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ORIGINAL PAPER

Mindfulness in Orthopedic Rehabilitation: Can the Use of a Mindfulness Diary Positively Influence the Therapeutic Outcome of Orthopedic Rehabilitation?

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Abstract

Objectives Mindfulness is a proven therapeutic practice for reducing anxiety, depression, and chronic pain, which are factors that influence the success of hip/knee replacement surgery. The present study aimed to investigate the effect of mindfulness bibliotherapy in rehabilitation on anxiety, depression, and health status. The objective was to determine whether there is a connection between the level of mindfulness before rehabilitation and the health status after rehabilitation.

Method Ninety-three patients ($M_{age} = 63.34$, $SD = 10.49$) from an outpatient rehabilitation clinic participated in the study. Forty-three patients were included in the mindfulness bibliotherapy group, and 45 were included in the waitlist control group. Anxiety, depression (both measured with the Hospital Anxiety and Depression Scale), quality of life (measured with the SF-36), and walking ability (measured with the Timed "Up and Go"-Test), as well as orthopedic measurements and dispositional mindfulness, were measured before and after the intervention. A follow-up measurement was carried out 4 weeks after the end of rehabilitation.

Results A significant interaction effect between test time (pre- and post-test) and group (mindfulness bibliotherapy and waitlist control group) was detected for the measurement of Anxiety. The Anxiety score decreased in the intervention group from the pre-test to the post-test and the follow-up. In addition, the five subscales of dispositional mindfulness, age, and gender predicted mental health status (measured with the mental health scale of the SF-36) at the end of rehabilitation, $F(7, 85) = 2.52$, $p = 0.021$, even though no individual predictor reached significance.

Conclusions Mindfulness diary practice can be a helpful therapy approach to support patients and to regain the goal of full capacity for working life and everyday life after surgery. Further studies need to investigate more intensively the relationships between the mode of action of mindfulness interventions in the setting of orthopedic rehabilitation.

Preregistration This study was preregistered in OSF (https://osf.io/4tmwq/).

Keywords Mindfulness · Rehabilitation · Orthopedic · Joint surgery

In 2021, over 300,000 joint replacement operations were performed on knee and hip joints in Germany despite the existing COVID-19 pandemic. An artificial joint, an endoprosthesis, is implanted to replace a diseased joint wholly or partially (Endoprothesenregister Deutschland, 2022). After successful treatment, follow-up rehabilitation (AHB) is usually carried out in an outpatient (the patient received the treatment but did not spend the night there) or inpatient rehabilitation clinic to restore health. The therapy concept includes functional, educational, psychotherapeutic, and psychosocial aspects. Depending on the funding agency and indication, there are different specifications for the content of the rehabilitation measure. With the rehabilitation therapy standards for the various indication groups, the German Pension Insurance has developed a treatment protocol based on scientific findings to improve the quality of care. In addition to exercise therapy and physiotherapeutic measures to improve joint mobility and function, as well as training of daily living (ADL training), relaxation methods and psychological interventions are also part of the therapy plan

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for knee and hip total endoprosthesis (TEP) care (Deutsche Rentenversicherung, 2020). Illness, pain, and rehabilitation are conceptualized as a complex interaction of social, biological, and psychological factors (Bhatia et al., 2020; Gatchel et al., 2007).

The relevance of the biopsychosocial model in orthopedic research has been shown in several studies: The diagnosis of depression, together with other factors, represents an increased risk of reoperation for total knee arthroplasty (Walter et al., 2021). Perceived pain in gonarthrotic patients is influenced by psychological and psychosocial factors (Eberly et al., 2018). In addition, despite extensive post-operative therapies, patients are not satisfied with the outcome in approximately 20% of cases (Gunaratne et al., 2017). Fear, pain, and long-term functional limitations can cause this dissatisfaction.

Regarding the mental state of the patients before the surgery, the results showed that the mental state before the operation already influences the pre-operative state of health of the affected joint and the general condition (Lavernia et al., 2015). At the same time, it plays a decisive role in the success and course after the intervention (Benditz et al., 2017; Khatib et al., 2015). Furthermore, in knee arthroplasty patients, higher pre-operative pain amplification is associated with increased post-operative pain. A correlation between poor pre-operative mental health and long-term lower post-operative functioning can be established (Vissers et al., 2012). Pre-operatively measured depression and anxiety in patients usually means an increased risk of complications after surgery, as well as lower functional improvements (La et al., 2020). A review of pre-operative psychological factors in knee TEP surgery written in 2016 showed that increased anxiety and pre-operative pain were the most significant factors indicating poorer outcomes in TEP surgery (Alattas et al., 2017). Kinesiophobia, an excessive irrational fear of movement and physical activity, is also a negative influencing factor (Filardo et al., 2017). Low levels of depression and high mental and physical health scores are associated with significant improvements in quality of life after surgery (Moghtadaei et al., 2020). A study published in 2020 identified a group wherein psychological markers predicted short- and long-term satisfaction after surgery (Xu et al., 2020). In addition, hospital stays lasted 1 day longer in dissatisfied patients than satisfied patients (Ali et al., 2017).

Apart from these results in inpatient, there are also long-term effects of pre-operative anxiety and depression. These include functional limitations and poorer quality of life even 1 year after knee TEP (Utrillas-Compaired et al., 2014), as well as higher dissatisfaction even months after surgery (Duivenvoorden et al., 2013). However, studies on psychological interventions in outpatient rehabilitation centers after orthopedic surgery are lacking. Nevertheless, they are essential because they investigate the relevance of psychological aspects of the healing process.

To achieve the long-term success of a joint operation, mindfulness training, which involves being aware of the present moment (Kabat-Zinn, 2013), could supplement previous therapy methods. Targeted mindfulness training is widely used in the form of standardized procedures such as Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT), whose effectiveness has been confirmed by numerous studies and meta-analyses (Abbott et al., 2014; Fjorback et al., 2011; Grossman et al., 2004). These manuals are used in therapy for stress (Chang et al., 2004), anxiety (Grossman et al., 2014), depression (Strauss et al., 2014), and pain patients (Bakhshani et al., 2016). These psychological factors impact the long-term success of knee and hip surgery. Elevated anxiety levels represent an increased risk of dissatisfaction after surgery (Alattas et al., 2017); in turn, the lower the depression level and the better the mental constitution, the higher the improvement in quality of life (Moghtadaei et al., 2020). However, it remains unknown whether the proven effects of targeted mindfulness training could also occur specifically in orthopedic rehabilitation and thus improve the success of therapy after knee/hip joint replacement.

While the MBSR program, a standardized mindfulness intervention, may not be practical for everyday use in a rehabilitation clinic due to its high time and financial costs, the emergence of "self-help" methods has provided a more feasible alternative. One such method is bibliotherapy, a therapy presented as a book or workbook, which has shown effectiveness in treating various conditions. Notably, studies have found that "self-help" interventions can be as effective as "face-to-face" ones. This underscores the practicality and potential of bibliotherapy in a rehabilitation setting.

A viable solution could be bibliotherapy incorporating mindfulness elements, as demonstrated by Tavallaei et al. (2018). This uses a written-down version of the MBSR program, performed independently by the study participants. Included are various mindfulness elements, for example, mindful sitting, walking, and eating, as well as loving-kindness meditation (Tavallaei et al., 2018). The mode of action and concept of this mindfulness bibliotherapy would be a valuable practice for the rehabilitation of knee and hip surgery to ensure long-term patient satisfaction. In addition, implementing such a form of therapy into the existing daily therapy routine is relatively easy, as no additional therapist capacities are needed. For this purpose, the period of the intervention would have to be compressed to a duration of 3 to 4 weeks to establish compatibility with the duration of rehabilitation.

The study presented here aimed to investigate the effectiveness of a mindfulness bibliotherapy intervention in orthopedic rehabilitation after knee/hip joint replacement.

With the help of mindfulness bibliotherapy adapted to the duration of rehabilitation, the therapy success of patients after knee/hip joint surgery should be improved regarding anxiety and depression, physical function, and the state of health, as well as motoric aspects. Those outcomes were chosen because they represent biological, physical, and social aspects investigated in the framework of the biopsychosocial model. The variety of measurements gives the possibility to obtain a more holistic view of the effectiveness of the intervention. The selection of tests used for this purpose was based on comparable studies (Alattas et al., 2017; Vissers et al., 2012; Xu et al., 2020). For the intervention, we used the workbook on MBCT (Teasdale et al., 2020) because MBCT was primarily established to reduce anxiety and depression. Similar to the study by Tavallaei et al. (2018), it includes mindfulness elements. In addition to the previously mentioned measures, dispositional mindfulness was assessed due to its inverse relationship with psychopathological symptoms such as depression (Tomlinson et al., 2018). Furthermore, the effect of a mindfulness intervention might depend on dispositional mindfulness: In a study with university students, the anxiety level decreased only in those individuals with a high level of dispositional mindfulness (Sousa et al., 2021).

The following hypotheses were formulated: Referring to the study by Tavallaei et al. (2018), we hypothesized that mindfulness bibliotherapy would positively influence the rehabilitation process in terms of joint mobility (measured with knee- and hip functionality scores), motor function (measured with the Timed "Up and Go"-Test), and quality of life (measured with the SF-36) (Hypothesis 1). According to the evidence on the effectiveness of mindfulness training in the treatment of anxiety (Grossman et al., 2014) and depression (Strauss et al., 2014), an improved emotional state (e.g., lower anxiety and depression, measured with the Hospital Anxiety and Depression Scale) was hypothesized after implementation of the intervention (Hypothesis 2). In addition, higher levels of mindfulness, as measured by the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006), were expected to correlate with post-rehab health status (Hypothesis 3) positively. Exploratory regression analysis was conducted using the five different subscales of the FFMQ and two demographic variables (gender and age) (Hypothesis 4).

Method

Participants

During the recruitment period from mid-January to early April 2022, 93 patients from an outpatient rehabilitation center in Germany (ZAR Regensburg) were recruited for the study. Individuals undergoing rehabilitation for knee or hip TEP who met the following inclusion criteria were included: at least 18 years of age and sufficient reading and comprehension ability. All patients who met the inclusion criteria were automatically scheduled to receive information about the study on the first rehabilitation day and could decide whether to participate. All participants ($M_{age} = 63.34$ years, $SD = 10.49$) volunteered to participate in the study and signed an informed consent form. The cause of rehabilitation was knee joint surgery in 46.20% of cases and hip joint surgery in 53.80%. Of the 43 patients with knee surgery, 53.50% were female and 46.50% male ($M_{age} = 64.30$). 44.00% of the 50 hip surgery patients were female and 56.00% male ($M_{age} = 62.52$).

For Hypotheses 1 and 2, the appropriate number of participants was calculated using G*power (Faul et al., 2007). A small to medium effect size has been chosen. With an effect size of $f = 0.15$, a power of $1 - \beta = 0.80$, and an alpha standard probability of 0.05, a power analysis for the ANOVA of our main Hypotheses 1 and 2 with the within-subjects factor time of measurement (pre and post intervention) and one between-subjects factor group (control and intervention) factor resulted in a required sample size of $n = 90$. The sample sizes were calculated for two measurement points as it was preregistered. However, because we got the possibility to analyze the data at a follow-up measurement after 4 weeks, we conducted 3 (pre-, post, and follow-up) *2 (intervention, control group) analyses of variance for the variables except for the Timed "Up and Go"-Test (pre and post). For this, the required sample size was $n = 74$. For Hypothesis 3, two linear regressions with seven predictors (five FFMQ scales, sex, and age) and the criteria mental and physical health at post-test, a small to moderate effect size of $f = 0.15$, a power of $1 - \beta = 0.80$, and an alpha standard probability of 0.05 resulted in a required sample size of $n = 80$.

Procedure

The intervention takes the form of mindfulness bibliotherapy. Bibliotherapy is a form of therapy intended to lead to recovery with the help of a reading. Based on the MBCT workbook by Teasdale et al. (2020), the workbook was compressed to 24 days and tailored to outpatient rehabilitation after knee and hip surgery. To meet the scientific standards of a mindfulness intervention, the created intervention was reviewed by both a practicing mindfulness teacher and an experienced mindfulness researcher and mindfulness mediation teacher. The book content can be obtained from the authors. Patients receive this "self-help" book on the first day of rehabilitation and work through it for 24 days; see supplementary material. The book contains both active exercises and written tasks. The active exercises include,

for example, mindful breathing and walking, as well as a mindfulness eating exercise. The practical exercises are also reflected in writing.

The study was a randomized controlled trial. Participants were randomly assigned to the intervention group (IG) or control group (CG). Patients in the mindfulness intervention received the baseline questionnaires and the mindfulness workbook during the informational interview. The questionnaires were completed and handed in on the same day. Intervention also began on the first day of rehabilitation and was carried out parallel to standard rehabilitation. In the case of assignment to the control group, only the questionnaires were handed out, and standard rehabilitation was carried out. In both cases, the Timed "Up and Go"-Test was performed during the first day of the rehabilitation. On the last day of rehabilitation, the patients received the questionnaires for the second measurement, completed on-site; the motor function test was also completed a second time. If study-related questions arose among the participants during or after the study period, personal contact with the study management was always possible. During the study, there was also the possibility of a follow-up measurement 4 weeks after rehabilitation, which deviates from the preregistration. The follow-up was carried out for the HADS, SF-36, FFMQ, and KOOS/HOOS.

Measures

The data collection of all parameters took place at the measurement points at the beginning of rehabilitation (T0) and the end of rehabilitation (T1). Five questionnaires and one practical test were used, presented in more detail below. A follow-up survey (T2) was conducted for the questionnaires. The follow-up measurement was not mentioned in the OSF pre-registration. During the study, however, the possibility for a follow-up measurement arose. This resulted in an unplanned follow-up measurement.

To collect demographic data, a self-constructed questionnaire was used to determine age, gender, and reason for rehabilitation (knee/hip TEP) as well as employment, physical activity, and level of knowledge about mindfulness and existing meditation practice.

Self-reported mindfulness was assessed using the German version of the Five Facet Mindfulness Questionnaire (FFMQ-D) (Michalak et al., 2016). Through 39 items, the five factors observing, describing, acting with attention, accepting without evaluation, and non-reactivity are measured. The items must be answered on a 5-point Likert scale ranging from *rarely* (1) to *almost always* (5) (Michalak et al., 2016). The internal consistency of the five scales and the total score in our study varied between 0.66 and 0.71 for Cronbach's α and between 0.65 and 0.69 for McDonald's ω.

The Timed "Up and Go"-Test is a performance test for measuring mobility. It measures the time in seconds from standing up from a sitting position, walking 3 m, turning around, walking back, and sitting down again without outside assistance (Podsiadlo & Richardson, 1991).

Anxiety and depression were assessed by the German version of the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983; German version by Herrmann-Lingen et al., 2019). It is used for patients with physical complaints or diseases and comprises 14 items, which are divided into the subscale Anxiety (7 items) and Depression (7 items). The internal consistency of the two scales in our study varied between 0.83 and 0.87 for both Cronbach's α and McDonald's ω.

The SF-36 was used to assess health-related quality of life (Morfeld et al., 2011). The extended version used, with 36 items, assesses eight dimensions of subjective health. These include physical functioning, role functioning, and pain, as well as general health perception, vitality, social functioning, emotional role functioning, and psychological well-being. In the study, the acute version was used to determine the past week's health status. The internal consistency of the subscales in our study varied between 0.73 and 0.78 for Cronbach's α and between 0.81 and 0.83 for McDonald's ω.

The Knee Injury and Osteoarthritis Outcome Score (KOOS) (Roos et al., 1998) or the Hip Disability and Osteoarthritis Outcome Score (HOOS) (Nilsdotter et al., 2003) was used to record the diagnosis-specific condition depending on the affected joint. With five subscales of Symptoms, Pain, Activities of daily living, Sports and Leisure, and Quality of life affected by the affected knee, the KOOS collects information through a total of 42 items with a 5-point Likert scale (KOOS, 2023). Analogous to the KOOS, the HOOS asks these questions about the affected hip joint.

Data Analyses

IBM SPSS 28 was used for data analyses. For descriptive analyses, demographic variables, such as age and gender distributions, will be reported. Furthermore, variables of interest for our present study, such as profession, physical activity, and knowledge of mindfulness, will be reported.

The effectiveness of the intervention was investigated with a repeated-measures ANOVA. The level of significance is set at 5%. The between-subject factor was group (IG, CG), and the within-subject factor time of measurement (pre, post, and follow-up intervention). The dependent variables were the following: mindfulness (FFMQ), anxiety and depression (HADS), the effect of osteoarthritis of the knee/hip joint on affected patients (KOOS, HOOS), motor function (Timed "Up and Go"-Test), and health status (SF-36).

To investigate the relationship between dispositional mindfulness at the pre-test and health (physical and mental)

at the post-test, a regression analysis was conducted using the FFMQ scales and two demographic variables (sex and age).

Results

A total of 93 patients participated in the study, of which 48.40% were women, 51.60% were men, and 0% identified as non-binary or another gender. The mean age of the patients was 63.34 years ($SD = 10.49$); see Table 1

Table 1 Demographic data by group membership

Dependent variables	Control *n* (%)	Intervention *n* (%)
Gender		
Women	21 (43.80)	24 (53.30)
Men	27 (56.30)	21 (46.70)
Diverse	0 (0.00)	0 (0.00)
Cause of rehabilitation		
Knee joint surgery	22 (45.80)	21 (46.70)
Hip joint surgery	26 (54.20)	24 (53.30)
Working status		
Working	19 (39.60)	22 (48.90)
Retired	29 (60.40)	23 (51.10)
Physical stress at work		
None	7 (14.60)	6 (13.30)
Light	7 (14.60)	10 (22.20)
Heavy	5 (10.40)	7 (15.60)
Mental stress at work		
None	8 (16.70)	8 (17.80)
Light	8 (16.70)	11 (24.40)
Heavy	3 (6.30)	4 (8.90)
Frequency of physical activity		
None	3 (6.30)	2 (4.40)
Occasionally	12 (31.30)	8 (17.80)
Regularly	14 (29.20)	14 (31.10)
Daily	19 (39.60)	21 (46.70)
Frequency of sporting activity		
None	19 (39.60)	17 (37.80)
Occasionally	15 (31.30)	12 (26.70)
Regularly	9 (18.80)	16 (35.60)
Daily	5 (10.40)	0 (0.00)
Knowledge about mindfulness		
First contact	43 (89.60)	35 (77.80)
Already busy	4 (8.30)	8 (17.80)
Regular practice	1 (2.10)	2 (4.40)
Meditation practice		
None	40 (83.30)	39 (86.70)
Occasionally	4 (8.30)	4 (8.90)
Regularly	4 (8.30)	2 (4.40)

for relevant demographic variables. Five patients were excluded because they did not complete the follow-up measurement. Participants were free to participate in the follow-up survey and did not have to explain why they no longer wanted to participate.

The test for normal distribution (Kolmogorov–Smirnov) showed that the normal distribution was violated for anxiety, depression, and mindfulness in the pre-test but not for the measurement of the SF-36. In the post-test, normal distribution was violated for the mental health component of the quality-of-life test and depression and anxiety but not for the physical component of the SF-36 and mindfulness. Since simulation studies have shown that ANOVA with repeated-measures analyses is relatively robust against violations of the normal distribution assumption (Vasey & Thayer, 1987), we continue with the data. The original sample ($n = 95$) has been reduced because five patients did not complete the questionnaire at follow-up. Sphericity was given in the case of the Timed "Up and Go." The following variables showed sphericity according to the Mauchly test for sphericity: SF-36 physical health ($p = 0.946$), HADS Anxiety ($p = 0.367$), FFMQ total ($p = 0.070$), FFMQ Describing ($p = 0.101$), FFMQ Attention ($p = 0.092$), FFMQ Accepting ($p = 0.279$), and Quality of Life associated with the affected joint ($p = 0.187$). In the remaining cases, the condition of sphericity was violated, so a Greenhouse–Geisser correction for degrees of freedom was applied. Results for the repeated-measures analyses of all variables are listed in Table 2.

The relevant results were two statistically significant interactions. The first interaction was between the factor time (pre-, post, and follow-up test) and group for the dependent variable HADS Anxiety $F(2, 172) = 3.41$, $p = 0.035$, $\eta_p^2 = 0.038$. The second interaction was between the factor time (pre-test, post-test) and group for the dependent variable Timed "Up and Go"-Test $F(1, 91) = 5.05$, $p = 0.027$, $\eta_p^2 = 0.053$. To determine the differences in more detail, Bonferroni-corrected *t*-tests were carried out. For the HADS, there was a significant difference for the intervention group between the pre- and post-test, $t(44) = 3.53$, $p < 0.001$, Cohen's $d = 2.53$, and the pre-test and follow-up, $t(42) = 3.98$, $p < 0.001$, Cohen's $d = 2.45$ but not between post-test and follow-up, $p = 0.086$. For the control group, there were no differences between the pre- and post-test and the post-test and the follow-up, both $p > 0.06$ (Fig. 1).

Regarding the Timed "Up and Go"-Test, both the intervention and control group improved significantly from pre- (IG: $M = 17.58$ s, $SD = 6.39$, CG: $M = 21.45$, $SD = 7.43$) to post-test (IG: $M = 10.25$ s, $SD = 1.98$, CG: $M = 11.10$, $SD = 2.08$). The improvement in the control group was higher than in the intervention group ($d = 0.431$).

Regression analysis for the dependent variables mental and physical health (SF-36) at the post-test was calculated with the predictors age, gender, and the five mindfulness

Table 2 Repeated-measures ANOVA for differences between the mindfulness (IG) and control group (CG)

Dependent variable	Main and interaction effects	*n*	$F(df_{eff}, df_{err})$	*p*	η_p^2	Differences between IG and CG
Timed "Up and Go"-Test						
	Effect of time		173.35 (91.00)	< 0.001	0.656	
	Effect of group		173.35 (1.00)	< 0.001	0.656	IG > CG
	Time x group		5.05 (1.00)	0.027	0.053	
SF-36 KSK		88				
	Effect of time		147.48 (85.00)	< 0.001	0.776	
	Effect of group		153.74 (2.00)	< 0.001	0.641	IG > CG
	Time x group		0.79 (2.00)	0.457	0.009	
SF-36 PSK		88				
	Effect of time		4.21 (85.00)	0.018	0.090	
	Effect of group		5.21 (2.00)	0.006	0.057	IG > CG
	Time x group		0.23 (2.00)	0.793	0.003	
HADS-A		88				
	Effect of time		8.14 (85.00)	< 0.001	0.165	
	Effect of group		9.75 (2.00)	< 0.001	0.102	IG > CG
	Time x group		3.42 (2.00)	0.035	0.038	
HADS-D		88				
	Effect of time		8.14 (85.00)	< 0.001	0.161	
	Effect of group		7.75 (1.79)	< 0.001	0.083	IG > CG
	Time x group		1.93 (179)	0.153	0.022	
FFMQ		88				
	Effect of time		1.50 (85.00)	0.228	0.034	
	Effect of group		1.89 (2.00)	0.154	0.022	IG > CG
	Time x group		0.78 (2.00	0.459	0.009	
Pain		88				
	Effect of time		54.23 (85.00)	< 0.001	0.561	
	Effect of group		80.36 (1.36)	< 0.001	0.483	IG > CG
	Time x group		0.20 (1.36)	0.731	0.002	
Symptoms		88				
	Effect of time		45.64 (85.00)	< 0.001	0.518	
	Effect of group		70.38 (1.53)	< 0.001	0.450	IG > CG
	Time x group		0.07 (1.53)	0.074	0.001	
Activity		88				
	Effect of time		94.60 (85.00)	< 0.001	0.690	
	Effect of group		141.90 (1.43)	< 0.001	0.623	IG > CG
	Time x group		0.08 (1.43)	0.861	0.001	
Functionality		88				
	Effect of time		59.75 (85.00)	< 0.001	0.584	
	Effect of group		73.27 (1.87)	< 0.001	0.460	IG > CG
	Time x group		1.40 (1.87)	0.249	0.016	
QOL		88				
	Effect of time		59.00 (85.00)	< 0.001	0.581	
	Effect of group		71.20 (1.93)	< 0.001	0.453	IG > CG
	Time x group		0.069 (1.93)	0.928	0.001	

Note. *KSK*, physical health; *PSK*, mental health; *HADS-A*, HADS-Anxiety; *HADS-D*, HADS-Depression; QOL, quality of life

subscales. The Durbin-Watson statistic had a value of 1.94 in the case of SF-36-PSK (Mental Health) and 1.80 in the case of SF-36-KSK (Physical Health), according to which there was no autocorrelation in the residuals. There was also a normal distribution of the residuals. The model has a medium goodness of fit for SF-36 PSK with an $R^2 = 0.17$ (adjusted $R^2 = 0.10$) and a low goodness of fit for SF-36 KSK with an $R^2 = 0.05$ (adjusted $R^2 = -0.03$) (Cohen,

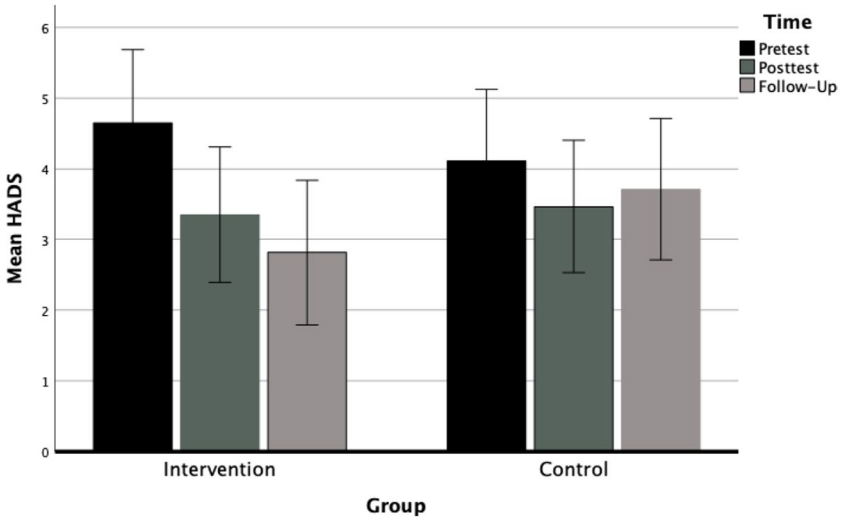

Fig. 1 Mean (error bars, 95% CI) of HADS in the pre-test, post-test, and follow-up dependent on group

1988). The overall model including predictors of gender, age, and the five subscales of mindfulness was statistically significant in predicting the SF-36 mental health criterion, $F(7, 85) = 2.52$, $p = 0.021$ (Table 3). However, none of the investigated predictors significantly predicted the physical health criterion.

Discussion

The present study investigated the effect of mindfulness bibliotherapy on physical and psychological parameters after hip/knee TEP fitting in an outpatient rehabilitation setting. The basis for the hypotheses raised was the current state of research on the effectiveness of mindfulness interventions in different settings, specifically the use of bibliotherapy and the importance of mental health status in orthopedic rehabilitation. In the study, significant effects were measured for anxiety and motor skills. However, only the effect on anxiety was interpretable. In addition, a correlation between self-reported mindfulness, age, gender, and mental health status at the end of rehabilitation was identified.

Mindfulness has been successfully used in treating anxiety (Grossman et al., 2014) and depression (Strauss et al., 2014), but targeted mindfulness training has also been shown to bring about success in the treatment of chronic pain (Bakhshani et al., 2016). Furthermore, it has been shown that mindfulness-based interventions are feasible for use in surgical patient populations (Hymowitz et al., 2022). Thus, mindfulness as a therapeutic approach appears to be a good complement to the relaxation methods used so far, such as autogenic training and progressive muscle relaxation, as well as the complementary movement therapy measures such as Qi Gong, Tai Chi, and yoga (Deutsche Rentenversicherung, 2020). The integration of relaxation methods (Lin, 2012) and the mentioned exercise therapies into the rehabilitation therapy standards show the importance of psychological factors for successful rehabilitation, which is confirmed by numerous studies, for example, on the influence of anxiety and depression on the therapy outcome in orthopedic diseases (Ali et al., 2017).

The present study provides evidence that mindfulness bibliotherapy in outpatient orthopedic rehabilitation as an additional therapy offer is easy to implement from an

Table 3 Regression analysis with the criterion mindfulness towards psychological health status

	b	*SE*	*β*	*t*	*p*
Constant	42.044	11.020		3.815	< 0.001
Age	− 0.136	0.096	− 0.146	− 1.417	0.160
Gender	3.400	2.006	0.174	1.695	0.094
FFMQ-Observe	− 0.147	0.209	− 0.086	− 0.704	0.483
FFMQ-Describe	− 0.203	0.180	0.135	1.127	0.263
FFMQ-Acting with awareness	0.300	0.205	0.181	1.463	0.147
FFMQ-non-judgmental	0.136	0.193	0.084	0.703	0.484
FFMQ-non-reactivity	0.082	0.258	0.040	0.318	0.752

organizational and economic point of view and can be a good support for the users. Significant effects of the intervention could be demonstrated for anxiety (HADS Anxiety), indicating that the intervention has a positive effect, at least on the psychological factor of anxiety. This is partly in line with the study of Ali et al. (2017). For all other measured variables, no advantage could be shown for the mindfulness bibliotherapy group.

There is an accumulation of evidence supporting the hypothesis that a higher level of mindfulness measured by the FFMQ at the beginning of rehabilitation correlates positively with the state of mental health after rehabilitation. This aligns with a study by university students showing that trait mindfulness is related to psychological aspects after a short mindfulness intervention (Sousa et al., 2021). However, no single predictor was significant, and the explained variance was relatively small. One reason for this might be that the patients included in this study have little mindfulness experience.

Limitations and Future Research

The effect of mindfulness on various parameters and in therapeutic application has been proven by many studies, as was made clear in the introduction. Nevertheless, the established hypotheses could not be completely confirmed. This may be due to some limitations of the present study.

This includes first the chosen intervention. Although bibliotherapy has the advantage of a resource-saving and easy-to-organize implementation in the regular rehabilitation routine, the participants' actual implementation and engagement intensity could not be objectively tracked. However, the actual effects of the intervention can only be achieved if it is also sufficiently used. An alternative could be a digital form (app-based), which could be used, for example, to reproduce the frequency of the call, duration of the processing, etc., and thus make precise statements about the use. Due to the selected target group and the associated expected higher age, an analog intervention was deliberately preferred to the digital variant to achieve a higher acceptance of the intervention. The expectations of the sample are reflected in the actual sample, which had an average age of 63.34 years, of which over 50% of the participants were already retired at the start of rehab. For future interventions, however, the use of a digital alternative could make sense since, on the one hand, the proportion of surgical interventions on knee and hip joints in the younger age groups is increasing significantly (Rupp et al., 2020), and on the other hand, the coming potential patients are already increasingly using mobile end devices. Even before the COVID-19 pandemic, the number of users over 65 increased significantly from 2009 (37.80%) to 2019 (74.20%) (Seifert, 2022). Nevertheless, the extent to which mindfulness fits with mobile end devices and other technical presentations should be considered. Many mindfulness apps offer a cheaper alternative to mindfulness courses. The effectiveness of some mindfulness apps has already been proven by scientific studies (Gál et al., 2021). However, incoming push messages or calls on the smartphone can disrupt learning, making it more difficult. In addition, bibliotherapy may not be sufficient for people who have had no previous contact with the topic of mindfulness (84%). After all, this is a complex concept that requires much practice. Even in guided mindfulness therapies, implementation in daily life often fails once the therapist is no longer present (Derra & Schilling, 2017).

In addition to the intervention, the selected setting might be a limiting factor. Due to the outpatient rehabilitation measure, both groups (IG and CG) may be influenced by several factors that were not recorded during the data collection. In outpatient orthopedic rehabilitation, the patients are picked up by the patient transport in the morning and are driven home again at the end of the rehabilitation day around 3:00 p.m. In exceptional cases, the transport is taken over by relatives. The fact that the assessment of therapy outcomes occurred close to the patients' homes has numerous advantages, such as the assessment in a familiar environment and the availability of support by relatives. Nevertheless, the influences of the social environment, the different living situations, the distance, and the associated daily travel time cannot be excluded in outpatient rehabilitation. For this reason, the form of rehabilitation must be chosen according to the needs of the rehabilitant (Spies et al., 2020).

Limitations such as a very small or selective sample, which most studies on mindfulness interventions in physical rehabilitation have (Hardison & Roll, 2016), do not apply in the present study at first glance. However, the statistical power could have been influenced by the low reliability of the mindfulness measurement (but see Zimmerman & Zumbo, 2015).

Finally, if we consider the current state of research on the application and effect of mindfulness and the importance of psychological health in orthopedic diseases, mindfulness training presents itself as a helpful therapeutic approach. The conducted study also showed that mindfulness bibliotherapy has positive effects on psychological and physiological parameters. Furthermore, the level of mindfulness at the beginning of rehabilitation is related to psychological health status after rehabilitation. Due to the importance of psychological health for long-term success after TEP surgery in conjunction with the identified correlation, one's mindfulness before surgery may also predict long-term success after surgery. To investigate this assumption and, thus, the more precise meaning of mindfulness in orthopedics, further hypothesis-guided research is needed. The limitations of the present study provide

hints for the planning and implementation of further scientific investigations based on this hypothesis.

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Data Availability Data can be obtained at OSF, https://osf.io/4tmwq/.

Declarations

Ethics Approval The responsible ethics committee of the University of Regensburg approved the study (21–2539-101). The experiment was conducted according to the guidelines set forth by the Declaration of Helsinki.

Informed Consent The rehabilitation clinic was informed about the project. After providing the patients with an information sheet and a consent form, they gave their written informed consent, and data were processed anonymously.

Conflict of Interest The authors declare no competing interests.

Use of Artificial Intelligence AI was not used.

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