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Evaluation of a manualised neurofeedback training in psychosomatic-psychotherapeutic outpatient treatment (Neuro-pp-out): study protocol for a clinical mixed-methods pilot study

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ABSTRACT

Introduction Electroencephalographic neurofeedback (NFB), as a non-invasive form of brainwave training, has been shown to be effective in the treatment of various mental health disorders. However, only few results regarding manualised and standardised NFB trainings exist. This makes comparison as well as replication of studies difficult. Therefore, we developed a standard manual for NFB training in patients with mental health disorders attending a psychosomatic outpatient clinic. The current study aims at investigating the conduction of a standardised manual for NFB training in patients with mental health disorders. If successful, the study provides new opportunities to investigate NFB in a more controlled and comparable manner in clinical practice.

Methods and analysis 30 patients diagnosed with a mental health disorder will be included. After the educational interview, patients will undergo baseline diagnostics (T0). The subsequent intervention consists of 10 sessions of NFB training aiming at increasing sensorimotor rhythm and alpha-frequency amplitudes and decreasing theta-frequency and high beta-frequency amplitudes to induce relaxation and decrease subjective stress. All patients will undergo a post-treatment diagnostic assessment (T1) and a follow-up assessment 8 weeks following the closing session (T2). Changes in amplitude bands (primary outcome) will be recorded with electroencephalography during pre-assessments, post-assessments and follow-up assessments and during NFB sessions. Physiological (respiratory rate, blood volume pulse, muscle tension) and psychometric parameters (distress, perceived stress, relaxation ability, depressive and anxiety symptoms, insomnia, self-efficacy and quality of life) will be assessed at T0, T1 and T2. Moreover, satisfaction, acceptance and usability will be assessed at T1 after NFB training. Further, qualitative interviews about the experiences with the intervention will be conducted with NFB practitioners 6 months after the study starts. Quantitative data will be analysed using repeated measures analysis of variance as well as mediation analyses on mixed linear models. Qualitative data will be analysed using Mayring's content analysis.

Ethics and dissemination The study was approved by the ethics committee of the Medical Faculty of the University of Duisburg-Essen (23–11140-BO) and patient enrolment began in April 2023. Before participation, written informed consent by each participant will be required. Results will be published in peer-reviewed journals and conference presentations.

Trial registration number Prospectively registered on 28 March 2023 in the German clinical trials register, DRKS00031497.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study examines a manualised neurofeedback training in order to provide a standardised intervention that is easily applicable.
⇒ This study uses a mixed-methods approach that involves both patients and practitioners and represents an important step toward implementation.
⇒ This study incorporates many different data, that is, physiological, quantitative psychometrical and qualitative data, to evaluate the manualised neurofeedback training in order to give a more sophisticated idea of the training success.
⇒ Since the study is a pilot study, there is no control group for efficacy testing.

INTRODUCTION

Current data show that in Germany the number of days of absence at work due to mental illnesses has continued to rise since 2021.[1] The most common mental illnesses leading to sick leave include depressive disorders, adjustment disorders, neurotic disorders and anxiety disorders.[1] The continuous rise of absenteeism at work due to mental illnesses is associated with declined health-related quality of life.[2] Affected individuals face multifaceted challenges, such as a

decline in daily functioning, interpersonal relationships and overall perceived personal well-being. In 2022, the steep rise of 9.1% in the number of days of absence due to mental illnesses compared with the previous year, outlines the increased need for therapy options.[2]

The use of neurofeedback (NFB), or electroencephalographic biofeedback, is associated with a growing interest in research, but also in clinical care. With the help of NFB, learning processes can be facilitated, patient motivation increased and behaviour modified.[3] NFB is a non-invasive brain training technique based on the real-time processing of electroencephalogram (EEG) signals, the extraction of the parameters of interest and subsequent visual or auditory feedback representation. Modulating brain activity by unvolutional processes and later on volitional control is used to change behaviour.[4] The effect of modifying the amplitude of certain frequency bands is produced through conditioning.[5] Attention and hyperactivity disorders, depression disorders, stroke, epilepsy, migraine and chronic insomnia are some of the conditions for which NFB is most commonly used.[4] In psychosomatic medicine, the central idea of which is that both body and mind contribute to human functioning and represents an independent specialty in Germany,[6 7] feedback-based therapies have been used for depression and anxiety disorders,[8] post-traumatic stress disorder[9] and eating disorders.[10]

Overall, current research has already extensively demonstrated that patients with mental health disorders benefit from feedback-based therapies. Nevertheless, there are no standardised protocols or manuals for NFB treatments in the psychosomatic-psychotherapeutic setting. Unfortunately, most studies use different NFB protocols and training procedures. Therefore, patients not only receive a distinct training intensity but also experience a different procedure during training sessions. For example, each NFB practitioner interacts slightly differently with patients while conducting NFB sessions, which might have an impact on the training success. Moreover, this leads to difficulties in comparing research findings and investigate effects in different disorders, replication of such findings, as well as in the adaptation of such protocols in clinical practice. In order to demonstrate an effect in NFB training and minimise confounding variables, a standardised procedure is necessary. Our study group implemented biofeedback training in inpatient psychosomatic-psychotherapeutic care, making clear the need for further investigation.[11]

To address these problems and simplify workflows, we developed a standard manual for the implementation of NFB training as a transdiagnostic method in patients with mental health disorders, which aims at increasing relaxation and attention as well as decrease subjective stress through training of sensorimotor rhythm (SMR) frequency and alpha frequency amplitudes as well as reduction of theta frequencies and high-beta frequencies. We were inspired by several studies and regarded these parameters as useful for different types of disorders, since most psychosomatic disorders lack the ability to relax and focus as well as commonly display an increased perception of stress. Furthermore, choosing the mentioned parameters was based on experience by a supporting expert in NFB training (AK). Bouny *et al*[12] could show that the training of the SMR frequency significantly improved the attention of the patients.[12] Furthermore, training of the alpha frequency was associated with a significant improvement in the ability to relax.[13] In addition, an increase in alpha band frequency was associated with an increased ability to relax.[14] Moreover, cognitive abilities such as reaction time, cognitive control and selective attention could also be improved in healthy patients by training the alpha band.[15] While theta reduction can be used to improve attention skill,[16] the high-beta band is associated with stress experience.[17] Therefore, the reduction of high-beta frequencies reduces the perception of stress.[18] Additionally, previous research demonstrates an improvement in various psychological parameters through NFB training. For example, existing research was able to show that high-beta down-training improved quality of life, sleep quality, distress, self-efficacy, depressive and anxiety symptoms.[19] The modulation of frequencies will take place at coordinate Cz, which receives projections of thalamic structures associated with executive functions of attention and information processing as well as memory processes.[20] Moreover, modulation at Cz is a common approach in most existing NFB protocols,[21] measuring activity in the somatosensory cortex, including attention, mental processing, calmness, emotion and empathy.[17]

Objectives and research question

In order to define standards in research, the primary objective of the study is to implement and validate a manualised electroencephalographic NFB training showing that the intervention significantly affects relevant electroencephalographic parameters. The secondary objective is the clinical and structural evaluation of the manualised NFB offer in an outpatient psychosomatic-psychotherapeutic setting. We hypothesise that the manualised NFB training leads to an increase in SMR and alpha frequency amplitudes, a decrease in theta frequency and high-beta frequency amplitudes, as well as an increase in heart rate variability, decrease in muscle tension and respiratory rate. Moreover, we expect an increase in mood, ability to relax, attention, self-efficacy, quality of life, an improve in sleep, as well as a decrease in subjective stress and depressive and anxiety symptoms. In addition, we will investigate the satisfaction and acceptance with and of the NFB training among patients and NFB practitioners, that is, staff conducting NFB training.

METHODS AND ANALYSIS

This study protocol is reported according to the Standard Protocol Items: Recommendations for Interventional Trials checklist (SPIRIT)[22] and the Consensus on the reporting and experimental design of clinical and

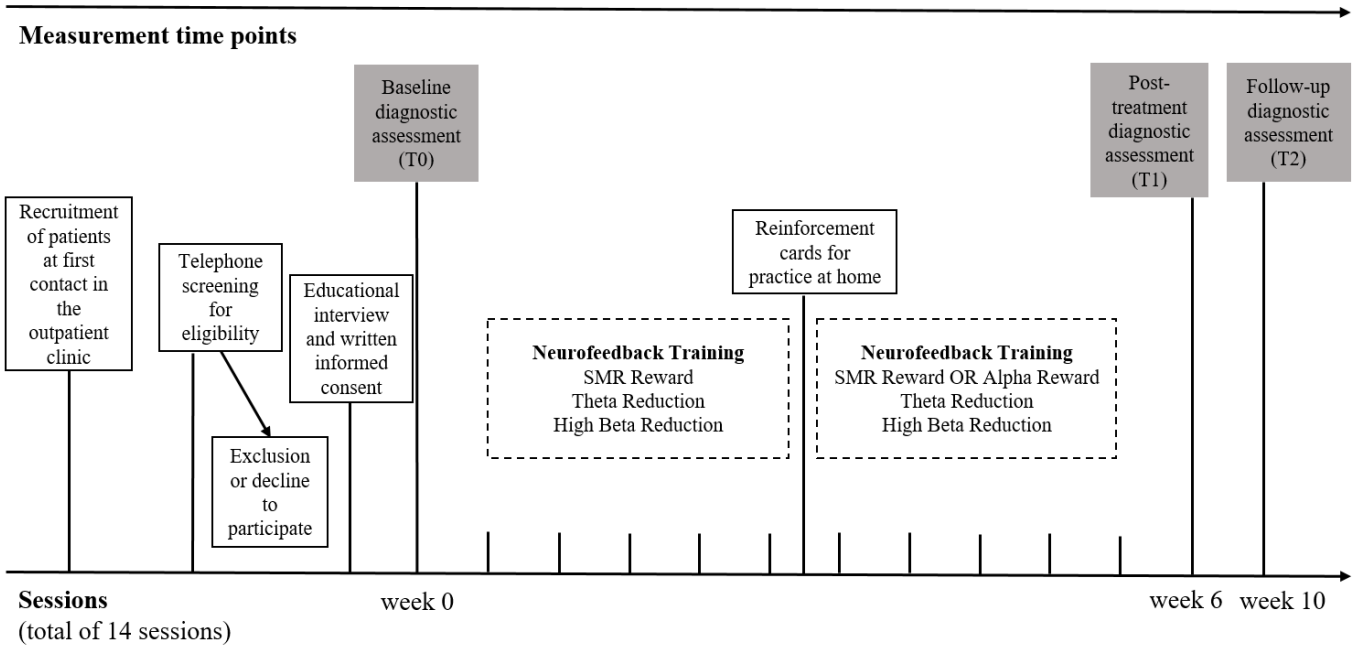

Figure 1 Trial flow and intervention scheme of the Neuro-pp-out study. SMR, sensorimotor rhythm.

cognitive-behavioural neurofeedback studies (CRED-nf checklist, see online supplemental material).[23] In case of important modifications, the ethics committee as well as the trial registration will be updated.

Study design

This study is a monocentric, prospective, interventional, mixed-methods pilot study with one arm to investigate a manualised NFB training. The mixed-methods approach was chosen to use quantitative data to investigate the influence of the NFB training on patients' symptoms and brain frequencies and to use qualitative data to uncover areas of concern in the implementation and to derive suggestions for improvement, which will be taken into account in a potential subsequent randomised controlled trial. The study follows a single-arm design due to two rationales: (1) Ethical reasons, since the NFB training was implemented as part of our routine care; (2) this pilot study intended to obtain initial indications of the influence of the manual and to gather practical experience before planning a larger-scale study with two groups. The trial comprises three distinct measurement time points (see figure 1 and table 1): the baseline assessment before the intervention (T0), a post-treatment assessment (T1) and a 2-month follow-up assessment (T2). In addition, continuous assessments are planned during the experimental intervention (in-treatment assessment: mood, psychological distress, sense of control of NFB outcomes). Before participation, written informed consent by each participant will be required. Participants will drop out, if they do not fulfil the inclusion criteria anymore. Participants who drop out due to other reasons, will be contacted via telephone and asked for the reasons for discontinuing. Table 1 presents the instruments used at each time point. Six months after the study starts, qualitative interviews with NFB practitioners will be performed.

Participant eligibility and recruitment

Main inclusion and exclusion criteria were set in line with comparable studies in NFB research.[12 13 15–17] Patients will be included if they have a confirmed mental health disorder that is commonly treated in specialised psychosomatic outpatient clinics in Germany (ie, depression, eating disorder, somatoform disorder, post-traumatic stress disorder) and are aged between 18 and 75 years, due to usual operationalisation criteria. Moreover, patients will be included if they have given their informed consent. Since NFB training is introduced as part of the routine care in our clinic, patients with different diseases are included in the study.

Patients with neurological diseases or diseases affecting the central nervous system will be excluded. Further, patients who receive current psychological treatment (≥1 session every other week) will be excluded, due to uncontrollable therapy effects that confound with NFB training. Moreover, a lack of German language skills constitutes an exclusion criterion since the questionnaires that will be used for quantitative data assessment are validated in the German language.

Patients will be recruited in personal contact as part of their treatment at the Clinic for Psychosomatic Medicine and Psychotherapy of the LVR-University Hospital Essen. Flyers and information sheet will be spread. Patients who meet the inclusion criteria will be informed about the possibility of participating in the study. If interested, a telephone screening for eligibility will be performed by the principal investigator (PI) and an appointment for the educational interview will be made.

Table 1 Assessment schedule for patients

Measures	T0: baseline	In-treatment	T1: post-intervention	T2: follow-up at 2 months
Primary outcomes				
Alpha frequency	X	X	X	X
SMR frequency	X	X	X	X
Theta frequency	X	X	X	X
High-beta frequency	X	X	X	X
Respiratory frequency	X		X	X
Muscle tension	X		X	X
Blood volume pulse	X		X	X
Secondary outcomes				
Mood before/after session		X		
Subjective stress level before/after session		X		
Feeling of control during a session		X		
DT	X		X	X
PSQ	X		X	X
RSQ	X		X	X
PHQ	X		X	X
GAD	X		X	X
ISI	X		X	X
GSE	X		X	X
WHOQOL-Bref	X		X	X
Evaluation of NFB-manual				
ZUF-8			X	
SUS			X	
Self-generated items reg. acceptance			X	

DT, distress thermometer; GAD, General Anxiety Disorder Scale; GSE, General Self-efficacy Scale; ISI, Insomnia Severity Index; NFB, neurofeedback; PHQ, Patient Health Questionnaire; PSQ, Perceived Stress Questionnaire; RSQ, Relaxation State Questionnaire; SUS, System Usability Scale; WHOQOL-Bref, WHO Quality of Life Questionnaire; ZUF-8, Patient Satisfaction Questionnaire.

NFB practitioners will be asked to be interviewed 6 months after the study starts. Inclusion criteria for NFB practitioners are written informed consent and regular conduction of NFB training. There are no criteria for the exclusion of NFB practitioners.

Intervention: manualised neurofeedback training

The manualised NFB training includes 14 sessions, in which patients learn to modify their brain frequencies (see figure 1). This manual aims at increasing attention and relaxation by increasing SMR and alpha frequency amplitudes and inhibit theta and high-beta frequencies (see online supplemental material for full manual). The manual provides detailed instructions and a guideline for the exact session structure for conducting the described NFB training. Patients will receive two sessions per week over a course of 7 weeks. This is based on previous studies that demonstrated significant success with a frequency of two sessions per week.[24–26] A last follow-up session will be conducted after 2 months. The manual comprises the NFB training sessions, the educational session and the diagnostic session to guarantee a standardised procedure for all 14 sessions. During the educational session, patients will receive information about NFB, the training procedure and will have the opportunity to try the NFB training for 15 min. Moreover, the manual contains detailed instructions on performing physiological diagnostics in sessions 2, 13 and 14. This will give patients as well as NFB practitioners the opportunity to track the training progress. Diagnostics were developed based on relaxation exercises and existing stress protocols to investigate the influence of NFB training on brain frequency amplitudes under stress and relaxation (see secondary outcome measures for detailed information). Comic videos and moving bar scales will be used for visual feedback. Before each training session, patients will be asked to answer two questions about their subjective stress level and mood during the day. After each training session, patients will be asked about their current subjective stress level and mood and if they had a feeling of control during the session. Based on these questions, it is optional to

continue SMR band training or change to alpha band training after the first five training sessions. A cut-off value of ≥11 on a scale from 0 to 20 of the item 'feeling of control during the session' will be the indicator for the change to alpha band training. Moreover, the manual describes the use of reinforcement cards after the fifth session, which can be used to transfer the NFB learning in patients' everyday situations.

Outcomes

Primary outcome measures

The primary outcome measures are the changes in the electroencephalographic frequency amplitudes of patients to validate the NFB-manual. The theta band (4–8 Hz), alpha band (8–12 Hz), SMR band (12–15 Hz) and high-beta band (23–30 Hz) will be measured during the training sessions as well as during the two diagnostic sessions in which the frequencies will be assessed under different tasks (table 1). The NFB treatment as well as the diagnostics will be carried out with the device Nexus-10 and the corresponding programme BioTrace (Mind Media, Herten).

Secondary outcome measures

For the clinical evaluation of the intervention, the influence of the manualised NFB training on (1) muscle tension, blood volume pulse and respiratory rate as well as on (2) mood, subjective stress, feeling of control, (3) distress and perceived stress, (4) ability to relax, (5) depressive symptoms, (6) anxiety symptoms, (7) insomnia, (8) self-efficacy, (9) quality of life as well as (10) satisfaction, (11) usability, (12) acceptance and feasibility among patients and (13) acceptance and experiences among NFB practitioners will be investigated. See below for a detailed description of each secondary outcome. Socio-demographic data (age, gender, psychological diagnosis) will be gathered during the telephone interview.

1. *Physiological measures*: At assessment points T0, T1 and T2, psychophysiological NFB-related and relaxation-related diagnostics will be conducted to verify the stress-induced and relaxation-induced physiological response. During the performance of various tasks, different physiological measures will be recorded using the Nexus-10 device: Blood volume pulse, respiratory rate measurement, shoulder-neck electromyography, EEG at scalp location Cz. The diagnostic measurement follows a 14 min-protocol: 2 min baseline measurement, 2 min stress induction by using the Stroop test,[27] 2 min relaxation (beach images and calm music), 2 min stress induction by mental arithmetic (based on Kirschbaum, Pirke & Hellhammer, 1993),[28] 2 min relaxation (beach images and calm music), 2 min stress induction by reporting a recent stressful event and 2 min relaxation (beach images and calm music).
2. *Subjective mood, stress and feeling of control*: Before and after each training session patients' subjective stress and mood levels will be assessed with self-generated items ('How was your mood today?', 'How is your mood now?', 'How was your stress level today?', 'How is your stress level now?') on a 5-point Likert scale (0–4). The subjective feeling of control during the session will be measured using a self-generated item ('Did you feel like you could influence the bars in the neurofeedback session today?').
3. *Distress and perceived stress:*
   1. We will apply the distress thermometer for assessing distress.[29] It is an established and rapid screening tool for stress, presented as a visual thermometer on a scale from 0 ('no stress') to 10 ('extreme stress'). A value of 5 indicates that a patient is distressed and needs support.
   2. To assess the perceived stress, we will assess the Perceived Stress Questionnaire (PSQ-20).[30] The PSQ comprises 20 questions and serves as a valid and reliable instrument for assessing current, subjective stress experience.
4. *Relaxation:* The patient's ability to relax will be assessed with the Relaxation State Questionnaire (RSQ).[31] The RSQ assesses the current state of relaxation of individuals and includes 10 items.
5. *Depressive symptoms:* We will use the Patient Health Questionnaire (PHQ)-8 in its validated German version to measure depression symptoms.[32] Answers are rated on a 4-point Likert scale from 0 ('not at all') to 3 ('nearly every day'). A sum score of ≥10 is considered the cut-off for the presence of a major depression, a score of ≥20 is considered severe major depression.
6. *Anxiety symptoms:* The General Anxiety Disorder Scale is a 7-item module of the PHQ, which screens for and assesses the severity of a generalised anxiety disorder on a 4-point Likert scale from 0 ('not at all') to 3 ('nearly every day').[33] Scores of ≥5, ≥10 and ≥15 are considered the cut-off for mild, moderate and severe generalised anxiety, respectively.
7. *Insomnia*: To measure sleep difficulty, we will apply the Insomnia Severity Index (ISI).[34] It contains seven questions about sleep quality, sleep characteristics and life impact rated on a 7-point Likert scale. Scores of ≥8, ≥15, ≥22 are considered subthreshold, moderate and severe insomnia, respectively.
8. *Self-efficacy*: Self-efficacy will be assessed using the General Self-Efficacy Expectancy scale (GSE).[35] The scale contains 10 items and is used to quantify general self-efficacy expectancy.
9. *Quality of life*: We will measure quality of life with the WHO Quality of Life Questionnaire (WHOQOL)-Bref questionnaire.[36] It contains 26 items to assess quality of life in four domains: social, psychological, physical and environmental quality of life. The WHOQOL-Bref has good to excellent reliability as well as good validity.
10. *Satisfaction*: To evaluate satisfaction with the NFB training, we will apply the Patient Satisfaction Questionnaire (ZUF-8).[37] The ZUF-8 presents a globally used instrument and includes eight items. Kriz *et*

al defined a cut-off value of 23.5 in a psychosomatic cohort indicating high satisfaction.[38]

11. *Usability*: We will use an adaptation of the System Usability Scale (SUS) to investigate the acceptance and usability of the NFB offer with 10 items on a 5-point Likert scale.[39] By translating the SUS score into acceptance ranges, scores of 73%, 85% and 100% representing good acceptance, excellent acceptance and the best imaginable acceptance, respectively.[40]
12. *Acceptance and feasibility*: We will measure the acceptance and feasibility of the intervention using a self-generated questionnaire, which contains 10 items (see online supplemental material).
13. *Acceptance and experiences of NFB practitioners:* We will investigate the acceptance and experiences among NFB practitioners with the intervention by conducting qualitative interviews. The interview guideline consists of seven questions (see online supplemental material).

Trial procedures and timeline

The trial will take 10 weeks for each patient to complete (see figure 1). During the first contact in the Clinic for Psychosomatic Medicine and Psychotherapy, an information sheet about the NFB training will be handed out. If patients are interested in taking part in the study, a short telephone interview (approximately 15 min) with the PI will be conducted screening for inclusion criteria and to arrange the first appointment. During the educational interview, patients will be informed about the purpose of the study and the voluntary nature of participation by a member of the study team. After the patients give their consent, a short session of NFB training will be conducted to allow the patient to become familiar with NFB (the patient consent form is shown in the online supplemental appendix). Baseline diagnostic assessment (T0) will be performed during another session, which follows a 14 min-protocol. In addition, psychometric data will be collected at this time point (table 1). Further on, the NFB intervention will be conducted using the developed manual (see online supplemental material). The 10 NFB sessions will take 30 min and will be performed twice a week over the course of 5 weeks. During the NFB training, patients will be sitting in a relaxing chair in front of a monitor at a distance of 1.5 metres. Before and after each training session, patients are asked to answer two questions about their subjective stress level and current mood. After each NFB session, patients will additionally state whether they had the impression of influencing the bar charts today. After the NFB intervention and after 8 weeks, a post-treatment diagnostic assessment (T1) and a follow-up diagnostic assessment (T2) will be conducted and psychometric data will be collected. To improve adherence, patients who have not answered the questionnaires at time points T0, T1 and T2 within 2 days will be reminded via email. If patients express interest, they can undergo an exit interview with the PI. Completers are defined as patients who completed 6 or more of the 10 intervention sessions.

Sample size calculation

To estimate the required sample size, we conducted an a priori power analysis using G*Power.[41] The primary hypothesis was that the NFB training would lead to an increase in SMR and alpha frequency amplitudes, a decrease in theta frequency and high-beta frequency amplitudes, as well as an increase in heart rate variability, a decrease in muscle tension and respiratory rate. To assess the efficacy of the intervention, repeated measures analyses of variance (ANOVA) with the respective measurements (T0-T2) as a within-subject factor will be performed. For the sample size calculation, a preferred test strength of 1-ß=0.8 was chosen. We expect a moderate effect size of partial η^2_p=0.06, and a mean correlation between within-subject measures of r=0.3, which results in a required sample size of n=27.[42] Based on a previous study of our study group on NFB treatment in the outpatient setting, we expect a dropout rate of 13%.[43] Therefore, we will include 31 participants in the study.

Data management and monitoring

The study team will establish the data monitoring. The database is only accessible to the study staff and researchers of the project. To protect confidentiality, the participants' data will be pseudonymised and stored for 10 years. The pseudonymised data will be in a locked file. The interviews will be recorded with a password-protected recording device and transcribed by the f4x transcription tool. The speech recognition runs exclusively on ISO-27001 certified servers in Germany. No conclusions will be drawn about individual persons on the basis of the recordings. The audio recordings will be deleted immediately after transcription. For further scientific analysis of the interview texts, all information that could lead to an identification of the participants will either be anonymised or completely removed from the text. The interview data will be stored in a locked cabinet to which only the study team has access. Personal data will be stored separately from the interview data collected and inaccessible to third parties. After completion of the research project, the personal data will be automatically deleted and the collected interview data must be stored for a period of 10 years within the legal retention period. After that, all data will be deleted. Data collected from the trial will be anonymously available on request after the major results are published. The statistical analysis plan and all relevant documents will be stored and made available by request. Access to data storage will be restricted to authorised personnel. Patient consent forms will contain a section concerning the aforementioned aspects of data storage and data sharing. The local ethics committee evaluates compliance with ethical criteria. The trial conduct will be audited regularly by the PI. Adverse events and dropouts throughout the trial will be assessed and documented by the study team. The study team supervises and

monitors the proposed trial and is obliged to take appropriate actions.

Statistical methods

Data from patients who discontinued the treatment before the sixth session, will be excluded from the analysis. Based on the intention-to-treat principle, non-compliance to the treatment or deviation from the treatment plan will not lead to the exclusion of participants.[44] To perform the imputation, the SPSS multiple imputation module will be used. This module follows a 'monotone missing pattern' and includes complete data for sex, age and baseline measurements of both primary and secondary outcomes. The imputation process will involve 3000 imputations, with the analysis date serving as the seed. Outliers will be included in the analysis unless they indicate impossible values. To investigate if violations of the sphericity assumptions occurred, Mauchly's sphericity test will be conducted. In case of violated sphericity, the Greenhouse-Geisser correction will be applied. To test the primary hypotheses, a repeated measures ANOVA (pretreatment vs post-treatment vs follow-up) will be performed with the primary outcome measurement assessing changes in brain wave bands alpha, SMR, theta and high-beta and the secondary outcome measurement assessing stress, relaxation ability, depressive and anxiety symptoms, insomnia, self-efficacy and quality of life. It is important to establish plausible relationships between the direct effect of electroencephalographic activity produced by the NFB and the change in psychopathology and burden. Thus, difference scores between T0 and T1 for each variable will be calculated. Subsequent correlation analyses—using Pearson or Spearman correlation coefficients—will be performed to identify meaningful overlaps. Since the electroencephalographic frequency bands are measured and, hence, available across all NFB sessions, individual trajectories and factors influencing them can also be assessed. Here, mixed linear models will be used to elucidate the temporal development of frequency bands across all sessions. In the same vein, we will assess whether these changes are mediated by (1) the extent of control subjects perceive during the sessions and (2) the change in mood and (3) the change in stress from before to after the session. Mediation analyses on mixed linear models can be performed using popular packages within the R-framework. Similarly, we will explore whether changes in symptom indicators (eg, depression, insomnia, see table 1) or physiological parameters that are not measured during the NFB session (eg, respiratory frequency) between T0 and T1 are mediated by changes in stress, mood, as well as the intrasession perception of control. Here, we also plan to apply standard mixed linear models. Yet, in case of significant violations of the models' assumptions (eg, homoscedasticity or normality of random effects) or convergence issues, we will—after careful consideration of their appropriateness—resort to using other statistical methods (eg, generalised estimating equations, Bayesian mixed linear models with a non-gaussian response distribution, robust regressions on difference scores). Acceptability and satisfaction will be analysed using descriptive statistics.

For consecutive analysis of qualitative data, the verbatim transcription of all qualitative interviews will form the basis. Qualitative data analysis will be conducted using the software MAXQDA 2022 (Verbi Software, 2019). We will use Mayring's method of structured content analysis to analyse all interviews.[45] Initially, a deductive category system will be derived from the semi-structured interview guideline. Two analysing researchers, who differ in age to provide varied perspectives, will code two interviews to further develop the category system. After discussing the developed category system, it will be used as a reference for coding all interviews. Throughout the analysis, the researchers independently will make additions, deletions or changes to the categories based on the text material. Additional categories that are relevant but missing will be inductively added until the category system will reach saturation. All interview quotations will be translated from German to English for publication purposes.

Ancillary and post-trial care

Patients will be supervised by a schooled study team and are asked about their well-being during and after every session. No post-trial care is established.

Patient and public involvement

Neither patients nor the public were directly involved in the development of this study design. However, the manual was developed by incorporating experience reports and results of our own preliminary work as part of an implementation study, in which patients were involved by answering quantitative questionnaires regarding satisfaction, acceptance and feasibility of the NFB training.[11]

Ethics and dissemination

From our point of view, the trial poses no distinct ethical concerns. Risks or harms that could affect patients during the study are not anticipated, nor are harms or serious adverse events. In case of unexpected disadvantage or serious adverse events, they are documented and reported by the study team. During the trial, patients have contact with a member of the study team. The risk of the proposed trial was evaluated based on published literature in similar trials conducted before.[8–10] NFB involves the chance of improvement of mental health and various mental health disorders. Side effects of NFB are fortunately rather rare and due to overexertion caused by extensive sessions and not to the NFB itself. The most commonly reported side effects are fatigue, pain, sleep disturbances and muscle stiffness and—spasms.[5] Due to therapy sessions of 30–45 min, side effects caused by overexertion are not expected.

For the NFB practitioners, study participation will not affect the employment relationship. Termination of the interview is possible at any time without disadvantages.

The Ethics Committee of the Medical Faculty Essen has approved the study (23–11140-BO). Written informed consent is obligatory for all patients to participate and is obtained after providing oral and written information. All participating patients can withdraw at any time without any disadvantage.

Results will be published in peer-reviewed journals and conference presentations. Key findings will also be published in lay language on the publicly accessible website and disseminated via various (social) media channels.

Contributors are entitled to authorship if they were either involved in the implementation, planning or organisation of the study or supported the creation of the manuscript. There are no plans to consult professional writers.

DISCUSSION

Patients with mental health issues suffer from a significant symptom burden. NFB represents an efficient therapy option for the treatment of several disorders, for example, anxiety and depression disorders, post-traumatic stress disorders, eating disorders and somatoform disorders, by the training of different brain frequencies. Even though NFB is heavily researched and shows promising results in the treatment of mental health disorders there is a fundamental lack of a standardised approach.

The present pilot study is designed to investigate whether a manualised NFB training presents an effective and feasible treatment option and leads to successful changes in brain frequency amplitudes as well as in psychopathological outcomes.

If the manualised NFB training is effective, it will provide new opportunities to investigate NFB in a more controlled and comparable manner in clinical practice. Until now, there are no standardised protocols in this research area. If we do not define different standardised and manualised protocols, we will not be able to compare NFB training in different cohorts or investigate the effects on psychopathological parameters in different studies. A standardised NFB training would thus offer the possibility to compare the effects of NFB in different cohorts and across different studies, which was previously limited due to the use of different protocols and different procedures during the training itself.

With this standardised and manualised training method, future studies can be conducted with less effort for institutions. First, projects that offer NFB could be supported by staff who are not officially trained NFB trainers. These could deliver the training after less extensive training by using the manual. Furthermore, the manual would allow a flexible implementation of the NFB training, as different trainers could carry out the training with the same patient. Especially in the case of substitution situations, workflows would be simplified. Nevertheless, the patients would receive a high-quality NFB training, which would be robust against external structural factors. Noise, such as created by implementation effects, would be reduced, since all NFB users would use the exact same procedure.

However, the limitations of the study must be considered. First, the study only includes patients who initially visited the respective clinic for psychosomatic medicine. Recruitment is therefore restricted to the usual patient clientele for the clinic. Moreover, due to the pilot character of the study, there only is an intervention group, but no control group. Therefore, this study will provide assumptions of the effectiveness of NFB training, but future studies should include a control group and use randomisation to assess effectiveness and efficiency. As a result, the generalisability of this study is limited and should only be interpreted as a forerunner for a larger-scale study.

This is the first study examining a manualised NFB training in order to provide a standardised intervention. It uses a mixed-methods approach that involves both patients and practitioners and represents an important step towards implementation. Even though the manualised training is not a substitute for individual training in the treatment of various mental health disorders, the project offers the opportunity to take NFB research a step further by standardising and manualising the application of the training, which could facilitate comparisons between diseases and replication of studies in the future.

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