Exploring the relationship between grit, physical activity and fatigue in individuals suffering from post COVID: A cross-sectional study

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Abstract

Post-acute COVID-19 syndrome (post COVID) has emerged as a condition with a high prevalence among individuals recovering from COVID-19. Post COVID describes the sequelae of COVID-19 and is characterised by a number of symptoms of which fatigue is the most prevalent and severe. Moreover, post COVID often interferes with the engagement in physical activity (PA). PA can not only bring benefits for recovering individuals with it but it also carries risks. In this context, the personality trait grit was expected to account for individual differences in the level of PA that recovering individuals engage in. Due to the importance of fatigue in the post COVID recovery process, it was expected that fatigue moderates the relationship between grit and PA. Convenience sampling was used to recruit 50 participants (female: 68%, age: M = 35.86, SD = 13.07) that were presented with questionnaires to measure the constructs grit, PA and fatigue. In order to analyse the cross-sectional data, linear regression- and moderation analyses were used. No significant relationship between grit and PA were found in a linear regression model. Post-hoc analysis revealed that a relationship between grit and PA in the post COVID recovery process was more adequately described by a quadratic model than a linear model. The model for the moderation analysis was significant (R^2 = .166, F(5, 44) = 3.06, p = .037). However, the interaction between grit and fatigue was not significant, yet the coefficient for fatigue was significant (B = -115.58, p = .014). Therefore, the current study confirms the major role that fatigue plays in the experience of individuals suffering from post COVID. Furthermore, the current study questions the existence of a linear relationship between grit as predictor and PA as outcome in the post COVID recovery process. In this context, future research should focus on investigating the potential quadratic relationship between grit and PA.

Keywords: Post-acute COVID-19 syndrome, post COVID, physical activity, grit, fatigue, post COVID recovery process, post-exertional malaise, cross-sectional, linear regression analysis, moderation analysis

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1 Introduction

Although many people recover quickly from the coronavirus disease 2019 (COVID-19), other people experience long-term effects of the viral infection which is a condition termed post acute COVID-19 syndrome (post COVID) (Fernández-de-las-Peñas et al., 2021). For individuals with this condition, managing physical activtiy (PA) throughout their recovery process is a challenge with ambiguities because PA can affect recovery both negatively and positively (Humphreys et al., 2021; Salman et al., 2021). The positive psychological construct "grit" offers potential for explaining individual differences in regard to PA during the recovery process of individuals suffering from post COVID (Schimschal et al., 2021). Grit is a personality trait that determines "an individual's tendency to persistently pursue long-term goals despite challenges and obstacles" (Schmidt et al., 2017, p.1). Another factor that has an influence on PA during post COVID sufferers' recovery process is the intensity of fatigue that individuals experience (Gaber, 2021; Humphreys et al., 2021; Twomey et al., 2021). Gaber (2021) describes fatigue as the most common long-term complication that individuals recovering from COVID-19 have to deal with. Therefore, the aim of the current study was to examine the relationship between grit and PA in individuals suffering from post COVID with severity of fatigue as a moderating variable.

1.1 Post COVID: Definition, prevalence, and symptomatology

Post COVID is a phenomenon that can occur after an infection with severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2) (Fernández-de-las-Peñas et al., 2021). Due to the novelty of post COVID, research on the syndrome is still in its early development (Fernández-de-las-Peñas et al., 2021; Nalbandian et al., 2021). The World Health Organisation (WHO) defines post COVID as a condition that occurs "in individuals with a history of probable or confirmed SARS CoV-2 infection, usually 3 months from the onset of COVID-19 with symptoms that last for at least 2 months and cannot be explained by an alternative diagnosis." (World Health Organisation, 2021, p.11).

Furthermore, the WHO describes fatigue, shortness of breath, and cognitive dysfunction as examples for common symptoms of post COVID (World Health Organisation, 2021). In a recent meta-analysis, Alkodaymi et al. (2022) investigated the symptomatology in the recovery process of 257,348 COVID-19 sufferers at four follow-up points between three and twelve months after the initial onset of the disease. The most common symptom was fatigue with a prevalence ranging from 32% to 41% (Alkodaymi et al., 2022). In this connection, shortness of breath was the symptom with the second highest prevalence of 21%

to 31% (Alkodaymi et al., 2022). Moreover, Huang et al. (2021) found in their study on the long-term consequences of COVID-19 that 76% of a sample of previously hospitalised COVID-19 patients showed at least one symptom until six months after the infection. This shows that a large proportion of COVID-19 patients develop ongoing symptoms which indicates a high prevalence for post COVID.

Post COVID is characterised by a number of other physiological and psychological symptoms (Malik et al., 2022). Post-exertional malaise (PEM) is a phenomenon that often accompanies the symptomatology of individuals suffering from post COVID. PEM is described as "a worsening of symptoms and reduction in function after physical, cognitive, or emotional activity that would not have caused a problem before illness" (Twomey et al., 2021, p. 3). This relapse of symptoms often interferes with the engagement in PA (Twomey et al., 2021). Other common physiological symptoms of post COVID include olfactory issues, headaches and chest pain (Malik et al., 2022). Furthermore, post COVID sufferers often report symptoms of depression and post-traumatic stress disorder (PTSD) which illustrate the psychological complications that the syndrome can bring with it (Malik et al., 2022). Descriptions of the symptomatology of post COVID make apparent that dealing with this condition is a challenge of high difficulty. Therefore, the personality trait grit can facilitate the explanation of individual differences in regard to symptom management during recovery processes (Schimschal et al., 2021). This can allow for a more tailored approach to the individual needs of individuals suffering from post COVID (Schimschal et al., 2021).

1.2 Grit: Definition and relation to post COVID and PA

Grit was first introduced by Duckworth et al. (2007) in the context of research on the relevant predictors for personal success. Duckworth et al. (2007) identified two dimensions of grit: perseverance of effort and consistency of interest. The perseverance of effort facet of grit describes that in order to achieve mastery in any area of life, willingness for deliberate practice and tolerance of failures is needed (Schmidt et al., 2017). The consistency of interest facet refers to the need for an initial interest in the subject and the continuous maintenance of this interest over a long period of time in order to have success (Schmidt et al., 2017). Gritty individuals are characterised by their long-term stamina and approach "achievement as a marathon" (Duckworth et al., 2007, p. 1088). In contrast, individuals with lower levels of grit often get discouraged by challenges and interpret resistance as a signal for changing trajectory (Duckworth et al., 2007). Given that post COVID illustrates a major challenge in the life of individuals recovering from the condition, the level of grit an individual possesses can

influence recovery processes (Humphreys et al., 2021; Schimschal et al., 2020).

Traino et al. (2019) found in their study that adolescents and young adults with chronic health conditions that possess high levels of grit had better health care management skills and increased mental and physical health-related quality of life. Higher levels of grit were also associated with more exercise behaviour in a study by Reed (2014) in which "grit provided significant predictive capability for exercise score" (p. 390). Additionally, in a study on the influence of grit on lifestyle factors during the COVID-19 pandemic, de Zepetnek et al. (2021) found associations between high levels of grit and higher PA scores, as well as lower sedentary behaviour scores. De Zepetnek et al. (2021) concluded that high levels of grit provide advantages that enable to remain healthier lifestyles in the face of adversity. Therefore, higher levels of grit can have a positive effect on the recovery efforts of individuals that suffer from post COVID.

In contrast to these positive aspects of grit, Houston et al. (2021) investigated in their study the "dark side of grit" (p. 17). Gritty individuals tend to show perfectionistic tendencies (Houston et al., 2021). Moreover, Houston et al. (2020) state that "grittiness in some situations, may lead to overinvestment of time and effort in unsolvable problems or unobtainable goals" (p.17). According to this description, long-term stamina and approaching "achievement as a marathon" (Duckworth et al., 2007, p. 1088) does not necessarily have to mean that the goals themselves are realistic. When combining this with individuals high in grit being less likely to change trajectories because of resistance (Duckworth et al. 2007), it becomes apparent that a situation in which an individual with a high level of grit encounters an unobtainable goal is problematic (Houston et al., 2021). Especially in the context of symptom relapses in post COVID sufferers with PEM, gritty individuals not changing trajectory and adjusting goals regarding PA can lead to an overall worsening of the individual's state of health (Houston et al., 2021; Twomey et al., 2021). Therefore, higher levels of grit do not only have the potential for positive effects on individual's recovery efforts but it can also cause harm in the context of PA during the post COVID recovery process.

Additionally, Khan et al. (2021) found in their study that high levels of grit can have a "too-much-of-a-good-thing" (p. 1336) effect on goal-pursuit processes. Khan et al. (2021) describe that the positive nature of the psychological resource grit is reversible which results in a pitfall that can have a negative impact on individuals that possess a high level of grit. This adds to the notion of the negative aspects of grit concerning goal-setting that Houston et al. (2021) describe. Therefore, a gritty individual risks continuously triggering the relapse of

symptoms by setting goals that are too ambitious in regard to engaging in a particular level of PA. Not being able to accept that a change of trajectories is inescapable due to PEM and clinging on unrealistic goals puts individuals with high levels of grit at risk of a misdirected use of their strengths. In contrast, individuals with lower levels of grit can be expected to change trajectories and give up their PA goals before they are at risk of overexertion. However, less gritty individuals are also endangered because PA is not only a risk factor in the recovery process of post COVID but can also provide health benefits (Jimeno-Almazán et al., 2021). These health benefits would not be accessible to individuals that change trajectories too fast. Therefore, the level of grit that an individual possesses can provide information on how PA is approached in the post COVID recovery process.

1.3 PA: Definition and relation to post COVID and grit

PA is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen et al., 1985, p. 126). Therefore, PA includes not only physical exercise but also basic activities of daily living (ADL's), such as housework or grocery shopping (Humphreys et al., 2021). PA takes a special role in the recovery process of individuals suffering from post COVID (Humphreys et al., 2021). This is because it can have both positive and negative effects on post COVID sufferers' state of health (Humphreys et al., 2021).

PA can have a positive effect on the recovery process of post COVID sufferers, as being able to manage ADL's or even engage in physical exercise can provide recovering individuals with a sense of normality and control (Humphreys et al., 2021). Furthermore, PA is especially important for conditions with pulmonary complications such as post COVID because it can revert muscle dysfunctions resulting from lung diseases (Jimeno-Almazán et al., 2021). In other words, the lack of fitness resulting from post COVID can be counteracted by systematically engaging in PA (Jimeno-Almazán et al., 2021). Moreover, not engaging in physical activity "can downregulate the ability of organ systems to resist to viral infection and increase the risk of damage to the immune, respiratory, cardiovascular, musculoskeletal systems and the brain" (Woods et al., 2020, p. 55). Therefore, it is inevitable to include PA in post COVID sufferers' recovery processes. However, the negative consequences that can result from PA complicate the recovery process of individuals suffering from post COVID (Salman et al., 2021).

As already described, PEM plays a crucial role in causing the complexities of PA in the context of post COVID (Twomey et al., 2021). Especially for gritty individuals that do not

find a balance between exertion and rest in regard to PA, PEM can cause a vicious circle in which too much exertion leads to continuous relapses of symptoms. As the most common symptom of post COVID, fatigue often plays a role in this vicious circle (Twomey et al., 2021). Furthermore, the relationship between fatigue and PA can represent another vicious circle in itself (Primdahl et al., 2019). This is because fatigue can interfere with recovery efforts such as PA which can then result in additional increases in fatigue (Aaronson et al., 1999; Primdahl et al., 2019). Combining the beneficial and detrimental effects PA can have on the recovery process that post COVID entails, it becomes apparent that more clarity and tailoring is needed for advice concerning PA during the recovery process of post COVID sufferers (Humphreys et al., 2021). Not only encountering a vicious circle revolving around fatigue when engaging in levels of PA that are too low but also when engaging in PA levels that are too high makes it difficult to establish reasonable PA levels. Therefore, fatigue and PEM contribute significantly to the overall decrease in health-related quality of life that individuals suffering from post COVID experience (Malik et al., 2022; Twomey et al., 2021).

1.4 Fatigue: Definition and relation to post COVID, grit and PA

Fatigue is a common symptom that accompanies many different disorders such as cancer, rheumatoid arthritis, and multiple sclerosis (Shen et al., 2006). Valko et al. (2008) state that "fatigue is a subjective experience, and includes such symptoms as rapid inanition, persisting lack of energy, exhaustion, physical and mental tiredness, and apathy" (p. 1601). Moreover, issues with chronic fatigue after viral infections with other coronaviruses such as SARS-Cov 1 and MERS-Cov are also common and were known prior to the existence of COVID-19 (Gaber, 2021; Islam et al., 2020; Malik et al., 2022).

Usually, severity and duration of the acute phase of a viral infection determine the extent to which post-viral fatigue manifests itself in recovering individuals (Gaber, 2021). This is in contrast to COVID-19 being relatively mild in most individuals but post COVID sufferers being more likely to experience prolonged and more severe fatigue compared to other upper respiratory viral infections which reflects the central role that fatigue plays for individuals suffering from post COVID (Gaber, 2021). Furthermore, Twomey et al. (2021) conclude in their study that post COVID is primarily characterised by "chronic fatigue that is clinically relevant and is at least as severe as fatigue in several other clinical conditions, including cancer" (p. 1). The severity (Twomey et al., 2021) and high prevalence of fatigue (Alkodaymi et al., 2022) in combination with the vicious circles revolving around PA, fatigue and PEM make apparent that fatigue can influence the level of PA that post COVID sufferers

engage in.

Recovering individuals that experience fatigue, engage in less PA than healthy individuals and often avoid activities that are estimated to result in higher fatigue completely (Vercoulen et al., 1997). However, not sufficiently engaging in PA prevents recovering individuals from rebuilding their strength (Jimeno-Almazán et al., 2021) and gaining a sense of normality and control (Humphreys et al., 2021). Especially for individuals with low levels of grit and high levels of fatigue this can result in PA levels that are too low. In contrast, individuals with higher levels of grit and tendencies to perfectionism can engage in PA levels that are too high. However, the severity of fatigue that post COVID sufferers experience (Twomey et al., 2021) indicates that even individuals high in grit will be impacted in regard to their level of PA. In conclusion, the ambiguities in grit described by Houston et al. (2021) and Khan et al. (2021), as well as the ambiguities in PA and fatigue during post COVID recovery processes (Humphreys et al., 2021; Twomey et al., 2021) illustrate the need for knowledge development regarding the intertwinement between the described relationships.

1.5 Research questions and hypotheses

The current study aimed to explore the relationship between grit and PA in individuals suffering from post COVID, and examine the moderating effect of fatigue on this relationship. Due to the previously described tendencies in regard to perfectionism and unrealistic goal-setting (Houston et al., 2021; Khan et al. 2021) it was expected that higher levels of grit predict higher levels of PA in individuals suffering from post COVID.

RQ1: What is the relationship between grit and weekly time spent with physical activity in individuals suffering from post-acute COVID-19 syndrome?

H1: Higher levels of grit were hypothesised to predict more weekly time spent with physical activity in individuals suffering from post-acute COVID-19 syndrome.

Due to the findings of Alkodaymi et al. (2021), Gaber (2021) and Twomey et al. (2021) that describe fatigue as the most severe and prevalent symptom of post COVID, it was expected that fatigue moderates the relationship between grit and PA. Higher levels of fatigue were expected to lessen the impact that grit has on PA. In connection, lower levels of fatigue were expected to amplify the effect of grit on PA.

RQ2: To what extent is the relationship between grit and physical activity moderated by the intensity of fatigue that individuals suffering from post-acute COVID-19 syndrome experience?

H2: An increase in fatigue was hypothesised to result in a decrease of the effect of grit on PA and a decrease in fatigue was hypothesised to result in an increase of the effect of grit on PA in individuals suffering from post-acute COVID-19 syndrome.

2 Method

2.1 Design

The current study assessed the connection between the independent variable grit and the dependent variable PA, as well as the potential moderating effect of fatigue on this relationship. The cross-sectional study was carried out by a team of six student researchers. For the purpose of data collection, a survey was conducted using Qualtrics. Participants were able to access a Qualtrics link to the survey with their device and operating system of choice. Moreover, the survey was made available in English and in German to broaden the potential applicant pool. Furthermore, short versions of questionnaires were selected in order to decrease the amount of mental exertion the participants have to engage in. This was important because not only physical exertion can lead to a worsening of symptoms due to PEM but also mental exertion (Twomey et al., 2021). This, in combination with post COVID sufferers often experiencing difficulties in regard to concentration made apparent that a more extensive survey could have impaired the quality of responses (Poenaru et al., 2021).

2.2 Participants

Five inclusion criteria were determined that participants had to meet in order to be suitable for the study: 1. Participants must be at least 18 years old; 2. Participants must have been infected (assumed or confirmed) with SARS-Cov-2 at least 12 weeks prior to responding to the survey; 3. Participants must have at least one symptom that can be ascribed to post-COVID; 4. Participants must be proficient in either the English or the German language; 5. Participants must not use a wheelchair.

A priori power analysis with g*power version 3.1 (Faul et al., 2009) was conducted. For the moderation analysis in regard to *H2*, detecting a medium effect with an alpha of .05 and statistical power of .80 required a sample size of 77. Although 336 potential participants took part in the survey, 286 individuals had to be excluded due to violations of inclusion criteria or incomplete responses. This resulted in a drop-out rate of 85.12% and left a total of 50 participants that were recruited through convenience sampling (online social networks and

social environment of researchers) for the current study. This resulted in an actual power of .58 for the moderation analysis.

2.3 Materials

Both the English and German versions of the survey consisted of three questionnaires that measured the constructs grit, PA and fatigue, as well as a fourth section regarding demographic and other information. In this fourth section, participants were asked to indicate their gender, age, nationality, current symptoms, physical impairments, exact time of infection, if they were hospitalised due to COVID-19 and how they determined the existence of the infection. See *Appendices A, B* and *C* for English and German versions of the questionnaires.

2.3.1 Grit

In order to assess grit, the short grit scale (GRIT-S) developed by Duckworth and Quinn (2009) was used. Their questionnaire includes a perseverance of effort subscale, as well as a consistency of interest subscale that both consist of four items. Accordingly, in the current study, individual differences in grit were measured with a five-point Likert scale in which respondents had to indicate to what extent certain statements apply to them. The response options ranged from 1 = “not at all like me” to 5 = “very much like me”. The GRIT-S consists of a perseverance of effort- (e.g., “I am a hard worker”) and a consistency of interest (e.g., “I often set a goal but later choose to pursue a different one”) subscale with four items each. In this connection, a higher mean score indicates a higher level of grit. In Duckworth’s and Quinn’s (2009) study, four distinct samples were used to investigate the internal consistency of the scale. They identified that Cronbach’s alphas ranged from .73 to .79 for the consistency of interest subscale and from .60 to .78 for the perseverance of effort subscale.

Schmidt et al. (2017) developed and validated a German equivalent of the GRIT-S which was used for the German questionnaire in the current study. In three different samples, the internal consistency of the scale ranged from Cronbach’s alphas of .72 to .8.

2.3.2 PA

PA was assessed with the international physical activity questionnaire short form (IPAQ-SF). The IPAQ-SF (IPAQ-group, n.d.) consists of six items assessing PA. The six items are separated into two questions each for vigorous PA, moderate PA, and light PA. One of the two questions for each subcategory of PA pertains to the number of days a respondent was physically active in the respective intensity of PA (e.g., “During the last seven days, on how

many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?"), whereas the other question assessed the exact time in hours and minutes spent with PA, also corresponding to vigorous, moderate or light intensity (e.g., "How much time did you usually spend with moderate physical activities on one of those days?"). The timeframe that respondents were asked to reflect on was one week. Craig et al. (2003) investigated psychometric properties of the IPAQ-SF in twelve different countries. In their results, 75% of Spearman's correlation coefficients were above .65 which indicates a good test-retest reliability. Concurrent validity between the IPAQ-SF and its longer version was described by a pooled Spearman's correlation coefficient of .67.

A German version of the IPAQ-SF was validated by Mäder et al. (2006). They found a Spearman's correlation coefficient of .39 when exploring the relationship between responses from the German IPAQ-SF with data derived from an accelerometer that tracks PA reliably (Mäder et al., 2006).

The IPAQ-group (n.d.) describes on their website (www.ipaq.ki.se) that it is advisable to differentiate between the three different categories of PA by means of calculating MET-minutes per day. MET-minutes are named after the resting metabolic rate (Ainsworth et al., 2000). In this procedure, light, moderate, and vigorous PA are multiplied by different factors. In the context of the IPAQ-SF, the factors for light PA, moderate PA, and vigorous PA are 3.3, 4, and 8 respectively.

2.3.3 Fatigue

Fatigue was assessed with the Fatigue Severity Scale (FSS) which was developed by Krupp et al. (1989). The FSS makes use of a seven-point Likert scale that allows respondents to indicate to which extent nine statements (e.g., "My motivation is lower when I am fatigued.") apply to them. Response options for the items range from 1 for "strongly disagree" to 7 for "strongly agree". In this context, higher mean scores represent more severe fatigue. In regard to internal consistency, Krupp et al. (1989) found a Cronbach's alpha of .88. Originally, Krupp et al. (1989) validated the FSS for patients with multiple sclerosis and systemic lupus erythematosus. Subsequently, the FSS was used in research pertaining to various medical conditions involving fatigue as a symptom (Shahid et al., 2011).

For the German version of the survey, the German translation of the FSS validated by Valko et al. (2008) was used. In their sample, they found a Cronbach's alpha of .93.

2.4 Procedure

Before the start of the data collection, ethical approval for the current study was given by the ethics committee of the University of Twente's Behavioural-, Management-, and Social Sciences faculty. The data collection took place between the 6th of April and 21st of May 2022. The link was published several times on different social networks (Instagram, Reddit and Facebook) at varying times of day. In order to inform potential participants about the nature of the study without having them to click on a link, a short recruitment text (see *Appendix D*) was developed. Subsequently, the recruitment text was translated into German to allow for the inclusion of German-speaking online communities. Additionally, sufferers of post-COVID in the social environment of the student researchers were asked to take part in the survey.

After potential participants clicked on the link to the survey, they were presented with the informed consent section of the survey (see *Appendix E*) which provided them with more detailed information regarding inclusion criteria, the purpose of the study, study procedures, confidentiality and the voluntary nature of participation. After giving informed consent, the participants were asked to indicate when they got infected with COVID-19 in order to check if they met the corresponding inclusion criterion of an infection at least 12 weeks prior to taking part in the survey. The participants were able to choose between three response options: 1. "less than 12 weeks ago", 2. "12 weeks ago or longer", 3. "I did not have COVID-19". Answering this question with the options 1 or 3 resulted in the participant being excluded from the study by being redirected to the end of the survey.

The informed consent and time of infection question were the only two sections of the survey that forced the participants' response. The following questions of the survey did not force responses due to allowing for the participation of respondents that felt comfortable with some but not all questionnaires. Another reason for not forcing the majority of responses was that participants were enabled to take breaks and return to the survey at a later point in time. Participants who indicated an infection that had been 12 weeks or longer in the past, continued filling out the questionnaire concerning the student researchers' variables of interest. Demographic and other information were collected at the end of the survey. The average duration that participants needed to complete survey was 2 hours due to some participants that took a break and continued filling out the survey at a later point.

2.5 Data Analysis

In order to analyse the data, the software platform IBM SPSS Statistics (Version 24) was used. Descriptive statistics were examined for the sample characteristics and constructs. To have a better overview on the sample's PA level, participants were divided into three categories according to the guidelines of the IPAQ-group (n.d.). Respondents that indicated a PA level that is below 600 MET-minutes per week were classified as inactive. Indicating a PA level between 600 and 3000 MET-minutes per week resulted in being classified as moderately active. Furthermore, respondents that indicated a PA level that is higher than 3000 MET-minutes per week were classified as highly active.

For inferential analyses, the predictor variable grit and the moderator variable fatigue were mean-centred due to the data originating from Likert scales and therefore not having a meaningful value for zero which would complicate the interpretation of the model (Zhang & Wang, 2017). Furthermore, mean-centring can help with reducing multicollinearity in moderation models (Hayes et al., 2012). In order to answer *H1*, the predictive capabilities of grit in regard to PA as outcome were examined through simple linear regression. For answering *H2*, the PROCESS macro tool developed by Hayes (2012) was used. The effect of fatigue as linear moderator on the linear relationship between grit and PA was examined. Due to grit, PA, and fatigue violating the assumption of normality regarding the regression- and moderation analysis, bootstrapping was utilised to confirm the results.

In order to explore the relationship between grit and PA further, it was decided to conduct a post-hoc analysis by means of visualising this relationship with a scatterplot. Due to a negative quadratic trend that was observable in this scatterplot, it was decided to visualise the curve that describes the quadratic relationship between grit as predictor and PA as outcome. Subsequently, the simple linear regression model and the quadratic model were compared in regard to their ability to describe the relationship between grit and PA.

3 Results

3.1 Descriptive Statistics

3.1.1 Demographics

After the exclusion of participants that violated inclusion criteria or had incomplete responses, a total of 50 participants were included in the final sample. The sample consisted of 34

women, 15 men and one individual identifying as non-binary. The age of the participants ranged from 18 to 62 years old (M = 35.86, SD = 13.07). Eleven different nationalities were reported by 40 participants, while 10 participants did not indicate their nationality. The most common nationalities were US-American (26%, n = 13) and German (20%, n = 10). Most of the participants got their COVID-19 diagnosis due to a positive polymerase chain reaction (PCR) test (68%, n = 34). Fatigue (94%, n = 47) and difficulties concentrating, memory problems and/or confusion (82%, n = 41) were the most common symptoms among the participants. Number of symptoms per participant ranged from one out of nine to eight out of nine (M = 4.82, SD = 1.78). Only a small number of participants were hospitalised due to COVID-19 (6%, n = 3), whereas the majority was not (94%, n = 47). Detailed demographics can be found in **Table 1** and **Table 2**.

Table 1

Frequencies (n) and Percentages (%) for Age, Gender, Nationality, Hospitalisation, Diagnosis and Mean (M) for Age

Item	Category	*n*	*%*	*M*
Age	Total	50	100	35.86
Gender	Female	34	68	-
	Male	15	30	-
	Other	1	2	-
Nationality	US American	13	26	-
	German	10	20	-
	Canadian	5	10	-
	British	4	8	-
	Serbian	2	4	-
	Other	6	12	-
	Unknown	10	20	-
Hospitalisation	Yes	3	6	-
	No	47	94	-
Diagnosis	PCR test	34	68	-
	Antigen test	7	14	-
	Assumed	9	18	-

Notes. Abbreviations: PCR = polymerase chain reaction, US = United States; Standard deviation for Age: SD = 13.07; Other nationalities (n = 1): Dutch, Finnish, French, Indian, Italian, Pakistani

Table 2

Mean (M) for Number of Symptoms per Participant and Frequencies (n) and Percentages (%) for Presence of Symptoms

Item	Category	*n*	*%*	*M*
Number of Symptoms per Participant	Total	50	100	4.82
Presence of Symptoms	Fatigue	47	94	-
	Cough	13	26	-
	Fever and Chills	8	16	-
	Shortness of Breath	32	64	-
	Difficulties Moving or Talking	23	46	-
	Loss of Taste or Smell	12	24	-
	Difficulties Concentrating, Memory Problems and/or Confusion	41	82	-
	Pain, Aches or Soreness	33	66	-
	Changes in Mood and/or Anxiety	32	64	-

Note. Standard deviation for number of symptoms per participant: *SD* = 1.78

3.1.2 Grit, PA, and Fatigue

The sample can be described as having a slightly below average level of grit when comparing the current sample ($M = 3.29$, $SD = 0.38$) with the sample used in Duckworth & Quinn's (2009) original study concerning grit ($M = 3.4$, $SD = .70$, $n = 1554$). In the current study, grit was not normally distributed which was indicated by a Shapiro-Wilk test ($W = .94$, $p = .015$). Therefore, it is important to note that the median of grit in the sample is slightly higher than the mean ($Mdn = 3.38$, $IQR = .63$).

Regarding the PA scores, 12 participants were classified as inactive (24%), 24 as moderately active (48%), and 14 as highly active (28%). Taking the average number of 4.82 symptoms per participant into account, only 12 participants being inactive indicates that the sample is characterised by a relatively high level of PA. Light PA in hours per week had the highest mean of 6.51, while moderate PA had a mean of 2.28 and vigorous PA had a mean of 1.18. The variable of analysis for inferential statistics was PA defined as MET-minutes per day (M = 343.04, SD = 459.27). A Shapiro-Wilk test indicated that PA is not normally distributed (W = .66, p < .001). Regarding this variable, the sample median is lower than the mean (Mdn = 207.43, IQR = 376.41).

The sample's level of fatigue (M = 5.78, SD = 1.39) can be described as very high compared to the sample of Valko et al. (2008) (M = 4.66, SD = 1.64, n = 188). A Shapiro-Wilk test indicated that the assumption of normality for fatigue was violated (W = .81, p < .001). In this context, the median for fatigue is higher than the mean (Mdn = 6.44, IQR = 1.72). Detailed descriptive statistics for the constructs grit, PA, and fatigue can be found in **Table 3**.

Table 3

Minimum (min), Maximum (max), Median (Mdn), Interquartile Range (IQR), Skewness, and Kurtosis for Grit, PA, and Fatigue

Construct	min	max	Mdn	IQR	Skewness	Kurtosis
Grit	2.63	3.88	3.38	.63	-.11	-1.13
Physical Activity in MET-minutes per day	0	2772.00	207.43	376.41	3.47	15.94
Fatigue	1.33	7.00	6.44	1.72	-1.40	1.32

3.2 Inferential Statistics

3.2.1 Regression Analysis

Initially, bootstrapping (1000 samples) with Bias-corrected and accelerated (BCa) confidence interval type was utilised to make a simple linear regression more suitable for the non-normally distributed data. The fitted regression model predicting PA on the basis of grit was not significant (R^2 = .024, F(1, 48) = 1.20, p = .278). The bootstrapping results confirm the

insignificance of the model (B = -189.54, 95% *CI* [-517.85, 46.67], p = .23). Therefore, *H1* was rejected.

3.2.2 Moderation analysis

PROCESS was used to assess the linear moderation of fatigue on the linear relationship between grit and PA. The overall model was significant (R^2 = .166, F(5, 44) = 3.06, p = .037). Although the overall model was significant, only the coefficient for fatigue indicated a significant effect on PA (B = -115.58, 95% *CI* [-206.48, -24.68], p = .014). This means that for every 1 unit increase in fatigue, PA in MET-minutes per day decreases by 115.58. The effect of grit and the interaction of grit and fatigue on PA were not significant, as confirmed by the bootstrapping confidence intervals. Therefore, *H2* was rejected. All statistics for the regression- and moderation analyses can be found in **Table 4**.

Table 4

Unstandardised coefficients (B), standard errors (SE), t-values (t), p-values (p), and BCa 95% confidence intervals (lower; upper) for regression- and moderation analyses with Physical Activity in MET-minutes per day as outcome variable

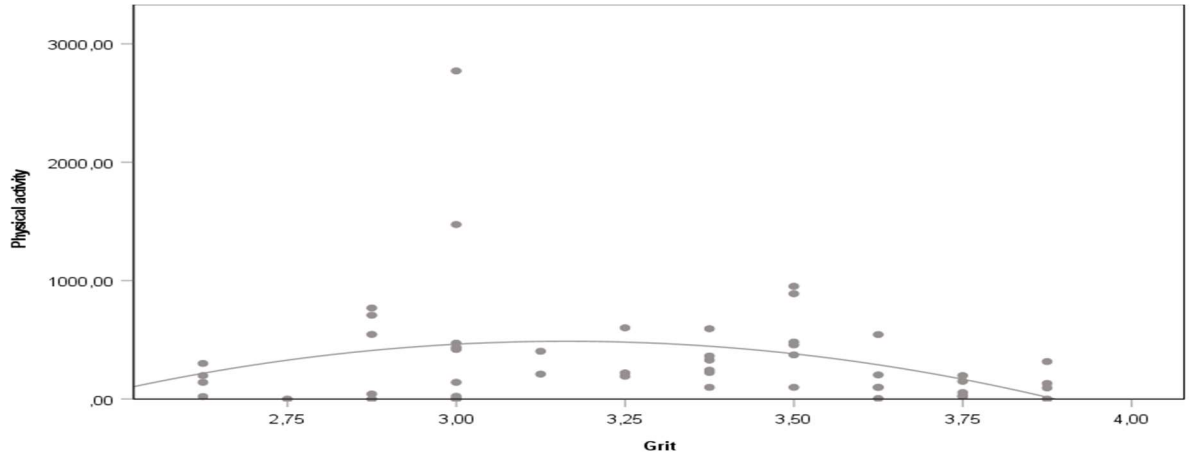
Type of analysis	Construct	*B*	*SE*	*t*	*p*	lower	upper
Regression analysis	Grit (mean-centred)	-189.54	143.40	-1.10	.23	-517.85	46.67
Moderation analysis	Grit (mean-centred)	-121.73	166.13	-.74	.47	-518.29	158.66
	Fatigue (mean-centred)	-115.58	75.20	-2.56	.014	-300.53	-20.63
	Grit*Fatigue	122.78	187.29	1.19	.24	-128.88	610.80

3.2.3 Post-hoc analysis

By means of a scatterplot, the suitability of a quadratic model in regard to the relationship between grit and PA was examined. Estimating the most suitable quadratic curve resulted in a model that explained 9.5% of the variance in PA (R^2 = .095). Therefore, the quadratic model was a better fit for the relationship between grit and PA than the linear model (R^2 = .024). The scatterplot visualising the quadratic model can be found in **Figure 1**. A scatterplot for the linear model can be found in *Appendix F*.

Figure 1

Quadratic model for the relationship between grit (5-point Likert scale) as predictor and PA (MET-minutes per day) as outcome (R^2 = .095)



4 Discussion

4.1 Implications

This study aimed to explore the relationship between grit and PA, while also examining the moderating effect of fatigue on this relationship. The first research question pertaining to the relationship between grit and PA was: What is the relationship between grit and weekly time spent with physical activity in individuals suffering from post-acute COVID-19 syndrome? In contrast to the expectation, the results did not provide sufficient evidence for a predicting effect of grit on PA. However, post-hoc analysis indicated that a quadratic model describes this relationship more appropriately than a linear model. The second research question was: To what extent is the relationship between grit and physical activity moderated by the intensity of fatigue that individuals suffering from post-acute COVID-19 syndrome experience? Fatigue was not found to moderate the relationship between grit and PA in the current study's sample.

4.1.1 Hypothesis 1

The post-hoc analysis of the current study reveals that a quadratic model with grit as predictor was able to explain more of the variance in PA than a linear model. In this quadratic model, increases in grit only lead to increases in PA to a certain degree. Approximately at a score of 3.2 for grit, a threshold is reached and PA decreases again with increasing grit levels. The relationship between grit and PA in the quadratic model is in line with previous literature

concerning the negative side of grit (Houston et al., 2021; Khan et al., 2021) until the model's turning point is exceeded. In contrast, the decreasing PA levels for individuals with higher grit scores than the turning point are not in line with the negative side of grit. However, this trend can be explained by other previous studies that emphasised the positive aspects of grit. When taking into consideration that gritty individuals tend to focus on long-term goals (Duckworth et al., 2007) and often possess good health care management skills (Traino et al., 2019) it is likely that gritty individuals are more invested in searching for high-quality information than less gritty individuals. This might enable them to pre-emptively adjust their PA levels and prevent the occurrence of PEM.

Without access to proper information, it can be counter-intuitive for gritty individuals to pace themselves in regard to PA during the post COVID recovery process because they are used to getting an advantage by means of their work ethic (Meriac et al., 2015). However, having access to information concerning the relationship between PA and post COVID can help individuals that possess high levels of grit with realising that momentarily pacing oneself in regard to PA should not be perceived as laziness. In other words, the long-term orientation of gritty individuals (Duckworth et al., 2007) might allow them to control their perfectionistic tendencies more effectively when realising that overexertion endangers the achievement of long-term goals regarding PA. This is reflected in the decreases in PA for individuals with higher grit levels in the quadratic model. Therefore, the quadratic model is not in line with *H1* of the current study. According to the quadratic model, individuals with moderate grit levels are at the highest risk of overexertion. Although individuals with lower and higher grit levels are not as much at risk for overexertion than individuals with moderate grit levels, engaging in PA levels that are too low can bring its own complications with it.

In previous literature it was described that not engaging in sufficient PA levels during the post COVID recovery process prevents individuals from experiencing physical and mental health benefits (Humphreys et al., 2021; Jimeno-Almazán et al., 2021). Lower PA levels for individuals high in grit might be attributable to their long-term goal orientation. Therefore, it is probable that gritty individuals are not at risk of engaging in PA levels that are too low for more time than necessary. An explanation for less gritty individuals engaging in less PA than individuals moderate in grit might be that they change trajectories in response to resistance (Duckworth et al., 2007) before they engage in higher PA levels. Continuously changing trajectories might put individuals with a low level of grit at risk of refraining from PA for more extensive periods than recommendable. Further, combining the implications of the quadratic model of the current study can inform sufferers of post COVID with differing levels

of grit, as well as health-care professionals about the most appropriate and individualised approach in regard to PA during the post COVID recovery process.

It is likely that gritty individuals do not need as much assistance with developing long-term strategies than individuals with lower levels of grit. According to the quadratic model, individuals with low levels of grit and PA might have to be encouraged to develop goal-attainment strategies. In contrast, individuals with moderate grit levels might have to be reminded of the severity of post COVID due to the high levels of PA that they engage in. Especially for individuals that do not possess high levels of grit it is of utmost importance for health-care professionals to provide information regarding the complexities and benefits of PA during the post COVID recovery process. Moreover, Duckworth (2016) suggests that although grit is a trait-level construct and therefore relatively stable over time by definition, it can be developed through mindsets, skills and enabling environments. Research suggesting that grit can be developed is useful for post COVID sufferers and health-care professionals as it opens up the possibility to develop interventions that aim at fostering grit in sufferers of post COVID. Individuals with low or moderate levels of grit that train their grittiness might become more likely to consider the long-term consequences of their actions than before the exposure to such training.

4.1.2 Hypothesis 2

The moderation analysis of the current study revealed that fatigue is in a direct relationship with PA and does not moderate the relationship between grit and PA. This study's results show that fatigue is a predictor of PA in a negative linear relationship. Although this is not in line with *H2* of the current study, it still resonates with the importance of fatigue in the experience of post COVID sufferers that was described in previous literature (Twomey et al., 2021). This study shows that PA decreases with increasing fatigue levels. PEM can serve as a potential explanation for this. Combining that PEM often triggers fatigue (Twomey et al., 2021) with the tendency of individuals with high levels of fatigue to avoid activities that can result in additional increases of fatigue (Vercoulen et al., 1997) shows how the relationship between fatigue and PA is experienced by individuals suffering from PEM in the post COVID recovery process. When PA results in relapses of fatigue due to PEM, individuals can be expected to engage in less PA in order to prevent additional relapses.

According to the results of the moderation analysis, fatigue is a more important factor for predicting PA than grit. It could be that post COVID is characterised by such severe levels of fatigue that the effect of grit on PA becomes negligible. The severity of fatigue that post

COVID sufferers experience is also reflected in the average level of fatigue in the current study's sample. This is consistent with post COVID sufferers' descriptions of fatigue and its relationship to PA in the qualitative study by Humphreys et al. (2021). Experiencing the complexities of PA in the form of fatigue and PEM can lead to individuals trying to break out of this vicious circle by decreasing their PA levels. However, this can cause a lack of perceived control (Humphreys et al., 2021) and prevents these individuals from regaining their strength (Jimeno-Almazán et al., 2021). Therefore, fatigue predicting less PA might mitigate the risk for overexertion and relapses of symptoms in this sense but it puts individuals with lower PA levels at risk to experience the vicious circle resulting from engaging in PA levels that are too low as described by Primdahl et al. (2017).

4.2 Limitations and strengths

The cross-sectional design of the study makes it difficult to determine the direction of causality in the relationships that were studied. For example, in the context of the prediction of PA on the basis of fatigue it could also be that low PA levels cause higher levels of fatigue and not the other way around (Primdahl et al., 2017). Not understanding how the relationship that an individual has with PA changed due to post COVID makes it difficult to investigate the relationship between grit, PA, and fatigue. Vicious circles revolving around PA, fatigue and PEM make apparent that time is an important factor in interpreting how these concepts affect each other. However, the study did not assess at which points the participants were in their individual recovery process. Therefore, a snapshot of the relationship between grit, PA, and fatigue might have not been sufficient to provide a complete picture of the interplay between the constructs. Moreover, the highest score for grit was only 3.88 which means that the sample did not include extremely gritty individuals. Therefore, the current study can also not provide the complete picture in regard to the construct grit.

A high drop-out rate of participants (85.12%) resulted in sample size requirements being violated for all of this study's analyses. Therefore, less statistical power was achieved than initially aimed for. For the regression analysis, the probability of not detecting an effect that is actually there is quite high (23%). Although bootstrapping was utilised to counteract the violations of sample size requirements, the low statistical power in the current study adds to the notion of the results not providing a complete picture of the relationships between grit, PA and fatigue. Furthermore, the post-hoc analysis that shows a quadratic relationship between grit and PA indicates that the assumption of linearity was violated for the regression- and moderation analysis. Therefore, the results of the current study that assume a linear

relationship between grit and PA have to be treated carefully.

The high drop-out rate might be explained by the concentration difficulties that post COVID sufferers often experience (Poenaru et al., 2021). Although short versions of questionnaires were selected, the survey could have been too demanding for some of the respondents. In this context, making use of self-report measures could have impaired the validity of the current study. Especially in the responses from the IPAQ-SF, it was observable that the instructions were unclear to some participants. This became apparent through inconsistencies in reporting time spent with PA in minutes or hours. Not only the experience of symptoms such as concentration difficulties could have impaired the quality of responses but also the selection of questionnaires itself. The short versions that were selected for grit and PA might not have been sufficient in extensiveness to capture the complexity of these concepts.

The symptomatology that characterises the sample resembles the prevalence of symptoms that was attributed to post COVID in previous studies (Alkodaymi et al., 2022). Furthermore, only a small number of assumed infections and the majority of the sample indicating positive PCR- or antigen tests makes it more likely that respondents actually had post COVID. Furthermore, this study aimed to investigate scarcely researched relationships. Grit as an explanatory factor in the context of post COVID and individual differences in PA was not studied before. Therefore, this study illustrates a starting point for further investigations concerning grit and PA in post COVID sufferers. The potential quadratic relationship between grit and PA in the post COVID recovery process should be investigated further in order to provide post COVID sufferers with individualised advice concerning the balance of exertion and rest in regard to PA.

4.3 Future research

Investigating the quadratic relationship between grit and PA in the post COVID recovery process could be done by means of quadratic regression analysis in which grit and its square number are included as predictors of PA. Furthermore, in order to take different stages of recovery processes into account, longitudinal designs should be applied to investigate the relationship between grit and PA. This would also make it possible to get a more comprehensive picture of the vicious circles revolving around PA, fatigue and PEM. For example, combining a retrospective study design with a cohort study design can allow for investigating how participants' relationship with PA changed due to post COVID and also how factors such as PEM and fatigue influence individuals with differing levels of grit over

time in their recovery process. Ambiguities in grit (too-much-of-a-good-thing-effect) and PA (vicious circles due to both PA and physical inactivity) and how these affect each other over time are important to understand in order to enable disease management that is effective. In this context, it would be advisable to make use of the experience sampling method (ESM) which is "a research procedure for studying what people do, feel, and think during their daily lives" (Larson & Csikszentmihalyi, 2014, p. 21) that is often used for longitudinal study designs. Especially for PA and fatigue which are not as stable as grit over time, ESM can help with capturing potential fluctuations that the current study was not able to detect.

Future studies should consider not measuring PA with the IPAQ-SF while taking into account that questionnaires that are too extensive can also impair the quality of responses. In general, it is probable that objective measures of this study's constructs can provide more meaningful results in comparison with data derived from self-report. In this context, accelerometers are an option to measure PA objectively (Trost & O'Neil, 2014). These motion sensors track PA reliably and illustrate less of a burden for sufferers of post COVID than other instruments that measure PA objectively such as heart rate monitoring (Trost & O'Neil, 2014). Moreover, future studies might get a better picture of the relationship between grit and PA when controlling for variables such as access to information, other personality traits or PEM. The importance of PEM in the post COVID recovery process implies that future research revolving around grit and PA in post COVID sufferers should include PEM as a predicting or moderating variable. In general, more research has to be done in order to clarify which levels of PA are recommendable at different stages in the recovery process. Therefore, longitudinal studies should also assess fluctuations in the experience of symptoms due to engaging in PA levels that are both too low or too high. Moreover, mental- and physical health related quality of life could be assessed for groups with differing PA levels in order to investigate the effect that PA has on post COVID patients.

4.4 Conclusion

The aim of the current study was to explore the relationship between grit and PA in individuals suffering from post COVID, as well as investigating a potential moderating effect of fatigue on this relationship. This study's findings suggest that there is no linear relationship between grit and PA in this context. However, this study implies that the relationship between grit and PA in the post COVID recovery process can be more appropriately described by a quadratic model in which individuals with moderate grit levels are most likely to engage in PA levels that are too high. Regarding the risk of overexertion in the post COVID recovery

process, the quadratic model emphasises the positive aspects of grit which mainly revolve around the focus on long-term goals. More research has to be done to investigate this quadratic relationship. Furthermore, this study highlights the important role that fatigue plays for post COVID sufferers. Although fatigue is not a moderator of the relationship between grit and fatigue in the current study's sample, it predicts PA in a negative linear relationship. The PA level of the study's sample is relatively high when taking the high prevalence for various symptoms into account. Therefore, more advice regarding the complexities of PA during the post COVID recovery process should be presented to post COVID sufferers. However, the sample also includes individuals that are completely inactive which puts them at risk of experiencing physical- and mental health complications. This highlights the need for more research investigating appropriate PA levels for individuals recovering from post COVID.

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Appendices

Appendix A: English and German versions of the GRIT-S

English:

1. New ideas and projects sometimes distract me from previous ones.
2. Setbacks don't discourage me
3. I often set a goal but later choose to pursue a different one.
4. I am a hard worker.
5. I have difficulty maintaining my focus on projects that take more than a few months to complete.
6. I finish whatever I begin.
7. I am diligent.
8. I have been obsessed with a certain idea for a short time but later lost interest.

German:

1. Neue Ideen und Projekte halten mich manchmal von vorherigen ab.
2. Von Rückschlägen lasse ich mich nicht entmutigen.
3. Ich setze mir oft ein Ziel, entscheide mich dann aber später doch ein anderes Ziel zu verfolgen.
4. Ich bin ein hart arbeitender Mensch.
5. Ich habe Schwierigkeiten auf Projekte fokussiert zu bleiben, wenn diese mehrere Monate dauern.
6. Alles was ich beginne, bringe ich auch zu Ende.
7. Ich bin fleißig.
8. Ich war schon einmal für eine kurze Zeit von einem Projekt oder einer Idee besessen, habe später aber das Interesse verloren.

Appendix B: *English and German versions of the IPAQ-SF*

English:

Vigorous physical activity:

1. During the last 7 days on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?
2. How much time did you usually spend doing vigorous physical activities on one of those days? (Example: one and a half hours = Hours per day: 1 / Minutes per day: 30)

Moderate physical activity:

1. During the last 7 days**,** on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.
2. How much time did you usually spend doing moderate physical activities on one of those days?

Light physical activity:

1. Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.
2. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

German:

Anstrengende physische Aktivität:

1. An wie vielen der vergangenen 7 Tage haben Sie anstrengende körperliche Aktivitäten wie Aerobic, Laufen, schnelles Fahrradfahren oder schnelles Schwimmen verrichtet?
2. Wie viel Zeit haben Sie für gewöhnlich an einem dieser Tage mit anstrengender körperlicher Aktivität verbracht? (Beispiel: eineinhalb Stunden = Stunden pro Tag: 1 / Minuten pro Tag: 30)

Moderate physische Aktivität:

1. An wie vielen der vergangenen 7 Tage haben sie moderate körperliche Aktivitäten, wie das Tragen leichter Lasten, Fahrradfahren bei gewöhnlicher Geschwindigkeit oder

Schwimmen bei gewöhnlicher Geschwindigkeit verrichtet? Hierzu zählt nicht zu Fuß gehen.

2. Wie viel Zeit haben Sie für gewöhnlich an einem dieser Tage mit moderater körperlicher Aktivität verbracht?

Leichte physische Aktivität:

1. An wie vielen der vergangenen 7 Tage sind Sie mindestens 10 Minuten ohne Unterbrechung zu Fuß gegangen? Dieses beinhaltet Gehstrecken daheim oder in der Arbeit, gehen um von einem Ort zu einem anderen zu gelangen, sowie alles andere Gehen zur Erholung, Bewegung oder Freizeit.
2. Wie viel Zeit haben Sie für gewöhnlich an einem dieser Tage mit Gehen verbracht?

Appendix C: English and German versions of the FSS

English:

1. My motivation is lower when I am fatigued.
2. Exercise brings on my fatigue.
3. I am easily fatigued.
4. Fatigue interferes with my physical functioning.
5. Fatigue causes frequent problems for me.
6. My fatigue prevents sustained physical functioning.
7. Fatigue interferes with carrying out certain duties and responsibilities.
8. Fatigue is among my three most disabling symptoms.
9. Fatigue interferes with my work, family, or social life.

German:

1. Ich bin weniger motiviert, wenn ich müde bin.
2. Körperliche Bewegung macht mich müde.
3. Ich ermüde rasch.
4. Meine Müdigkeit beeinträchtigt meine körperliche Leistungsfähigkeit.
5. Meine Müdigkeit bereitet mir oft Probleme.
6. Mein Müdigkeit verhindert längerdauernde körperliche Tätigkeiten.
7. Meine Müdigkeit beeinträchtigt mich, gewisse Pflichten und Verantwortungen zu erfüllen.
8. Meine Müdigkeit gehört zu den drei Beschwerden, die mich am moisten behindern.
9. Meine Müdigkeit beeinträchtigt meine Arbeit, meine Familie oder mein soziales Leben.

Appendix D: English and German versions of the recruitment text

English:

Hey! Do you suffer from long-COVID and sometimes feel frustrated by the lack of knowledge regarding the condition? Coping with a scarcely researched disease is a tough challenge. Especially dealing with physical activity is an obstacle in the recovery process and in daily life. This is why our team of six student researchers at the University of Twente (Netherlands) decided to study the relationship between physical activity and various psychological concepts in the context of long-COVID. Are you interested in contributing to this research, and therefore helping with developing new treatment options, gaining new insights into your own daily activities and symptoms? Then please consider taking part in this study by filling out our questionnaire (approx. 20min).

https://utwentebs.eu.qualtrics.com/jfe/form/SV_23QURAdNURT6Hm6
Any questions before starting the survey? Contact k.s.rosen@student.utwente.nl. Thank you in advance!

German:

Hallo! Leiden Sie an Langzeit-COVID und sind manchmal frustriert über den Mangel an Wissen über diese Krankheit? Der Umgang mit einer kaum erforschten Krankheit ist eine große Herausforderung. Besonders der Umgang mit körperlicher Aktivität ist ein Hindernis im Genesungsprozess und im täglichen Leben. Deshalb hat unser Team von sechs studentischen Forschern an der Universität Twente (Niederlande) beschlossen, die Beziehung zwischen körperlicher Aktivität und verschiedenen psychologischen Konzepten im Zusammenhang mit der Langzeit-COVID zu untersuchen. Sind Sie daran interessiert, einen Beitrag zu dieser Forschung zu leisten und damit zur Entwicklung neuer Behandlungsmöglichkeiten beizutragen und neue Erkenntnisse über Ihre eigenen täglichen Aktivitäten und Symptome zu gewinnen? Dann nehmen Sie bitte an dieser Studie teil, indem Sie unseren Fragebogen ausfüllen (ca. 20 Minuten).

https://utwentebs.eu.qualtrics.com/jfe/form/SV_23QURAdNURT6Hm6
Haben Sie noch Fragen, bevor Sie mit der Umfrage beginnen? Kontaktieren Sie k.s.rosen@student.utwente.nl. Wir danken Ihnen im Voraus!

Appendix E: English and German versions of informed consent

English:

Informed Consent - Physical Activity in Post-COVID Patients

Researchers (Bachelor):

Antje Brot,

Kai Rosen,

Lara Uppenkamp,

Silas Mergehenn,

Simon Ziemer,

And Yannick Phillipp.

Researcher (Supervisor):

Gerko Schaap

Inclusion Criteria

Only participants with probable or confirmed SARS-Cov-2 infection, usually 12 weeks from the onset of COVID-19 with symptoms that last for at least 8 weeks and cannot be explained by an alternative diagnosis, are eligible for this study.

Purpose of the Study

This study is carried out as part of a bachelor's research project on the physical activity of post-COVID patients. Before you decide to participate in this study, it is essential to know why the research is done and what it will involve. Please read the following information carefully.

Managing physical activity can be difficult for individuals with post-COVID not only because of physical symptoms such as fatigue but also because of physiological symptoms that often accompany the syndrome. Therefore, investigating this relationship is important to enabling more informed decision-making in developing interventions or other efforts to facilitate the recovery process of individuals suffering from post-COVID.

If there are any questions, do not hesitate to approach one of the researchers for more information or, if you feel more comfortable talking to a more experienced professional, the supervisor.

Study Procedures

The study consists of seven short questionnaires that need to be filled in. Participation is entirely voluntary, and the procedure can be stopped at any time without giving any reason for it. The questionnaires will take around 20 minutes to complete, and if you feel the need to take a break, you can do so.

Confidentiality

Your response to this survey will be anonymous; the researchers will only know you by a number. Participants' data will be kept confidential except in cases where the researchers are legally obligated to report specific incidents. These incidents include, but may not be limited to, incidents of abuse and suicide risk. Data will be stored safely and no longer than two years before being deleted.

German:

Informationen zur Studienteilnahme und Einverständniserklärung – Physische Aktivität von Corona Langzeit-leidenden

Bachelor Studenten:

Antje Brot,
Kai Rosen,
Lara Uppenkamp,
Silas Mergehenn,
Simon Ziemer,
und Yannick Phillipp.

Supervision:

Gerko Schaap

Teilnahmebedingungen

Nur Personen, mit einer vermuteten oder bestätigten SARS-CoV-2 Infektion, die drei Monate nach Beginn der COVID-19 Erkrankung für mindestens zwei Monate Symptome gezeigt haben, die nicht anders erklärt werden können sind zu dieser Studie zugelassen.

Hintergrund und Ziele der Studie

Diese Studie ist Teil eines Bachelor-Projekts in Bezug auf die physische Aktivität von Menschen die unter Langzeitfolgen von COVID-19 leiden. Bevor Sie an dieser Studie teilnehmen, ist es wichtig, dass Sie wissen und verstehen, warum diese Nachforschungen betrieben werden und was Sie zu erwarten haben. Bitte lesen Sie den folgenden Absatz besonders sorgsam.

Sich physisch zu betätigen kann grade für Menschen die unter Langzeitfolgen des Corona Virus leiden schwierig sein. Physische Symptome wie Müdigkeit aber auch physiologische Symptome sind oft Teil der Langzeitfolgen. Dementsprechend wichtig ist es die Beziehung der Krankheit zu physischer Aktivitäten zu untersuchen und die Informationsgrundlage für potenzielle Interventionen oder andere Versuche der Heilung und Unterstützung für Langzeit-leidende zu erleichtern.

Sollten Sie noch irgendwelche Fragen haben, zögern Sie nicht uns zu kontaktieren. Im Fall, dass Sie lieber mit jemandem sprechen wollen, der mehr Erfahrung hat, kontaktieren Sie gerne den Supervisor.

Ablauf der Studie

Die Studie besteht aus sieben kurzen Fragebögen. Die Teilnahme an dieser Studie ist freiwillig and kann jeder Zeit gestoppt werden, ohne dies begründen zu müssen. Das Ausfüllen der Fragebögen dauert ca. 20 Minuten. Sie können jeder Zeit eine Pause machen und zu einem späteren Zeitpunkt weitermachen.

Diskretion

Ihre Antwort zu den Fragebögen ist anonym und wird nur in Zusammenhang mit einer Nummer einsehbar sein. Die Daten eines jeden Teilnehmers werden vertraulich und diskret behandelt, außer in Fällen, in denen wir dazu legal dazu verpflichtet sind sie zu melden. Das beinhaltet beispielsweise Vorfälle von Missbrauch oder Suizidrisiko und ist nicht darauf beschränkt. Ihre Daten werden sicher aufbewahrt und nicht länger als zwei Jahre gespeichert und anschließend gelöscht.

Appendix F: Linear model for the relationship between grit (5-point Likert scale) as predictor and PA (MET-minutes per day) as outcome (R^2 = .024)