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Flotation restricted environmental stimulation therapy and napping on mood state and muscle soreness in elite athletes: A novel recovery strategy?

Matthew W. Driller[a,*], Christos K. Argus[b,c]

[a] Health, Sport and Human Performance, University of Waikato, Hamilton, New Zealand
[b] ACT Brumbies Rugby, Canberra, Australia
[c] Research Institute for Sport and Exercise, University of Canberra, Canberra, Australia

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ABSTRACT

Relaxation techniques and napping are very popular strategies amongst elite athletes recovering from the psychophysiological demands of training and competition. The current study examined a novel relaxation technique using restricted environmental stimulation therapy in a flotation tank (FLOAT). FLOAT involves reducing the level of environmental stimulation while achieving a sense of near weightlessness through floating in an enclosed, warm, saline-dense water tank. Sixty elite, international-level athletes (28 male, 32 female) across a range of 9 sports, completed a ~45 min FLOAT session following exercise training for their sport. Pre and post FLOAT, athletes filled out a multidimensional mood-state questionnaire (MDMQ) containing 16 mood-state variables as well as a question on perceived muscle soreness. Group data were analysed for pre to post FLOAT for all measured variables. Further analyses were performed on all variables for athletes that napped during FLOAT (n = 27) and compared to those that did not nap (n = 33). A single FLOAT session significantly enhanced 15 of the 16 mood-state variables ($p < 0.05$) and also lowered perceived muscle soreness ($p < 0.01$). *Small* (n = 3) to *moderate* (n = 6) effect sizes in favour of napping for 9 of the 16 mood-state variables were found when compared to the no nap group. FLOAT may be an effective tool for both physical and psychological recovery following training in elite athletes. Furthermore, napping in combination with FLOAT may provide additional benefits to enhance certain mood-state variables. This study serves as a pilot study for future research into the performance recovery of elite athletes following FLOAT.

1. Introduction

Flotation-restricted environmental stimulation therapy (REST) involves lying supine in a dark, sound-reduced tank, while immersed in a saline solution, effectively increasing the density of the water which allows an individual to float (Van Dierendonck & Te Nijenhuis, 2005). This form of therapy has been used as a relaxation tool for stress-management (Van Dierendonck & Te Nijenhuis, 2005), for treatment of chronic pain (Fine & Turner, 1985), headaches (Rzewnicki, Wallbaum, Steele, & Suedfeld, 1990), hypertension (Kristeller, Schwartz, & Black, 1982), insomnia (Ballard, 1993), rheumatoid arthritis (Turner, DeLeon, Gibson, & Fine, 1993), behavioural problems (Suedfeld & Bow, 1999), and also to increase internal focus and primary-process orientation important for complex skill execution (Norlander, Bergman, & Archer, 1999). More recently, anecdotal reports and unpublished observations (Klockare, 2012) of athletes using flotation tanks to aid in their recovery from training and competition have yielded interest in this strategy. Indeed, the psychophysiological stress, coupled with inadequate recovery often experienced by elite athletes can lead to overtraining and under-performance (Budgett, 1998), hence the need for strategies that target both physiological and psychological recovery.

Flotation REST was developed in the 1960's by John Lilly as a method of sensory deprivation to treat various behavioural and health disorders (Lilly, 1977). Participants lay in a flotation tank containing water that is dense with Epsom salts (Mg_2SO_4). The Epsom salt solution allows participants to float supine, with the face and ventral portion of the body above the water line. This environment generally brings about an automatic relaxation response and can elicit the onset of sleep (Van Dierendonck & Te Nijenhuis, 2005). The relaxation response has been shown to alter a number of psy-

* Corresponding author.
E-mail address: mdriller@waikato.ac.nz (M.W. Driller).

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chophysiological measures from pre to post flotation sessions on a wide range of stress-related measures. Changes in these measures include increases in EEG theta and alpha waves, decreases in plasma and urinary cortisol, ACTH, aldosterone, renin activity, epinephrine, heart rate and blood pressure following flotation sessions (Turner & Fine, 1990, 1993). Furthermore, self-reports using psychometric scales or open-ended questions, indicate deep relaxation for the vast majority of subjects following flotation REST (Forgays, Forgays, Pudvah, & Wright, 1991; Schulz & Kaspar, 1994). Alongside physical recovery strategies such as ice-baths, compression garments and massage, relaxation strategies have also become a popular method of recovery from exercise (Venter, Potgieter, & Barnard, 2010). Techniques such as progressive muscle relaxation (PMR) and meditation are commonly used by athletes to enhance performance and post-exercise recovery (Hashim, Hanafi, & Yusof, 2011; Venter et al., 2010). It is also widely accepted that sleep, including napping, is another key strategy for athletes recovering from exercise, through various psychophysiological pathways (Samuels, 2009). However, no research has been performed evaluating the use of flotation REST and napping for relaxation and recovery in an elite athlete setting.

The aforementioned previous research on flotation REST has mostly focused on the treatment of various health-related issues. To our knowledge, only one study has assessed the effect of flotation REST in an exercise-recovery setting. Morgan, Salacinski, & Stults-Kolehmainen, (2013) investigated the use of a 1-h flotation session following maximal eccentric muscle contractions of the knee extensors and flexors. Their results indicated that flotation REST had a significant impact ($p < 0.05$) on lowering blood lactate and perceived pain compared with a 1-h passive recovery session in 24 untrained healthy men. These significant results warrant further research into whether the same effect would be seen in a highly-trained athletic population. However, while not in an exercise-recovery setting, several studies evaluating sport performance in athletes have yielded positive results following flotation REST. In several studies, flotation REST has been combined with visual imagery training, or used as a pre-competition strategy and resulted in subsequent positive outcomes. Significant improvements to basketball free-throw shooting (Suedfeld & Bruno, 1990; Wagaman, Barabasz, & Barabasz, 1991), tennis first-serving percentage (McAleney, Barabasz, & Barabasz, 1990), archer accuracy (Norlander et al., 1999) and rifle marksmanship (Barabasz, Barabasz, & Bauman, 1993) have all been attributed to the benefits associated with the psychological and muscle relaxation attained during flotation REST.

In summary, positive effects, both physiological and psychological, have been demonstrated following flotation REST in numerous different populations ranging from healthy individuals to those with chronic diseases. While there are promising indications that flotation REST may be effective in an exercise-recovery setting (Morgan et al., 2013), there is a distinct lack of research investigating the use of flotation REST as a recovery strategy in an elite athlete population. Therefore, the aim of the current study was to assess the effect of a flotation REST session on mood-state variables and perceived muscle soreness following exercise in elite, international level athletes.

2. Method

2.1. Participants

Restricted environment stimulation therapy sessions in a flotation tank (FLOAT) were performed by 60 elite Australian athletes. All athletes volunteered to participate in the study and had not previously taken part in a FLOAT session. The study was completed by 28 male and 32 female athletes across a wide range of sports (athletics = 8; basketball = 8; boxing = 2; cycling = 10; football = 11; netball = 15; rowing = 2; rugby = 2; swimming = 2). All athletes represented their country at an international-level for their chosen sport and took part in the study during the in-season phase of training. As athletes were from a mix of summer and winter sports, the study took place over a 6-month period to ensure that athletes participated during their respective competition seasons. The study was approved by a institutions Human Research Ethics Committee.

2.2. Design

On a single occasion, athletes attended the institutions recovery centre for the FLOAT session. All athletes were to arrive at the session within 1–3 h of finishing their last training session for their sport (mean ± SD: 2.5 ± 1.0 h). Athletes filled out the questionnaires immediately pre and 10-min post FLOAT. Athletes were instructed to arrive at the FLOAT sessions in a hydrated state.

2.3. Methodology

FLOAT sessions involved athletes lying supine in a light-proof flotation tank (Apollo Float Tanks, Australia) in ~30 cm deep saline solution (Epson salts – Mg_2SO_4) warmed to ~35 °C. The float tank was insulated on the inside so as to maintain a constant temperature and to isolate the participant from sound and sight. Air temperature inside the float tank was also maintained at ~35 °C, to ensure that the sensation between air and water was minimized. Earplugs and an air cushion were provided for comfort and neck support and athletes donned their normal swimwear during FLOAT. Athletes were instructed to float for ~45 min (mean ± SD: 48 ± 15 min), as this is the recommended average duration from a previous meta-analysis (Van Dierendonck & Te Nijenhuis, 2005). Athletes reported whether or not they napped during the FLOAT session and if so, their estimated duration of the nap. In the current study, a nap was defined as "falling asleep" for any period of time during the FLOAT session.

The pre and post questionnaire was completed by all athletes that participated in the current study. Information relating to sport, level of competition and time of last training session was collected. In addition to the background information, immediately before and 10-min after FLOAT, a modified version of a validated multidimensional mood-state questionnaire (MDMQ) was completed to assess different mood dimensions including: pleasant–unpleasant, awake–sleepy, and calm–restless (Steyer, Schewenmezger, Notz, & Eid, 1994). The questionnaire contained a list of 16 mood-state descriptors (e.g exhausted, tense, fresh, sleepy), each with a 6-scale, Likert format response (definitely not, not, not really, a little, very much, extremely). The athletes also indicated on a 10 cm visual analogue scale their level of general muscle soreness (0 = not sore at all, 10 = maximal muscle soreness).

2.4. Statistical analysis

Descriptive statistics are shown as means ± between-subject standard deviations unless stated otherwise. Magnitudes of the standardised effects were calculated using Cohen's *d* and interpreted using thresholds of 0.2, 0.5, 0.8 for *small, moderate and large*, respectively (Cohen, 1988). An effect size of ±0.2 was considered the smallest worthwhile effect with an effect size of <0.2 considered to be *trivial*. The effect was deemed *unclear* if its 90% confidence interval overlapped the thresholds for *small* positive and negative effects (Batterham & Hopkins, 2006). Paired student t-tests were used to compare pre and post FLOAT in SPSS version 19 (New York, USA) and statistical significance was set at $p \leq 0.05$.

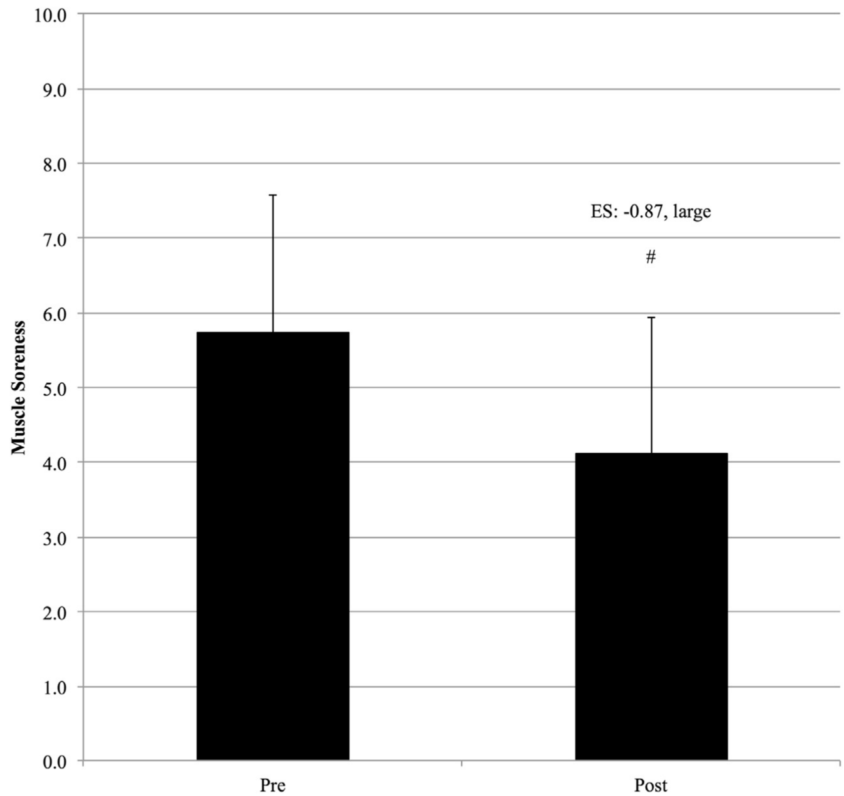

Fig. 1. Mean muscle soreness (out of 10) pre and post FLOAT with Effect Size (ES). Error bars represent between-subject standard deviations. # = Significant difference pre to post ($p < 0.01$).

3. Results

There was a significant ($p < 0.01$) reduction in perceived muscle soreness pre to post FLOAT (Fig. 1). The mean reduction in muscle soreness across the whole group was −1.6 (out of 10) and resulted in a *large* effect size (ES ±90% CI; −0.87 ±0.15). A *moderate* correlation ($r = -0.35$) between pre FLOAT muscle soreness and pre to post change in muscle soreness was found (Fig. 3), indicating that higher pre-FLOAT muscle soreness was associated with greater reductions in muscle soreness following the FLOAT session.

Fifteen of the 16 mood-state variables from the MDMQ were significantly enhanced following FLOAT ($p < 0.05$, Table 1). The "Alert" sub-scale resulted in no mean change pre to post FLOAT with an *unclear* effect. The remaining 15 variables resulted in *small* to *large* effects, with the largest effects following FLOAT seen in the "worn-out", "tired", "relaxed", "at-ease", "tense" and "fresh" sub-scales. The greatest pre to post change was seen in the "relaxed" mood-state sub-scale with a mean change of 1.5 ± 1.3.

Twenty-eight of the 60 athletes reported napping during FLOAT. The mean estimated sleep duration was 26 ± 13 min. There was a significant difference ($p < 0.05$) between nap and no-nap groups for the pre to post change during FLOAT for 5 of the 16 mood-state variables ("worn-out", "at-ease", "tense", "fresh" and "exhausted"). There was a *small* to *moderate* effect for 9 of the 16 mood-state variables in favour of individuals who napped compared to those that did not nap during FLOAT (Fig. 2). Five of the mood-state variables resulted in an *unclear* difference between groups, with the "nervous" sub-scale resulting in a *small* effect in favour of the no-nap group. The mood-state variable resulting in the greatest effect in the napping group was the "fresh" sub-scale (ES ±90% CI; 0.69 ± 0.44, *moderate*). There was no significant difference ($p > 0.05$) and a *trivial* effect between napping and no napping groups for muscle soreness (ES ±90%CI; 0.05 ± 0.24).

4. Discussion

The purpose of the current study was to determine the effects of flotation restricted environmental stimulation therapy (FLOAT) following exercise training on mood-state variables and muscle soreness in 60 elite athletes. Analysis of pre to post FLOAT data resulted in significant improvements to 15 of the 16 mood-state variables and perceived muscle soreness. Furthermore, when FLOAT was combined with napping, there was an additional significant improvement in 5 of the 16 mood-state variables. This is the first study to assess changes in mood-state and muscle soreness following the use of this potential recovery strategy in elite athletes.

The findings in the current study are in support of previous research, highlighting improvements in mood following a flotation REST (Van Dierendonck & Te Nijenhuis, 2005). Indeed, a meta-analysis by Van Dierendonck and Te Nijenhuis (2005) reported that floatation REST had large improvements in psychological wellbeing (ES; 1.09). The authors went on to conclude that floatation REST appeared to be more effective than other stress reduction strategies (Van Dierendonck & Te Nijenhuis, 2005). As suggested by Morgan et al. (2013) it is likely that a lack of sensory stimuli involved in flotation REST treatment dampens arousal of the central nervous system thus leading to an increased state of relaxation. This increased state of relaxation may be related to changes in a number of the mood-state variables pre to post FLOAT.

Improvements in mood-state and wellbeing following relaxation strategies have been well documented (Van der Klink, Blonk, Schene, & Van Dijk, 2001). For example, Hashim et al. (2011) reported that relaxation training improved mood-states of adolescent soccer players, specifically, confusion, depression, fatigue, and tension subscales. A meta-analysis examining the effect of relaxation strategies performed by Van der Klink et al. (2001),

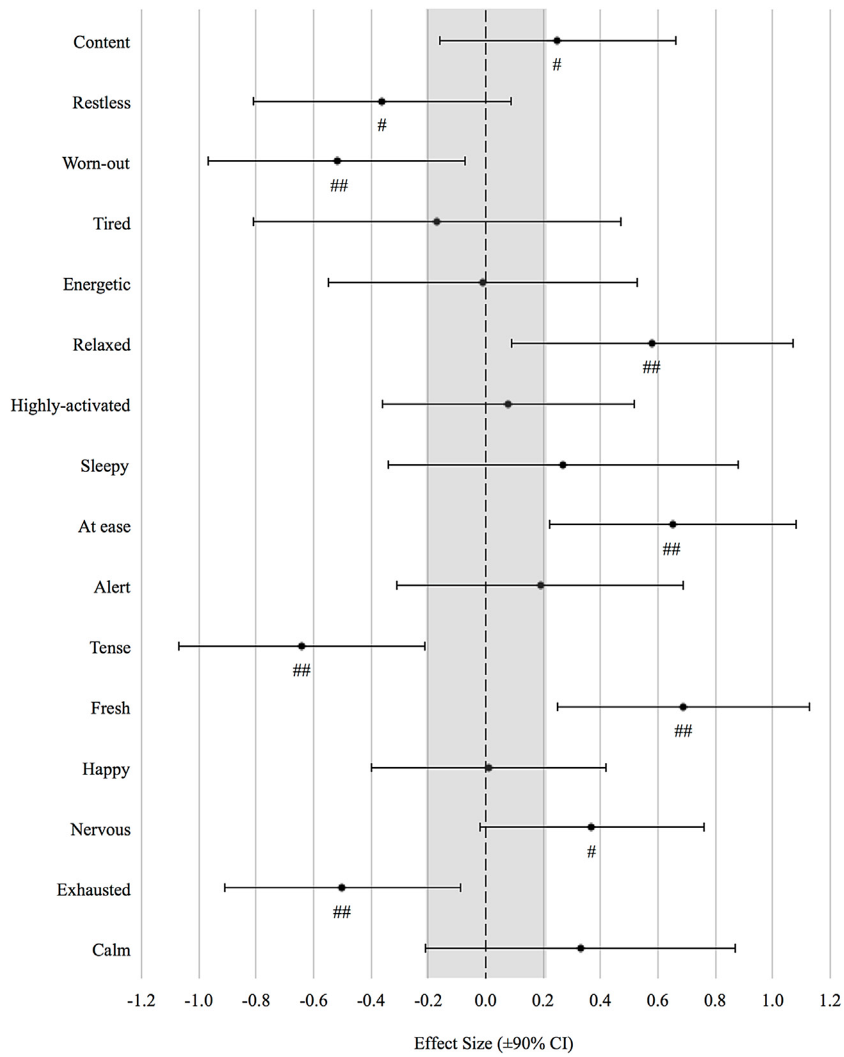

Fig. 2. The effect of napping when compared to no-napping during FLOAT on the pre to post change in multi-dimensional mood-state variables. Error bars represent 90% confidence intervals, with the shaded area representing the smallest worthwhile effect (0.2). # = *small* effect, ## = *moderate* effect. Where 90% confidence intervals overlap *small* positive and negative effects, the result was deemed *unclear.*

concluded that relaxation strategies positively affected wellbeing and mood (ES; 0.35). Importantly, improvements in wellbeing and mood-states observed following differing strategies, such as FLOAT,

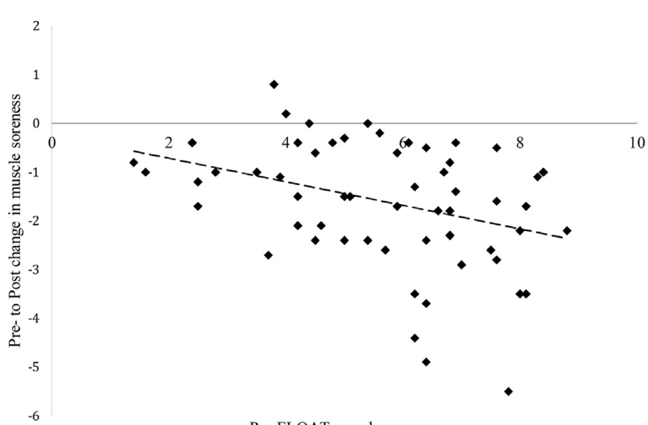

Fig. 3. Pre FLOAT muscle soreness (x-axis) and pre- to post-FLOAT change in muscle soreness (y-axis). Dashed line represents trend between the two represented values (r = −0.35).

can have positive impact on the training and performance of athletes (Beedie, Terry, & Lane, 2000). Indeed, pre-performance mood responses have been shown to have a predictive effect of performance outcome (Beedie et al., 2000). Beedie et al. (2000) reported that successful athletic performance outcomes were associated with lower tension, depression, anger, fatigue, and confusion scores and higher vigour scores than unsuccessful performances.

Similarly, recovery strategies are commonly utilised by athletes following exercise and competition in order to expedite psychophysiological aspects of recovery (Argus, Driller, Ebert, Martin, & Halson, 2013; Rattray, Argus, Martin, Northey, & Driller, 2015). Indeed, previous research has shown that subjective feelings of recovery following a recovery strategy (such as hydrotherapy) are related to subsequent performance (Cook & Beaven, 2013; Laurent et al., 2011). For example, Cook and Beaven (2013) reported that individual perception of recovery were significantly related ($r = 0.59$; $p = 0.04$) to repeated sprint performance following an intense 60-min conditioning session. As such, the improvements in mood-state and perceived ratings of soreness observed in the current study may have positive implications for athletes. Furthermore, anecdotal reports from athletes and coaches concur with these findings, noting that athletes with positive mood states and

Table 1
Pre to post FLOAT change in the multidimensional mood-state questionnaire for nap, no-nap and both groups combined. Effect sizes for each pre to post comparison are shown with 90% confidence intervals (CI). * Represents significant pre to post difference ($p < 0.05$).

Mood-state:	Nap (n = 28) ΔPre-Post (Mean ± SD)	Effect Size (Mean ±90% CI)	No-Nap (n = 32) ΔPre-Post (Mean ± SD)	Effect Size (Mean ±90% CI)	Combined (n = 60) ΔPre-Post (Mean ± SD)	Effect Size (Mean ±90% CI)
Content	0.4 ± 0.8*	0.43 ± 0.27 *small*	0.2 ± 0.9	0.22 ± 0.30 *small*	0.3 ± 0.8*	0.33 ± 0.20 *small*
Restless	−0.9 ± 1.1*	−0.78 ± 0.31 *moderate*	−0.5 ± 1.1*	−0.47 ± 0.31 *small*	−0.7 ± 1.1*	−0.64 ± 0.22 *moderate*
Worn-out	−1.6 ± 1.1*	−1.44 ± 0.33 *large*	−1.0 ± 0.9*	−1.03 ± 0.30 *large*	−1.3 ± 1.1*	−1.24 ± 0.22 *large*
Tired	−1.0 ± 1.3*	−1.03 ± 0.43 *large*	−0.9 ± 0.9*	−1.56 ± 0.48 *large*	−1.0 ± 1.1*	−1.2 ± 0.29 *large*
Energetic	0.4 ± 1.0	0.62 ± 0.53 *moderate*	0.4 ± 0.9*	0.41 ± 0.31 *small*	0.4 ± 0.9*	0.47 ± 0.26 *small*
Relaxed	1.8 ± 1.3*	1.50 ± 0.36 *large*	1.1 ± 1.2*	1.01 ± 0.33 *large*	1.5 ± 1.3*	1.26 ± 0.25 *large*
Highly-activated	0.4 ± 1.2	0.35 ± 0.38 *small*	0.3 ± 0.9	0.25 ± 0.25 *small*	0.3 ± 1.0*	0.29 ± 0.21 *small*
Sleepy	−0.3 ± 0.9	−0.38 ± 0.37 *small*	−0.5 ± 0.9*	−0.90 ± 0.53 *large*	−0.4 ± 0.9*	−0.63 ± 0.30 *moderate*
At ease	1.1 ± 0.9*	1.23 ± 0.34 *large*	0.5 ± 0.8*	0.62 ± 0.28 *moderate*	0.8 ± 0.9*	0.89 ± 0.21 *large*
Alert	0.1 ± 1.1	0.12 ± 0.37 *unclear*	−0.1 ± 1.1	−0.06 ± 0.33 *unclear*	0.0 ± 1.1	0.00 ± 0.24 *unclear*
Tense	−1.7 ± 1.1*	−1.45 ± 0.32 *large*	−1.0 ± 0.8*	−1.25 ± 0.28 *large*	−1.3 ± 1.0*	−1.32 ± 0.21 *large*
Fresh	1.7 ± 1.1*	1.49 ± 0.32 *large*	1.0 ± 1.0*	1.03 ± 0.31 *large*	1.3 ± 1.1*	1.28 ± 0.22 *large*
Happy	0.3 ± 0.8	0.31 ± 0.31 *small*	0.3 ± 0.8	0.27 ± 0.27 *small*	0.3 ± 0.8*	0.28 ± 0.19 *small*
Nervous	−0.4 ± 0.9*	−0.35 ± 0.29 *small*	−0.8 ± 1.0*	−0.71 ± 0.28 *moderate*	−0.6 ± 1.0*	−0.53 ± 0.20 *moderate*
Exhausted	−1.1 ± 0.9*	−0.95 ± 0.26 *large*	−0.5 ± 1.1*	−0.49 ± 0.31 *small*	−0.8 ± 1.1*	−0.72 ± 0.20 *moderate*
Calm	0.8 ± 1.4*	0.65 ± 0.38 *moderate*	−0.5 ± 0.8*	0.69 ± 0.33 *moderate*	0.6 ± 1.1*	0.65 ± 0.25 *moderate*

feelings of 'freshness' have more consistent and ultimately better training and performance outcomes.

Previous research has shown that the long-term use (12 sessions) of flotation REST may lead to improvements in night-time sleep quality in individuals recovering from stress-related illness (Bood et al., 2006). As well as improved sleep quality, results from their study indicated that pain areas, stress, anxiety, and depression decreased whereas optimism, and the hormone prolactin increased when compared to a control group (Bood et al., 2006). Sleep is widely regarded as one of the best recovery strategies for athletes recovering from the physiological and psychological stresses of training and competition (Halson, 2014; Samuels, 2009). While night-time sleep following FLOAT was not assessed in the current study, the effect of sleep during FLOAT was evaluated. Our findings would suggest that the combination of sleep with FLOAT may be even more beneficial to overall mood-state than FLOAT alone. When compared to no napping, the group that napped resulted in *moderate* effects for feeling more "fresh", "at ease", "relaxed and less 'exhausted', "tense" and "worn-out". These findings are in agreement with previous literature reporting benefits of napping to general mood-state in healthy participants. Kaida et al. (2007) showed enhanced dimensions of mood status ("pleasantness", "satisfaction" and "relaxation) following a 20-min nap when compared to a control trial in 16 healthy females. Similarly, Hayashi et al. (1999) showed improved subjective sleepiness, self-confidence and vigilance performance in seven young adults following a 20-min nap compared to a control. In addition to enhanced mood-state, napping has also been shown to improve cognitive and physical performance in athletes (Waterhouse, Atkinson, Edwards, & Reilly, 2007). Waterhouse et al. (2007) reported improvements in 2 m and 20 m sprint times, alertness, sleepiness, short-term memory and accuracy at a eight-choice reaction time test following a 30-min nap in ten male athletes. These studies further add to the support of FLOAT combined with napping as an exercise-recovery strategy.

Given the applied nature of the current study, and the difficulty to perform controlled studies in an elite athlete setting, there are a number of limitations associated with the experimental design that should be addressed in future research. The lack of control group makes it difficult to determine whether or not the change in mood-state or muscle soreness may be attributed to FLOAT or whether the same magnitude of change would have been seen after ~45 min of relaxing in a dark room. However, while it is difficult to draw comparisons to the population assessed in the current study, previous research has shown that FLOAT resulted in significantly greater levels of mental relaxation ($p < 0.05$) when compared to a control condition of sitting in a reclining chair for 60-min in 12 male participants (Turner & Fine, 1983). The limited access to elite athletes in the current study, made it challenging to perform a similar control trial. Furthermore, while not possible in the current study, it would have been advantageous to standardise the exercise session performed by all athletes before FLOAT, similar to that of the Morgan et al. (2013) study. A further addition to strengthen the study design would have been to include performance measures pre and post FLOAT so that comparison could be made with a control trial. However, given the range of athletes from different sports in the current study, formulating a standardised, fatigue-inducing exercise protocol (causing similar levels of muscle soreness) and designing a reliable performance test, which is relevant to all athletes, would have been difficult.

5. Conclusion

In conclusion, the current study has resulted in significant benefits to mood-state and muscle soreness following the use of a rather novel strategy that involves floating on saline-dense water in an enclosed, restricted environmental chamber, in elite, international athletes. To our knowledge, this was the first study to assess this strategy in an elite sporting population. Moreover, the study has highlighted that when napping is combined with FLOAT, additional benefits to mood-state may be gained. The current study serves to provide some promising preliminary results on the use of this recovery strategy in athletes and warrants further research. Further research should employ the use of a control group and also include standardised fatigue protocols pre FLOAT and performance tests pre and post FLOAT to determine whether the changes in mood-state and muscle soreness could transfer to sporting performance.

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