Original Article

Fear of COVID-19, Physical Activity, and Psychopathology

A Cross-Sectional Study

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Abstract: *Background*: The COVID-19 pandemic was associated with high fear of infection and consequences of the pandemic, decline in physical activity and increase in depressive symptoms. *Aims*: This study assessed whether fear of COVID-19 is cross-sectionally associated with symptoms of depression in a clinical outpatient sample and if physical activity moderates this effect. *Methods*: Data was collected between March 2021 and May 2022 at 10 study sites in a cross-sectional assessment of 401 participants, aged 18–65 (M = 42.08, SD = 13.26, 71.0% female). All participants fulfilled diagnostic criteria for major depressive disorders, insomnia, panic disorder, agoraphobia, or posttraumatic stress disorder. Data was analyzed using linear regression models including fear of COVID-19 (disease anxiety; consequence anxiety), self-reported physical activity, physical activity measured by accelerometers (min/week), as well as the interaction of these variables as predictors, depressive symptoms as the outcome. *Results*: The primary model's fit was significant, $F(15, 377.13) = 1.89$, $p = .022$. Consequence anxiety was significantly and positively associated with depressive symptoms ($\beta = 0.12$, $t = 2.33$, $p = .020$). We further observed a negative association between self-reported physical activity and depressive symptoms ($\beta = -0.15$, $t = -2.73$, $p = .007$). There was no significant interaction effect. *Limitations*: These results should be interpreted as an observational association. *Conclusion*: Results show that fear of the consequences of COVID-19 was positively associated with depressive symptoms, but physical activity did not moderate this association. We report an independent, negative association between self-reported physical activity and depressive symptoms.

Keywords: mental health, physical activity, COVID-19, anxiety, depression

During the COVID-19 pandemic, people were confronted with a new fast-spreading virus that was associated with a minimum of 1.1 in the age group of 18–29-year-olds) to a maximum of 305 (in the age group of $\geq$ 85-year-olds) deaths per 10,000 COVID-19 cases, lack of treatment methods and overstrained health systems, especially at the beginning of the pandemic (Meyerowitz-Katz & Merone, 2020; Wiersinga et al., 2020). Worldwide, cross-sectional studies indicate a high score on the fear of COVID-19 (FoC) scale (Luo et al., 2021), which assesses anxiety

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symptoms (assessed with items such as sweating, increased heart rate or palpitations, feeling uncomfortable or afraid, fear of dying) caused by thinking of COVID-19 and worrying about being infected with COVID-19. FoC was negatively associated with well-being (Winter et al., 2020) and depressive symptoms (Erbiçer et al., 2021). Further, COVID-19 worries over the last 2 weeks were one of the strongest predictors of current mood states during the pandemic (Nikolaidis et al., 2021).

Previous studies related to other health threats report that experiencing fear of a negative health outcome lead to higher intentions and behaviors to avoid the negative consequences (Tannenbaum et al., 2015). This is supported by first cross-sectional studies during the COVID-19 pandemic (Anderson & Stockman, 2022; Fink et al., 2021; Harper et al., 2021; Hartmann & Müller, 2023; J. Kim et al., 2022; Šuriņa et al., 2021). FoC (assessed using validated scales that measure anxiety symptoms related to thoughts about COVID-19 and concerns about the risk of infection) was positively associated with acceptance and adherence to the publicly recommended preventive measures such as working from home and social distancing (Anderson & Stockman, 2022; Hartmann & Müller, 2023; Winter et al., 2020), as well as hygienic behavior (Harper et al., 2021; K. Kim et al., 2022). Further studies report small to moderate, positive associations between fear of contracting COVID-19 or losing family members because of COVID-19 with adherent safety behavior such as personal preventive measures (Šuriņa et al., 2021) and self-reported worry about COVID-19 with dysfunctional safety behavior, such as stockpiling hygiene articles and basic food, or selfish behavior (Fink et al., 2021). With FoC increasing the odds of adhering to preventive measures (Anderson & Stockman, 2022; Hartmann & Müller, 2023; Winter et al., 2020), it might be one factor explaining the frequently reported reduced physical activity (PA) levels during the COVID-19 pandemic (Caputo & Reichert, 2020; Hoffart et al., 2020).

PA is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985). General guidelines, also for persons with noncommunicable diseases, recommend at least 75 min of high intensity ($\geq$ 6 metabolic equivalents of tasks [MET]) or 150 min of moderate intensity ($\geq$ 3 MET) of PA per week or an equivalent combination of both (ACSM, 2017; Garber et al., 2011; Geidl et al., 2020; World Health Organization, 2021). Systematic reviews and meta-analytic data suggest that PA of any intensity is associated with lower mortality (Ekelund et al., 2019), lower psychological distress and higher psychological well-being (Amagasa et al., 2018). In terms of mental health benefits, previous studies have revealed positive preventive and interventional effects of PA for depressive disorders, anxiety disorders, post-traumatic stress disorders (PTSD), and insomnia (Ashdown-Franks et al., 2020; Banno et al., 2018; Heissel et al., 2023; Morres et al., 2019; Pearce et al., 2022; Rosenbaum et al., 2015; Schuch et al., 2019). These disorders often occur comorbidly (Kessler et al., 2005) and all share common symptoms, including a sad mood, lack of interest, worry, concentration problems, sleep issues, and irritability, which can be summarized as depressive symptoms (Afzali et al., 2017; Beard et al., 2016). The ideal dose of PA for benefits for depressive symptoms remains a subject of discussion. While some research points to 150–450 min per week as linked to reduced depression risk (Kim et al., 2012), recent findings suggest that even just 75 min of moderate to vigorous leisure-time PA per week reduce the risk of developing depression (Pearce et al., 2022). Meta-analytic evidence further suggests large therapeutic antidepressant effects of exercise interventions that implement moderate to vigorous PA amounting to a total of at least 60 min/week (Heissel et al., 2023; Morres et al., 2019; Schuch et al., 2016). Positive effects of exercise, leisure-time PA and transport PA for depressive symptoms are consistently reported, while non-leisure PA (e.g., domestic and occupational) did not have positive effects on depressive symptoms (White et al., 2017). Previous studies report an association between COVID-19 preventive measures and various domains of PA: aggregated cell-phone data indicates reduced mobility during lockdowns (Caselli et al., 2022), leading to less transport PA. An international study highlights a notable shift in behavior during the COVID-19 pandemic, reporting increased odds of engaging in sedentary leisure-time activities compared to participating in leisure-time PA (Morse et al., 2021). This change underscores the pandemic's impact on lifestyle patterns, potentially driven by restrictions, limited access to exercise facilities, and changes in daily routines.

Even before the pandemic, research highlighted several barriers that people with mental health disorders face in engaging in PA, such as a lack of confidence in their ability to exercise, low motivation, and placing a low priority on PA (Glowacki et al., 2017). The pandemic's preventive measures, including the closure of sports clubs and exercise facilities and restrictions on group exercise, exacerbated these challenges. Individuals with high FoC are more likely to adhere to such guidelines (Harper et al., 2021; Hartmann & Müller, 2023), which associated with decreased activity levels (Kuśnierz et al., 2021). Meta-analytic evidence suggests that reduced engagement in leisure activities is linked to higher odds of depression (Bone et al., 2022). Based on these findings, we hypothesize a positive association between FoC and depressive symptoms, and a negative association between PA and depressive symptoms in a cross-sectional assessment of a clinical outpatient sample. We further assume that individuals who maintain PA despite elevated FoC experience less of an impact on their depressive symptoms.

Methods

Study Design

While this study is part of a multicenter, randomized controlled trial implementing a PA intervention, this report is based on cross-sectional data of the initial assessment point of the ImPuls study (Wolf, Seiffer, Zeibig, Welkerling, Bauer, et al., 2021; Wolf et al., 2024). The study protocol has been published (Wolf, Seiffer, Zeibig, Welkerling, Bauer, et al., 2021) and was registered in the German Clinical Trial Register (ID: DRKS00024152, 05/02/2021). The current analysis was further pre-registered before access to the cross-sectional data was granted (https://doi.org/10.17605/OSF.IO/DRB8N). The study has been approved by the local ethics committee for medical research at the University of Tübingen (ID: 888/2020B01, 02/11/2020). Written informed consent was obtained from all participants in the study.

Procedure

This study was conducted at 10 different study sites in Baden-Württemberg, Germany. The initial assessment point provides cross-sectional data of 401 participants (18–65 years) with a diagnosis of major depressive disorder, insomnia, panic disorder, agoraphobia, or PTSD. Data was collected between March 2021 and May 2022. Patients were recruited through (social) media, two major health insurances (AOK Baden-Württemberg [AOK BW], Techniker Krankenkasse [TK]), inpatient psychiatric departments, general practitioners, and psychiatric and psychotherapeutic outpatient units. All participants were first contacted by phone where they received general study information and completed a preliminary screening for inclusion and exclusion criteria, and screening for somatic contraindications for exercise (Thomas et al., 1992). In case of a potential somatic contraindication, they were referred to a general practitioner or medical specialist and could only participate after medical clearance for moderate to vigorous PA (MVPA). Potentially eligible participants then had an inhouse meeting at the nearest study site, where they were informed about study procedures in person and provided informed consent. Eligibility was finally confirmed through a structured clinical interview (Beesdo-Baum et al., 2019) with a study psychologist. Once six patients at one study site were eligible for participation, they received an online questionnaire, which could be answered over a period of 14 days. Within the same period, they completed a 7-consecutive-day measurement with accelerometer-based PA sensors (MOVE 4; movisens GmbH). After completing these assessments, participants went on to complete the study protocol of the main study (Wolf, Seiffer, Zeibig, Welkerling, Bauer, et al., 2021; Wolf et al., 2024).

Participants

Participants were between the age of 18 and 65 years, membership of the insurance companies AOK BW or TK, fluent in German, with no medical contraindications for exercise, and diagnosed by clinical psychologists who conducted a structured clinical interview according to ICD-10 with at least one of the following disorders: major depressive disorders (F32.1, F32.2, F33.1, F33.2), insomnia (F51.0), panic disorder (F41.0), agoraphobia (F40.0, F40.01) or PTSD (F43.1). Exclusion criteria included: continuously performing exercise more than once a week for at least 30 min each time with at least moderate intensity over a period of 6 weeks within the last 3 months before study diagnosis, medical contraindication established by the general practitioner or a medical specialist, acute mental and behavioral disorders due to psychotropic substances (F10.0, F10.2-F10.9; F11.0, F11.2-F11.9; F12. 0, F12.2-F12.9; F13.0, F13.2-F13.9; F14.0, F14.2-F14.9; F15.0, F15.2-F15.9; F16.0, F16.2-F16.9; F17.2-F17.9; F18.0, F18.2-F18.9; F19.0, F19.2-F19.9), acute eating disorders (F50), acute bipolar disorder (F31), acute schizophrenia (ICD-10 F20), acute suicidality.

Measures

Depressive Symptoms

Depressive symptoms were assessed by the total score of the patient health questionnaire-9 (PHQ-9; Kroenke et al., 2001; Spitzer et al., 1999). The PHQ-9 module includes nine items, each representing one of the DSM-IV-TR (Diagnostic and Statistical Manual of Mental Disorders) criteria for a depressive episode (American Psychiatric Association, 2000), over the last 2 weeks. Items are rated on a 4-point Likert scale (range: 0–3), and result in a total score ranging from 0 to 27, with higher scores indicating higher severity of depressive symptoms. Patients can be classified into five categories according to the total score: absence of depressive disorder (0–4), mild depressive disorder (5–10), medium depressive disorder (10–14), severe depressive disorder (15–19), and most severe depressive disorder (20–27). Participants are further classified into fulfilling symptoms of a major depressive disorder with a total score > 9 in primary care and other medical settings. This cut-off was shown to have a sensitivity and specificity of

0.88 and 0.85, respectively (Levis et al., 2019). Internal consistency of Cronbach's of the original validation study was $\alpha = .88$ (Gräfe et al., 2004). Cronbach's α in our study was $\alpha = .79$.

Fear of COVID-19

FoC was assessed with the German version of the Pandemic Anxiety Scale (PAS; McElroy et al., 2020). The PAS consists of seven self-report items, rated on a 5-point Likert scale ranging from 0 = *strongly disagree* to 4 = *strongly agree*. Higher values indicate higher anxiety. The scale allows the calculation of a total score and sub-scores of the subscales disease anxiety (four items) and consequence anxiety (three items). The subscale disease anxiety focuses on concerns about catching COVID-19 (self or family and friends), leaving home, and transmitting the virus to someone else. The subscale consequence anxiety focuses on concerns about missing work or school, financial difficulties, and long-term consequences on the economy. Internal consistency of Cronbach's α of the original validation study was $\alpha = .70$. Cronbach's α in our study was $\alpha = .74$. We performed a confirmatory factor analysis (CFA) to examine the two-factor structure of the PAS in our study. The model fit indices suggest a less than satisfactory fit of the two-factor structure in our sample $\chi^2(12) = 77.67$, $p > .001$; RMSEA = 0.11 [0.09; 0.14]; CFI = 0.92; TLI = 0.87, $\omega_{total} = 0.99$, $\omega_{hierarchial} = 0.54$.

Accelerometer-Based Physical Activity

Accelerometer-based PA was assessed via accelerometer-based sensors (Move 4, movisens GmbH). The sensor assesses PA of a person based on kinematic data in three dimensions and atmospheric air pressure. This allows estimating the amount of PA through step counts and PA of different intensities for a specified time based on validated algorithms (Anastasopoulou et al., 2012, 2014). Participants wore the sensors for 7 consecutive days on the right hip. According to common guidelines, data was included, if at least 4 days with at least 8 h of wearing time were recorded (Donaldson et al., 2016; Trost et al., 2005). PA was defined according to the position statement of the American College of Sports Medicine (Garber et al., 2011) as any activity that exceeds 1.99 metabolic equivalents (MET), with light intensity PA requiring 2.0–2.9 METs, moderate 3.0–5.9 METs, and vigorous 6.0 METs, and included as average time spent in PA in minutes per week. We also collected average time spent in sedentary behavior (defined as < 2.0 MET) in minutes per week and average number of steps per day for exploratory analyses.

Self-Reported Physical Activity

Self-reported PA in minutes per week was assessed using the self-report PA-index (including job transportation, walking, cycling, physically demanding housework) of the Physical Activity, Exercise, and Sport Questionnaire (BSA questionnaire; Fuchs et al., 2015). Participants specified type, duration (min), and frequency (days/last 4 weeks) of PA in the last 4 weeks which is then averaged to a total score of PA in min/week.

Control Variables

Age and gender were assessed as part of the demographic questionnaire administered at the same measurement as outcomes and predictors. Incidence of COVID-19 was included from a German infection database (Destatis, 2021). COVID-19 incidence was defined as confirmed COVID-19 cases in the last 7 days per 100,000 residents at the first day of assessment.

Sample Size

The sample size of the study was determined a priori based on the primary hypothesis of the main randomized controlled trial (Wolf, Seiffer, Zeibig, Welkerling, Bauer, et al., 2021; Wolf et al., 2024) resulted in a minimum of $N = 375$. The power analysis for the linear regression model in this report was conducted using G*Power, assuming an medium effect size $F^2 = 0.15$, $\alpha = 0.05$, $1 - \beta = 0.95$, and 14 predictors and resulted in a required sample size of $n = 194$.

Statistical Methods

Data preparation and statistical analyses were carried out using the statistical analysis software R version 4.1.1 (2021-08-10) and RStudio (2022.07.1+554 "Spotted Wakerobin" Release). The analytic code is provided at https://osf.io/5rcuz/.

Descriptive Statistics

Descriptive statistics, including frequencies (*n*) and percentages (%), were generated for categorical variables; means (*m*) and standard deviations (*SD*) were generated for continuous variables.

Data Transformation

Numerical data was *z*-standardized to ensure comparability of scales in the model. Self-reported PA with a total of > 55,000 min/week on the PA Index of the BSA questionnaire was manually checked for plausibility. Two values were excluded in the PA Index because the values seemed unrealistic. For accelerometer data, data with at least 4 valid days of measurement was included. To ensure the comparability of the results, we computed a mean activity/step/sedentary time value of the valid days, respectively. For light

PA, moderate to vigorous PA, and sedentary behavior, we multiplied the result by seven, to obtain a measure of minutes/week. All values were checked for normality of distribution, visually and based on skewness. Self-reported PA and incidence were log-transformed, due to the skewness of data. Histograms of the distributions are presented in Electronic Supplementary Material, ESM 1, and Figure E1.

Data Analysis

Data analysis of the primary outcome was performed using structural equation modeling in R, using the *lavaan* package (Rosseel, 2012). We used maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled test statistic (Rosseel, 2012).

We employed a multiple linear regression model to assess the contributions of accelerometer-measured light (X1), moderate to vigorous PA (X2), and self-reported PA (X3), as well as with FoC, separated into the subscales of fear of disease (X4) and fear of consequences (X5). We further included age (C1), gender (C1), and 7-day incidence at the time of assessment (C3) as covariates. Age and gender have been reported to be associated with depressive symptoms (Bonful & Anum, 2019). The regression model further included interactions of PA with FoC. It was specified as $Y = \beta_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 X_1 + \beta_5 X_2 + \beta_6 X_3 + \beta_7 X_4 + \beta_8 X_5 + \beta_9 X_1 X_4 + \beta_{10} X_2 X_4 + \beta_{11} X_3 X_4 + \beta_{12} X_1 X_5 + \beta_{13} X_2 X_5 + \beta_{14} X_3 X_5 + \varepsilon$, where Y represents depressive symptoms measured by the PHQ-9 score. Prior to interpretation, assumptions of the linear model were examined using the Global Validation of Linear Models Assumptions function (Peña & Slate, 2006). In addition, we performed a visual inspection of scatter plots (residuals vs. fitted, residuals Q-Q plot, square root of residuals vs. fitted values, residuals vs. leverage) and examined potential multicollinearity, using the variance inflation factor (VIF) on each included term.

We performed two planned sensitivity analyses, using alternative sensor-derived activity measures, that is, sedentary behavior and steps, instead of accelerometer-measured light and moderate to vigorous PA. These outputs, derived from the same algorithm as the original measures, were analyzed to verify the robustness and consistency of our findings.

Results

Sample Characteristics

Out of 1,284 interested individuals screened for eligibility, 675 participated in the initial interview, 600 participated in the diagnostic interview, and 401 were eligible and agreed to participate in the study, resulting in data of 401 participants to be included in the cross-sectional analysis. One participant ended the participation of the study after the first assessment, resulting in 400 participants being enrolled in the further protocol. The complete flow of participants with reasons for exclusion and termination of participation is represented in Figure 1. Of the 401 participants included in this report, 71.0% were female, with a mean age of m = 42.08 years (SD = 13.26). According to the DSM-5 interview, the sample included patients with a current episode of major depressive disorder (n = 289, 72.07%), any anxiety disorder (n = 83, 20.70%), PTSD (n = 7, 17.96%), or insomnia (n = 81, 20.20%). 25% of participants (n = 89) had at least one other inclusion diagnosis, and 49% (n = 196) had at least one additional psychiatric diagnosis not included in the study criteria. The mean score of depressive symptoms was m = 13.77 points on the PHQ-9 scale (SD = 4.99). Sample characteristics are represented in Table 1. A correlation matrix of all variables included in the models is presented in ESM 1, Table E1.

Missing Values

After data collection, we observed 3.0% of missing data on scale level. In total, 398 out of 401 records (97.0%) contained a missing value. The MCAR (Missing Completely at Random) test indicated that the missing data were random (p = 1.000). We used multiple imputations to create and analyze 10 imputed datasets. Incomplete variables were imputed based on the computed scale values under conditional specification. The multiple imputation model included all variables that were later included in the analysis. All further analyses were then conducted on the 10 imputed datasets and results were pooled according to Rubin's rules (see Rubin, 1987). Depressive symptoms were not significantly different between the group with missing data compared to the group with complete data (t = 0.14576, df = 12.612, p = .886).

Primary Analysis

Diagnostic tests indicated that our model met all necessary assumptions. The overall fit of the model was statistically significant $F(15,\ 377.13) = 1.89$, $p = .022$. No significant interactions were found within the model. The results indicated significant main effects of self-reported PA ($\beta = -0.15$, $t = -2.73$, $p = .007$) and fear of the consequences of COVID-19 ($\beta = 0.12$, $t = 2.33$, $p = .020$) on depressive symptoms. All results are reported in Table 2.

Sensitivity Analyses

Diagnostic tests for the sensitivity analysis also confirmed that the models met all necessary assumptions. In addition, VIF < 2 for all included terms indicated no multicollinearity. The model examining sedentary behavior as a predictor resulted in a significant overall fit, $F(12,\ 383.15) = 2.05$,

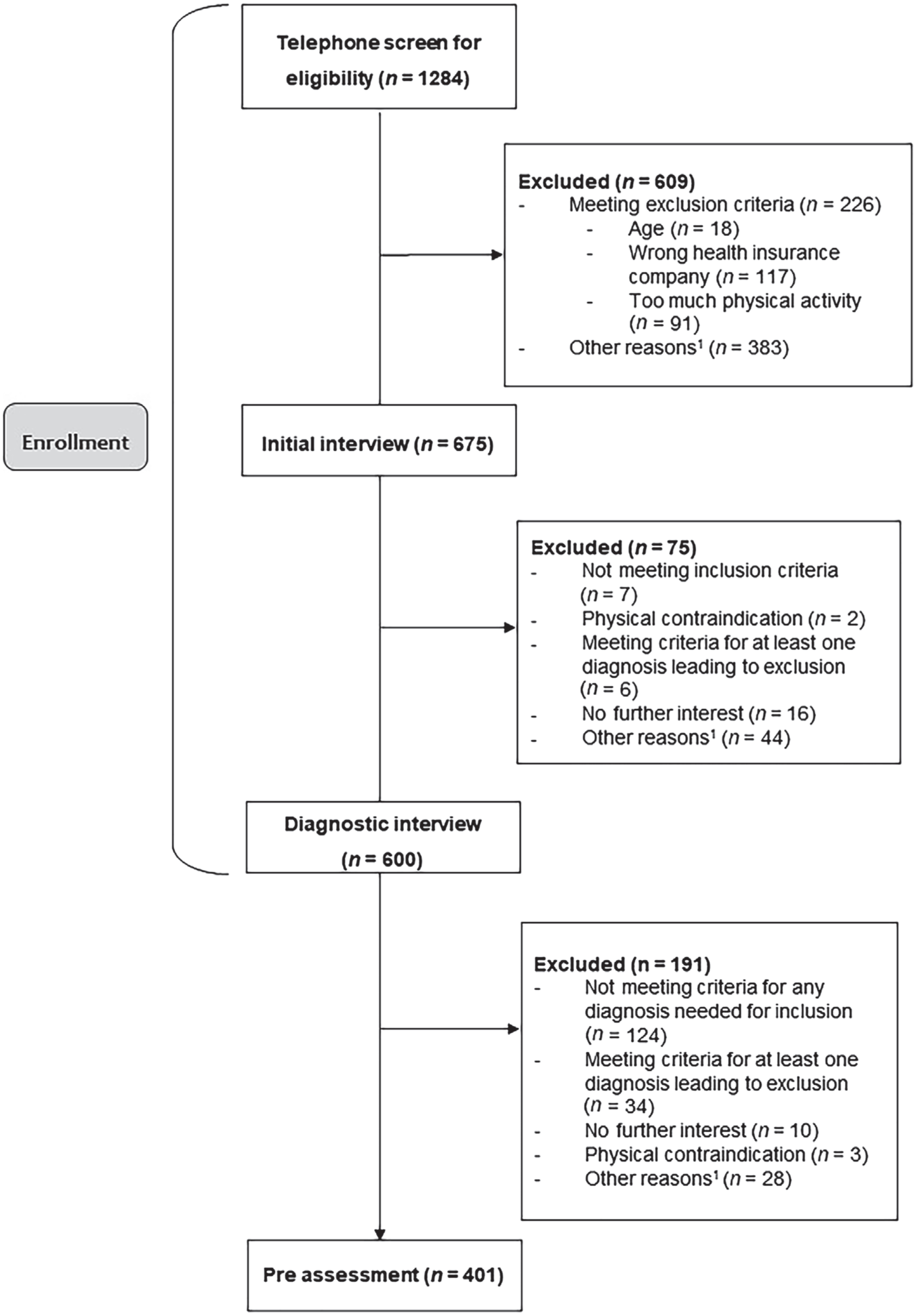

Figure 1. Flow of participants through the study, up to the point of the first assessment included in this paper.

p = .044 (Table 3). No significant interactions were identified. The results revealed significant main effects of self-reported PA (β = −0.17, t = −3.14, p = .002) and fear of the consequences of COVID-19 (β = 0.13, t = 2.35, p = .019) on depressive symptoms. Additionally, the model including steps as a predictor demonstrated a statistically significant overall fit, F(12, 382.98) = 2.16, p = .046 (Table 4). No significant interactions were observed. The results indicated significant main effects of self-reported PA (β = −0.16, t = −2.87, p = .004) and fear of the

Table 1. Description of the sample

	N (%)	Mean (*SD*)	Missing
Age (years)		42.08 (13.26)	1%
Gender			
Men	106 (26.43)		0%
Women	286 (71.32)		0%
Diverse	9 (2.24)		0%
Mental health			
Depressive symptoms		13.77 (4.99)	0.25%
Physical activity, self-report			
Minutes/week		372.83 (619.99)	4.49%
Physical activity, accelerometer-measured			
Minutes/week spent in moderate to vigorous PA		332.07 (219.96)	11.47%
Minutes/week spent in at least light PA		465.96 (198.98)	11.47%
Minutes/week spent in sedentary behavior		4826.97 (766.36)	11.47%
Steps taken per day		6676.44 (2974.26)	11.47%
Fear of COVID-19			
Fear of disease		6.84 (3.68)	1%
Fear of consequence		4.28 (3.21)	1%
Total score		11.12 (5.67)	1%
COVID-19 related information			
Incidence rate		450.32 (573.34)	0%

Note. Mean and standard deviation (*SD*) reported for continuous variables, number (*N*), and percent for categorical variables. MET = metabolic equivalent of tasks. Physical activity intensity classified according to Garber et al. (2011).

consequences of COVID-19 ($\beta = 0.12$, $t = 2.28$, $p = .023$) on depressive symptoms.

Discussion

Contrary to our hypotheses, we did not find an interaction effect of PA and FoC in association with depressive symptoms. In all our specified models, anxiety concerning the negative consequences of the COVID-19 pandemic was significantly, positively associated with depressive symptoms. In addition, a significant negative association between self-reported PA and depressive symptoms emerged in all models. However, regarding PA measured by accelerometers, neither the time spent in light PA, nor moderate to vigorous PA, nor sedentary behavior, nor the number of steps taken per day was associated with depressive symptoms in any model.

In our clinical outpatient study, we discovered that the relationship between FoC and depressive symptoms was mainly linked to the subscale consequence anxiety, which comprises of pandemic-related concerns such as missing work or school due to COVID-19, financial strain, and worries about long-term job prospects and the economy. This aligns with prior research indicating that individuals in isolation or quarantine, experiencing financial difficulties or perceived job instability are more likely to experience depressive symptoms (Butterworth et al., 2012; Guan et al., 2022; Henssler et al., 2021; Kim & von dem Knesebeck, 2016). This might have been exacerbated by patients experiencing a negative emotional bias, common in mental disorders (Li & Li, 2022; Roiser et al., 2012). In a negative attentional bias, negative representations of the past are increasingly remembered, even despite the availability of new, positive information (Everaert et al., 2018). Therefore, patients reporting higher concerns about the consequences of COVID-19 might have focused more on anticipated negative outcomes rather than the actual risk of infection or the outcomes they realistically experienced. This is supported by the fact that unlike the anxiety of being infected with COVID-19, the anxiety of the consequences of COVID-19 was not connected to the realistic risk of contracting the virus in our sample, since it was not associated with COVID-19 infection rates during the assessment period.

We reported a negative association between self-reported PA and depressive symptoms, which has been routinely reported before COVID-19 in both cross-sectional (Schuch et al., 2017) and prospective studies (Schuch et al., 2018), and after the onset of the pandemic (Seiffer et al., 2023; Wolf, Seiffer, Zeibig, Welkerling, Brokmeier, et al., 2021). This association did not hold when measuring PA with accelerometers. In average, participants' accelerometer data indicated roughly twice as much PA compared to the self-report data. This is unusual, since previous evidence suggests that participants commonly overestimate PA

Table 2. Primary model: The effects of fear of COVID-19 and physical activity on depressive symptoms

	β	*SE*	*t*	*df*	*p*-value
Intercept	0.03	0.06	0.49	381.07	.626
Gender [ref.: female]					
Male	−0.12	0.12	−1.04	379.77	.301
Diverse	−0.07	0.34	−0.21	363.87	.833
7-day incidence rate (per 100,000 residents)	0.03	0.05	0.53	379.85	.597
Age (years)	−0.09	0.05	−1.83	369.05	.069
Physical activity (min/week)					
LPA (< 3 MET)	−0.05	0.06	−0.8	115.66	.424
MVPA (≥ 3MET)	−0.04	0.06	−0.72	222.44	.473
Self-report PA (BSA-F)	−0.15	0.05	−2.73	305.81	.007*
Fear of COVID-19 (PAS)					
Fear of consequences	0.12	0.05	2.33	380.76	.020*
Fear of disease	0.00	0.05	−0.07	380.66	.945
Interaction terms					
Fear of consequences × LPA	0.09	0.06	1.48	281.26	.141
Fear of consequences × MVPA	−0.04	0.06	−0.6	260.4	.552
Fear of consequences × Self-report PA	−0.05	0.05	−0.9	260.05	.37
Fear of disease × LPA	−0.08	0.07	−1.17	173.61	.243
Fear of disease × MVPA	0.04	0.06	0.7	281.87	.482
Fear of disease × Self-report PA	0.03	0.06	0.51	234.05	.608
Fit measures					
R^2 = 0.08					
R^2 (adjusted) = 0.04					
$F(15, 377.13) = 1.89$, $p = .022$					

Note. All numeric variables were *z*-standardized before inclusion in the model. LPA/MVPA = light/moderate to vigorous physical activity (min/week), assessed through accelerometer data; MET = metabolic equivalent of tasks; BSA-F = Leisure-Index of the Physical Activity, Exercise, and Sport Questionnaire (Fuchs et al., 2015); PAS = Pandemic Anxiety Scale (McElroy et al., 2020); *SE* = standard error; *df* = degrees of freedom; Outcome = depressive symptoms (PHQ-9; Kroenke et al., 2001; Spitzer et al., 1999). $*p < 0.05$.

(Fiedler et al., 2023) and underestimate sedentary time (Dyrstad et al., 2014) in self-report questionnaires, compared to accelerometer measurements. The sensors might have been more sensitive to movement than expected or the underestimation of self-reported PA might be due to recall bias and an underestimation of intensity or duration, as self-reported PA must be consciously remembered by the participants (Fransson et al., 2008; Skender et al., 2016). Salience effects of wearing the accelerometer might have led to more PA during the 1-week measuring period compared to the 4-week recall in the self-report measures (Burchartz et al., 2020). In the self-report data, patients might also not have considered the PA from some daily activities, which the accelerometer categorized as PA based on the applied algorithm. Consequently, in our sample the relationship of PA with depressive symptoms does not seem to be solely reliant on a dose-response relationship, as reported in previous studies in the general population (Kim et al., 2018), but might rather be due to consciously engaging in PA to regulate affective states. Using PA as an affect regulation strategy, has been associated with a positive experience of PA, whereas lack of this PA-specific affect regulation has been associated with feeling agitated and tense (Sudeck et al., 2018). First cross-sectional evidence during the COVID-19 pandemic indicates that knowing to use PA as an adaptive coping skill for negative affect, is associated with fewer symptoms of depressive disorders (Rösel et al., 2022). In an RCT, employing a supervised PA intervention combined with psychosocial components for a sample with mental illnesses, increases in PA-specific affect regulation were associated higher reductions in global symptom severity (Zeibig et al., 2023).

In our study, we shed a new light on the association of the concerns about the negative consequences of the COVID-19 pandemic with depressive symptoms in a diverse sample with a single or comorbid clinical diagnosis of major depressive disorder, insomnia, panic disorder, agoraphobia, or PTSD. Strengths include the large clinical outpatient sample, verification of the clinical diagnosis through structured clinical interviews by mental health professionals, assessment of all measures on clinically valid rating scales, collection and anonymization of data by an external institution responsible for data management and blinding of the participants to the research questions investigated in this report, reducing

Table 3. Sensitivity analysis: The effects of fear of COVID-19 and sedentary behavior on depressive symptoms

	β	*SE*	*t*	*df*	*p*-value
Intercept	0.04	0.06	0.66	384.5	.511
Gender [ref.: female]					
Male	−0.13	0.12	−1.13	381.11	.261
Diverse	−0.18	0.34	−0.53	357.76	.594
7-day incidence rate (per 100,000 residents)	0.03	0.05	0.5	384.5	.615
Age (years)	−0.1	0.05	−2.02	380.52	.044*
Physical activity/Sedentary behavior (min/week)					
Sedentary behavior	−0.02	0.05	−0.29	328.54	.769
Self-report PA (BSA-F)	−0.17	0.05	−3.14	307.02	.002*
Fear of COVID-19 (PAS)					
Fear of consequences	0.13	0.05	2.35	382.54	.019*
Fear of disease	0.00	0.05	−0.01	383.37	.991
Interaction terms					
Fear of consequences × Sedentary activity	0.01	0.05	0.24	339.81	.812
Fear of consequences × Self-report PA	−0.03	0.05	−0.62	323.73	.535
Fear of disease × Sedentary activity	0.01	0.06	0.2	197.83	.844
Fear of disease × Self-report PA	0.01	0.05	0.12	305.87	.907
Fit measures					
R^2 = 0.06					
R^2 (adjusted) = 0.03					
$F(12, 383.15) = 2.05, p = .044$					

Note. All numeric variables were *z*-standardized before inclusion in the model. PA = physical activity; BSA-F = Leisure-Index of the Physical Activity, Exercise, and Sport Questionnaire (Fuchs et al., 2015); PAS = Pandemic Anxiety Scale (McElroy et al., 2020); *SE* = standard error; *df* = degrees of freedom; Outcome = depressive symptoms (PHQ-9; Kroenke et al., 2001; Spitzer et al., 1999). $*p < 0.05$.

Table 4. Sensitivity analysis: The effects of fear of COVID-19 and steps on depressive symptoms

	β	*SE*	*t*	*df*	*p*-value
Intercept	0.03	0.06	0.56	385.27	.574
Gender [ref.: female]					
Male	−0.13	0.12	−1.11	383.62	.268
Diverse	−0.15	0.34	−0.45	371.4	.652
7-day incidence rate (per 100,000 residents)	0.03	0.05	0.51	385.29	.608
Age (years)	−0.1	0.05	−1.93	378.94	.054
Physical activity					
Steps (*n*)	−0.05	0.05	−0.84	215.74	.402
Self-report PA (BSA-F, min/week)	−0.16	0.05	−2.87	295.16	.004*
Fear of COVID-19 (PAS)					
Fear of consequences	0.12	0.05	2.28	384.04	.023*
Fear of disease	0.00	0.05	−0.01	383.37	.991
Interaction terms					
Fear of consequences × Sedentary activity	−0.01	0.05	−0.27	302.37	.786
Fear of consequences × Self-report PA	−0.03	0.05	−0.58	317.19	.561
Fear of disease × Sedentary activity	−0.03	0.05	−0.57	352.6	.567
Fear of disease × Self-report PA	0.02	0.06	0.3	281.25	.761
Fit measures					
R^2 = 0.07					
R^2 (adjusted) = 0.04					
$F(12, 382.98) = 2.16, p = .046$					

Note. All numeric variables were *z*-standardized before inclusion in the model. PA = physical activity; BSA-F = Leisure-Index of the Physical Activity, Exercise, and Sport Questionnaire (Fuchs et al., 2015); PAS = Pandemic Anxiety Scale (McElroy et al., 2020); *SE* = standard error; *df* = degrees of freedom; Outcome = depressive symptoms (PHQ-9; Kroenke et al., 2001; Spitzer et al., 1999). $*p < 0.05$.

potential bias. Data was collected multicentric over a large range of time points with different incidence rates and enforced restriction during the COVID-19 pandemic in Germany, covering and reflecting the dynamic development of the pandemic. In addition, PA was assessed both, in self-report and through accelerometer data, providing us with a comprehensive picture of PA behavior.

The present study also has some limitations. Since we focused on a sedentary sample, we could only investigate the association and interaction effects of everyday PA. Previous interventional studies for patients with mental illnesses mostly focused on exercise interventions, which have been reported to yield the same effects as pharmacotherapy for depressive symptoms (Heissel et al., 2023; Morres et al., 2019; Schuch et al., 2016). Excluding patients with high levels of exercise therefore limits the generalization of our findings depending on the domain of PA and might be associated with smaller associations of PA with depressive symptoms in our study (Lopes et al., 2023; White et al., 2017).

Our dataset used for the imputation had a high percentage of missing data, with 97% of datasets containing a missing value. This was primarily due to missing demographic information, as 32% of participants did not report their working hours per week, and 69% did not provide information on their sick leave in the past year. Since no other variable had more than 11% of missing data, the overall missing data was 3%. Additionally, the MCAR test indicated that the missing data were random, meaning there is no systematic pattern or bias in the missing values. This suggests that the missing data do not introduce significant bias into the analysis. As a result, we can assume that the impact of missing data on the validity and generalizability of our findings is minimal, as the missingness is unlikely to distort the relationships between variables.

The accelerometer data contributed notably to the missing values in the analyses, with 11% of data missing. On the one hand, this was due to organizational and technical challenges, such failure of the sensors or as participants being unable to collect the accelerometers during the required assessment period. On the other hand, patients with depression are more likely to be non-compliant to medical treatment (DiMatteo et al., 2000). This might have also applied to our participants: those with more pronounced depressive symptoms were also less compliant when it comes to collecting, wearing, and returning accelerometers, leading to attrition. However, there was no significant difference in depressive symptoms between those with and without missing data, making attrition bias less likely.

Furthermore, accelerometer-based PA assessments have recognized limitations in accurately capturing certain types of physical exercise, such as strength training, swimming, and cycling. However, given that the accelerometer data indicated higher levels PA compared to participants' self-reported data, this limitation does not appear to have had a significant impact on our findings.

Furthermore, the use of non-waterproof activity sensors may have limited our ability to capture all PA performed by participants, particularly water-based activities such as swimming. However, given that the accelerometer data indicated higher levels of PA compared to participants' self-reported data, this limitation does not appear to have had a significant impact on our findings.

In contrast to the original literature, the two-factor structure of the FoC scale shows only an acceptable fit, which somewhat limits the strength of its validity and reliability.

Lastly, our study relies on cross-sectional data, meaning that the associations we have reported cannot provide us with insights into the causal relationships between the variables. It is imperative that further prospective studies will be conducted, where data is collected over an extended period, enabling to better explore and analyze the causal dynamics at play.

Conclusion

Our research indicates that in this clinical outpatient sample, PA does not act as a moderator between FoC and depressive symptoms. However, we observed two distinct associations: first, a direct link between FoC consequences and depressive symptoms, and second, a separate association between self-reported PA and depressive symptoms. These findings highlight the importance of addressing individuals' fears related to the pandemic's repercussions and emphasize the need to develop effective coping strategies. Although PA does not mitigate the FoC consequences, it does demonstrate positive effects on reducing depressive symptoms. Hence, promoting PA remains crucial as a preventive and intervention strategy.

Electronic Supplementary Materials

The following electronic supplementary material is available with this article at https://doi.org/10.1027/2512-8442/a000178

ESM 1. Correlation matrix; Histograms of the distributions of variables.

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Conflict of Interest
The authors declare that they have no competing interests.

Publication Ethics
The study has been registered at the German Clinical Trial Register (ID: DRKS00024152, 05/02/2021) and has been approved by the local ethics committee for medical research at the University of Tübingen (ID: 888/2020B01, 02/11/2020). Written informed consent was obtained from all participants in the study.

Authorship
B.S., S.W., J-M.Z., A.L.F., L.Z., L.S., A.R-M., G.S., T.E., conception, study design; B.S., original draft; S.W., J.-M.Z., B.S, J.W., T.S., A-K. F., study organization, recruitment and assessment, data management; A.L.F., L.Z., representatives of two health insurance companies, providing the routine data for the health economics analysis and supported patient recruitment; E.H., M-M.G., K.T., T.N., T.E., data management, data handling; B.S., statistical analysis; B.S., S.W., K.T., results – interpretation. All authors have read and agreed to the final version of this manuscript. All authors contributed to the revision of the final study protocol.

Open Science
Open Code: The analytic code is provided at https://OSF.IO/5RCUZ (Wolf et al., 2025).
Open Data: Access to data will be provided to anyone legitimately interested in it. Participants gave informed consent for their data to be published after deidentification (except for the routine/administrative data from the statutory health insurers).

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