

The long-term effect of surf therapy on posttraumatic stress, depression, and anxiety symptomology among current and former Australian defence force members - A nonrandomised controlled longitudinal study in a community setting

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ABSTRACT

Background: Surf therapy programs have demonstrated engagement among military samples, showing promising concurrent short-term reductions in symptoms of posttraumatic stress disorder, major depressive disorder, and generalised anxiety disorder; however, the long-term retained benefits of such programs have not been studied beyond three months.

Methods: This nonrandomised controlled longitudinal study recruited current and former Australian Defence Force personnel ($N = 116$) to examine the effect of a ten-session surf therapy program ($n = 88$) compared to a control group (no intervention; $n = 28$). Validated self-assessment measures of post-traumatic stress, depression and anxiety symptoms were recorded at pre and post intervention, and at one month, four months, and seven months follow up.

Results: Linear mixed model results reveal statistically significant post-program reductions in symptoms of posttraumatic stress (PCL-M; $\beta = -11.92$, 95% CI [-17.44, -6.36]), depression (MDI; $\beta = -7.87$, 95% CI [-12.35, -3.38]) and anxiety (GAD-7; $\beta = -4.02$, 95% CI [-6.42, -1.57]), which were retained at 7-months follow-up. Clinically significant changes were also observed on all three outcomes. No changes were observed in the control group. Additional statistically significant beneficial effects for each model outcome were recorded for leisure surfing following the program. Most surf therapy participants continued surfing post program, indicating effective lifestyle change.

Conclusions: This is the largest quantitative surf therapy study among adults to date, and the first to follow up seven months post program. It confirms previous surf therapy findings of high engagement and transdiagnostic effects, and provides new clinically relevant knowledge by demonstrating retained beneficial effects regardless of continued surfing post program.

1. Introduction

Australian Defence Force (ADF) members are at significantly elevated risk of mental, physical, and social dysfunction following discharge (Van Hooff et al., 2018). Among former ADF members, the estimated ICD-10 lifetime prevalence of posttraumatic stress disorder (PTSD) is 24.9%, of any affective disorder (e.g., depression) is 39.6%, and of any anxiety disorder (other than PTSD) is 31.9% (Van Hooff et al., 2018). PTSD, Major Depressive Disorder (MDD) and Generalised

Anxiety Disorder (GAD) are among the most prevalent mental disorders among military populations, and commonly occur together (Nichter, Norman, Haller, & Pietrzak, 2019; Rytwinski, Scur, Feeny, & Youngstrom, 2013; Walter, Levine, Highfill-McRoy, Navarro, & Thomsen, 2018). GAD is characterised by excessive, uncontrollable worry and autonomic arousal interfering in daily functioning, while (MDD) is characterised by low mood and loss of interest in pleasurable daily activities (American Psychiatric Association, 2013). PTSD shares many similar symptoms with MDD and GAD; however, intrusive symptoms

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such as nightmares and flashbacks are unique to PTSD (Brewin & Holmes, 2003). According to Foa, Steketee, and Rothbaum (1989)'s fear network model of PTSD, intrusions reflect unprocessed memories of trauma, which drive a vicious circle of PTSD by escalating hyperarousal states, passive coping by avoiding reminders that may trigger re-experiencing, leading to feelings of incompetence and depression, thereby reinforcing a self-belief of uncontrollability over unwanted stimuli. Longitudinal studies among veterans have shown PTSD to predict onset of depression, anxiety, and physical impairment (Ahmadian, Neylan, Metzler, & Cohen, 2019; Ginzburg, Ein-Dor, & Solomon, 2010). Comorbidities among military samples involving PTSD, MDD and GAD are associated with greater PTSD symptom severity (Knowles, Sripada, Defever, & Rauch, 2019), and much greater risk of suicide (Jakupcak et al., 2009; Nichter et al., 2019) than those with PTSD alone. Higher symptom severity in these disorders are associated with greater risk of functional impairment (Helmer et al., 2009; Macdonald-Gagnon, Stefanovics, Potenza, & Pietrzak, 2024; Richardson, Long, Pedlar, & Elhai, 2008; Rona et al., 2009), anger (Jakupcak et al., 2007), substance abuse (Van Hooff et al., 2018), social isolation (Karstoft, Armour, Andersen, Bertelsen, & Madsen, 2015), and physical inactivity (Zen, Whooley, Zhao, & Cohen, 2012).

PTSD, MDD and GAD remain difficult to successfully treat using psychotherapies which often yield modest clinical response rates (Cuijpers et al., 2024). Meta-analyses of randomised controlled trials (RCTs) of PTSD psychotherapies have found that veterans respond less favourably than civilians, between one-half to two-thirds of veterans retain a PTSD diagnosis following treatment (Steenkamp, Litz, Hoge, & Marmar, 2015; Straud, Siev, Messer, & Zalta, 2019), and concurrent depression severity attenuates treatment effect (Kline, Cooper, Rytwin-ski, & Feeny, 2021). Real world effectiveness studies have found more modest results than RCTs (Hengartner & Ploderl, 2022; Levi, Ben Yehuda, Pine, & Bar-Haim, 2022; Maguen et al., 2023) and the long term retained benefits after treatment often range from small to moderate (Phelps et al., 2018), to little or none (Grau, Sripada, Pietrzak, Ganoczy, & Harpaz-Rotem, 2022; Milliken, Auchterlonie, & Hoge, 2007). Pharmacological agents such as selective serotonin re-uptake inhibitors (which are commonly prescribed for PTSD, MDD and GAD) perform no better (Bryant, 2019; Lee et al., 2016; Levi et al., 2022; Warden, Rush, Trivedi, Fava, & Wisniewski, 2007; Watts et al., 2013). In a systematic umbrella review, Moncrieff et al. (2022) called into question the chemical imbalance theory linking serotonin depletion to depression, concluding that "long term antidepressant use might produce compensatory changes that are opposite to their acute effects" (Moncrieff et al., 2022, p. 12).

It has been reported that only 21% of service members and 27% of former service members who screen positive for a mental health or substance use disorder are currently receiving care (Colpe et al., 2015; Kline et al., 2022). The most significant barriers to seeking treatment are the widespread preference for self-management (Naifeh et al., 2016), stemming from the military culture of stoicism (i.e., self-reliant 'tough soldier'), the associated stigma of not fulfilling this role (Adler, Britt, Riviere, Kim, & Thomas, 2015; Keeling, Barr, Atuel, & Castro, 2020; Randles & Finnegan, 2022), and avoidance of therapies involving reliving past trauma (Schottenbauer, Glass, Arnkoff, Tendick, & Gray, 2008). These barriers remain entrenched after discharge from service (Sharp et al., 2015). Researchers investigating these barriers have called for re-examining traditional mental health treatments to leverage the military population preference for self-management (Adler et al., 2015; Forbes et al., 2019; Hawkins, Townsend, & Garst, 2016), and for the development and testing of novel vigorous physical activities to treat and prevent PTSD, MDD and GAD (LeardMann et al., 2011; Walter et al., 2019).

One such emerging treatment that bypasses the barriers associated with these disorders is surf therapy: a physical activity that also concurrently facilitates health promoting pathways of exposure to natural environments, mindfulness, flow states, and social support

(Moreton, Brennan, Nicholls, Wolf, & Muir, 2022). Exercise and physical fitness are integral components of military service life (LeardMann et al., 2011) and as such, surfing may be an attractive therapeutic treatment option for veterans experiencing mental health problems whilst avoiding the barriers of stigma and trauma re-experiencing of conventional treatments (Caddick, Smith, & Phoenix, 2015). Surfing involves short intervals of moderate-to-vigorous intensity exercise (whilst catching and riding waves) together with sustained low-to-moderate continuous intensity (whilst paddling and waiting for waves) (Moreton et al., 2022). Recent evidence for physical activity improving symptoms of post-traumatic stress, depression and anxiety is compelling (Björkman & Ekblom, 2021; McGranahan & O'Connor, 2021; Reis, Gaddy, & Chen, 2022; Singh et al., 2023). Singh et al. (2023)'s umbrella review found that physical activity produced comparable or slightly larger effect sizes than standard treatments, higher intensity physical activity produced the largest benefits, with resistance exercise most beneficial for depression, and mind-body exercise most beneficial for anxiety.

Surfing in a natural ocean environment affords very little demand on working memory and provides respite from negative ruminations (Caddick et al., 2015; Gibbs et al., 2022). Nature-based activities have been found in a meta-analysis to have a beneficial effect on depression and anxiety symptoms (Coventry et al., 2021), and in a systematic review among veterans with PTSD, Greer and Vin-Raviv (2019) found improvements in PTSD, depression, stress and quality of life measures. Surf therapy applies the principles of mindfulness practice by intentionally attending moment-to-moment with non-judgment, thus broadly satisfying Shapiro, Carlson, Astin, and Freedman (2006)'s axioms of mindfulness. Surf therapy has qualitatively been found to be a mindfulness-inducing activity by eliciting interoceptive, momentary bodily attention by providing embodied positive psychosomatic experiences (Britton, Kindermann, & Carlin, 2020; Caddick et al., 2015; Harris, 2015; Marshall, Ferrier, Martindale, & Ward, 2023). The development of such mindfulness while surfing has been found to be transferable to daily life activities (Gibbs et al., 2022), and enduring at 10 months follow up (Wilkie, Fisher, & Kemp, 2022). Recent meta-analyses of mindfulness-based stress reduction practices significantly improved biological markers related to stress, depression, and anxiety symptomology (Pascoe, Thompson, & Ski, 2017), and higher trait mindfulness is strongly associated with lower symptoms of PTSD, anxiety and depression (Carpenter, Conroy, Gomez, Curren, & Hofmann, 2019). In veteran populations, mindfulness practices have shown to be effective in alleviating PTSD symptom severity (Boyd, Lanius, & McKinnon, 2018; Cushing & Braun, 2018).

Surfing has been found to elicit flow in regular surfers (Morgan & Coutts, 2016; Nerothin, 2017); even among beginner surfers, Cheng and Lu (2015) found that flow fully mediated the causal relationship between surfing and wellbeing. Flow, or the state of optimal experience, is a subjective state of altered consciousness that occurs when one is fully engaged in a challenging activity (Csikszentmihalyi, 1975). Conceptually, flow consists of challenge skill balance, merging of actions and awareness, clear goals, unambiguous feedback, total concentration of task at hand, sense of control, loss of self-consciousness, transcendence of time, and autotelic experience (Jackson & Marsh, 1996). The peak performance state during flow has been described as invigorating by soldiers in the theatre of warfare (Harari, 2008). Flow states have been found to induce increased positive emotions and wellbeing (Boudreau, Mackenzie, & Hodge, 2020), increased positive affect (Reinhardt et al., 2008), resulting in reduced symptoms of PTSD, depression and anxiety (Garland et al., 2010; Kotler, Mannino, Kelso, & Huskey, 2022; Ley, Krammer, Lippert, & Rato Barrio, 2017).

Lastly, group surfing among military samples have been found to reduce social isolation, improve positive social interaction among peers and civilians, and increase social functioning (Caddick et al., 2015; Marshall, Ferrier, Ward, & Martindale, 2020; Walter, Otis, Miggantz, et al., 2023). Social functioning is impaired among the general population with depressive and anxiety disorders even after remission (Saris,

Aghajani, van der Werff, van der Wee, & Penninx, 2017). Recent meta-analyses among veterans reveal an inverse association between social support and PTSD, MDD and GAD, which is bi-directional and longitudinally predictive (Brewin, Andrews, & Valentine, 2000; Grover, Williamson, Burdett, Palmer, & Fear, 2024; Wang, Chung, Wang, Yu, & Kenardy, 2021). This unfortunate cycle is augmented among former service members after the loss of protective unit support following discharge (Kamphuis, Delahaij, Duel, Geuze, & Vermetten, 2021; Nielsen, Andersen, & Hogh, 2015; Pietrzak et al., 2010) who often experience difficulties re-integrating into the community, particularly for those who have been abruptly discharged from service (Barnett et al., 2021).

Receiving social support among veterans is associated with lower risk of PTSD, MDD and GAD, and is also associated with providing social support, which in turn is associated with altruistic behaviour and a lower risk of MDD and GAD (Na, Tsai, Southwick, & Pietrzak, 2022). However, veterans transitioning to civilian life maintain a strong military identity, which can create difficulties engaging in civilian social groups, and therefore would benefit from participation in veteran organisations for social support (Barnett et al., 2021). A key to unlocking these challenges may be participation in social physical activities, which have been found to generate trust and prosocial behaviours (Di Bartolomeo & Papa, 2019), and restore a sense of camaraderie formed by a shared military experience leading to the development and strong social connections (Caddick & Smith, 2014).

Recent quantitative surf therapy studies among military samples have found significant reductions in symptoms of PTSD, MDD and GAD (Crawford, 2017; Otis et al., 2020, 2024; Rogers, Mallinson, & Peppers, 2014; Walter et al., 2019; Walter, Otis, Miggantz, et al., 2023; Walter, Otis, Ray, et al., 2023). Crawford (2017) found significantly improved PTSD and MDD symptomology following a six-day intensive program, which remained significantly improved at one month follow-up although the magnitude of improvements had reduced. Investigating the effectiveness of a six-week program, Walter et al. (2019) found moderate-to-large statistically significant post-program reductions in PTSD, MDD, GAD, negative affect and increases in positive affect, as well as acute improvements from pre-to-post session, indicating an acute dose-response relationship. In a further analysis of the same sample, Otis et al. (2020) found that although service members with comorbid PTSD and MDD measured significantly worse symptoms of depression/anxiety and lower positive affect before each session, they experienced larger improvements in both measures after each session compared to those with either disorder alone. Taken together, these findings suggest that surf therapy may have transdiagnostic beneficial effects among those with comorbidities (who are less likely to respond to standard psychotherapy treatments; see Kline et al., 2021), and a dose-response relationship likely exists which may require ongoing surf therapy sessions for sustained recovery. Recent analyses of an RCT comparing six weeks of surf therapy to hiking, Walter, Otis, Ray et al. (2023) found a large and significant effect on depression measures with extended improvement at three months follow-up, Walter, Otis, Miggantz et al. (2023) found significant improvements in GAD symptoms which were retained at three months follow up, and Otis et al. (2024) found significant remission rates of PTSD and MDD (exceeding those of first-line treatments found in larger literature) regardless of comorbidity status, which were retained at three months post program.

It remains unknown however, if surf therapy program effects on posttraumatic stress, depression, and anxiety symptoms are maintained over the longer term (i.e., beyond three months follow up), and whether continued surfing is required to sustain those improvements. The present study aims to determine the immediate and long-term effects of a ten-session surf therapy treatment program on posttraumatic stress, depression, and anxiety symptomatology.

2. Materials and methods

2.1. Research design

This was a nonrandomised controlled longitudinal study among current service members (Regular ADF) and former service members (Transitioned ADF). The program was advertised as a general mental health and wellbeing activity to avoid any stigma surrounding mental health treatment (Sharp et al., 2015). The program did not target or screen for any mental health diagnosis. The intervention was a ten-session learn-to-surf program hosted by Veteran Surf Project; a non-profit organisation funded by the Australian Department of Veteran Affairs (DVA).

2.2. Setting and program format

The surf therapy program was held at Seven Mile Beach, Gerroa, NSW, a rural location bordering a National Park that offers a consistently gentle surf break. The program intervention was ongoing for 18 months from February 2021 to August 2022, and the study follow-up period concluded in March 2023. Surf therapy sessions were held twice a week on Wednesdays and Saturdays. Each 4-h session consisted of individual goal setting, surfing practice, and informal social interaction over lunch and coffee. To reduce attendance barriers (such as personal/work schedules, or illness fluctuations) a rolling cohort format was used, whereby participants were allowed to commence at any time during the intervention period and asked to attend once per week but allowed to complete any missed sessions on an alternate session day or by extending the program period. Intervention group sizes were between 10 and 20 participants at each session.

2.3. Participants and Procedure

Study participants ($N = 116$) were recruited directly via social media or referred by mental health practitioners and veterans' organisations. Participants were offered to join either the surf therapy group or the control group. Eighty-eight participants elected the surf therapy program and 28 individuals self-selected as control participants (i.e., no intervention). All participants were informed of the program duration and the option of being included in the study, which was offered as voluntary. Surf therapy program completion was pre-defined as having completed ten sessions. Upon completion, program graduates were encouraged to continue attending (with reduced instructor support) and to connect with each other for leisure surfing to facilitate the transition toward self-management via independently surfing. Ethics approval from DVA Human Research Ethics Committee was granted in December 2020 (approval # 232-20).

Potential participants who enquired about the program were provided the study information pack and, after deciding which group to join, signed the consent form. For the surf therapy group, self-administered surveys were collected at baseline immediately before the first surf therapy session (T1), and immediately after the tenth session (T2). Follow up surveys were collected at one month (T3), four months (T4) and seven months (T5) post program completion (Fig. 1 – Study data collection time points). For the control group, who were also veterans but who chose not to participate in the intervention, self-administered surveys were collected at time points T1 and T2 only. A gift card of AUD \$15 value was provided to all participants for each survey completed.

2.4. Dependent variable measures

2.4.1. PTSD checklist - military version (PCL-M)

The PCL-M is a validated self-report scale of PTSD symptom severity within the previous 28 days linked to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) (Guze, 1995). It

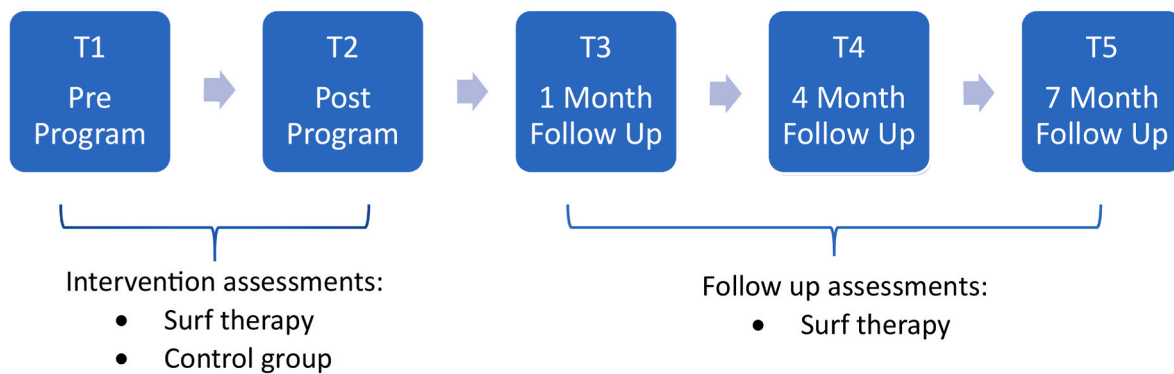


Fig. 1. Study data collection points.

consists of 17 question items using a Likert scale of five responses (ranging from *not at all* = 1, to *extremely* = 5) that can be summed to provide a total symptom severity score between 17 and 85 (Weathers, Litz, Herman, Huska, & Keane, 1993). PCL-M scores can be grouped into symptom severity bands of *low* (17–29), *moderate* (30–39), *high* (40–49), and *severe* (50–85) (Van Hooff et al., 2018). The PCL-M has been shown to have good psychometric properties, adequate internal consistency, test-retest reliability and convergent validity, and conservative indication of changes at follow-up when compared to clinician-administered PTSD scale (Forbes, Creamer, & Biddle, 2001; Monson et al., 2008). Monson et al. (2008) have suggested that clinically significant changes in DSM-IV PCL to be of ten or more points according to the protocol developed by Jacobson and Truax (1991). Sample-specific Cronbach alpha values for the PCL-M measure varied from 0.949 to 0.965, indicating a high reliability in all time points.

2.4.2. Major Depression Inventory (MDI)

The MDI is a validated psychometric self-report scale of depressive symptom severity within the last two weeks (Bech, Timmerby, Martiny, Lunde, & Soendergaard, 2015). The scale consists of 12 question items using a Likert scale of six responses (ranging from *none of the time* = 0, to *all of the time* = 5), with items 8 and 10 including two sub-items, of which each highest score is counted to form 10 items with a possible total of 50 points. The MDI has demonstrated acceptable convergence with the clinician administered Visual Analogue Scale (VAS), with clinical symptom severity score bands of: *none or doubtful* (0–20), *mild* (21–25), *moderate* (26–30), and *severe* (31–50) (Bech et al., 2015). We used a change from one clinical symptom severity band to another to represent clinical meaningful change. Sample-specific Cronbach alpha values for the MDI measure varied from 0.937 to 0.952, indicating a high reliability in all time points.

2.4.3. Generalised anxiety disorder seven item scale (GAD-7)

The GAD-7 is a validated self-report scale of anxiety symptom severity within the previous two weeks specifically linked to the DSM-IV criteria (Spitzer, Kroenke, Williams, & Lowe, 2006). It consists of seven question items using a Likert scale of four responses (ranging from *not at all* = 0, to *nearly every day* = 3), which are summed to provide a total score between 0 and 21. Scores are grouped into symptom severity bands that represent the risk for anxiety: *Minimal* (0–4), *mild* (5–9), *moderate* (10–14) and *severe* (15–21). The GAD-7 is among the most widely used anxiety measures, both in clinical practice and research due to its diagnostic reliability, and factorial, construct, and criterion validity (Dear et al., 2011; Johnson, Ulvenes, Øktedalen, Hoffart, 2019). A minimum clinically meaningful change has been determined as 3.8 points for a sample or 4 points for an individual (Toussaint et al., 2020). Sample-specific Cronbach alpha values for the GAD-7 measure varied 0.923 to 0.950, indicating a high reliability in all time points.

2.5. Other variables

Other variables were collected for consideration as potential confounding variables, including service status, age, sex, education level, religion, first language spoken as a child, relationship status, alcohol consumption, smoking status, and Aboriginality. Leisure activity engagement in the last four weeks was recorded by asking participants to list their top three leisure activities performed. The leisure activities were coded into types (i.e., leisure surfing, indoor sports and fitness, outdoor sports and fitness, creative, meditative, social, television, nothing).

2.6. Statistical analysis

All data were analysed as intention-to-treat. Descriptive statistics were presented using absolute and relative frequencies for categorical variables, and means and standard errors for continuous variables. Baseline sample characteristic differences between groups (surf therapy vs control) were analysed using a multiple logistic regression model with group as the dependent variable (Sperandei, 2014). For each outcome (i.e., PCL-M, MDI, and GAD-7), one linear mixed model with random intercepts for individuals to accommodate the repeated measures design was built, starting from the full model (including all sociodemographic variables) and a stepwise method was used for variable selection, forcing for the presence of group, time, and the interaction group and time in all models. A completers-only sensitivity analysis was performed to investigate any effect of non-completers when compared to the intention-to-treat analysis. This is presented in the supplementary material. All analyses were performed in R, version 4.3.1 (R Core Team, 2023), using package “lme4” (Bates, Mächler, Bolker, & Walker, 2015). Model assumptions were tested using package “HLMdiag” (Loy & Hofmann, 2014).

3. Results

3.1. Sample characteristics

Study participants ($N = 116$) were recruited and self-selected to participate in either the surf therapy group ($n = 88$), or the control group ($n = 28$). Of the 88-person surf therapy group, 62 (70.5%) completed all ten sessions of the program. Non-completers attended an average of 4 sessions (Range: 1 to 8, $SD = 2.4$) and were excluded from further follow up. Reasons for non-completion were injury (not surfing related) ($n = 4$), work time conflict ($n = 3$), family time conflict ($n = 1$), surgery ($n = 2$), COVID-19 concerns ($n = 4$), deployed ($n = 2$), aversion to groups ($n = 2$), and unknown ($n = 8$). Of the 28-person control group who completed the first survey (T1), 20 completed the second survey (T2; 71.4%).

Sample characteristics are presented in Table 1. The only statistically significant difference between groups at baseline was that the surf

Table 1
Sample characteristics.

	Baseline (T1)				Post (T2)		1 mth Follow-Up (T3)		4 mth Follow-Up (T4)		7 mth Follow-Up (T5)	
	Total Sample (N = 116)	Surf Therapy (n = 88)	Control (n = 28)	Surf Therapy x Control (p-values)	Surf Therapy (n = 62)	Control (n = 20)	Surf Therapy (n = 58)	Control	Surf Therapy (n = 54)	Control	Surf Therapy (n = 59)	Control
Age (years) (mean, SD)	47.5 (13.5)	44.7 (11.1)	58.5 (14.9)	0.089	44.4 (10.8)	61.5 (16.3)	45.1 (10.8)	–	44.9 (11.2)	–	45.2 (10.9)	–
Sex												
Male (n, %)	102 (87.9)	74 (84.1)	28 (100.0)	–	51 (82.3)	20 (100.0)	49 (84.5)	–	44 (81.5)	–	49 (83.1)	–
Female (n, %)	14 (15.9)	14 (15.9)	0 (0.0)	0.996	11 (17.7)	0 (0.0)	9 (15.5)	–	10 (18.5)	–	10 (16.9)	–
Education												
Up to Year 12 (n, %)	9 (7.8)	24 (27.3)	11 (39.3)	–	12 (19.4)	12 (60.0)	10 (17.2)	–	12 (22.2)	–	12 (20.3)	–
Vocational Diploma (n, %)	53 (45.7)	42 (47.7)	13 (46.4)	0.697	35 (56.5)	7 (35.0)	35 (60.3)	–	31 (57.4)	–	34 (57.6)	–
Tertiary Education (n, %)	19 (16.4)	22 (25.0)	4 (14.3)	0.589	15 (24.2)	1 (5.0)	13 (22.4)	–	11 (20.4)	–	13 (22.1)	–
First language spoken												
English only (n, %)	109 (94.0)	82 (93.2)	27 (96.4)	–	55 (88.7)	20 (100.0)	54 (93.1)	–	49 (90.7)	–	53 (89.8)	–
English and a second language (n, %)	6 (5.2)	5 (5.7)	1 (3.6)	0.845	7 (11.3)	0 (0.0)	3 (5.2)	–	4 (7.4)	–	4 (6.8)	–
Prefer not to say (n, %)	1 (0.9)	1 (1.1)	0 (0.0)	–	0 (0.0)	0 (0.0)	1 (1.7)	–	1 (1.9)	–	2 (3.4)	–
Relationship status												
Alone (n, %)	30 (25.9)	24 (27.3)	6 (21.4)	–	15 (24.2)	5 (25.0)	14 (24.1)	–	16 (29.6)	–	15 (25.4)	–
With partner (n, %)	86 (74.1)	64 (72.7)	22 (78.6)	0.993	47 (75.8)	15 (75.0)	43 (74.1)	–	38 (70.4)	–	42 (71.2)	–
Prefer not to say (n, %)	0 (0.0)	0 (0.0)	0 (0.0)	–	0 (0.0)	0 (0.0)	1 (1.7)	–	0 (0.0)	–	2 (3.4)	–
Aboriginality												
Not Aboriginal (n, %)	110 (94.8)	83 (94.3)	27 (96.4)	–	58 (93.5)	20 (100.0)	55 (94.8)	–	52 (96.3)	–	56 (94.9)	–
Aboriginal (n, %)	4 (3.4)	3 (3.4)	1 (3.6)	0.901	3 (4.8)	0 (0.0)	3 (5.2)	–	2 (3.7)	–	2 (3.4)	–
Prefer not to say (n, %)	2 (1.7)	2 (2.3)	0 (0.0)	–	1 (1.6)	0 (0.0)	0 (0.0)	–	0 (0.0)	–	1 (1.7)	–
Religion												
Christianism (n, %)	41 (35.3)	24 (27.3)	17 (60.7)	–	19 (30.6)	11 (55.0)	20 (34.5)	–	20 (37.0)	–	20 (33.9)	–
No religion (n, %)	52 (44.8)	45 (51.1)	7 (25.0)	0.301	28 (45.2)	7 (35.0)	29 (50.0)	–	27 (50.0)	–	26 (44.1)	–
Other (n, %)	18 (15.5)	15 (17.0)	3 (10.7)	0.487	15 (24.2)	2 (10)	9 (15.5)	–	7 (13.0)	–	12 (20.3)	–
Prefer not to say (n, %)	5 (4.3)	4 (4.5)	1 (3.6)	–	0 (0.0)	0 (0.0)	0 (0.0)	–	0 (0.0)	–	1 (1.7)	–
Smoking status												
Never smoked (n, %)	68 (58.6)	55 (62.5)	13 (46.4)	–	37 (59.7)	9 (45.0)	36 (62.1)	–	32 (59.3)	–	35 (59.3)	–
Former smoker (n, %)	40 (34.5)	28 (31.8)	12 (42.9)	0.374	22 (35.5)	8 (40.0)	20 (34.5)	–	21 (38.9)	–	22 (37.3)	–
Current smoker (n, %)	7 (6.0)	4 (4.5)	3 (10.7)	0.216	3 (4.8)	3 (15.2)	2 (3.4)	–	1 (1.9)	–	1 (1.7)	–
Prefer not to say (n, %)	1 (0.9)	1 (1.1)	0 (0.0)	–	0 (0.0)	0 (0.0)	0 (0.0)	–	0 (0.0)	–	1 (1.7)	–
Alcohol consumption (drinks per week) (mean, SD)	11.4 (13.5)	11.2 (13.8)	11.7 (13.0)	0.367	4.9 (5.8)	11.8 (13.3)	5.2 (6.9)	–	4.9 (6.5)	–	5.1 (6.0)	–
ADF status												
Transitioned ADF (n, %)	98 (84.5)	70 (79.5)	28 (100.0)	–	48 (77.4)	20 (100.0)	46 (79.3)	–	43 (79.6)	–	46 (78.0)	–
Regular ADF (n, %)	18 (15.5)	18 (20.5)	0 (0.0)	0.996	14 (22.6)	0 (0.0)	12 (20.7)	–	11 (20.4)	–	13 (22.0)	–
Psychotherapy treatments in previous month^a												
PTSD (n, %)	46 (39.7)	36 (40.9)	10 (35.7)	–	21 (33.9)	7 (35)	20 (34.5)	–	19 (35.2)	–	19 (32.2)	–
Anxiety (n, %)	47 (40.5)	40 (45.5)	7 (25.0)	–	23 (37.1)	8 (40.0)	20 (34.5)	–	19 (35.2)	–	20 (33.9)	–
Depression (n, %)	50 (43.1)	41 (46.6)	9 (32.1)	0.196	23 (37.1)	7 (35)	21 (36.2)	–	19 (35.2)	–	20 (33.9)	–

^a Only depression treatment was included in the baseline comparison between groups due to the high collinearity between the three treatments.

therapy group were more likely to report social leisure activities than the control group ($p = 0.029$) (Fig. 2, tile 2F). However, we found one trend worth noting: the surf therapy group tended to be younger ($p = 0.089$). Participants were predominantly male, middle-aged, with higher levels of education (i.e., vocational diploma or above), transitioned from the ADF, Christian, non-smokers, with an alcohol consumption of about 11 drinks per week. Fig. 2 shows the top 3 leisure activities in which participants reported engaging. Surfing for leisure was the only activity that showed an evident change in engagement patterns over time.

3.2. Descriptive results

Fig. 3 presents the raw (unadjusted) results for the three outcome measures (i.e., PCL-M, MDI, and GAD-7) across time.

Raw mean PCL-M scores (and SEs) for the surf therapy sample decreased from 45.9 (± 2.0) (high symptom severity range) at T1 to 30.5 (± 1.6) (moderate symptom severity range) at T2, indicating clinically significant change, and such reductions were maintained at 7-months post intervention (T5; $M = 30.3$, $SE = \pm 1.7$). In the control group, mean scores (and SEs) for PCL-M increased non-significantly from 39.2 (± 3.2) at T1 to 41.6 (± 4.0) at T2 (Fig. 3, tile 3A).

MDI mean score in the surf therapy group decreased from 24.3 (± 1.3) (mild symptom severity range) at T1 to 9.5 (± 1.0) (none or doubtful symptom severity range) at T2, indicating clinically significant change, and was maintained at 7-months (T5; $M = 10.5$, $SE = \pm 1.0$). In the control group, MDI scores increased non-significantly from 19.7 (± 2.5) at T1 to 20.2 (± 2.8) at T2, with no symptom severity band change (Fig. 3, tile 3B).

GAD-7 mean score in the surf therapy group, decreased from 10.9 (± 0.7) (moderate symptom severity range) at T1 to 3.4 (± 0.4) (no

symptom severity range) at T2, indicating clinically significant change, and was maintained at 7-months (T5; $M = 3.7$, $SE = \pm 0.6$). In the control group, GAD-7 scores reduced from 7.8 (± 1.2) at T1 to 7.6 (± 1.6) at T2 (Fig. 3, tile 3C).

3.3. Model results

Model results for PCL-M, MDI and GAD-7 are presented in Fig. 4. All three outcomes presented statistically significant reductions in scores for the surf therapy group post intervention (Fig. 4, T2 * Group: Surf Therapy) with no change for the control group (Fig. 4, T2). Additionally, this effect remained stable for the entire follow up period (Fig. 4, T3, T4 and T5). Leisure surfing was associated with an additional significant beneficial effect for PCL-M, MDI and GAD-7 (Fig. 4, Leisure Surfing: Yes). Similarly, the practice of Indoor Sports & Fitness and Outdoor Sports & Fitness activities were also associated with lower scores; however, it is important to highlight that leisure surfing was the only activity that showed an evident change in engagement patterns over time (Fig. 2, Tile 2A). See Supplementary Table S1 for the full model results. Also of interest is that recent treatment for PTSD, depression and anxiety were all associated with higher score values; however, this is not causal relationship and probably reflects the fact that individuals with more symptoms are more likely to be under treatment.

The results for the sensitivity analysis performed with completers only is presented in the Supplementary Tables S2 and S3. It is important to highlight that no substantial differences were found in comparison to the intention-to-treat analysis.

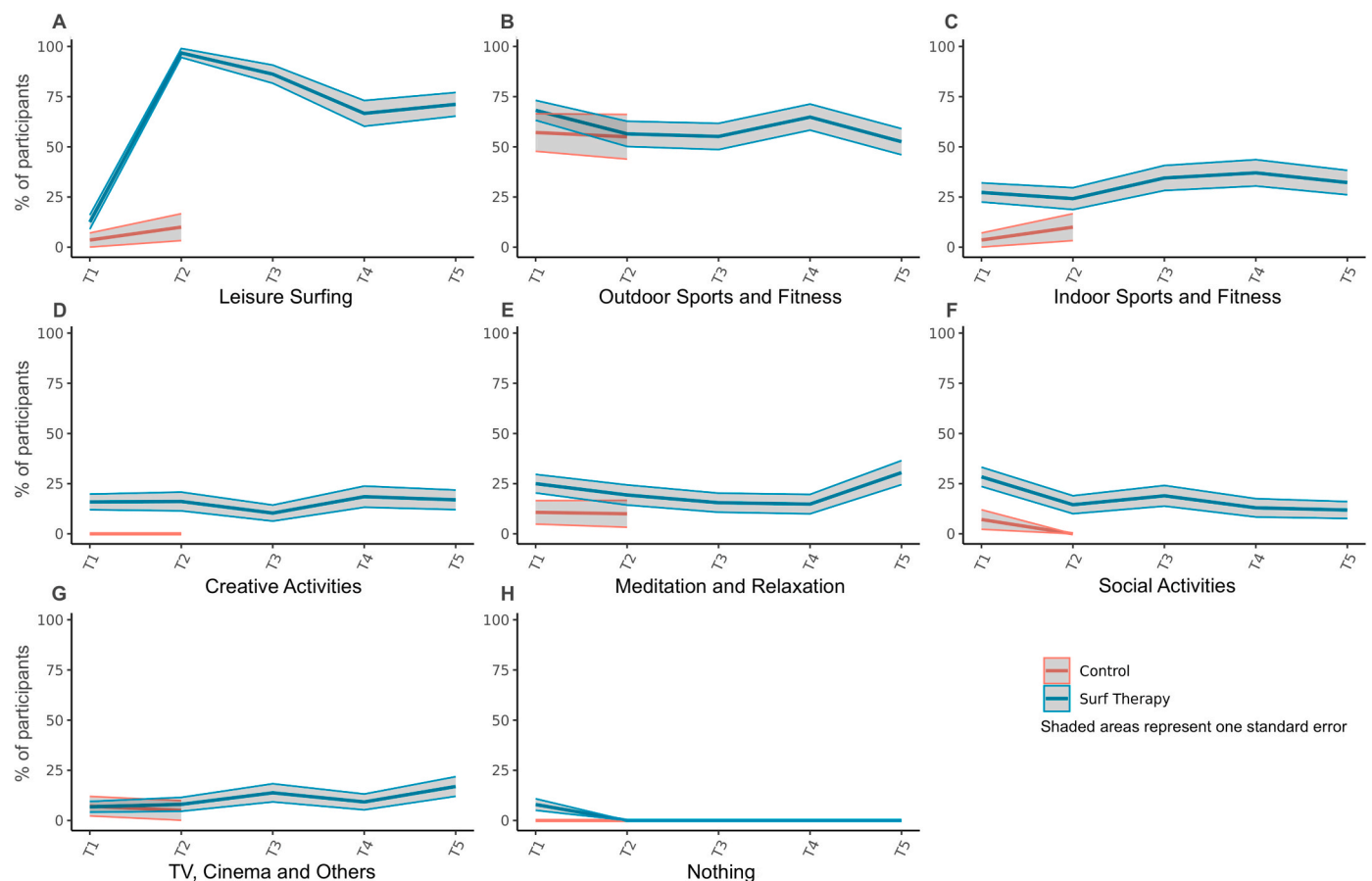


Fig. 2. Top three leisure activities reported in previous month (expressed as average of participants and standard error bands) at study assessment points comparing surf therapy group ($n = 88$) to control group ($n = 28$). T1 = Baseline, T2 = post 10 session program, T3 = 1 month follow up, T4 = 4 month follow up, T5 = 7 month follow up. Social activities participation (Tile F) showed significant difference between groups at baseline ($p = 0.029$).

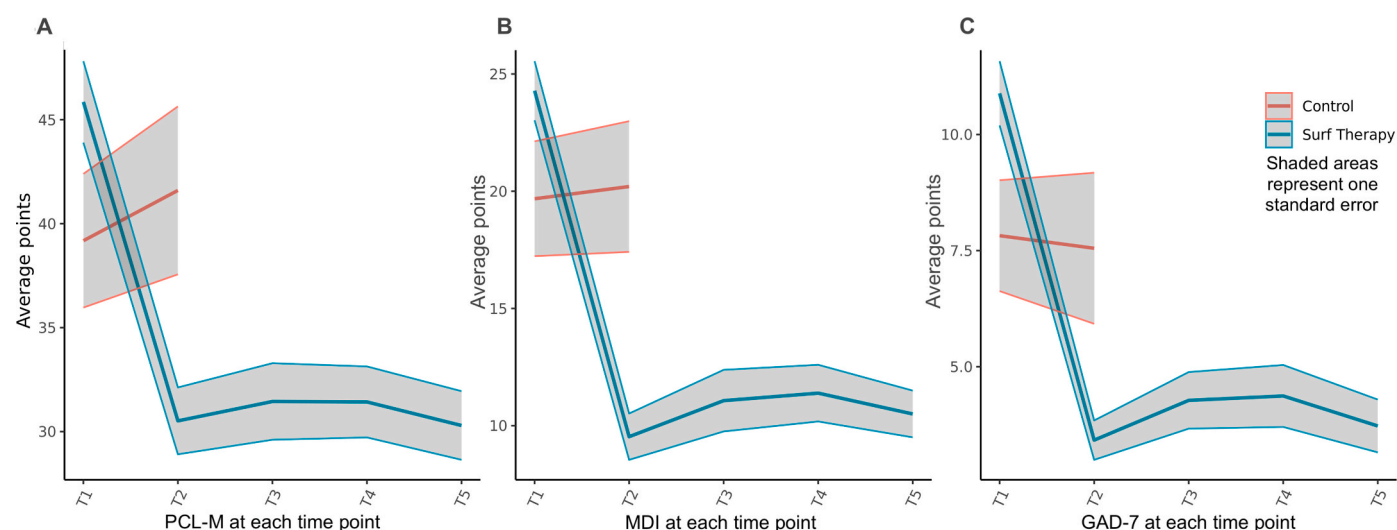


Fig. 3. Raw mean (unadjusted) scores and standard error bands at study assessment points comparing surf therapy group ($n = 88$) to control group ($n = 28$). PCL-M = Posttraumatic Checklist Military version (scale range: 17 to 85), MDI = Major Depression Inventory (scale range: 0 to 50), GAD-7 = Generalised Anxiety Disorder (scale range: 0 to 21). T1 = Baseline, T2 = post 10 session program, T3 = 1 month follow up, T4 = 4 month follow up, T5 = 7 month follow up.

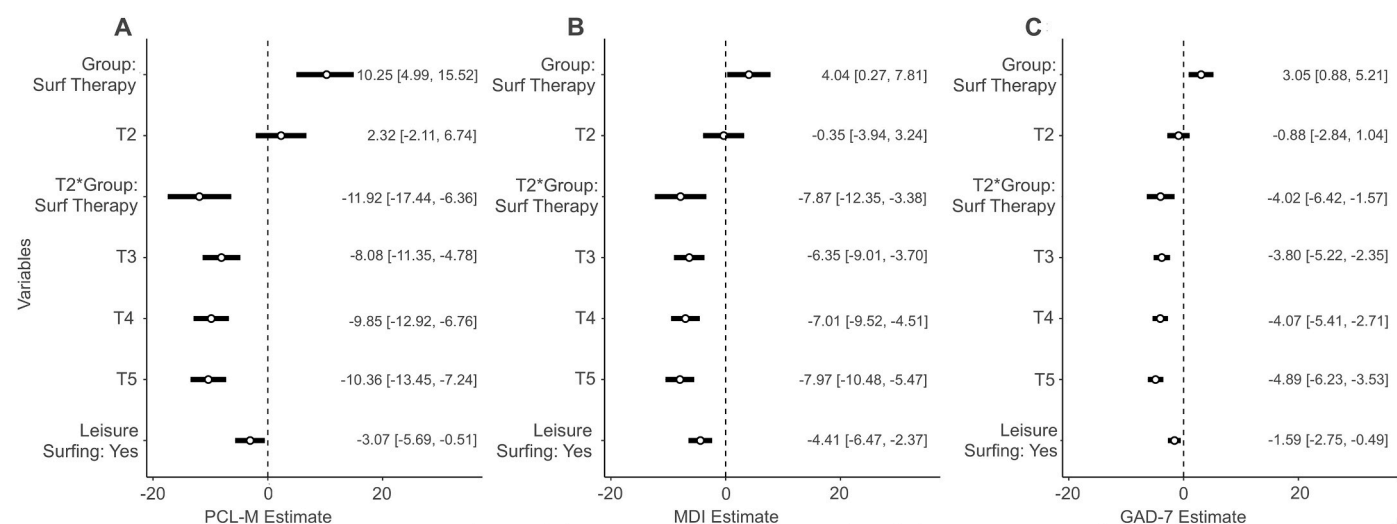


Fig. 4. Summary of linear mixed models examining estimate of effect by time point. Lower scores indicate reduced symptomologies. PCL-M = Posttraumatic Checklist Military version (scale range = 68). MDI = Major Depression Inventory (scale range = 50). GAD-7 = Generalised Anxiety Disorder (scale range = 21). Group: Surf Therapy = Surf therapy group at baseline, T2 = Control group post program, T2 * Group: Surf Therapy = Group $\times$ Time interaction at post program, T3 = Surf therapy group at 1 month follow up, T4 = Surf therapy group at 4 months follow up, T5 = Surf therapy group at 7 month follow up, Surfing:Yes = leisure surfing. All models were adjusted for age, gender, ADF status, ATSI status, education, religion, language, relationship status, smoking and drinking habits, and other leisure activities.

4. Discussion

This nonrandomised controlled longitudinal study investigated the effect of a ten-session surf therapy program on the symptomologies of posttraumatic stress, depression, and anxiety among a sample of current and former ADF members. To our knowledge, this is the largest quantitative surf therapy study among adults to date in terms of sample size ($N = 116$), length of program (10 sessions), and follow-up post program (7 months).

Our post program findings replicate prior surf therapy results of both statistically and clinically significant reductions in posttraumatic stress, depression, and anxiety symptoms in military samples (Crawford, 2017; Otis et al., 2020, 2024; Rogers et al., 2014; Walter et al., 2019; Walter, Otis, Miggantz, et al., 2023; Walter, Otis, Ray, et al., 2023), and add weight to the proposition put forth by Otis et al. (2020, 2024) that surf

therapy may be a transdiagnostic intervention. Our results of significant improvements in the symptomologies of posttraumatic stress, depression and anxiety suggest that surf therapy may be targeting core vulnerabilities of these disorders (see Barlow, Curren, & Woodard, 2021; Gutner, Galovski, Bovin, & Schnurr, 2016; Tabibnia, 2020). According to the tri-partite model of resilience building proposed by Tabibnia (2020), most behavioural and psychological strategies target one of three pathways: downregulating negative affect (e.g. active coping); upregulating positive affect (e.g. physical exercise, social connection); or transcending the self (e.g. exposure to nature, mindfulness, flow); however strategies that target all three pathways may achieve larger beneficial outcomes. We describe these concurrent pathways in terms of surf therapy in more detail below.

Central to our novel findings is that reduced posttraumatic stress, depression and anxiety symptomology was maintained seven months

post program regardless of continued surfing. Surfing within a restorative natural ocean environment facilitates state mindfulness (Marshall et al., 2023), flow (Cheng & Lu, 2015), immediate respite from symptoms (Caddick et al., 2015) and immediate increased positive affect and reduced negative affect (Otis et al., 2020; Walter et al., 2019). Immediate increases in positive affect (repeatedly measured after sessions of resistance training) have been found to predict reductions in PTSD (Whitworth et al., 2023), and increased mindfulness has been found to be maintained at six to ten months following surf therapy (Wilkie et al., 2022). Whilst the theoretical model of flow is a phenomenologically distinct experience (Kotler et al., 2022), increased mindfulness has been found in meta-analysis to be bi-directionally associated with increased flow (Schutte & Malouff, 2023), and both appear to have neurological mechanistic effect by down regulating the default mode network (Brewer et al., 2011; Kotler et al., 2022). Garland, Farb, R. Goldin, and Fredrickson (2015) have suggested that mindfulness provides an attentional shift from the stressor to the interpretive context allowing reappraisal to occur (see Lazarus & Folkman, 1984), providing disidentification from reflexive self-narratives and for the selection of new narratives more congruent with reality (see Shapiro et al., 2006), thereby generating positive emotions and enabling active coping with stressors (see Garland, Gaylord, & Park, 2009). Repeated episodes of state mindfulness may result in the development of trait mindfulness over time (Garland et al., 2010), feeding further positive emotions, active engagement of stressors and prosocial interactions in an upward spiral of broadened awareness and eudaimonic meaning (Garland et al., 2015). Participants in our study were afforded the opportunity to develop active coping skills by completing a series of physical and psychological challenges while surfing, that became gradually more demanding in line with increased skill and competence (Bandura, 1977; Csikszentmihalyi, Abuhamdeh, & Nakamura, 2014; Ryan & Deci, 2000). The development of active coping skills has been found to reduce intolerance of uncertainty (a transdiagnostic factor of PTSD, anxiety and depression), which is associated with reductions of intrusion and arousal clusters of PTSD (Badawi, Steel, Harb, Mahoney, & Berle, 2022; McEvoy, Hyett, Shihata, Price, & Strachan, 2019). Although the active ingredients, pathway mechanisms and dose-response of surf therapy remain empirically unknown, we speculate that exposure to several pathways simultaneously over the course of the program may have contributed to the stable symptomology reductions at seven months follow up. Further research, however, is warranted.

Our models also found that participants who continued surfing for leisure experienced significant additional improvement in posttraumatic stress, depression, and anxiety symptomologies. Although this is a novel finding, our results appear to be consistent with, and longitudinally extend the programmatic dose-response findings of Walter, Otis, Ray, et al. (2023) and Walter, Otis, Miggantz, et al. (2023). Our results are also consistent with prior research by Levin and Taylor (2011) and Amrhein, Barkhoff, and Heiby (2016), which found a cross-sectional correlation of significantly lower depression and anxiety symptoms among regular surfers than normative samples. Taken together, these results indicate that after learning to surf, veterans experiencing mental health challenges may be able to further self-regulate posttraumatic stress, depression, and anxiety symptoms by independently surfing for leisure.

We found that most (71.2%) of the program completers reported continued surfing seven months after the program. This finding closely parallels Godfrey, Devine-Wright, and Taylor (2015)'s longitudinal finding of a continued surfing rate of 70% among children participants post program, and echoes Wilkie et al. (2022)'s findings among surfing participants with acquired brain injuries who reported wellbeing-promoting behavioural changes 6–10 months post program. Our results are also consistent with the broader physical exercise literature among participants with PTSD, MDI and GAD of continued increased physical activity at six months post intervention (Babyak et al., 2000; Bichler et al., 2022).

Surfing has been found to facilitate flow states (Morgan & Coutts, 2016; Nerothin, Mitten, Harper, & Ponting, 2018), during which autotelic positive emotions elicit nonconscious incentive salience to repeat the rewarding activity (Csikszentmihalyi et al., 2014; Norsworthy, Jackson, & Dimmock, 2021). Participants in physical activity with mental illness are highly motivated by the prospect of improving their mental health, yet stress and depression are also barriers to participation (Firth et al., 2016) and therefore require initial support to provide the required activation energy until self-determined motivation and habit formation have been sufficiently established (Knappen, Vancampfort, Moriën, & Marchal, 2015). Although the dose-response and required session repetitions under instruction to establish intrinsic activation are empirical questions yet to be answered (Otis et al., 2020), we postulate that the program length of ten sessions may have sufficiently provided participants with the required skill to become somewhat autonomous in surfing (i.e., catching their own waves), providing the intrinsic motivation to enable continued surfing post program. This assumption is consistent with the upward spiral theory of lifestyle change (Anderson & Heyne, 2016).

Our high participation completion rates together with high continued leisure surfing rates demonstrate high acceptability of surf therapy among Australian military veterans, mirroring the findings in other countries such as the United States and United Kingdom (Caddick et al., 2015; Rogers et al., 2014; Walter, Otis, Ray, et al., 2023). This appears to answer the calls by researchers for treatment programs to meaningfully engage veterans who choose self-management of their mental health conditions outside of the existing standard of care treatments (Adler et al., 2015; Forbes et al., 2019; Hawkins et al., 2016).

This study has numerous strengths that contribute to the literature on surf therapy practice and research. The surf therapy group was measured longitudinally over five time points, thus providing meaningful indication of longer term retained beneficial effects. Because post-program surveys were administered immediately following the last session (and may be conflated with acute effects of surfing), the first of three follow-up surveys beginning at 1-month post-program allow these acute effects to be resolved. The program and the study were concurrently designed by the study authors with input from mental health practitioners and the veteran community. An example of this stakeholder engagement was to accommodate participant symptom fluctuations by affording flexible attendance and thus more accurately capture the program impacts in a community setting (Richardson et al., 2005). The program was advertised as a wellbeing activity for those who may be experiencing mental health symptoms yet did not impose diagnostic criteria for participation. This attracted a heterogeneous sample of veterans with differing mental health needs, some of whom may not have been comfortable seeking help from mental health professionals. Indeed, 16% of the full surf therapy sample scored in the high to very high symptom severity band for PCL-M but had never been diagnosed previously. This greatly enhances the generalisability of the results to the wider veteran community because the study suggests that surf therapy has the potential to help those with or without a diagnosis and had overall beneficial effect regardless of baseline symptom severity. The activity completion rate was very high as demonstrated by 70.5% of the surf therapy group completing the program. The study compliance rate was also very high with 67.0% of the enrolled surf therapy group providing 7-month follow-up surveys. The community surf club culture designed into the program attracted program graduates to continue surfing, which is evidenced by the high proportion who reported leisure surfing at seven months (71.2%) follow up (compared to only 11.4% at baseline), which confirms the acceptability and persistent engagement of the activity.

The non-randomisation of participants is a limitation of this study. By allowing participants to choose the surf therapy group, the majority did so, thus the control group was undersized compared to the surf therapy group and all three baseline scores were higher in the surf group, possibly indicating self-selection bias. The study protocol

specified removal of surf group non-completers from further study, which precluded comparison analysis of non-completers to completers. However, a completers-only sensitivity analysis has been performed to partly overcome this design limitation. Whilst both groups completed pre- and post-program assessments, only the surf therapy group completed follow-up assessments, which may restrict the understanding of how the surf therapy group fared compared to the control group over the follow-up time points. The PCL-M from the DSM-IV was used instead of the PCL from the DSM-5 (American Psychiatric Association, 2013) to allow comparisons with DVA literature (Van Hooff et al., 2018). Whilst this may limit direct score comparisons to the DSM-5, readers are referred to Moshier et al. (2019)'s empirical crosswalk and LeardMann et al. (2021)'s comparative study which found excellent agreement between estimated PCL using both DSM-IV and DSM-5, and observed PCL using DSM-5.

No data on DSM-IV PCL-M Criterion A index trauma were collected, which is required for a formal PTSD diagnosis as per DSM-IV. Assessments only included self-report measures, which can be subject to bias and interpretation. The pre and post program (T1 and T2) measures for the surf therapy group were collected immediately before the first session and immediately after the tenth session, thus some acute session effects may be conflated with programmatic effects at T2. However, the study design utilised the first follow up point (T3) at one month post program to allow for acute session effects to be washed out. Such acute session effects may explain the non-significant rebound in average scores from T2 to T3. Another limitation concerning surf therapy more generally is that given surfing requires an ocean (or a river or purpose-built wave pool), surf therapy may not be accessible to populations that do not have ready access to the ocean. Surfing also requires short bursts of vigorous physical activity, which may not be appealing to everyone. Indeed, we found a non-significant trend that the surf therapy group attracted those who were younger (mean age: 45 years) than the control group. This trend makes sense in that older participants may prefer not to engage in surf therapy, which is also an indicator of possible self-selection bias. However, as our results of high engagement and high retention rates indicate, surf therapy appears to be culturally acceptable and engaging among veterans who are physically able to complete a series of ten surf therapy sessions.

Our findings of simultaneous symptom reductions of posttraumatic stress, depression, and anxiety (in a sample at high risk of multiple comorbidities) suggest that surf therapy addresses the underlying transdiagnostic processes rather than targeting individual symptoms or a specific disorder (Barlow et al., 2021; Gutner et al., 2016). Additionally, the retained symptom reductions indicate that surf therapy may provide an effective tool for symptom self-management while alleviating the burden on the public health system. Such findings are relevant to clinicians, researchers, and policymakers in considering surf therapy within a social prescription framework (Liebmman, Pitman, Hsueh, Bertotti, & Pearce, 2022) for at-risk veterans who face many barriers to receiving mental health care, most notably the staunch preference for self-management (Naifeh et al., 2016). Surf therapy is a non-stigmatising intervention that could be utilised among at-risk current and former service members (Caddick et al., 2015) to reverse the downward spiral of negative symptom progression before becoming chronic (McFarlane, Lawrence-Wood, Van Hooff, Malhi, & Yehuda, 2017; Pietrzak, Javier, Krystal, & Southwick, 2021). This warrants further investigation of surf therapy as an early intervention among members returning from deployment (Smid, Kleber, Rademaker, van Zuiden, & Vermetten, 2013). Future quantitative surf therapy research could consider adopting an RCT design with a control group engaged in standard treatment, such as trauma-focussed therapies, enabling a direct outcome comparison. Future mixed methods investigations could be used to elucidate the theoretical and empirical mechanisms between surf therapy, flow and/or mindfulness trait development, and transferability of skill acquisition/mastery among cohorts with negative affective symptoms (see Carpenter et al., 2019; Kotler et al., 2022). Although alcohol

consumption was not an outcome under investigation in this study, the mean self-reported drinks per week reduced by half among the surf therapy group post-program (and was retained at seven months follow-up), which also warrants further investigation. Practitioners may consider broadening inclusion criteria to include participants who may wish to avoid the associated stigma of a clinical diagnosis prior to engagement (Sharp et al., 2015).

5. Conclusions

This is the largest quantitative surf therapy study among adults to date, the first to investigate a ten-session surf therapy program format, and the first to follow up seven months post program. It confirms previous surf therapy findings of transdiagnostic beneficial effects on the symptomologies of posttraumatic stress, depression, and anxiety. It provides new clinically relevant knowledge by demonstrating retained effects regardless of continued surfing post program, additive benefits of continued leisure surfing, and that surf therapy is an engaging treatment option for veterans ultimately enabling self-management and demonstrable lifestyle change.

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Transparency

The datasets generated in this study are available upon reasonable request to the authors.

CRedit authorship contribution statement

Rusty Moran: Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Sandro Sperandei:** Writing – review & editing, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation. **Nicole Peel:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Tonia Gray:** Writing – review & editing, Supervision. **Arianne Reis:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

Rusty Moran is a qualified surfing instructor and was remunerated from the grant funds for the delivery of the surf therapy classes. All other work performed by RM was unpaid as part of his PhD candidature. All other authors declare that they do not have any competing interests.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.mhpa.2024.100629>.

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