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Comparison of 1-hour floatation-REST versus conventional napping on heart rate variability in active individuals

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ABSTRACT

Objectives This study aimed to investigate the short-term effects of a 1-hour floatation-resting environmental therapy (FLO) versus conventional napping (NAP) on heart rate variability (HRV) in highly trained individuals.

Methods 20 non-fatigued participants underwent a prospective randomised interventional study comparing the impacts of FLO and NAP on both supine and standing HRV. Measurements were taken before and after each intervention under controlled conditions, and subjective experiences were assessed through questionnaires.

Results FLO and NAP were associated with changes in HRV parameters but did so differently. NAP significantly enhanced supine parasympathetic activity, as evidenced by increased log-transformed root mean square of successive differences (p=0.02) and power spectral density (p=0.03) relative to heart rate (HR) values, confirming its effectiveness in promoting autonomic recovery. In contrast, despite being better perceived regarding subjective well-being (p=0.04), FLO conferred no significant changes in supine root mean square of successive differences and decreased power spectral density relative to HR (p=0.02). However, post-intervention comparisons were not statistically different. While supine HR decreased significantly following both interventions, standing HR measurements showed a non-significant increase for FLO compared with NAP (p=0.056).

Conclusion In highly trained individuals, FLO and NAP demonstrated minimal impact on acute autonomic function. NAP appears more effective for enhancing short-term parasympathetic activity, while FLO provides a more enjoyable experience. These findings underscore the importance of personalised recovery strategies and emphasise the need for further research into individual responses and the long-term effects of these interventions.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Napping improves parasympathetic activity and short-term recovery.
⇒ Literature on floatation-REST's effects on mental and physical recovery is limited and shows mixed results.

WHAT THIS STUDY ADDS

⇒ This study directly compares floatation-REST and napping on heart rate variability (HRV) among trained individuals.
⇒ It demonstrates that napping enhances parasympathetic activity, while floatation-REST does not impact HRV but improves subjective well-being.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study highlights the importance of personalising recovery strategies based on individual physiological responses.
⇒ It offers new insights into refining recovery modalities for athletes.
⇒ The findings encourage further investigation into specific scenarios where floatation-REST could be advantageous.

INTRODUCTION

Optimal athletic performance depends on an athlete's ability to balance training, competition, recovery and other life demands.[1] Recovery is defined as physiological and psychological regeneration that occurs passively in the absence of excessive training and competition. To accelerate this regeneration process, athletes employ numerous recovery strategies that may be categorised as either active or passive. Active strategies include, for example, cooldown jogging, whereas passive strategies encompass techniques such as massage.[2] Other popular recovery modalities among athletes include cryotherapy, stretching, electromyostimulation and sauna sessions. These strategies are systematically integrated into an athlete's regimen to maintain high-performance capacity alongside systematic monitoring of training load and fatigue.[3 4]

The efficacy of a specific recovery method must be investigated with tools that can measure objective and subjective responses to the intervention.[1] The ideal way to determine the impact of a recovery intervention is to measure maximal sport-specific performance. However, cost and logistical limits often render this approach impractical. As such, coaches and sports scientists routinely

Figure 1 A floating tank. https://surface-flottaison.ch/app/uploads/2018/03/04-Tube-01-e1522308290352.jpg.

employ alternative measurement techniques. Characteristics of effective tools for recovery assessment are characterised by (1) sensitivity to change, (2) provision of immediate feedback, (3) time-efficiency (5–10min), (4) ease of use, (5) cost-effectiveness, (6) minimal interference with training, (7) ability to monitor numerous athletes simultaneously, (8) non-invasiveness and (9) validity and (10) reliability.[5] An increasingly popular method that meets many of these criteria is heart rate variability (HRV) analysis. HRV is performed by applying temporal, frequential and non-linear analyses to beat-to-beat cardiac interval variations during standardised resting heart rate (HR) measurements, providing an indirect evaluation of autonomic nervous system (ANS) function, which responses inform on internal load.[6–9] Monitoring of vagally-mediated indices of HRV provides useful information on athletes' fatigue status[7 10] and is therefore used in high-level athletes to optimise training schedules and competition performance.[4 10]

Novel recovery aids are brought to the commercial market annually without thoroughly analysing their effectiveness.[11] Among them, restricted environmental stimulation therapy in floatation tanks (FLO) is increasingly used by athletes. Driller and Argus 2016 FLO is performed by placing an athlete in a quiet, dark tank filled with skin temperature and high-concentration salted water to facilitate passive flotation (figure 1). As a deep relaxation method that improves body and mind recovery, FLO is increasingly accessible with technology developed by several commercial vendors. FLO has been investigated in non-athlete cohorts with demonstrated effects on chronic pain,[12] stress, anxiety, depression, sleep quality,[13–16] body image,[17] generalised anxiety disorder[15] and performance.[18 19] Of note, outcomes data are not universally positive, with some studies showing conflicting results.[20 21]

Data defining the impact of FLO on athlete recovery are limited. Several recent studies suggest that FLO may facilitate recovery and enhance performance by improving mood, reducing muscle soreness[22 23] and influencing hormonal pathways associated with muscle repair and growth.[20] Additionally, its potential benefits in stress reduction and recovery enhancement have been highlighted among populations subjected to high-intensity stress, such as Special Forces operators.[19] We know only two studies have collected HRV data in conjunction with FLO. Loose *et al* reported a slight post-intervention increase in overall HRV (SD of normal-to-normal intervals) and vagally-related variables (root mean square of successive difference (RMSSD)) in chronic pain disorder patients.[21] In contrast, a comparison of anxious and non-anxious participants undergoing an FLO session or watching a nature documentary showed no difference in RMSSD but did observe increased high-frequency power and lower diastolic blood pressure, suggesting increased vagal tone.[24] One study specifically investigated the effects of FLO on exercise recovery and found that FLO significantly improved sprint performance, pain thresholds, muscle soreness, fatigue and sleep quality compared with passive recovery, underscoring its potential as an effective recovery modality.[25] However, additional investigation of FLO on athlete recovery is required to enable coaches and sports medical staff to best advise their athletes about its potential utility.

This study aimed to compare the short-term effects of a single session of FLO and a conventional nap on the autonomic nervous system using comprehensive HRV analyses. We hypothesised that a 1-hour FLO session would boost the vagal tone in trained individuals, as reflected by parasympathetic-mediated HRV metrics, to a higher magnitude than a conventional nap. A secondary objective of this study was to document and compare the subjective participant's experience during FLO and conventional napping.

METHODS

Participant

Participants were recruited via flyers, social media and emails. Inclusion criteria included: (1) age between 18 and 40 years; (2) ≥4 sessions of exercise per week; (3) weekly training volume of ≥5hour; (4) tier 3 and 4 of McKay's participant classification framework[26]; (5) self-participants were required to score below 20 on the French society of sports medicine overtraining questionnaire, indicating non-fatigue.[27–29] Exclusion criteria focused on disallowing active musculoskeletal or cardiovascular issues and specific contraindications to FLO. Complete inclusion and exclusion criteria, similar to those used in a prior FLO study,[30] are provided in the online supplemental material.

Design

This prospective study used a repeated measures design to assess the effects of a 1-hour FLO session versus a conventional nap on HRV, with sessions spaced by at least 24 hours and no more than 7days. Each intervention's order was randomised, and sessions were conducted between 08:00 and 12:00 to control for circadian influences.[31]

HRV measurements were taken in a controlled setting before and after interventions.

Heart rate variability

Collection

Each participant was requested to present for the visits in standardised conditions (eg, avoiding exercise, heavy meals and stimulants for 24 hours before the visits) to minimise HRV confounding factors. Participants were not advised about specific hydration protocol before interventions and were not restricted from drinking water prior to testing. Hydration status was not measured. Before and after interventions, RR intervals were recorded using validated equipment (Polar H10 sensor and V800 watch, Polar Electro Oy, Kempele, Finland)[32 33] during a 6 min supine rest, followed by a 5 min standing session. This dual position was used HRV to evaluate autonomic responses under different physiological conditions. The supine measurement reflects baseline parasympathetic activity, while the standing measurement introduces orthostatic stress, challenging the ANS and providing insights into sympathetic activation and parasympathetic withdrawal.[34] Participants were placed on a massage table in the same calm room of the floatation tank to ensure similar temperature and atmosphere for both visits (23.9±6.3°C, humidity: 55.6±18.3%), in the dark, with eyes closed, without movement and were asked not to think about anything specific. Then the investigator entered the room and asked the participant to stand up for 5 min with the following instructions: remaining motionless, without foot movements or alternating foot pressure. Participants were asked to relax with the arms passively hanging along the body and not to focus their thoughts on specific topics. Participants were instructed to breathe spontaneously without guided pacing to reflect their natural breathing patterns.

Data treatment

HRV analyses were performed between the 3rd and 6th min supine and the 2nd and 5th min standing.[35] Each file was visually inspected for artefacts and ectopic beats, which were automatically and manually corrected using Kubios Premium (Kubios, Finland).[36] Any signal with significant artefacts or signal showing signs of non-sinus rhythm was excluded. Standardised HRV variables[6 37] were analysed in time-domain, frequency-domain and non-linear-domain with focus on vagally-related HRV variables supine (HR, RMSSD,[6] (low frequency (LF)+HF high frequency (HF))/HR,[38] SD1, SD2, SD2/SD1, detrended fluctuation analysis alpha 1 (DFA1) (38–40) and on blood pressure regulation variables in standing position (HR, LF, LF/HR[10 39] and DFA1). We included a combination of linear and non-linear HRV measures to provide a more comprehensive assessment of autonomic function in both positions.

Floatation

Floatation was performed in an i-sopod floating tank (Floatation Systems, London, England), filled 31 cm deep with water containing 500 kg of dissolved Epsom salts (magnesium sulfate, density range=1.23 and 1.28 g/cm^3). Participants must shower before FLO and receive instructions: ‘You are familiar with floatation, having already practised a session. Some additional information to optimise your session is as follows: You may float up to 60 minutes but can stop and leave the pod anytime. You can choose to float with or without light. Try to find a state of calm for the body and mind. Relax. At the beginning and the end of the session, music will be broadcast in the box to inform you that the session is starting and stopping. We encourage you to complete the full 60-minute session if possible’.

Nap

The nap session (NAP) intervention took place in the same room as the FLO intervention and was conducted with participants in the supine position on a massage table with no illumination. The following instructions were given: ‘The aim is to get comfortable lying on your back on a massage table. You can dress in a tracksuit. A blanket is at your disposal if you think it will be cold. You can fall asleep. Try to find a state of calm for the body and mind. Relax. You can interrupt the nap at any time. The nap will end when the investigator hits the room door 10 times louder and louder’. NAP was terminated by an investigator who knocked on the door after 1 hour.

Questionnaires

After both FLO and NAP interventions, participants quantified their level of general well-being using a Visual Analogue Scale utilising a range of 0–100, which was reflected by a horizontal line on REDCap, a secure web application designed for building and managing online surveys and databases.

Statistical analyses

Baseline HRV data are presented as mean±SD in the online supplemental material to depict the initial physiological states of participants. This unadjusted data demonstrated significant interindividual variability, enhancing the transparency of subsequent analyses and supporting the integrity of our methodological approach. Presenting these baseline measures ensures the clinical relevance of HRV metrics is immediately evident and interpretable.

Normality was assessed using the Shapiro-Wilk test on variables of interest, and subsequent data are expressed as mean±SD if normally distributed and median (25th; 75th percentile) if non-normally distributed. All data except HR, SD1/SD2, DFA alpha 1 supine and HR standing were transformed with natural logarithm to better approximate normality.

For the analysis of the intervention effects on HRV, a repeated measures two-way analysis of variance (ANOVA) (time (pre- vs post-) × intervention (FLO vs NAP)) was conducted using the Geisser-Greenhouse correction to account for any deviations from sphericity, with matched values organised both stacked and spread across a row. Each comparison stood alone with Fisher's least significant difference test applied as post hoc treatment if repeated measures ANOVA revealed a significant main effect (time or intervention) or interaction effect to test the significance of the differences.

Subjective questionnaires were analysed with a two-tailed paired t-test for normally distributed data and a two-tailed Wilcoxon matched-pairs signed-rank test for non-normally distributed data. A p value of <0.05 was considered to indicate statistical significance for all analyses. Study data were collected and managed using REDCap electronic data capture tools hosted at Lausanne University Hospital. All statistical analyses were performed with GraphPad Prism (V.10.1.2, GraphPad Software).

Table 1 Participants' characteristics

Sex (F/M) – (%/%)	4/16 to 20/80
Age (years)	30±6
Weight (kg)	74±12
Height (cm)	176±7
BMI (kg/m^2)	23.6±3
Training weekly hours (h)	10.2±4.9
Training weekly sessions (u)	5.3±2.2
Overtraining score (FLO)	4.3±3.9
Overtraining score (NAP)	5±4.7*
Sport type	Athletics (2), bodybuilding (3), callisthenics (1), crossfit (1), cycling (2), soccer (1), climbing (1), weightlifting (1), diving (1), pole dance (1), running/trail running (2), triathlon (1), yoga/dance/trail running (1), yoga/HIIT (1), yoga/cycling/trail running (1)

Overtraining score is positive out of 54 possible items.
*No statistical difference in questionnaires between sessions (p=0.438, Wilcoxon).
BMI, body mass index; F, female; FLO, floatation session; HIIT, high-intensity interval training; M, Male; NAP, nap session.

RESULTS

Participants

We recruited 24 participants who initially accepted the invitation to participate. A total of four participants were excluded due to scheduling conflicts, leaving a final participant cohort of 20 people. Two participants exhibited non-sinus rhythm during supine HRV assessment and were referred for further investigation, which revealed benign conditions. Consequently, their supine data were excluded from the analysis. One data standing (post NAP) was significantly artifacted and then excluded (missing completely at random). The medians of all of the other post-NAP data imputed all the variables coming from this signal. This approach was chosen for its simplicity and robustness, minimising the introduction of bias and preserving the data set's overall integrity.[40] Final analyses, therefore, included 18 supine and 20 standing pre–post intervention HRV data sets. Participants (20% women) were 30±6 years of age. The average time between intervention visits was 2.7±2.7 days (min: 1; max: 7). Participant physical activity data is shown in table 1. Data examining training load revealed no evidence of overtraining, and the results were similar between both visits. There were no adverse events during any portion of this study.

Supine

Significant effects of both FLO and NAP on HRV in a supine position were observed across time-domain, frequency-domain and non-linear HRV variables, as seen in table 2. Taking all participants and measurements together, the interventions had no significant effects overall. Time (PRE-/POST) had significant effects on HR and trends for log-transformed RMSSD (lnRMSSD). Specifically, both interventions resulted in a significant decrease in HR as reflected by pre-intervention to post-intervention Δ natural logarithm (ln)HR (p=0.0001) without interaction effect (FLO Δ = −2.9 bpm, p=0.0116, NAP Δ = −4.6 bpm, p=0.0003). However, there was no significant difference in ΔlnHR when comparing FLO to NAP.

Significant interaction effects between time (PRE vs POST) and intervention (FLO vs NAP) were observed for lnRMSSD (lnLF+lnHF)/lnHR, lnSD1 and lnSD2. When looking at multiple comparisons, despite PRE-values being significantly different between groups (p=0.045), only NAP had decreased vagally related lnRMSSD (p=0.022) (equal to lnSD1, which is the same measure). However, no significant differences were revealed between groups after interventions. The combined frequency domain measure relative to HR ((lnLF+lnHF)/lnHR) were also different pre-interventions (p=0.022) but increased after NAP, whereas decreasing after FLO, but post-interventions comparisons were not statistically different. Figure 2 shows a graphic representation of the main variables of interest.

Standing

There were significant effects on HRV in a standing position across time frequency-domain and non-linear HRV variables (table 3). Taking all participants and measurements together, time (PRE-/POST) significantly affected HR, lnLF and lnDFA alpha 1, all of which increased. No interaction effects were observable. Specifically, a significant main effect of time (p=0.0228), showing an overall increase in HR across both intervention changes (FLO Δ = +4.1 bpm, p=0.013; NAP Δ = +1.4 bpm, p=0.223), was observed but there was no significant group effect

Table 2 Comparisons of time-domain and frequency-domain and non-linear HRV variables pre-FLO and post-FLO and NAP in supine position

	FLO		NAP		Two-way ANOVA p value		
	PRE	POST	PRE	POST	Time effect	Intervention effect	Time* intervention interaction effect
HR (bpm)	58.1±8.9	55.1±7.8	59.9±9.7	55.3±8.2	**0.0001**	0.4305	0.2402
lnRMSSD	4.124±0.507	4.082±0.404	3.979±0.472†	4.188±0.504*	0.0727	0.7459	**0.0178**
(lnLF+lnHF)/lnHR	3.654±0.51	3.534±0.422*	3.455±0.388†	3.644±0.498*	0.4426	0.5201	**0.0058**
lnSD1	3.78±0.507	3.738±0.405	3.634±0.472	3.844±0.505*	0.0724	0.7459	**0.0177**
lnSD2	4.474±0.377	4.422±0.353	4.369±0.305	4.573±0.348*†	0.1531	0.5797	**0.0163**
SD2/SD1	2.1±0.7	2.1±0.8	2.2±0.9	2.2±0.9	0.9884	0.2359	0.8913
DFA alpha 1	0.934±0.317	0.915±0.374	0.947±0.379	0.918±0.342	0.5666	0.8748	0.9299

Data are mean±SD. Bold indicates p-values <0.05.
*Variables statistically different between PRE and POST (p<0.05).
†Variables statistically different between FLO and NAP (p<0.05).
ANOVA, analysis of variance; DFA, detrended fluctuation analysis; FLO, floatation session; HF, high frequencies; HR, heart rate; LF, low frequencies; Ln, natural logarithm; NAP, nap session; RMSSD, root mean square of successive difference.

(p=0.8395). However, there was no significant difference in HR change when comparing FLO to NAP. Interestingly, the interaction between time and intervention approached marginal significance for HR (p=0.0507), suggesting a potential differential pattern in how HR responded over time between the two groups, with FLO maybe increasing HR and warranting further investigations. The same analysis for frequency-domain lnLF and lnLF/LnHR was observed (p=0.097 and p=0.073, respectively), suggesting that NAP may increase LF to a different extent than FLO.

This analysis underscores that while both interventions impacted HRV, the response patterns within and between groups were generally similar, as demonstrated by the comparable HRV response metrics in figure 3.

Subjective experience data

Subjective participant experience differed between FLO and NAP. Specifically, only 7/20 (35%) participants reported having fallen asleep during FLO (35%), while 16/20 (80%) slept during NAP. A total of 15/20 (75%) participants reported a higher enjoyability score following FLO, 3/20 (15%) reported a higher enjoyability score following NAP and 2/20 (10%) reported no difference. There was no significant difference in how pleasant the participants scored in both interventions (FLO=86 (83.3; 98.8) vs NAP=83 (71; 90), p=0.1467). Similarly, participants reported similar levels of discomfort with both interventions (FLO=0 (0; 6.8) vs NAP=2.5 (0; 11.5), p=0.3662). The assessment focused on improved overall well-being indicated a significantly higher score for FLO (81.5 (78.3; 88.8)) compared with NAP (71.5 (67; 80.8), p=0.035). These data suggest a more favourable subjective short-term benefit of FLO than NAP (figure 4).

DISCUSSION

This study investigated the impacts of floatation and conventional napping on HRV, an indirect marker of autonomic function, in active, non-fatigued participants. Our analysis revealed marginal changes in time-domain and frequency-domain and non-linear HRV variables in

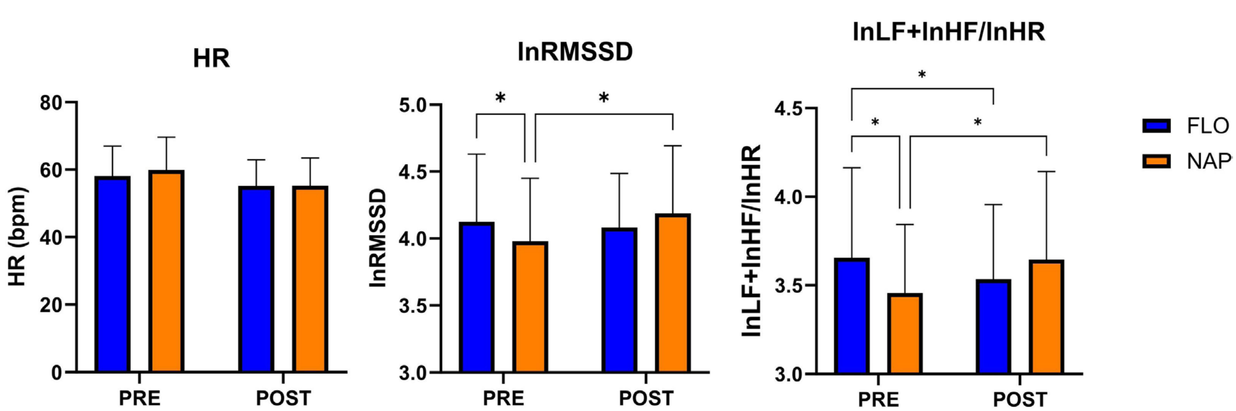

Figure 2 Heart rate (HR), log-transformed root mean square of successive differences (lnRMSSD) and the ratio of log-transformed low-frequency and high-frequency powers to log-transformed HR (lnLF+lnHF/lnHR) before (PRE) and after (POST) interventions. FLO, floatation, NAP, napping. *Indicates a statistically significant differences (p<0.05).

Table 3 Comparisons of time-domain and frequency-domain and non-linear HRV variables pre-FLO and post-FLO and NAP in standing position

	FLO		NAP		Two-way ANOVA p value		
	PRE	POST	PRE	POST	Time effect	Intervention effect	Time* intervention interaction effect
HR (bpm)	80.3±11.3	84.4±9.9	82±11.4	83.4±10.7	**0.0228**	0.8395	0.0507
lnLF	7.152±0.741	7.241±0.869	6.941±1.053	7.562±0.798	**0.0217**	0.7708	0.0973
lnLF/lnHR	1.637±0.186	1.636±0.207	1.582±0.26	1.715±0.189	0.0655	0.8092	0.0731
lnDFA alpha 1	0.402±0.14	0.497±0.109	0.385±0.194	0.474±0.113	**0.0004**	0.4732	0.8654

Data are mean±SD. Bold values indicate p-values <0.05.
*Variables statistically different between PRE and POST (p<0.05).
ANOVA, analysis of variance; DFA, detrended fluctuation analysis; FLO, floatation session; HR, heart rate; LF, low frequencies; Ln, natural logarithm; NAP, nap session.

response to these interventions, underscoring similar autonomic responses to these recovery modalities, with no significant differences between groups post-interventions. More precisely, supine and napping significantly affected vagally-related variables despite FLO being better perceived in terms of well-being.

Contrary to expectations, FLO did not significantly alter autonomic measures, as suggested by other studies. Al Zoubi *et al* demonstrated decreased functional connectivity (reduction in the synchronisation between different regions of the brain associated with intrinsic mental activity (medial prefrontal cortex and the posterior cingulate cortex and precuneus)) following FLO, suggesting a potential physiological basis for the relaxation response mediated through autonomic modulation.[41] FLO principle involves sensory deprivation, which is thought to reduce cognitive and physical stress by limiting external stimuli. This reduction in sensory input can lead to decreased activity in the default mode network, associated with self-referential thoughts and mind-wandering, as observed in this study.[41] Theoretically, this could facilitate relaxation and meditative calm, contributing to stress reduction and increasing HRV, which we could not confirm with our data. The initial unfamiliarity with the FLO environment can cause a mild stress response. However, since our participants were familiar with FLO, this effect was likely minimised. Feinstein *et al* and Flux *et al* underscored FLO's anxiolytic and acute cardiovascular effects, offering a mechanistic insight into how FLO might enhance recovery through autonomic responses to stress modulation.[24 30] However, they performed analysis during FLO but not in a pre-design/post-design. The slight differences observed in our study between FLO and NAP's effects on autonomic balance do not account for the increased well-being, which was also attested by Driller and Argus, alongside reduced muscle soreness.[23] This is complemented by Caldwell *et al* discussion on the perceived recovery benefits of FLO, aligning with our physiological evidence of FLO's rather subjective role in recovery enhancement.[18] Flux *et al* discuss the acute cardiovascular effects of FLO, including potential changes in blood pressure and HR, which indicate autonomic modulation.[24] However, the specific impact on HRV metrics and the distinction between sympathetic and parasympathetic activity require careful interpretation. Higher standing HR trends may be linked with decreased sympathetic tone, as a study showed a significant decrease in blood norepinephrine[18] and reduced blood pressure[24] after FLO interventions. However, our data with lnLF, did not

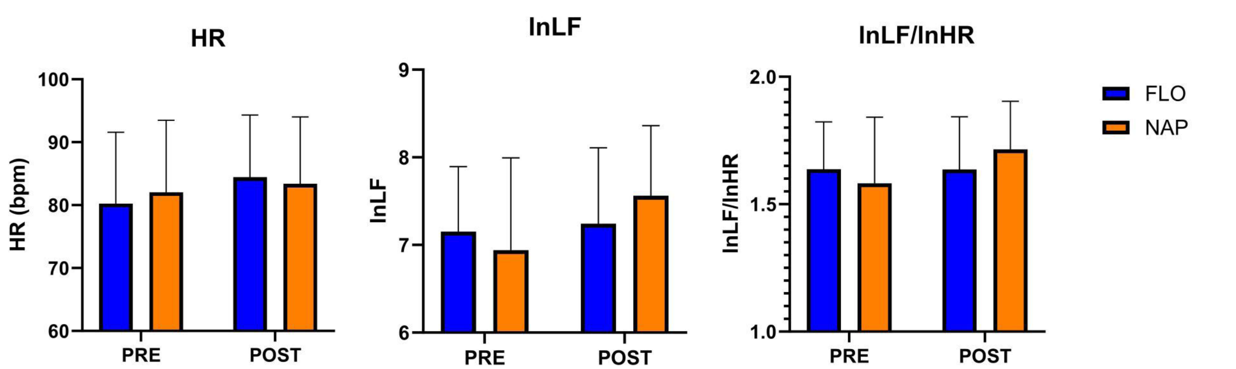

Figure 3 Heart rate (HR), log-transformed low-frequency power (lnLF) and the ratio of log-transformed low-frequency power to log-transformed HR (lnLF/lnHR) before (PRE) and after (POST) before (PRE) and after (POST) interventions. FLO, floatation; NAP, napping.

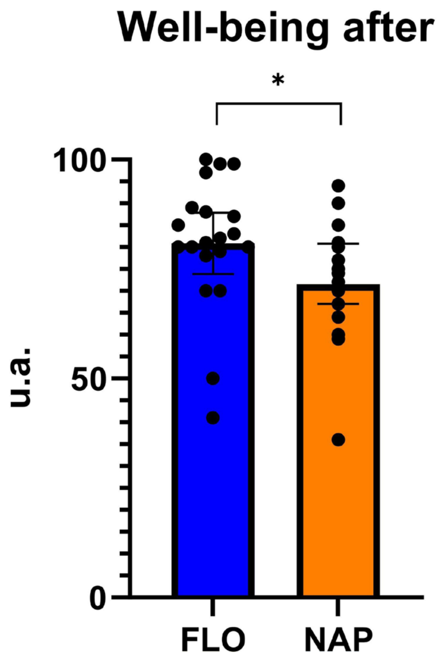

Figure 4 Well-being feeling after sessions Visual Analogue Scale scores. *Indicates a statistically significant difference (p<0.05). FLO, floatation; NAP, napping.

support this, showing no difference between PRE and POST FLO.

Furthermore, the subjective enjoyment and perceived well-being associated with FLO, as reported in our study, parallels several findings on floatation therapy's psychological benefits.[16 17 30 42] This suggests a link between psychological benefits and physiological effects on autonomic function, a relationship echoed by Bood *et al* in their early evidence of FLO's effectiveness in stress-related conditions.[13 43] Another study highlighted a significant effect on aspects of performance, pressure-to-pain threshold, perceived muscle soreness and physical fatigue and sleep quality the morning after an FLO session performed after exercising (Broderick *et al*, 2019). Our study corroborates the existing evidence on the psychological impacts of relaxation techniques but without short-term validation on HRV-related autonomic function.

Research supports the therapeutic benefits of napping on autonomic function, with improved mood, cognitive function and cardiovascular health, often linked to enhanced parasympathetic activity. Studies show napping can lower blood pressure, suggesting enhanced autonomic balance favouring parasympathetic dominance.[44] The expected effect of enhancing autonomic cardiovascular regulation, attributed to the restorative nature of sleep, even in short durations, was not measurable in our study as no control for effective sleep was performed. Aligning with general sleep physiology, vagal modulation notably increases during rapid eye movement (REM) sleep,[45] promoting relaxation and recovery.[44] In our design, a 1-hour period should not lead to REM, indicating that even shorter naps can reset a posteriori of the autonomic nervous system towards a more favourable recovery state. This duration differs from the commonly recommended nap lengths of 10–30 min for short naps or approximately 90 min to complete a full sleep cycle,[46] which may induce different HRV responses. Indeed, a recent meta-analysis suggests that nap duration plays a critical role in the benefits of napping, with longer nap opportunities, such as 90 min, resulting in greater improvements in physical and cognitive performance and reduced fatigue.[47]

The interpretation of FLO as potentially inducing physiological stress expressed by higher HR trends should be discussed. If FLO lowers blood pressure,[24] a possible delay in baroreflex activation while standing may be the source of increased HR. The literature on FLO predominantly underscores its relaxation and stress reduction benefits, with studies reporting reductions in stress, anxiety and muscle tension, as well as improvements in mood and well-being following FLO sessions,[15 30] in line with our participants' feelings. However, these studies often focus on psychological responses rather than direct measures of autonomic function like HRV. The discrepancy between our findings and the broader literature might stem from several factors, including the specific context of our study (eg, non-fatigued highly active participants), the measures used to assess stress and relaxation (eg, HRV methods (position, timing,…) vs subjective reports) or the nature of the FLO experience itself.

The floatation environment, with its warm, highly salted water, prompts concerns about hydration due to osmotic effects, although significant dehydration is unlikely given the skin's semi-permeability and the body's regulatory mechanisms.[48 49] Increased sweating in the warm floatation tanks could contribute to fluid loss, potentially affecting blood pressure more than osmosis. Dehydration can lower HRV by promoting the release of vasopressin in response to decreased blood volume, leading to vasoconstriction, increased blood pressure and enhanced sympathetic tone.[48 50] However, our results do not show an increased sympathetic tone and the comprehensive impact on hydration has not been thoroughly studied. Measuring body weight before and after sessions could provide insights into fluid loss. However, further research must account for ambient temperature, session length, individual sweat rates and initial hydration levels.

FLO and NAP might have variable effects on individuals based on personal preferences, prior experiences and individual differences in stress response and autonomic regulation. It is also possible that repeated exposures to FLO could lead to adaptation and more pronounced relaxation effects, as suggested by some longitudinal studies on FLO and subjective pain and stress-related psychological variables.[43] Finally, differences in study populations, methodologies and HRV analysis might contribute to differing findings. Athletes, for example, might have unique physiological and psychological responses to restorative practices compared with general populations. Furthermore, the adaptation to FLO over time, especially mid-terms (eg, responses between 1 hour and 24 hours post-intervention) and individual differences in perception and response to relaxation techniques underscore the complex interplay between physiological mechanisms and psychological experiences in determining the efficacy of recovery interventions. These inconsistencies highlight that athletes' perceived recovery levels do not always match objective measures.[51] Relying solely on subjective measures may overlook physiological stress or inadequate recovery. Therefore, integrating both subjective experiences and objective data is essential to optimise recovery strategies, leading to better performance outcomes.

Clinical implications

The low amplitude responses to FLO and NAP underline the importance of personalising recovery strategies. Athletes and coaches should consider individual preferences, experiences and the specific physiological responses to different recovery modalities when designing recovery protocols according to different fatigue states (functional over-reaching, non-functional over-reaching, overtraining[52]). Our data slightly favours NAP being implemented in athletes' training regimens as an effective strategy for enhancing autonomic recovery. While FLO has been associated with relaxation and stress reduction, its effects on HRV and autonomic function might not be as straightforward, at least on a short-term basis. Athletes and practitioners should consider trial sessions to gauge/assess individual responses before integrating FLO into regular recovery protocols.

Strengths, limitations and future research

This study provides crucial insights into the autonomic responses of highly trained athletes to FLO and NAP, offering evidence-based recovery strategies for sports science practitioners. Evaluating HRV across different postures deepens understanding of autonomic nervous system modulation via these techniques.

With a focus on immediate responses from 20 highly trained participants, the applicability of results to wider or recreational athlete populations is limited. Future research should extend to examining the mid-term and long-term effects and potential cumulative benefits of regular FLO and NAP, exploring their integration with broader recovery strategies for diverse groups.

Another limitation of our study is the absence of a control condition or control group, such as having participants rest quietly without any specific intervention or engaging in a standardised neutral activity. Although the NAP intervention involves rest, it was implemented as an active recovery strategy, with participants encouraged to relax and enjoy the nap as they would in their everyday lives. While our within-subjects design—with randomised intervention order and standardised testing times—helps control for individual variability and circadian influences, we acknowledge that we cannot entirely exclude the potential impact of residual circadian effects or a sedentary environment. Including a passive control condition in future studies would help distinguish the specific contributions of the FLO and NAP interventions from natural physiological fluctuations throughout the day, thereby enhancing the validity of our findings.

The lack of control over participants' hydration status and water intake prior to the interventions is also a limitation. Uncontrolled hydration may have introduced variability in our HRV readings,[53] potentially affecting the validity of our findings. Future studies should control for hydration status.

The higher enjoyability scores for FLO may be due to a novelty effect from participants' limited prior exposure; as familiarity grows, enjoyment may diminish. Practical factors like accessibility, cost and time requirements could also dissuade regular use. Since our study assessed only immediate responses after single sessions, we cannot determine long-term enjoyment or adherence. Therefore, initial preference for FLO may not translate into sustained use. Future research should investigate long-term enjoyment and feasibility to determine FLO's practical utility for athletes.

Future research should explore the chronic effects of incorporating FLO and/or NAP into regular training regimens over extended periods. Longitudinal studies could assess changes in resting HRV parameters to determine the sustained impact of these recovery strategies. Mechanistic studies are needed to elucidate the physiological and psychological underpinnings of the effects of FLO and NAP on HRV. Comprehensive research could assess their combined impact with other recovery modalities in treating symptomatic or fatigued athletes.[18,25] Further exploration into the clinical significance of these findings will help refine recovery and training optimisation across athletic disciplines.

CONCLUSION

This study revealed that both interventions had minimal impact on short-term HRV, with napping enhancing parasympathetic activity—a response not observed with floatation-REST (FLO), despite its improvement in subjective well-being. These results advance our understanding of the nuanced effects of relaxation techniques on autonomic function within sports science, especially for refining athlete recovery strategies. The findings underscore the importance of further investigating individual variations in response to FLO and its potential adaptability, enhancing our knowledge of effectively implementing these interventions for athlete recovery and overall well-being.

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