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To what extent does gender moderate the relationship between physical activity and depressive symptoms in post-COVID sufferers?

Simon J. Ziemer

Department of Psychology, University of Twente

Faculty of Behavioural, Management and Social Sciences

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First Supervisor: Gerko Schaap

Second Supervisor: Mark van Vuuren

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Abstract

Background: Higher levels of depression and lower levels of physical activity are common in post-COVID sufferers. This paper investigates the association between physical activity and depressive symptoms and the moderation of gender in a sample of post-COVID-19 sufferers.

Method: The study was based on a correlational survey design. The recruitment was done by convenience sampling. Physical activity was measured with the IPAQ-SF and depressive symptoms with the PHQ-9. The data of the 59 participants (M_{age} = 35.5, SD_{age} = 1.34, women: 74.6%) was analysed with SPSS. A Kendall Rank Analysis was performed to investigate the relationship between physical activity and depressive symptoms. The interaction effect of gender was examined with a moderation analysis.

Results: The correlation between physical activity and depressive symptoms was not significant. The moderation effect of gender on the correlation between physical activity and depressive symptoms was also not significant.

Conclusion: This paper is one of the first studies investigating the direct relationship between physical activity and depressive symptoms in a sample of post-COVID sufferers. Against expectations, neither an association between physical activity and depressive symptoms nor an interaction effect of gender was found. However, the sample distribution supports previous findings that post-COVID sufferers show higher levels of depressive symptoms.

Keywords: *Post-COVID, depressive symptoms, physical activity, gender, cross-sectional survey design, moderation analysis*

Table of contents

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Lack of physical activity is highly correlated with a higher risk of suffering from depressive symptoms (Bruce et al., 1994; Loprinzi, 2013; Paluska & Schwenk, 2000; Peluso & Guerra de Andrade, 2005; Teychenne et al., 2008). Especially post-COVID sufferers are more prone to show a reduced engagement in physical activity (PA) and an increased probability of displaying depressive symptoms ([DS] Delbressine et al., 2021; Matsumoto et al., 2022; Renaud-Charest et al., 2021; Sañudo et al., 2020). This paper explores a direct association between physical activity and depressive symptoms in a sample of post-COVID sufferers. Since women were found to show lower levels of PA, higher levels of DS and higher probabilities of suffering from a post-COVID condition, the moderating role of gender differences in this relationship is additionally analysed (Angst et al., 2002; Azevedo et al., 2007; Kockler & Heun, 2002; Lee, 2005; NDR, 2022; Seiffge-Krenke & Stemmler, 2002).

This study shows a high relevance since post-COVID is a newly emerging disease affecting many people (Carfì et al., 2020; Pavli et al., 2021). Investigating the relationship between physical activity and depressive symptoms should bring improved understanding concerning post-COVID and the relations between physical activity and depressive symptoms to give the best recovery support and improve the quality of life. By including gender, it is aimed to reveal helpful information concerning tailoring strategies for treating post-COVID.

A post-COVID condition occurs from a SARS-CoV-2 infection, also known as Corona Virus Disease 2019 (COVID-19). Acute COVID-19 is usually manifested by various symptoms such as fever, cough, fatigue, and loss of taste and/or smell. In extreme cases, the infection can also lead to death (WHO, 2021a). A large proportion of those affected recovers successfully from the initial symptoms. However, approximately 10% of COVID-19 sufferers complain about ongoing health problems three months after infection (Carfì et al., 2020; Pavli

et al., 2021). This condition is referred to as post-COVID or post-COVID syndrome, which is defined 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 two months and cannot be explained by an alternative diagnosis" (WHO, 2021b, p.11). In addition, the symptoms might vary in intensity and quantity. Generally, the probability of getting into a post-COVID condition is much higher for hospitalised sufferers because of their acute infection. About 85% of the hospitalised patients suffer from post-COVID. However, even an asymptomatic or mild infection might lead to a post-COVID-Syndrome (Anaya et al., 2021; CDC, 2021; Pavli et al., 2021).

Since there is little knowledge at the moment about post-COVID, professionals have problems identifying post-COVID and giving correct diagnoses, making sufferers feel neglected (Kingstone et al., 2020; Ladds et al., 2020). They require better support to cope with their post-COVID symptoms (Humphreys et al., 2021). Fatigue of post-COVID sufferers, one of the most common symptoms, is ranked as severe as fatigue in a cancer condition (Twomey et al., 2021). Thus, it is essential to take this illness seriously and understand the symptoms and impairments to develop the best possible support for recovery. Besides fatigue, post-COVID might lead to shortness of breath, chest pain, cognitive dysfunction, and muscle weaknesses which impact sufferers in several areas of their lives (Anaya et al., 2021; Förster et al., 2022; Pavli et al., 2021; WHO, 2021b).

One area affected by post-COVID is PA, which can be categorised into three intensity levels: light intensity, moderate intensity and vigorous intensity. An activity counts as physically active if the metabolic resting rate (METs) is above 1.5. The METs score shows the required oxygen consumption for a particular behaviour. Consequently, a higher METs score is associated with a higher intensity of PA. Activities scoring ≤1.5 METs are defined as sedentary behaviour or sleeping. Light-intensity activities include daily activities like washing

dishes, cooking, eating and office work. Moderate intensity refers to behaviour which requires slightly more energy, like walking and gentle swimming, whereas vigorous activity involves all exhausting exercises like jogging or cycling, generally, activities which prevent one from maintaining a conversation without interruption (Jetté et al., 1990; Norton et al., 2010, Tremblay et al., 2017).

Studies indicate a reduction of PA for post-COVID sufferers. Next to governmental COVID-19 restrictions such as lockdowns, self-quarantines, and gym closures, symptoms of post-COVID could also be responsible for PA reductions (Delbressine et al., 2021; Sañudo et al., 2020; Xiang et al., 2020). Considering the symptoms of post-COVID like difficulties in breathing, muscle weaknesses and fatigue, it seems trivial that sufferers show impairments in their PA (Anaya et al., 2021). This statement is supported by Twomey et al. (2021) and van Bakel et al. (2022), which show that people suffering from long-term effects show a reduced capacity to work and debilitation in physical functioning. Even light physical activity, including self-care and housework, was perceived as exhausting, making engagement in moderate-to-vigorous activities almost impossible (Humphreys et al., 2021). Moreover, Delbressine et al. (2021) and van Bakel et al. (2022) revealed a significant decrease in walking time. Besides harming recovery on a physical level and quality of life, reduced PA also might lead to consequences on a mental level.

A diminished PA level is inversely related to DS like lack of interest, concentration difficulties, lack of energy and sleep difficulties (APA, n. D; Loprinzi, 2013; Meyer et al., 2020; Paluska & Schwenk, 2000; Teychenne et al., 2008). Research revealed that people engaging in moderate-to-vigorous levels of exercise show lower levels of DS. Besides, also light physical activities like household chores and stretching are associated with lower levels of DS (Peluso & Guerra de Andrade, 2005; Toups et al., 2017; Xiang et al., 2020). Especially, household chores are decisive for displaying DS since doing household activities is used as an

indicator of normality. If exhaustion prevents engagement in such activities, as in the case of post-COVID sufferers, it might lead to perceived deviations of normality, resulting in DS. Besides, household chores can be connected with prosocial behaviour (e.g. cooking together), which diminishes levels of DS (Humphreys et al., 2021; Xiang et al., 2020).

PA is not only associated with DS but is also considered an important variable for treating DS and rehabilitating a post-COVID condition (Humphreys et al., 2021; Meyer et al., 2020). Dinas et al. (2010) state that PA has a comparable effect on depression like antidepressant treatments. In addition, Faghy et al. (2020) suggest including knowledge of PA-based treatment by collaborating clinical and sports medicine to create a multidisciplinary approach to provide the best possible support for treating the patients.

However, this effect of PA on DS is not unidirectional. There is also evidence that post-COVID sufferers show DS first, leading to reduced PA. Symptoms of post-COVID show similarities with DS, like lack of energy and sleep difficulties, Thus, it seems logical that higher levels of DS were found in post-COVID sufferers (Matsumoto et al., 2022; Renaud-Charest et al., 2021; WHO, 2021b). Lack of energy and sleep difficulties might result in fatigue which reduces the PA level (APA, n.d.; Roshanaei-Moghaddam et al., 2009; van Gool, 2003). Also, post-COVID and DS are related on a biological basis. Similar immune system dysregulations were found in people with post-COVID conditions and people showing DS (Boldrini et al., 2021; Chen et al., 2020; Han et al., 2020; Köhler et al., 2017; Lee & Giuliani, 2019; Mazza et al., 2020; Ragab et al., 2020; Roman & Irwin, 2020). Based on these findings, it is unclear whether DS influences PA or vice versa, which is why this study considers this relationship bidirectional.

Gender differences highly influence this relationship. Starting with DS, studies showed a higher prevalence of women displaying DS than men (Angst et al., 2002; Kockler & Heun, 2002; Lim et al., 2018; Mazza et al., 2020; Seiffge-Krenke & Stemmler, 2002; Wolanin

et al., 2016). Torre et al. (2021) found a higher depressive level in women in 25 European countries. PA levels also indicate gender differences. Men tend to report being more physically active than women (Azevedo et al., 2007; Lee, 2005; Martínez-González et al., 2001, Steptoe et al., 2002). Lastly, studies also suggest a higher prevalence of women suffering from persisting symptoms after a COVID-19 infection (Bai et al., 2022; NDR, 2022). In summary, women report engaging less frequently in PA, show a higher prevalence of depression and are more likely to suffer from post-COVID than men. Thus, by investigating the correlation between PA and DS in a post-COVID sample, the gender differences should be included.

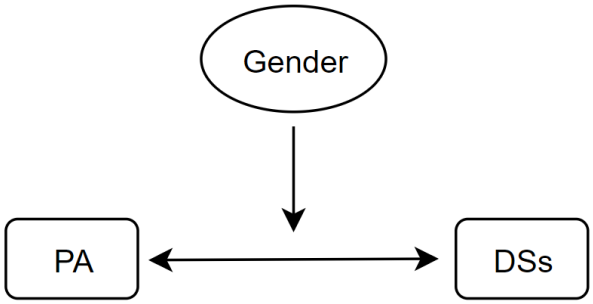
No research addresses the relationship between PA and DS moderated by gender in the context of post-COVID. This study aims to close this research gap by investigating this relationship in a sample of post-COVID sufferers regarding gender differences, as shown in Figure 1. Based on previous studies, the following hypotheses were expected.

Hypothesis 1: *"A low score in physical activity significantly correlates with a higher score in depressive symptoms"*.

Hypothesis 2: *"Gender significantly moderates the effect between physical activity and depressive symptoms"*.

Figure 1

Proposed Model



Methods

Design

This study was based on a cross-sectional survey design with the variables *PA* and *DS*. The moderator was *gender*. The online platform "Qualtrics" was used to create the questionnaire and data collection. This study was part of a joint data collection of six students, including variables and questionnaires that were irrelevant for this specific study. Before collecting data, the study design was approved by the BMS Ethics Committee of the University of Twente (request number: 220405). The data were collected during 43 days (08.04.22 – 21.05.22). The study consisted of a German and English survey which data were combined at the end of the study. Before publishing the survey, a pilot study was conducted. The pilot sample consisted of six people from a close social environment which verified the feasibility of the survey with a focus on understandability and technical problems.

Participants

The participants were recruited by convenience sampling. Based on a g*power sample size analysis ($\alpha = .05$, $f^2 = 0.1$, $[1-\beta] = .80$ and 3 predictors), the aspired size is $n = 81$. Some participants were recruited from close social circles, whereas others participated by accessing the link to the questionnaire via the Story function of Instagram, WhatsApp and Facebook. In addition, the German and English link to the survey was posted on Reddit three times and in five different Facebook groups, including post-COVID members. All Participants attended voluntarily. The inclusion criteria for all participants were a minimum age of 18 years, either male or female, proficiency in understanding English or German, and a COVID-19 infection, including suspected infections, 12 weeks ago or longer with at least one persisting symptom. To ensure only post-COVID sufferers were included, the survey assessed persistent symptoms and onset of the initial infection.

Materials and Measures

The study began with the informed consent, including contact details, inclusion criteria, background information of the study, the procedure, confidentiality statements and

the agreement of voluntary participation (Appendix A).

To measure the first variable *physical activity (PA),* the International Physical Activity Questionnaire-Short Form ([IPAQ-SF] Craig et al., 2017) was used. It is a self-administered questionnaire and was created for assessing cross-national PA and physical inactivity among 18 – 65-year-old adults in various settings. The total PA is measured in MET-min/week. The questionnaire is divided into four categories: vigorous activities, moderate activities, time spent walking, and time spent sitting. Each category is explained before answering the corresponding questions. The IPAQ-SF consists of 7 items with open-ended questions assessing PA over the last seven days. An example of an item is "*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)?"* with the answers *"Hours per day: _"* and *"Minutes per day: _* or *"Don't know/Not sure"* (Appendix B). The IPAQ-SF was tested in 12 different countries and showed good test-retest reliability (r_s = .76) and acceptable criterion validity (r_s = .30), which indicates at least equally good psychometrics compared with other self-reported questionnaires (Craig et al., 2003). The English and German version of the IPAQ-SF was used.

The dependent variable *depressive symptoms (DS)* was measured with the Patients Health Questionnaire ([PHQ-9] Zimmerman, 2019). It assesses DS following the DSM-5 criteria. This questionnaire was used because of its brevity, ease of interpretation, good internal consistency (α = .87), good convergent validity and discriminant validity (Beard et al., 2016). The questionnaire is built upon one main question "*The following 9 questions will assess how you felt during the past 2 weeks. How often have you been bothered by any of the following problems?"* following nine items, for instance, "*Little interest or pleasure in doing things"*. The answering scale is based on a 4-point Likert scale ranging from 1 = "*Not at all"* to 4 = "*Nearly every day"* (Appendix C). The English and German version of the PHQ-9 was

used.

The demographics were collected with the help of a self-created questionnaire consisting of eight items. These items assessed gender, age, nationality, diagnosis, presence of symptoms, hospitalisation, physical impairments and time of infection (Appendix D).

Procedure

All participants got access to the Qualtrics questionnaire via an online link. The first page included general information about the study. The English version also contained a link to the German questionnaire to enable people to switch the language. After agreeing with the consent form, the participants were asked about their first time of infection. If they did not answer "*12 weeks or longer ago*", they were forwarded to the end of the survey. The remaining participants were invited to fill out the questionnaire, including the IPAQ, PHQ-9 and demographics. After finishing all items, they were given contact details for follow-up questions and thanked for their participation.

Data Analysis

The data were analysed with IBM's software SPSS (Version 27). In accordance with the scoring protocol by Patterson (2005), the scores of the IPAQ-SF were transferred into MET-min/week. A detailed calculation scheme can be found in Appendix E. The MET-score was converted into MET-hours/week for better readability and comprehensibility. Two scores were truncated by following instructor guidelines because of too high, but still realistic, scores in PA (Patterson, 2005). A total sum score of the PHQ-9 for each participant was calculated following the scoring scheme (Zimmermann, 2019). During analysis, the scores were treated as continuous scores, whereas for later interpretation, the pre-existing categories were used (Appendix F).

The sample properties and distribution were assessed with the aid of descriptive and frequency analysis. In addition, the internal consistency of the PHQ-9 was assessed using Cronbach's alpha. Before testing the first hypothesis, the assumption of normality, linearity,

homoscedasticity, independence and outliers were checked. Due to violated assumptions, a Kendall Rank Analysis was performed to test the first hypothesis instead of a Pearson Correlation (Berg, 2019; Magiya, 2019). The second hypothesis was tested with a moderation analysis using the extension tool PROCESS v4.1 by Andrew F. Hayes, which makes use of bootstrapping (Hayes, n.D.). Bootstrapping was set to 5000 to counteract the non-parametric data and increase statistical power.

Results

Descriptive Statistics

In total, 219 people agreed to the informed consent. However, several responses were excluded based on the following reasons. One hundred fifty-three people did not finish the survey, one did not indicate a persisting symptom, one did not fit the minimum age, and four gave unrealistic answers concerning their level of PA. The final sample comprises 59 participants, predominantly women (74.6%), with a mean age of 35.5 (SD_{age} = 13.4). German (37.3%) and American (27.1%) were the two most common nationalities. Participants indicated on average 5.8 persisting symptoms, and four people (6.8%) were hospitalised due to COVID-19. This sample's most prevalent persisting symptom was fatigue (Table 1).

The sample scores of the IPAQ-SF showed a distribution skewed to the right with a mean of 30.2 MET-hours/week (*SD* = 30.9), demonstrating a moderate level of PA on average and high variability of scores (Appendix G). The sample scores of the PHQ-9 display a mean score of 12.2 (*SD* = 6.2), indicating a normal distribution ([Appendix H] Table 2). According to the PHQ-9 scoring system, this score indicates a moderate level of depression (Appendix F).

Table 1

Descriptive Statistics of the sample (N = 59)

Characteristic		*n*	*%*	*M*	*SD*	Min	*Max*
Age				35.5	13.4	18	62
Gender	Male	15	25.4				
	Female	44	74.6				
Nationality	German	22	37.3				
	USA	16	27.1				
	Other[a]	21	35.6				
Symptoms	Fatigue/Tiredness	54	91.5				
	Difficulties concentrating, memory problems and/or confusion	48	81.4				
	Shortness of breath	38	64.4				
	Pain/aches or soreness	38	64.4				
	Changes in mood and/or anxiety	38	64.4				
	Difficulties moving or talking	31	52.5				
	Loss of taste or smell	16	27.1				
	Cough	15	25.4				
	Fever and chills	10	16.9				
	Other[b]	28	47.5				

Notes. [a]Other Nationalities include British, Dutch, Canadian, French, Indian, Italian, Serbian, and Pakistan. [b]Other symptoms include mental disorders, cardiological dysregulations, rashes, vertigo, eye issues, numbness, throat swelling, tinnitus.

Table 2

Sample scores of the IPAQ-SF and PHQ-9

Variable					Skewness		Kurtosis	
	Min	Max	*M*	*SD*	Statistic	*SE*	Statistic	*SE*
Physical activity[a]	0	112.4	30.2	30.9	1.13	0.31	0.51	0.61
Depressive symptoms[b]	1	27	12.2	6.2	0.29	0.31	-0.43	0.61

Notes. [a] Measured in MET-hours/week. [b] Measured in scores of Physical health questionnaire.

Reliability Assessment

The Reliability Test of the PHQ-9 shows a Cronbach's alpha of .82. According to Taber (2018), these results indicate a desirable internal consistency for the PHQ-9.

First hypothesis - Kendall Rank Correlation

The analysis of assumptions revealed no violation of linearity, homoscedasticity and outliers. The assumptions of normality and independence were violated. A Kendall Rank Analysis was performed to test the first hypothesis. The assumption of a monotonic relationship was met (Appendix I). The Kendall Rank Correlation indicated an non-significant negative association between *PA* and *DS* ($r_\tau(59) = -.18$, $p = .054$). Therefore, hypothesis 1, "*A low score in physical activity significantly correlates with a higher score in depressive symptoms",* was rejected.

Second hypothesis - Moderation by Gender

The PROCESS MACRO analysis was performed twice because the moderation effect was examined for both directions. In Model A, *PA* was set as the independent variable (IV) and *DS* as the dependent variable (DV), with *gender* as moderator (M). In Model B, *DS* was set as IV, *PA* as DV and *gender* as M (Table 3). The overall Model of A ($F(3, 55) = 0.87$, $p = .465$, $R^2 = .05$) and Model B ($F(3, 55) = 1.20$, $p = .318$, $R^2 = .06$) were not significant. Also, *gender* as moderating variable did not show a significant effect in Model A ($b = 0.02$, $p = .789$) and Model B ($b = 1.24$ $p = .379$). Therefore, hypothesis 2, "*Gender significantly moderates the effect between physical activity and depressive symptoms*", was rejected.

Table 3

Results of moderation analysis

					95% CI	
	b	*SE*	*t*	*p*	*LL*	*UL*
Model A[a]						
Constant	13.87	3.66	3.79	.004	6.54	21.20
PA	-0.07	0.10	-0.69	.492	-0.26	0.13
Gender	-0.41	2.90	-0.14	.887	-6.23	5.40
Interaction	0.02	0.08	0.27	.789	-0.79	0.19
Model B[b]						
Constant	68.78	26.89	2.56	.013	14.90	122.66
DS	-2.68	1.96	-1.36	.178	-6.61	1.26
Gender	-19.96	19.56	-1.02	.312	-59.17	19.24
Interaction	1.24	1.40	0.89	.379	-1.56	4.05

Notes. Abbreviations: LL = lower limit; UL = upper limit. [a] dependent variable = depressive symptoms, independent variable = physical activity and moderator = Gender. [b] dependent variable = physical activity, independent variable = depressive symptoms and moderator = Gender.

Discussion

Main Findings

This study analysed the relationship between PA and DS within a sample of post-COVID sufferers. Besides, the moderation effect of gender on this relationship was investigated. No association between PA and DS was found in this sample. Gender also does not show an effect on this relationship.

Evaluation of first hypothesis

To test hypothesis 1, *"A low score in physical activity significantly correlates with a higher score in depressive symptoms*", the correlation between PA and DS was tested. There

was no significant association between the level of PA and DS. Based on previous research, it was expected to find a significant negative relationship between these two variables (Bruce et al., 1994; Loprinzi, 2013; Paluska & Schwenk, 2000; Peluso & Guerra de Andrade, 2005; Teychenne et al., 2008). However, it should be considered that the results are borderline insignificant. Thus, there might be a high probability of having significant results when repeating the study with a larger sample.

One reason for finding different results compared to previous research is because of assessing PA with the IPAQ-SF. The IPAQ-SF is not a reliable measurement of PA, especially when considering the context of post-COVID and the relation between PA and DS. Light physical activity typically includes daily activities like washing dishes, cooking, eating and office work. The IPAQ-SF considers only walking as light physical activity, thus excluding all other types of light physical activity. However, household and stretching have an important influence on DS (Peluso & Guerra de Andrade, 2005; Toups et al., 2017; Xiang et al., 2020). By disregarding these activities, the IPAQ-SF misses important activities with high relevance for this context.

Moreover, post-COVID does show a large variety of symptoms which were not included in previous research. Many symptoms directly influence PA and DS, which might mitigate the direct relationship between PA and DS. However, data on the effect of post-COVID on the relationship between PA and DS is minimal, making it difficult to find a valid reason.

Although the first hypothesis was rejected based on the results of this study, it should be interpreted with caution due to inconclusive results. Future research in this field is needed to make more serious interpretations of the relationship between PA and DS in post-COVID sufferers. For now, it can be said this sample of post-COVID sufferers did not show a relationship between PA and DS.

Evaluation of second hypothesis

The second hypothesis, "*Gender significantly moderates the effect between physical activity and depressive symptoms"*, also did not show a significant effect. Based on prior findings women show more DS (Angst et al., 2002; Kockler & Heun, 2002; Mazza et al., 2020; Seiffge-Krenke & Stemmler, 2002; Wolanin et al., 2016) and report a lower level of PA (Azevedo et al., 2007; Lee, 2005; Martínez-González, 2001, Steptoe et al., 2002) compared to men. Hence, it was assumed to find a significant moderation effect of gender on the relationship between PA and DS. These assumptions do not apply to the current sample since the moderation effect of gender on the relationship between PA and DS was not significant. The second hypothesis is also impacted by the fact that post-COVID is a new field of research. Previous studies found gender differences in a sample of healthy participants without considering a disease which impacts PA and DS like a post-COVID condition. Thus, based on the current findings, a moderation effect of gender does not influence the relationship between PA and DS in a sample of post-COVID sufferers.

Additional Findings

Besides deviations from past research, the sample distribution provides similar results to already existing characteristics of post-COVID sufferers. On average, the sample scored moderately on the level of depression. This is in line with the findings of Matsumoto et al. (2022) and Renaud-Charest et al. (2021), who say post-COVID exhibits an elevated level of DS. Since there is an overlap between depressive symptoms and post-COVID symptoms, this finding seems trivial. Additionally, the probability of suffering from a post-COVID condition is higher for women than men (Bai et al., 2022; NDR, 2022). This sample supports this finding since it contains women predominantly. However, women show a higher tendency to use the internet for health, whereby it is not surprising to receive more online responses from women (Baker et al., 2003). Since the most participants were recruited online, this result should be interpreted with caution.

Relationship between physical activity and depressive symptoms

When coming to the distribution of PA, the sample displays results that are inconsistent with previous findings. According to Delbressine et al. (2021), Humphreys et al. (2021) and Twomey et al. (2021), post-COVID sufferers show reduced levels of PA. Controversy, the present sample shows moderate levels of PA on average. One reason for a higher level of PA in previous research is the environmental circumstances which changed during the pandemic. This current study collected data during a phase of low governmental restrictions, including open fitness studios and no lockdowns. The other studies were conducted earlier, whereby those restrictions might reduce the level of PA in these studies. However, this explanation is vague since the symptoms of post-COVID are mainly responsible for the reduced engagement of PA (Delbressine et al., 2021; Sañudo et al., Tison et al., 2020; 2020; Xiang et al., 2020). A more valid reason for the disparity in results is the poor ability of the IPAQ-SF to assess PA correctly. Generally, self-reported measures are prone to recall difficulties and misinterpretation of questions. Dyrstad et al. (2014) revealed that participants tend to overestimate their vigorous activity. Hence, the assessed levels of PA are not reliable and might be lower when using more precise, objective techniques like an Accelerometer (Loprinzi, 2013).

Although this result did not meet expectations, it suggests that the PA level of post-COVID patients is not as poor as assumed, which is a positive finding since the negative effect of post-COVID on PA does not seem as severe as expected. On the contrary, the assumptions of elevated depression levels in post-COVID sufferers were confirmed. Since no correlation between PA and DS was found, the reason for moderate levels of DS cannot be explained by low levels of PA. When treating DS of post-COVID sufferers, PA should not be considered as a treatment method based on this study.

Strength and Limitations

The study showed several strengths. This study contributes to general literature in the new field of COVID-19 and was the first which investigates the direct association between

DS and PA with consideration of gender differences in post-COVID sufferers. In addition, the PHQ-9 shows high reliability in this study, indicating an appropriate measurement for assessing DS. Moreover, this research takes advantage of collaborative data collection. Resources of individual people were shared with the group whereby the whole group could profit from it. For instance, the fact that six people engaged in sample recruitment, the reachability of possible participants was higher compared to a single data collection. Also, the shared literature research created a discussion which gave impressions of different perspectives on this context.

Nevertheless, the study also had several limitations, which raise doubts about the results of this study. Although collaborative data collection brings advantages, it also comes with limitations. The group of researchers consisted of six students who partly investigated unrelated variables, which led to an increased processing time of the survey. Especially, a target group with concentration difficulties and a high degree of fatigue, as is the case with this sample, might show difficulties in persevering the whole survey (Anaya et al., 2021; Pavli et al., 2021; WHO, 2021b). This might be the reason why nearly 70% of the responses had to be excluded due to not completeness. These concentration difficulties are enhanced by general limitations related to voluntary online studies like uncontrolled distractions while answering the survey and low motivational cues. This study tried to counteract these difficulties by including a motivational halftime message "*You are halfway through the survey. Only 10 more minutes to go!"*. In addition, the demographic questionnaire, which requires the least concentration, was placed at the end of the survey.

Moreover, the sample size did not reach the aimed minimum of 81 participants, leading to reduced statistical power and increased margins of error. Also, the sample showed high internationality, including nine different countries, indicating heterogeneity. The findings of Tison et al. (2020) revealed significant regional variations in walking behaviour during the

COVID-19 pandemic. This was reasoned by the fact that some countries showed a more intensive or earlier outbreak of COVID-19, which requires stronger or earlier restrictions. Therefore, this sample seems to be highly biased by such regional differences. Besides, the sample includes a low number of male participants, which hinders from making valid conclusions concerning the moderation effect of gender.

Future Research

The literature in the field of post-COVID is limited because of the recency of post-COVID. As one of the first studies investigating the relationship between PA and DS within a post-COVID sample, it provides a basis for future research. Generally, the following research should use a larger sample but consider regional differences. Besides, PA should be assessed by objective measurements to prevent recall biases. In addition, the measurement of PA ideally includes a broad variety of light physical activity, especially household chores, which are found to be influential on DS. The IPAQ-SF is not an appropriate measurement and should not be considered for follow-up research in this context.

Although the PHQ-9 show reliable results for this study, it is also affected by the disadvantages of self-reported measurements. However, the questionnaire showed good internal consistency and is a suitable measure for assessing depression levels for post-COVID sufferers in future studies.

Besides, measuring the level of PA and DS only once might lead to distorted results. Since the symptoms of post-COVID vary in intensity and quantity, the level of PA and DS might also show variations. Thus, future research should use a repeated-measure design and assess the level of PA and DS for the same participants at two or more points of time.

Conclusion

This study investigated the moderation effect of gender on the relationship between physical activity and depressive symptoms in post-COVID sufferers. This research did not find significant results for a relationship between physical activity and depressive symptoms.

Also, gender did not significantly affect this relationship. This indicates that the relationship between PA and DS as well as the moderation effect of gender, does not exist in the present sample of post-COVID sufferers. However, the sample showed higher levels of depressive symptoms, which is consistent with previous research. More research in this field is needed to eliminate the uncertainties and enable more accurate decisions regarding recovery and treatments.

Reference list

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Appendices

Appendix A: Informed consent

Informed Consent - Physical Activity in Post-COVID Patients

Researchers (Bachelor):
Antje Brot (a.brot@student.utwente.nl),
Kai Rosen (k.s.rosen@student.utwente.nl),
Lara Uppenkamp (l.a.uppenkamp@student.utwente.nl),
Silas Mergehenn (s.j.mergehenn@student.utwente.nl),
Simon Ziemer (s.j.ziemer@student.utwente.nl),
And Yannick Phillipp (y.n.philipp@student.utwente.nl).

Researcher (Supervisor):
Gerko Schaap (g.schaap@utwente.nl)

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.

Voluntary Participation

Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you choose to participate, you will be asked to accept the statements below. After doing so, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not negatively affect you.

- I understand that my participation is voluntary. I am free to withdraw at any time, without giving a reason, and I voluntarily agree to participate in this study.

Appendix B: IPAQ-SF

International Physical Activity Questionnaire - Short Form

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?
_____ **days per week**
No vigorous physical activities ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?
_____ **hours per day**
_____ **minutes per day**
- ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate**

activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. 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.
_____ **days per week**
No moderate physical activities ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?
_____ **hours per day**
_____ **minutes per day**
 Don't know/Not sure

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.
5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?
_____ **days per week**
No walking ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?
_____ **hours per day**
_____ **minutes per day**
 Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.
7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?
_____ **hours per day**
_____ **minutes per day**
 Don't know/Not sure

Appendix C: PHQ-9

Nine Symptom Checklist

Over the last 2 weeks, how often have you been bothered by any of the following problems?

	Not at all	Several days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things.....	0	1	2	3
2. Feeling down, depressed, or hopeless.....	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much.....	0	1	2	3
4. Feeling tired or having little energy.....	0	1	2	3
5. Poor appetite or overeating.....	0	1	2	3
6. Feeling bad about yourself - or that you are a failure or have let yourself or your family down.....	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television.....	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed? Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual.....	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way.....	0	1	2	3

(For office coding: Total Score _____ = ___ + ___ + ___)

If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all	Somewhat difficult	Very difficult	Extremely difficult
☐	☐	☐	☐

From the Primary Care Evaluation of Mental Disorders Patient Health Questionnaire (PRIME-MD PHQ). The PHQ was developed by Drs. Robert L. Spitzer, Janet B.W. Williams, Kurt Kroenke and colleagues. For research information, contact Dr. Spitzer at rls8@columbia.edu. PRIME-MD© is a trademark of Pfizer Inc. Copyright© 1999 Pfizer Inc. All rights reserved. Reproduced with permission.

Appendix D: Demographic Questionnaire

What is your Gender?

- female
- male
- other

How old are you?

What is your nationality?

- German
- Dutch
- Other

How did you find out about your infection?

- positive PCR test
- positive Antigen test
- assumed infection

Which of the following symptoms do you currently experience? (for example, in the past week)

	Yes	No
fatigue / tiredness	☒	☒
cough	☒	☒
fever and chills	☒	☒
shortness of breath	☒	☒
difficulties moving or talking	☒	☒
loss of taste or smell	☒	☒
difficulties concentrating, memory problems and/ or confusion	☒	☒
pain/ aches or soreness	☒	☒
changes in mood and/ or anxiety	☒	☒
other namely...	☒	☒

Were you hospitalised due to COVID-19?

- yes
- no

Do you suffer from any physical impairments and if "yes" which (e.g. wheelchair).

- Yes…
- No

When were you originally infected with COVID-19? (approximately)

Appendix E: Scoring of the IPAQ-SF

*Walking MET-minutes/week = 3.3 * walking minutes * walking days*

*Moderate MET-minutes/week = 4.0 * moderate-intensity activity minutes * moderate days*

*Vigorous MET-minutes/week = 8.0 * vigorous-intensity activity minutes * vigorous-intensity days*

The Total Score is the sum score of all activities:

Total physical activity MET-minutes/week = sum of Walking + Moderate + Vigorous MET-minutes/week scores.

Appendix F: Scoring of the PHQ-9

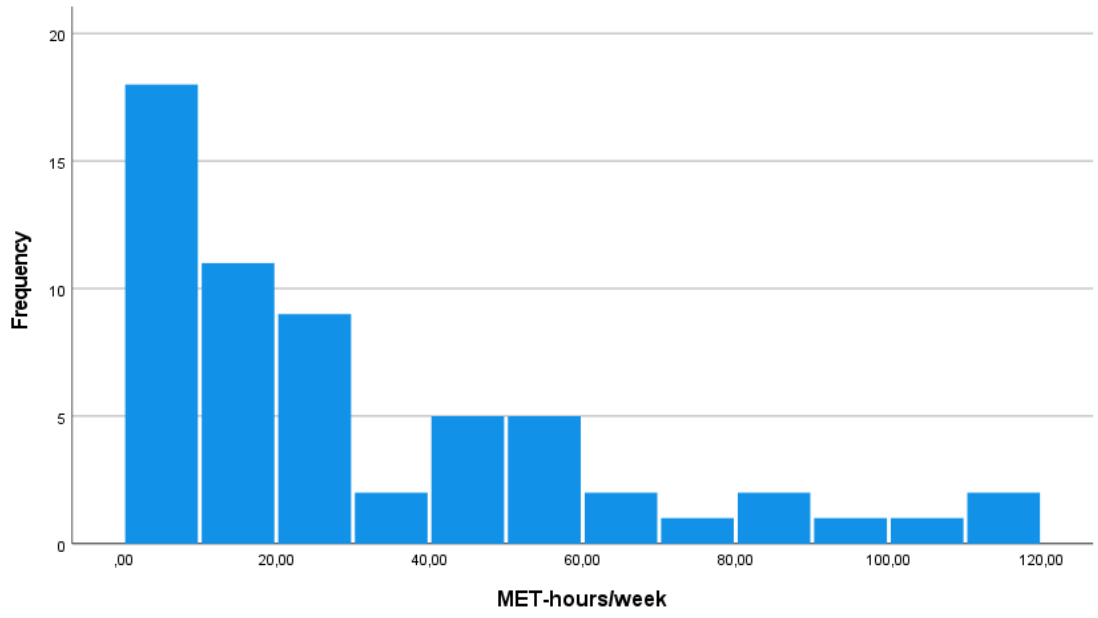
Interpreting PHQ-9 Scores

Diagnosis	Total Score	For Score	Action
Minimal depression	0-4	≤ 4	The score suggests the patient may not need depression treatment
Mild depression Moderate depression	5-9 10-14	5 - 14	Physician uses clinical judgment about treatment, based on patient's duration of symptoms and functional impairment
Moderately severe depression Severe depression	15-19 20-27	> 14	Warrants treatment for depression, using antidepressant, psychotherapy and/or a combination of treatment.

Appendix G: Distribution of MET scores

Figure G1

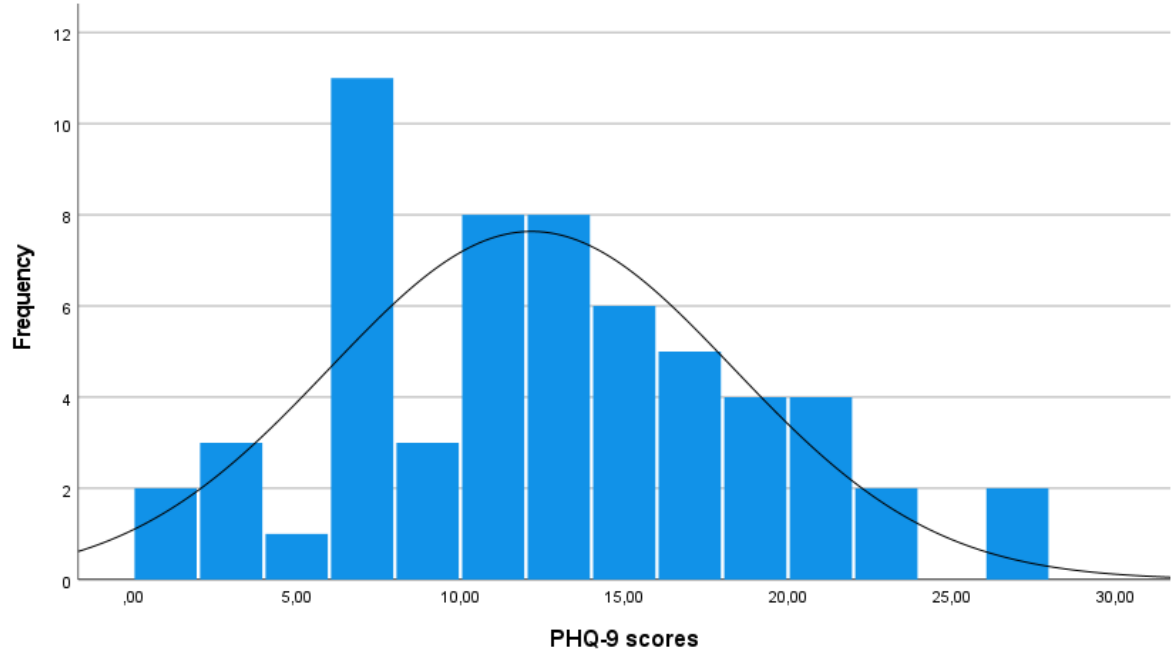
Frequency of MET-hours/week scores of the present sample



Appendix H : Distribution of PHQ-9 scores

Figure H1

Frequency of PHQ-9 scores of the present sample



Appendix I: Testing for monotonicity

Figure I1

Distribution of PA (MET-hours/week) and DS (PHQ-9 scores) visualised in a scatterplot