BMC Complementary Medicine and Therapies

SYSTEMATIC REVIEW Open Access

Surf therapy for people with mental health disorders: a systematic review of randomized and non-randomized controlled trials

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Abstract

Background Surf therapy is gaining popularity for improving mental health. However, there is limited research evidence to substantiate these claims. Therefore, this systematic review aimed to assess randomized or non-randomized studies analyzing the efficacy of surf therapy in improving symptoms of mental illness compared to non-exercising controls and/or alternative intervention, and to identify evidential gaps to inform future research.

Methods PRISMA 2020 reporting guidelines were followed. Eligibility criteria included participants of any age and sex, explicitly diagnosed with any mental health disorder, while exposed to surf therapy and compared to non-exercising controls and/or alternative interventions. The primary outcome consisted of changes in symptoms of mental illness scored from baseline to post-intervention. Any randomized or non-randomized trial design was considered. We searched Cochrane Library, CINAHL, EMBASE, PubMed, Scopus, SPORTDiscus and Web of Science databases (December 7, 2023), without language or publication date restrictions and without filters. Risk of bias was assessed using RoB 2. A meta-analysis could not be conducted due to heterogeneity of the studies; therefore, a narrative synthesis of individual study results was performed.

Results Of 5,666 records, three randomized controlled studies were included in the review. Overall, the findings of the three studies suggest no robust consistent evidence of improvement in mental health symptoms when comparing surf therapy to wait-list control groups or other nature-based exercise interventions (hike therapy). Certainty of evidence should be considered very low, as it is based on three randomized controlled trials.

Conclusion Although we believe that surf therapy provides an interesting approach, robust evidence is scarce. Routes for future well-designed, controlled studies are discussed.

Other No funding to report. Registration: PROSPERO CRD42021277060.

Keywords Mental health disorders, Exercise, Human physical conditioning, Blue space, Water sports, Surf therapy, Surfing, Physical activity

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Introduction

Mental health disorders are a prominent public health challenge [1] and detract from overall health status [2]. A mental health disorder is a condition diagnosed by a medical professional (e.g., psychiatrist) which interferes with an individual's cognitive, emotional, or social abilities, encompassing an extensive spectrum of disorders including depression, anxiety, and psychotic illness, which are classified according to the Diagnostic and Statistical Manual of Mental Disorders [3]. Almost one billion people worldwide suffer from a mental health disorder, with poor mental health being estimated to cost the world economy approximately $2.5 trillion US dollars in 2010 (including reduced productivity), projected to rise to $6 trillion by 2030 [4]. Despite advances in pharmacology and psychotherapy for a wide range of mental health disorders, many people do not achieve full remission [5, 6]. For example, the STAR*D study, the largest open trial assessing the effects of pharmacological antidepressants, psychotherapies, or both, demonstrated less than 50% success rate after the first treatment [7].

The beneficial effects of exercise on improving physical health and fighting mental health disorders have been widely studied [8–10]. Exercise interventions for people living with mental health disorders have witnessed an increase in the number of scientific articles including clinical trials [11–13] and systematic reviews [14, 15]. International guidelines for treating mental disorders are increasingly incorporating scientific evidence and recommending that physical activity and exercise be integrated into mental health care [14, 15]. The benefits are related to the improvement of quality of life [16], with the decreasing of psychiatric symptoms [17] and with an enhancement in neurocognitive functioning (e.g., working memory, social cognition) [18]. Current recommendations for exercise interventions pertain largely to aerobic activity and cardiorespiratory fitness, as most of the observational and interventional research in this area has focused on overall physical activity levels [19]. Additionally, muscular strength and resistance training may protect against mental health disorders [20]. However, aside from classical modalities of exercise training (i.e., aerobic and strength training), alternative exercise interventions may aid mental health.

Exercise interventions in a natural environment may improve mental health to a larger extent than physical activity alone [21, 22], particularly water-based interventions [23]. However, caution is needed, as this evidence comes from one observational survey [17] and one systematic review of longitudinal observational studies [18], rather than from controlled intervention research comparing exercise plus nature versus exercise alone. There might be a synergy between the psychological benefits of physical activity and the restorative effects (i.e., reduced stress, increased well-being) of contact with a natural environment [21, 22, 24]. Exercise outdoors in water (compared to out of water) produced greater improvements in self-esteem and mood, potentially protective against future long-term health threats [25].

A systematic review of blue space interventions (i.e., those including one or more types of visible outdoor surface waters) [26] showed that mental health, especially psychosocial well-being, can be improved with investment in blue spaces [27]. Theoretical proponents of blue space interventions suggest that the independent benefits of water may result from its unique sensory inputs [28], like the relaxing sounds of waves or the smell of salt water. However, it is also important to examine possible processes of surf therapy practice to understand why it may work [29]. An investigation of the mechanisms underpinning the effects of surf identified physical activity, water immersion, exposure to sunlight, transcendent experiences, reduction in rumination, and the satisfaction of basic psychological needs are factors that might explain the beneficial physiological and psychological changes [30].

The first peer-reviewed publication on surf therapy dates from 2010 [31], denoting that this is an emerging field. In December 2019, surf therapy was defined by the International Surf Therapy Organization (ISTO) as a method of intervention that combines surf instruction/surf and structured individual and/or group activities to promote psychological, physical, and psychosocial well-being (https://intlsurftherapy.org/) [32]. It is also important to note that "intervention" according to the American Psychological Association is defined as an "action intended to interfere with and stop or modify a process, as in treatment undertaken to halt, manage, or alter the course of the pathological process of a disease or disorder" (https://dictionary.apa.org/intervention).

To date, only one scoping review provides an account of the scientific evidence related to surf therapy [32]; the authors analyzed the period between 2008 and 2019 and 29 papers met the inclusion criteria. This review supported surf therapy as a means of improving psychosocial and physical outcomes and included recommendations for improving surf therapy research and practice, but the studies assessing mental health interventions with surf therapy were reported to be heterogeneous, both statistically (i.e., direction and magnitude of outcomes) and clinically (i.e., populations, interventions) [32]. Scoping reviews may be helpful precursors to systematic reviews [33], but high-quality systematic reviews are key tools to inform the development of trustworthy clinical guidelines [34]. The biggest barrier to understanding the efficacy of surf therapy is the lack of controlled evaluations (RCTs). To advance the field, this review aims to provide a more rigorous evaluation of surf therapy by conducting

a systematic review of randomized and non-randomized trials on surf therapy for people with mental health disorders, and to identify evidential gaps to inform future research. This sampling strategy provides a clearer picture of the current state of knowledge of the impact of surf therapy interventions in help-seeking individuals with mental disorders, therefore providing a more thorough assessment of the potential benefits of surf therapy on such populations.

Methods

The review used a narrative synthesis and was conducted according to the method outlined in Cochrane's guidelines [35] and reported according to PRISMA 2020 guidelines [36]. A PRISMA checklist 2020 provided with the submission.

Eligibility criteria

Peer-reviewed articles in full form (i.e., excluding abstract-only records) were considered, with no limitations on language or publication date. Eligibility criteria using the PICOS approach are presented in Table 1.

Table 1 Eligibility criteria (PICOS)

PICOS	Inclusion criteria
Participants	Participants of any age, sex, explicitly: (i) diagnosed with any mental health disorder, according to DSM-5® [3], ICD-11 [37] or assessed through a validated screening tool (e.g., PHQ-9, HADS). Previous versions of the instruments (e.g., DSM-4) were acceptable.
Interventions	Surf therapy, defined by the International Surf Therapy Organization (ISTO) as "combining surf and structured activities that promote psychological, physical and psychosocial wellbeing" (https://intlsurftherapy.org). Surf therapy can be applied either as a monotherapy, or as an adjunct to other therapies.
Comparators	Non-exercising controls and/or alternative interventions. The comparison group can be "no intervention", or "placebo". Usual care had to be described. In the absence of description, the authors of the study were contacted.
Outcomes	Primary outcome: changes in symptoms of mental illness scored from baseline to post-intervention. Outcomes must be assessed by medical diagnosis and/or properly validated scales, which may vary depending on the specific mental health disorder(s). Secondary outcomes: not determinant for purposes of eligibility.
Study design	Any design with at least two groups.

Legend: DSM-5 and DSM-4: The Diagnostic and Statistical Manual of Mental Disorders (versions 5 and 4, respectively); HADS – Hospital Anxiety and Depression Scale; ICD-11: International Classification of Diseases 11th Revision; PHQ-9: Patient Health Questionnaire

Information sources and search strategy

We searched Cochrane Library, CINAHL, EMBASE, PubMed, Scopus, SPORTDiscus and Web of Science databases on December 7, 2023, without language or publication date restrictions and without filters. SPORTDiscus was searched using EBSCOhost. The other databases were accessed directly.

General search strategy applied free text terms to the title or abstract:
("surf" OR "water sport*" OR "water-based sport*" OR "bluespace*" OR "blue space*")*
AND.
("depressi" OR "anxi*" OR "mental illness*" OR "mental disorder*" OR "mental health")*
A third line of code was applied to all fields/full text/all text (depending on the database):
("physical activity" OR "sport" OR "train*" OR "exercis*")*

Supplementary Table 1 presents the full strategies for each database. Additional searches included manual searches within the reference lists of the included studies, snowballing citation tracking, and consultation of external experts (Ph.D., published research on the topic) to provide additional suggestions of potentially relevant studies.

Selection process

Each record and each report were independently screened by JA and JGC and each report was retrieved. If there were disagreements between the two authors, FMC provided arbitrage until consensus was achieved. EndNote™ 21.2 for Mac (Clarivate™) was used to automated removal of duplicates, but further manual removal of duplicates was required.

Data extraction

LC and JA independently collected data from reports. In case of disagreements between the two authors, FMC provided arbitrage until consensus was achieved. No automation tools were used.

Data items

Primary outcomes: changes in symptoms of mental illness scored from baseline to post-intervention. Outcomes had to be assessed by medical diagnosis and/or properly validated scales, which may vary depending on the specific mental health disorder(s).

Secondary outcomes: (i) physical/physiological data (e.g., performance tests, body composition); (ii) psychosocial well-being (e.g., self-efficacy, social interaction); (iii) adverse effects resulting from, or associated with, the interventions.

Additional variables: (i) sample size and features (e.g., age group, gender, socioeconomic status, geographical location, specific mental health disorder(s), severity, or degree of mental health disorder); (ii) study design; (iii) funding sources and potential conflicts of interest.

Study risk of bias assessment

Risk of bias was performed at outcome-level, with a worst-case scenario provided for the study level. All included studies were randomized, and therefore were assessed using RoB 2 [38], which judges risk of bias arising from: (i) randomization process; (ii) deviations from intended interventions; (iii) missing outcome data; (iv) measurement of the outcome; and (v) selection of the reported result. Risk of bias was independently assessed by JA and JGC. FMC provided arbitrage until consensus was achieved in case of disagreements between the two authors.

Additional protocol-related information

Effect measures, synthesis methods, moderated analyses, and risk of publication bias assessment were not assessed, due to the identification of only three independent trials conducted in very heterogeneous populations and with quite distinct interventions and comparators. Certainty of evidence, as assessed through GRADE [39], was affected by these issues. All pre-planned analyses are available in the originally registered protocol (PROSPERO CRD42021277060).

Results

Study selection

The full study selection process is presented in Fig. 1. Given the broad-net strategy used in the search, we retrieved 5,666 records, of which 1,881 were duplicates. Screening of the title and abstract of the remaining 3,785 records identified only 7 studies potentially fitting all eligibility criteria [40–46]. Full-text analysis resulted in the exclusion of three studies: one did not use a surf intervention [42], one had a single group [43], and another had two groups (men vs. women) performing the same surf intervention [40]. Four controlled studies (all randomized) were included for analysis [41, 44–46]. However, two of the publications [45, 46] derived from the same trial, and so were treated as single trial. The reference lists of these trials were analyzed, with two potentially relevant titles being identified (not having previously been excluded in our selection process) [47, 48]; however, none fulfilled the eligibility criteria. Snowballing citation tracking in Web of Science showed no additional potentially eligible study. Three external experts were contacted, and one of them reported that the authors had located the literature that meets the eligibility criteria.

Risk of bias assessment

Risk of bias was assessed using RoB 2 and followed Cochrane's recommendations [35]. An intention-to-treat effect was considered. Overall risk of bias was high for all included studies. Problems arose with randomization (namely, improper description, no mentioning of

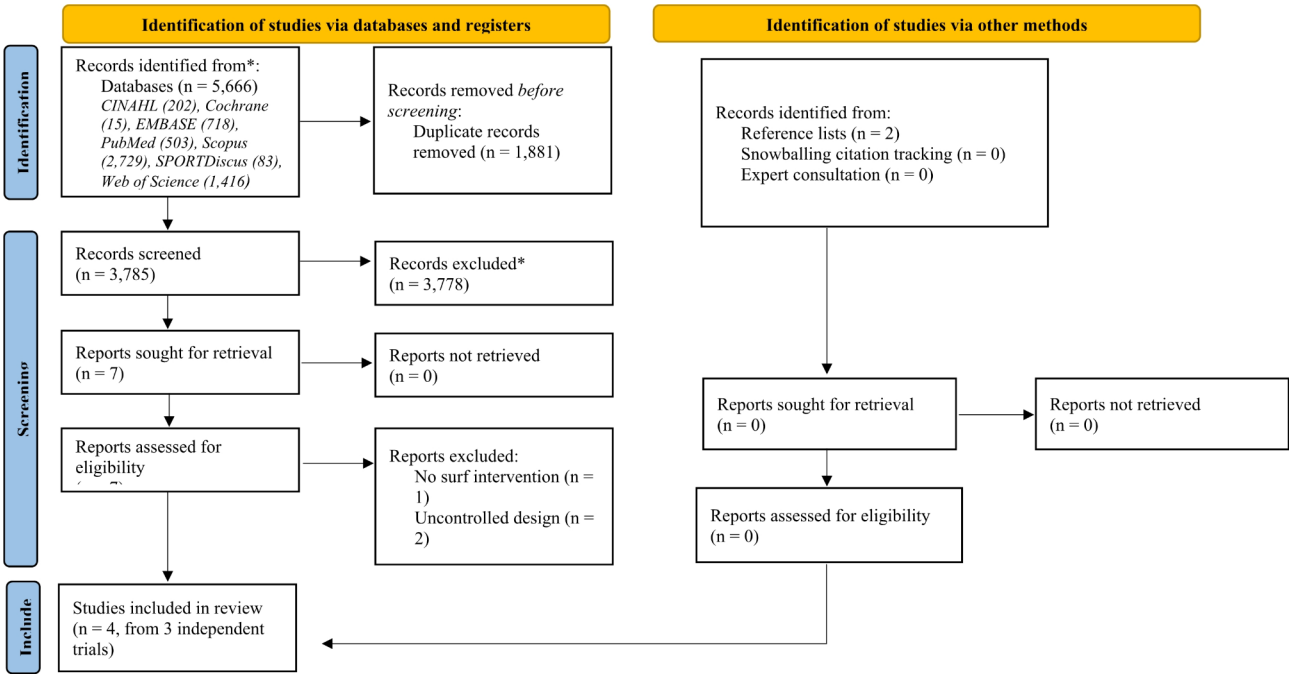

Fig. 1 PRISMA 2020 flow diagram. * Namely due to record type (e.g., abstract only, review) or failing to fulfill other eligibility criteria (e.g., healthy participants, no surf-related intervention)

allocation sequence concealment, and relevant intergroup differences at baseline) for two of three trials. All studies had high risk of bias for deviations from intended interventions (e.g., relevant co-interventions being applied to one experimental group but not the other and/or intention-to-treat analyses being replaced with per-protocol analyses). All studies also had high risk of bias for missing outcome data, with high dropout rates, often differing between intervention and comparator. Measurement of the outcome had high risk of bias, mostly due to referring to self-reported outcomes. The specific outcomes assessed and full reporting of reasons for each study's assessment are available in the supplementary Excel file (ROB2_IRPG_beta_v9_Surf therapy.xlsm). Figure 2 synthesizes information on the risk of bias.

Study characteristics and results

We found three randomized controlled trials of combined surf and psychological interventions [41, 44–46]. The characteristics of the three studies included in the review are summarised in the supplementary Table 2. The initial inclusion criteria required participants to have a diagnosis of a mental health disorder according to DSM-5® [3], ICD-11 [33], or to be assessed through a validated screening tool (e.g., PHQ-9, HADS). However, only one [46] of these three trials explicitly meets the criteria. The other two trials [42, 45], did not require a formal diagnosis by DSM or ICD criteria or a specific symptom score, although they fulfilled all other eligibility criteria. For instance, Olive (2023) only required a referral from a mental health or allied health professional (without a diagnosis or symptom screening for entry), and Pereira (2020) required participants to be in residential care (also without a diagnosis or symptom screening for entry). Consequently, an ad hoc change to this inclusion criterion was introduced: not all participants in these trials have a formal mental health diagnosis. Some may have elevated symptoms that are sub-threshold or may be at risk for a mental health disorder. Therefore, the data underlying this review encompasses a broader range of individuals than just those with a formal mental health diagnosis. This was done having a systematic review including a single paper.

One study [41] was performed on 73 children and adolescents (aged 7 to 17; mean age=13.83±2.60; 58.40% male, 41.60% female) in residential childcare, as part of the *Wave by Wave* surf therapy program, that combines surfing with a psychological intervention. Randomization allocated the participants to intervention (21 sessions of surf therapy program) or waiting-list groups. No significant statistical effects between the groups were noted for depression, anxiety, self-esteem, emotion regulation, social connectedness, sleep quality, and executive functions. The study reported effect size (Cohen's d) without reporting confidence interval. Cohen's d provides a measure of the effect size, indicating the magnitude of the difference between groups. However, without a confidence interval, it is unclear how precise this estimate is. A confidence interval would show the range within which the true effect size is likely to fall, giving a clearer picture of the reliability of the reported effect size.

A further randomized controlled trial involving children and adolescents aged 8–18 (11.28±2.34; 15 females) who were seeking help for mental health issues, compared a 6-week mentor-supported surf therapy program with a waitlist control group [44]. This program using surf therapy combined the process of learning to surf one-on-one together with group-based activities drawing on the principles of cognitive-behavioral therapy targeting the improvement of a set of core underlying psychological processes. These included internalization (e.g., anxiety) and externalization (e.g., aggression) of mental

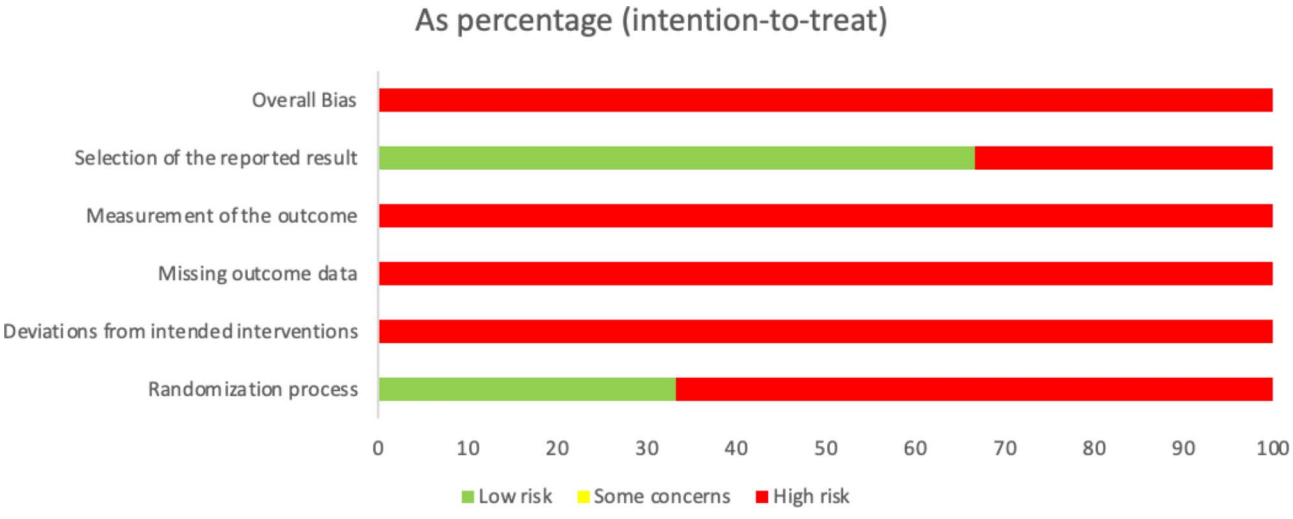

Fig. 2 Risk of bias in studies

health presentations. The study exclusively reported effect sizes within each intervention group (change from baseline), rather than conducting between-group analyses comparing intervention and control groups. For the RCADS (Revised Children's Anxiety and Depression Scale), children receiving the intervention demonstrated reductions in depressive (d=0.57, 95% CI = -5.12, 0.54) and anxiety symptoms (d=0.43, 95% CI = -6.66, 1.60), while the control group reported increases in both anxiety and depressive symptoms at 6 weeks post-randomisation. These reductions were not maintained at the 12-week follow-up after randomization. On the SDQ (Child reported Emotional symptoms), participants who received the intervention reported improvements six weeks after randomization, including reductions in emotional problems (d=0.79, 95% CI = [-2.77, -0.17]), overall difficulties (d=0.64, 95% CI = [-6.30, 0.30]), hyperactivity/inattention (d=0.28, 95% CI = [-2.06, 0.88]), and peer problems (d=0.56, 95% CI = [-2.39, 0.27]). However, these improvements were not maintained after the intervention ended, 12 weeks post-randomization.

Surf therapy and hike therapy were compared in another randomized controlled trial, with the results being distributed over two publications [45, 46]. This trial examined depression outcomes in 96 active-duty service members suffering from MDD who were randomly allocated to one of the two therapies for 6 weeks. Self-report and clinician-administered measures were completed at three different points: pre-program, post-program, and 3-month follow-up. Continuous depression outcomes altered significantly over time ($p<.001$) according to multilevel modelling results. Despite service members in hike therapy reporting higher average depression scores than those in surf therapy (which were already apparent at baseline), the rate of symptom improvement was not significantly different between groups. Concerning MDD diagnosis, no significant differences between the groups at post-intervention ($p=.401$) were noted. However, participants in the surf therapy had a higher probability of remitting from MDD than those in hike therapy at the 3-month follow-up ($p=.015$). Moreover, improvements in secondary outcomes (e.g., negative affect, anxiety) were not different between the two groups.

Certainty of evidence

The reduced number of studies (four publications corresponding to three independent trials) and their clinical heterogeneity (populations, specificity of the interventions and comparators) suggest caution when interpreting the results, despite all studies showing positive effects of surf therapy. Moreover, of three independent trials, one had high risk of bias across all domains [41], and another (two publications, same trial) had high risk of bias emerging from the randomization process [45, 46]. Therefore, there is currently very low confidence in the available body of evidence.

Discussion

Physical activity is widely recommended as a treatment modality for various physical or mental health disorders, and surf therapy is an emerging intervention in this context [32, 49], as it has been linked with improvements in mental health domains including prosocial behaviours, anxiety and depression symptoms, emotional and peer problems, hyperactivity/inattention, and overall difficulties [44, 50]. The goal of this study was to perform a systematic review of controlled studies assessing the efficacy of surf therapy for people with mental disorders, including (but not limited to) symptoms of depression or anxiety.

Initially, our goal was to conduct a thorough evaluation of surf therapy by systematically reviewing both randomized and non-randomized trials involving surf therapy for individuals with mental health disorders. However, we only identified four controlled studies from three independent trials (all randomized) [41, 44–46]. Overall, the data from these studies suggests a lack of robust evidence in support of surf therapy for adult veterans with MDD [45, 46] and children and adolescents at risk of mental disorders [41, 44]. Globally, our results corroborate those of a previous review [32] and suggest that although the number of scientific publications and specifically the randomized controlled trials have been increasing in recent years, the associations between mental health and surf therapy are heterogeneous and do not clearly support a beneficial effect of surf therapy, especially when compared with other control conditions.

The ISTO definition describes surf therapy as an activity that combines surf and structured activities, which promotes psychological, physical, and psychosocial well-being and that is structured, individual or in group (https://intlsurftherapy.org). The ISTO also uses the term "intervention" defined by the American Psychological Association as an action that aims to intervene and stop or change a process, e.g., the treatment undertaken to cease, manage, or change the course of the pathological process of a disease or disorder (https://dictionary.apa.org/intervention). However, the surf therapy intervention differed across the three studies. In one study [41], participants received surf therapy that combined surfing with psychological intervention. In another study [44], the intervention included group psychoeducation, surfing activities, and individual mentoring. In the third study [45, 46], optional yoga was offered to participants before each surf therapy session as part of the existing NMCSD program and the surf therapy intervention did not include a psychotherapy component.

When ISTO defines that surf therapy combining surf and structured activities promotes psychological, physical, and psychosocial well-being (https://intlsurftherapy.org), it seems important to define what kind of structured activities are involved. Moreover, since surf therapy is a multimodal intervention, it is important to decide whether the focus should be on identifying which specific aspects are crucial—such as the surfing activity itself, exposure to natural environments like blue spaces, or the psychological techniques used—or on evaluating whether the overall surf therapy approach is effective as a whole, regardless of the individual components. This involves analyzing the therapy to determine which specific elements (e.g., surfing activity, blue space exposure, mental health techniques) have the most significant impact, with the goal of understanding what makes surf therapy effective or ineffective.

Moreover, the activity in surf therapy does not appear to constitute exercise. The term exercise refers to a subcategory of physical activity that is planned, structured and repetitive and aimed at improving or maintaining one or more components of physical fitness [51]. A key element of this definition is that exercise is intended to improve or maintain specific components of physical fitness, rather than simply achieving or sustaining a predetermined level of fitness. None of the studies assessed components of physical fitness.

One study [52] reported that there was little evidence for the enhanced effects of surf therapy relative to hike therapy in active duty service members with major depressive disorder (MDD). The only significant difference between the groups was in MDD remission at the 3-month follow-up. However, individuals were allowed to participate in the nonrandomized intervention in the follow-up period due to the transitory nature of military service. Therefore, it might introduce potential confounding variables that could affect the study's outcomes. Additionally, the use of exercise interventions for the treatment of MDD, such as hike therapies, has grown significantly over the last several decades [53]. Hike therapy is a nature-based exercise and the effects of exercise on MDD are well-documented [54]. Therefore, hiking is not an appropriate control condition to determine the effects of surf therapy as a type of exercise intervention.

Considering the diversity of surf therapy interventions operating in culturally and linguistically diverse groups [e.g., war veterans [55], children and adolescents in post-conflict zones [56]], researchers should refrain from utilizing surveys designed to assess constructs within a particular culture with other cultural groups [57]. The specificities of surf therapy may vary depending on geographical location, life conditions within the country/region being assessed, language and culture, participant-related features (e.g., age, gender, previous experience with surf), programming parameters (e.g., length, frequency, volume, intensity, and contents of the sessions), and mental-health related features (e.g., specific type and severity of mental health disorder).

The quality of coach recruitment and the surf equipment could interfere with the successful implementation of surf therapy interventions. The importance of physical activity supervision by qualified professionals was highlighted in a systematic review that explored the predictors for dropouts in subjects with schizophrenia [58], with the provision of qualified professionals and continuous supervision being associated with reduced rates of dropouts. In this line, a recent study stated that exercise professionals should be recognized as important members of the standard multidisciplinary mental health team for patients being treated for mental illness [59].

In our systematic review, the few available randomized trials [41, 44–46] demonstrated that when comparing surf therapy to wait-list control groups or other nature-based exercise interventions (hike therapy), there was no robust, consistent evidence of improvement in mental health.

Additional challenges for surf therapy

Surf therapy may pose additional challenges: some populations may require considerable travel to engage in surf, which can raise the temporal and financial costs and reduce its feasibility. Even if the participants live near the sea, it is questionable if they will have the financial conditions to acquire their own surfboards and/or surf lessons, and the autonomy to independently engage in surf. Consequently, it is questionable if participants would keep engaging in surf post-intervention, and follow-up studies are warranted to assess this. A recent study highlighted a key limitation linked with surf therapy and physical activity programs, which is what happens after finishing the programs and if the positive changes are sustained [29]. Recent research suggests that positive changes in mental health are not sustained over time during follow-up evaluations [60].

Although parents, siblings and significant others could enhance the likelihood that the surf will continue once individuals have completed the program [32], it is crucial to consider their socioeconomic background, which could pose additional barriers to the continuity of the therapy (e.g., resources such as disposable income to purchase equipment, transportation) [61, 62]. In rural settings, surf therapy could perhaps be implemented in pools, but that usually requires expensive facilities.

Limitations

Our methodology does have some limitations, specifically, we did not seek grey literature, which is often standard practice in systematic reviews, especially in

specialized fields. Additionally, we did not search trial registries. Based on three independent randomized controlled studies, it is premature to provide clear and robust recommendations regarding the applications of surf therapy in the context of mental health, as well as their specific contents and dosage.

Practical suggestions for future research

Future research should focus on RCTs using blinded assessors and providing in-depth descriptions of the participants, their mental health disorders, and the context where the interventions are being conducted. Full reporting of participants, from recruitment to follow-up, should be provided, and dropouts and adverse effects acknowledged. Further, employing a mixture of qualitative and quantitative research methods, with multiple research methods should give different perspectives and might help to understand and go further in this field. Finally, long-term studies should assess feasibility, effectiveness, and follow-up to provide a more thorough understanding of the effects of surf therapy.

Conclusion

Our systematic review identified three independent trials, which found that the quality of evidence is currently limited by a high risk of bias, the heterogeneity of intervention protocols, and the lack of efficacy of surf therapy in improving mental health compared to non-exercising control conditions or alternative intervention (hike therapy). Future studies should focus on randomized controlled trials with well-defined protocols and longer follow-up periods to assess the sustainability of benefits. Additionally, exploring the specific components of surf therapy and their relative impact could help refine interventions for better clinical outcomes.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12906-024-04674-0.

Supplementary Material 1

Supplementary Material 2

Acknowledgements
Not applicable.

Author contributions
LC and JA conceived the study, registered the protocol, wrote the article, and approved the final draft. FMC, JGC, JF, and RRC contributed to writing and approved the article. All authors reviewed the manuscript.

Funding
There was no financial or non-financial support for the review. The were no funders or sponsors in the review.

Data availability
All data generated or analysed during this study are included in this published article.

Declarations

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Registration and protocol
The protocol for the systematic review was pre-registered in PROSPERO, with the code CRD42021277060 attributed on October 7, 2021.

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Received: 17 January 2024 / Accepted: 1 October 2024
Published online: 26 October 2024

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