < S2, S3
Sitting	3098.27 ± 1728.99	2490.81 ± 1872.61	2757.44 ± 1478.33	2367.73 ± 1391.34	21.87 ***	S1 > S2, S4
REAP-S	30.29 ± 4.09	31.19 ± 4.52	30.72 ± 4.22	31.32 ± 4.19	7.36 ***	S1 < S2

*** $p < 0.001$.

The overall results of the multi-study analysis highlight the importance of grit for living a healthy lifestyle in terms of PA, sitting time and dietary behaviors. For many, the choice to be physically active, minimize sitting time and consume a healthy diet result from the desire to avoid illness, reduce disease risk and enjoy healthy aging. Fundamentally, these are long-term goals that require consistency and perseverance when barriers are encountered. The finding that grittier individuals display improved health behaviors, especially during challenging times (i.e., during the COVID-19 pandemic), is encompassed by the conscientiousness component of grit [17], which is strongly associated with perseverance [42]. Hill and Jackson proposed the “invest-and-accrue” model of conscientiousness, where individuals with high conscientious personality traits invest in behaviors that allow for future success [13]. Applied to the context of healthy lifestyle behaviors, the “invest-and-accrue” model would predict that conscientious people will engage in behaviors known to improve long-term health.

Several limitations, not mentioned previously, were present in all 4 studies. First, all studies utilized a cross-sectional design, which limits the ability to determine cause and effect [43]. The data analyzed in the studies was all self-reported, which can be affected by social bias and participants’ ability to accurately recall the information requested [44,45]. The use of an online survey and recruiting methods may have biased the samples to be of higher socio-economic status [46,47]. Lastly, the data were collected during the COVID-19 pandemic, and physical distancing policies may have impacted participants in manners not accounted for in the studies [48–51]. Due to the cross-sectional design of the studies, we are unable to discern how, or if, the COVID-19 pandemic policies affected the reported relationships in the samples. The restrictions on human subject testing in our laboratories during the COVID-19 pandemic also influenced our methodology, i.e., the use of an online survey to collect the reported data. Future studies should consider assessing biochemical parameters and performing cardiopulmonary tests in order to assess the effects of physical activity on health.

9. Conclusions

In conclusion, for many individuals, living a healthy lifestyle is challenging due to numerous factors. The personality trait of grit appears beneficial for increasing levels of PA, reducing sitting time, and consuming a healthy diet. Given the health benefits of living a healthy lifestyle, practitioners should recognize the influence that attributes encompassed in grit—consistency of interest and perseverance of effort—have on individuals’ ability to engage in such behaviors. We recommended that practitioners use the short grit scale to assess grit as part of a health and wellness program so that they can understand their par-

participants' baseline grit status and use this information to develop customized intervention programs to optimize their participants' health and wellness.

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