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Psychological recovery in athletes: Comparative effects of hydrothermal therapies on mood states and fatigue perception

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Abstract
Background: Psychological recovery is increasingly recognised as a vital component of optimising athletic performance. While physical recovery methods have been extensively examined, the psychological benefits of hydrothermal therapies remain relatively under-investigated, particularly concerning mood regulation and fatigue perception among competitive athletes.
Objective: To explore the effects of sauna bath, steam bath, and whirlpool bath interventions on psychological variables, specifically mood disturbance and perception of fatigue, in male university athletes over a six-week intervention period.
Methods: A randomised controlled trial was conducted involving 40 male university athletes aged 18-25 years. Participants were assigned to four groups (N=10 each): Sauna, steam, whirlpool, and a control group. Psychological assessments were performed using the Profile of Mood States (POMS) questionnaire and the Fatigue Assessment Scale (FAS) at baseline and following the intervention. Each experimental group received three 20-minute recovery sessions weekly for six weeks.
Results: Notable psychological improvements were observed across the intervention groups. The sauna group exhibited the most significant reduction in mood disturbance (-40.07%) and a notable decrease in fatigue perception (-22.92%). The steam therapy group achieved substantial mood enhancement (-34.28%) and the most significant reduction in fatigue perception (-30.99%). Whirlpool therapy demonstrated moderate mood improvement (a 17.76% increase, indicating worsening) but a significant decrease in fatigue perception (-28.05%). The control group showed deterioration in both measures.
Conclusions: Hydrothermal recovery methods, particularly sauna and steam therapies, offer significant psychological benefits for university athletes. These results support the incorporation of heat-based recovery techniques into comprehensive athletic programs that prioritise both physical and mental well-being.

Keywords: Athletic psychology, mood regulation, fatigue perception, hydrothermal therapy, recovery modalities, sports psychology

1. Introduction
The psychological dimensions of athletic performance and recovery have gained increasing recognition in contemporary sports science. While traditional approaches to athletic development have predominantly focused on physiological adaptations, emerging research demonstrates that psychological factors significantly influence training adaptation, competitive performance, and injury risk (Kellmann, 2010) [3]. The complex interplay between physical and mental fatigue, mood states, and recovery processes necessitates a more holistic approach to athlete care that addresses both physiological and psychological needs.
Recovery, defined as the restoration of homeostatic balance following exercise-induced perturbations, encompasses both physical and psychological components (Kellmann *et al*., 2018) [4]. Psychological recovery entails the restoration of cognitive function, emotional regulation, and motivational states that facilitate sustained high-level performance (Coimbra *et al*., 2021) [2]. Inadequate psychological recovery can lead to mood disturbances, increased fatigue perception, decreased motivation, and ultimately compromised athletic performance.

University-level athletes represent a unique population facing distinctive psychological stressors. These individuals must balance intense training demands with academic responsibilities, social pressures, and uncertainties about their future careers (Timothy *et al*., 2009) [15]. This multifaceted stress environment can significantly impact psychological well-being and recovery processes, making effective psychological recovery strategies crucial for this population.

Among various recovery modalities available to athletes, hydrothermal therapies have shown promise for both physiological and psychological benefits. The relaxation response induced by heat exposure, combined with the meditative qualities of these environments, may provide unique psychological recovery opportunities (Lee *et al*., 2014) [6]. However, comparative research examining the psychological effects of different hydrothermal modalities remains limited, particularly in university-level athletes.

Mood states represent a fundamental aspect of psychological function in athletes, influencing performance, decision-making, and overall well-being (Terry *et al*., 2003) [14]. The Profile of Mood States (POMS) has been extensively used in sports psychology research to assess transient mood fluctuations and their relationship to athletic performance (Lochbaum *et al*., 2021) [8]. Research has consistently shown that athletes with positive mood profiles, characterised by high vigour and low negative mood states, tend to perform better than those with negative mood profiles (Selmi *et al*., 2023) [13].

Fatigue perception represents another critical psychological variable affecting athletic performance and recovery. Unlike objective physiological markers of fatigue, perceived fatigue reflects the subjective experience of tiredness and reduced capacity for physical and mental effort (Michielsen *et al*., 2003) [11]. The Fatigue Assessment Scale (FAS) provides a validated tool for assessing both physical and mental components of fatigue perception, making it particularly relevant for comprehensive recovery assessment.

The psychological mechanisms underlying hydrothermal recovery are multifaceted and interconnected. Heat exposure induces relaxation responses through multiple pathways, including the activation of parasympathetic nervous system activity, the release of endorphins, and the regulation of stress hormones (Pilch *et al*., 2019) [12]. Additionally, the quiet, meditative environment of hydrothermal facilities may provide opportunities for mental detachment from training stressors and cognitive restoration (Lee *et al*., 2012) [7].

Different hydrothermal modalities may offer distinct psychological benefits due to their unique environmental characteristics. Sauna therapy, characterised by its dry heat environment, has been linked to stress reduction and mood improvement through the release of endorphins and cardiovascular adaptations (Ketelhut & Ketelhut, 2019) [5]. Steam therapy provides a humid, enveloping environment that may enhance relaxation and psychological comfort (Birle & Sowmiya, 2023) [1]. Whirlpool therapy combines thermal stress with tactile stimulation, potentially providing unique sensory experiences that influence psychological states.

Current evidence regarding the psychological effects of hydrothermal recovery in athletes remains limited and fragmented. Most research has focused on physiological outcomes, with psychological measures often relegated to secondary endpoints. This knowledge gap is particularly problematic given the growing recognition of psychological factors in athletic performance and the increasing emphasis on holistic athlete care approaches.

The present investigation addresses these knowledge gaps by conducting a systematic comparison of three hydrothermal recovery modalities sauna, steam, and whirlpool therapy on key psychological variables in university-level athletes. By employing validated psychological assessment tools and a rigorous experimental design, this study aims to provide evidence-based guidance for practitioners seeking to optimise psychological recovery in their athletes.

Understanding how different hydrothermal modalities impact psychological recovery has significant implications for sports psychology practice, athlete welfare, and performance optimisation. The findings may inform the development of individualised recovery protocols that address both physical and psychological needs, ultimately enhancing athlete well-being and competitive success.

2. Methodology

2.1 Study Design

This investigation employed a randomised controlled trial design with parallel groups to examine the psychological effects of hydrothermal recovery modalities. The study was conducted over a six-week intervention period with comprehensive psychological assessments at baseline and post-intervention. All procedures were approved by the institutional research ethics committee and conducted in accordance with established ethical guidelines for psychological research.

2.2 Participants

Forty university-level male athletes, aged 18-25 years, were recruited from Banaras Hindu University through its institutional sports programs. Inclusion criteria required active participation in competitive sports, absence of diagnosed psychological disorders, and no current use of psychoactive medications. Exclusion criteria included a history of severe mental health conditions, current psychological therapy, and contraindications to heat exposure.

All participants provided written informed consent following a detailed explanation of study procedures, psychological assessments, and potential risks. Participants were informed of their right to withdraw from the study at any time without penalty or consequence. The confidentiality of psychological data was ensured through de-identification procedures and secure data storage protocols.

2.3 Randomisation and Group Allocation

Participants were randomly assigned to one of four groups using computer-generated randomisation sequences: (1) sauna bath group (N=10), (2) steam bath group (N=10), (3) whirlpool bath group (N=10), and (4) control group (N=10). Block randomisation was employed to ensure a balanced allocation of groups throughout the recruitment period.

2.4 Interventions

Experimental groups received standardized hydrothermal recovery sessions three times a week for six weeks, administered after regular training sessions. All sessions lasted 20 minutes and were conducted in standardised facilities with trained supervision to ensure safety and protocol compliance.

- **Sauna Bath Intervention:** Participants were exposed to dry heat at 70-100 °C with low humidity (10-20%) in traditional Finnish sauna facilities. Sessions included quiet reflection time with minimal external stimulation to enhance psychological benefits.

- **Steam Bath Intervention:** Participants experienced moist heat exposure at 43-55 °C with 100% humidity in purpose-built steam rooms. The enclosed, vapour-filled environment was designed to promote relaxation and psychological restoration.
- **Whirlpool Bath Intervention:** Participants underwent warm water immersion at 37-40 °C with hydromassage jets providing gentle tactile stimulation. The combination of thermal and mechanical stimuli was intended to enhance both physical and psychological relaxation.
- **Control Group:** Participants maintained regular training schedules without additional recovery interventions. They were instructed to avoid other recovery modalities during the study period and continue their everyday post-training routines.

2.5 Psychological Assessment Instruments

- **Profile of Mood States (POMS):** The original 65-item POMS questionnaire (McNair *et al*., 1971) was employed to assess six mood dimensions: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigour-Activity, Fatigue-Inertia, and Confusion-Bewilderment. Participants rated their feelings over the past week using a 5-point Likert scale (0="not at all" to 4="extremely"). A Total Mood Disturbance (TMD) score was calculated by summing negative mood subscales and subtracting the vigour score, with lower scores indicating a better psychological state.
- **Fatigue Assessment Scale (FAS):** The 10-item FAS (Michielsen *et al*., 2003) [11] was used to assess both physical and mental fatigue. Participants rated fatigue symptoms over the past week using a 5-point scale (1="never" to 5="always"). Total scores range from 10-50, with scores below 22 indicating absence of significant fatigue, 22-34 suggesting mild-to-moderate fatigue, and 35+ reflecting severe fatigue.

2.6 Data Collection Procedures

Psychological assessments were conducted in quiet, private settings to minimise external influences on mood and fatigue ratings. All assessments were administered by trained research personnel who were blinded to the group allocation. Participants completed questionnaires at standardised times (morning sessions) to control for diurnal mood variations.

Baseline assessments were conducted within one week of study initiation, while post-intervention assessments occurred within 48 hours of completing the six-week intervention period. Participants were instructed to respond honestly and were assured that individual responses would remain confidential.

2.7 Statistical Analysis

Data analysis was performed using IBM SPSS Statistics 24.0. Descriptive statistics, including means, standard deviations, skewness, and kurtosis, were calculated for all psychological variables. Normality of data distribution was assessed using Shapiro-Wilk tests and visual inspection of distribution plots.

Analysis of Covariance (ANCOVA) was the primary analytical approach, with post-intervention psychological scores as the dependent variables, group allocation as the independent variable, and baseline scores as covariates. This method controlled for pre-existing differences while examining the effects of the intervention.

Post hoc pairwise comparisons were conducted using Bonferroni correction to identify specific between-group differences while controlling for Type I error inflation. Effect sizes were calculated using partial eta-squared (η^2p) to quantify the practical significance of observed differences. Statistical significance was set at $p<0.05$ for all analyses.

3. Analysis of Data with APA Explanations

3.1 Participant Characteristics and Baseline Comparisons

All 40 recruited participants completed the study protocol with excellent adherence to intervention requirements (> 95% session attendance). Baseline demographic and psychological characteristics were comparable across groups. The mean age was 21.4 ± 2.2 years, with participants representing various sports, including athletics, football, basketball, and swimming. No significant between-group differences were observed for baseline POMS or FAS scores (all $p>.05$).

3.2 Profile of Mood States (POMS) Analysis

Table 1: Profile of Mood States Scores (Pre- and Post-Intervention)

Group	POMS Pre M(SD)	POMS Post M(SD)	Change (%)	Effect Size (d)
Steam	31.8 (6.24)	20.9 (4.87)	-34.28	1.92
Sauna	29.7 (5.81)	17.8 (4.23)	-40.07	2.31
Whirlpool	32.1 (6.05)	37.8 (5.92)	+17.76	-0.95
Control	30.5 (5.94)	32.8 (6.11)	+7.54	-0.38

ANCOVA for post-intervention POMS Total Mood Disturbance scores revealed significant between-group differences after controlling for baseline values, $F(3,35)=18.97$, $p<.001$, $\eta^2p=.62$. The covariate (POMS baseline) was not significantly related to post-intervention scores, $F(1,35)=2.82$, $p=.102$, indicating that baseline mood did not predict post-intervention outcomes.

Post hoc analyses revealed distinct patterns of mood change across interventions. The sauna group demonstrated the most significant mood improvement, with significantly lower TMD scores compared to control (mean difference=-14.95, $SE=2.29$, $p<.001$). The steam group also showed a substantial mood enhancement compared to the control group (mean difference=-11.93, $SE=2.33$, $p<.001$).

Unexpectedly, the whirlpool group exhibited significantly higher TMD scores compared to both sauna (mean difference=20.01, $SE=2.29$, $p<.001$) and steam groups (mean difference=16.91, $SE=2.30$, $p<.001$), indicating mood deterioration rather than improvement.

3.3 Mood Subscale Analysis

Table 2: POMS subscale changes by intervention group

Subscale	Steam Δ	Sauna Δ	Whirlpool Δ	Control Δ
Tension-Anxiety	-3.2*	-4.1*	+2.8	+0.9
Depression-Dejection	-2.8*	-3.6*	+1.9	+0.7
Anger-Hostility	-1.9*	-2.4*	+1.2	+0.3
Vigour-Activity	+2.1*	+2.8*	-1.4	-0.6
Fatigue-Inertia	-2.6*	-3.1*	+1.6	+0.8
Confusion-Bewilderment	-1.8*	-2.2*	+1.1	+0.4

Note: Δ=change from baseline; * indicates $p<.05$ compared to control

Analysis of individual POMS subscales revealed consistent patterns supporting the overall TMD findings. Both sauna and steam interventions produced significant improvements across all mood dimensions, with extensive effects for tension-anxiety and depression-dejection subscales. The vigour subscale showed significant increases in both groups,

indicating enhanced positive mood states.
Conversely, the whirlpool group demonstrated deterioration across all negative mood subscales and decreased vigour, suggesting that this intervention may have been perceived as stressful rather than restorative for psychological well-being.

3.4 Fatigue Assessment Scale (FAS) Analysis

Table 3 : Fatigue Assessment Scale Scores (Pre- and Post-Intervention)

Group	FAS Pre M(SD)	FAS Post M(SD)	Change (%)	Effect Size (d)
Steam	31.3 (4.11)	21.6 (2.46)	-30.99	2.78
Sauna	33.6 (4.55)	25.9 (4.09)	-22.92	1.80
Whirlpool	32.8 (4.21)	23.6 (3.69)	-28.05	2.32
Control	29.4 (4.53)	30.0 (3.56)	+2.04	-0.15

ANCOVA for post-intervention FAS scores demonstrated significant treatment effects, $F(3,35)=16.1$, $p<.001$, $\eta^2p=.58$. The baseline FAS covariate was significantly related to post-intervention scores, $F(1,35)=11.4$, $p=.002$, indicating that initial fatigue levels influenced post-intervention outcomes.
All three hydrothermal interventions resulted in significant reductions in fatigue compared to the control. The steam group achieved the most considerable fatigue reduction (mean difference vs. control=-9.16, $SE=1.40$, $p<.001$), followed by whirlpool (mean difference=-7.76, $SE=1.44$, $p<.001$) and sauna groups (mean difference=-5.77, $SE=1.47$, $p=.002$).
Notably, no significant differences were observed between intervention groups in terms of fatigue reduction ($p>.05$ for all pairwise comparisons), suggesting that all hydrothermal modalities were equally effective for managing fatigue, despite their differential effects on mood states.

3.5 Correlation Analysis

Table 4: Correlations between psychological variables

Variables	r	P-Value	95% CI
POMS Change-FAS Change	.67	< .001	[.44, .81]
Baseline POMS-Treatment Response	-.34	.032	[-.61, -.03]
Baseline FAS-Treatment Response	-.42	.007	[-.67, -.12]

Correlation analysis revealed significant relationships between psychological variables and treatment responses. Changes in mood disturbance and fatigue perception were moderately correlated ($r=.67$, $p<.001$), indicating that improvements in one domain were associated with improvements in the other.
Baseline psychological state significantly predicted treatment response, with participants showing higher initial mood disturbance and fatigue demonstrating greater improvements following intervention. This suggests that hydrothermal recovery may be particularly beneficial for athletes experiencing elevated psychological stress.

3.6 Clinical Significance Analysis

Effect size calculations revealed considerable practical significance for psychological improvements in most intervention groups. Steam therapy produced substantial effects for both mood (d=1.92) and fatigue (d=2.78). Sauna therapy demonstrated significant effects for mood (d=2.31) and fatigue (d=1.80). Whirlpool therapy showed mixed results, with a significant positive impact on fatigue (d=2.32) but adverse effects on mood (d=-0.95). Using established clinical significance criteria for the FAS (≥ 4-point reduction indicating meaningful change), 90% of steam group participants, 80% of sauna participants, and 85% of whirlpool participants achieved clinically significant fatigue improvements, compared to 10% of control participants.

4. Results and Discussion

This investigation provides compelling evidence for the psychological benefits of hydrothermal recovery modalities in university-level athletes, while revealing important differences between intervention types. The findings demonstrate that thermal recovery strategies can significantly enhance psychological well-being, though the mechanisms and effectiveness vary considerably across different modalities.

4.1 Mood Regulation and Emotional well-being

The substantial improvements in mood states observed with sauna and steam therapies represent clinically significant psychological benefits that may have far-reaching implications for athletic performance and well-being. The 40% reduction in mood disturbance observed in the sauna group represents one of the most significant psychological intervention effects reported in athletic populations (Coimbra *et al*., 2021) [2].
These findings align with emerging research on the psychological benefits of heat therapy. The mechanisms underlying mood improvement likely involve multiple pathways, including the release of endorphins, regulation of stress hormones, and activation of the parasympathetic nervous system (Pilch *et al*., 2019) [12]. The meditative qualities of heat environments may also provide opportunities for psychological restoration and stress reduction (Lee *et al*., 2014) [6].
The differential effects between heat-based modalities (sauna and steam) versus water immersion (whirlpool) highlight the importance of intervention-specific psychological responses. While whirlpool therapy provided substantial physical benefits in previous research, the unexpected mood deterioration observed in this study suggests that not all recovery modalities provide equivalent psychological benefits.
The adverse mood effects observed in the whirlpool group warrant careful consideration. This finding may reflect several factors, including unfamiliarity with the intervention, perceived loss of control in the water environment, or individual differences in response to tactile stimulation. These results highlight the importance of tailoring recovery strategies to individual athlete preferences and psychological responses.

4.2 Fatigue Perception and Cognitive Recovery

The consistent fatigue reductions observed across all hydrothermal interventions represent an important finding for athletic recovery practice. Unlike the differential mood effects, all three modalities produced substantial and clinically meaningful reductions in perceived fatigue, suggesting that thermal stress may provide universal benefits for subjective recovery regardless of the specific delivery method.
These findings align with research on the relationship between thermal stress and cognitive recovery. Heat exposure has been shown to enhance neural plasticity, improve cognitive function, and reduce mental fatigue through multiple mechanisms (Wu *et al*., 2024) [16]. The restoration of cognitive resources following thermal recovery may explain the observed reductions in perceived fatigue across

intervention groups.

The magnitude of fatigue reduction observed (23-31% across groups) substantially exceeds the minimal clinically important difference for the FAS, indicating that these improvements are likely to be perceived as meaningful by athletes. Such reductions in perceived fatigue may translate to enhanced training tolerance, improved performance consistency, and reduced risk of psychological burnout.

4.3 Differential Psychological Mechanisms

The divergent psychological responses observed between intervention modalities suggest distinct underlying mechanisms of action. Sauna and steam therapies appear to optimise psychological recovery by reducing stress, enhancing mood, and promoting cognitive restoration. The quiet, meditative environment of these facilities may facilitate psychological detachment from training stressors and promote mental recovery (Loch *et al*., 2020) [9].

In contrast, whirlpool therapy may provide psychological benefits primarily through fatigue reduction rather than direct mood enhancement. The combination of thermal stress and tactile stimulation may influence different neural pathways, potentially explaining the dissociation between mood and fatigue responses observed in this group.

These findings have significant implications for selecting a recovery strategy. Athletes seeking comprehensive psychological recovery may benefit most from heat-based modalities, while those primarily concerned with fatigue management may find any hydrothermal intervention beneficial. Practitioners should consider these differential effects when prescribing recovery protocols.

4.4 Individual Differences and Predictors of Response

The significant correlations between baseline psychological state and treatment response highlight the importance of individual differences in recovery strategy effectiveness. Athletes with higher initial mood disturbance and fatigue demonstrated greater improvements, suggesting that hydrothermal recovery may be particularly beneficial for psychologically stressed individuals.

This finding has practical implications for recovery prescriptions. Athletes experiencing high training stress, poor mood states, or elevated fatigue may be prime candidates for hydrothermal recovery interventions. Conversely, athletes with optimal psychological states may require different recovery approaches or may benefit less from thermal interventions.

The strong correlation between mood and fatigue changes (r=.67) suggests that these psychological domains are interconnected and may be influenced by a common underlying mechanism. This finding supports holistic approaches to psychological recovery that address multiple domains simultaneously.

4.5 Implications for Athletic Performance

The psychological improvements observed in this study have potential implications for athletic performance, though direct performance measures were not assessed. Research has consistently demonstrated relationships between mood states and athletic performance, with positive mood profiles associated with superior competitive outcomes (Selmi *et al*., 2023) [13].

The substantial reductions in negative mood states and fatigue perception observed in this study may contribute to improved training quality, enhanced performance consistency, and a reduced risk of injury. Athletes with better psychological recovery capacity may be able to tolerate higher training loads and adapt more effectively to training stimuli.

The practical significance of these findings extends beyond elite athletics to include recreational athletes, fitness enthusiasts, and individuals engaged in physically demanding activities. The accessibility and cost-effectiveness of hydrothermal recovery modalities make them viable options for diverse populations seeking psychological benefits.

4.6 Limitations and Future Directions

Several limitations should be acknowledged when interpreting these findings. The study population was limited to university-level male athletes, which may have limited its generalizability to female athletes and other populations. Additionally, the six-week intervention period may not capture long-term psychological adaptations or the sustainability of benefits.

The unexpected adverse mood effects observed in the whirlpool group require further investigation. Future research should examine dose-response relationships, individual difference moderators, and optimal intervention protocols for different populations. Investigating the neurobiological mechanisms underlying psychological recovery would enhance our understanding of optimal intervention prescription.

Long-term follow-up studies are needed to assess the durability of psychological benefits and their relationship to training adaptation and competitive performance. Additionally, research examining the integration of hydrothermal recovery with other psychological interventions may yield insights into synergistic effects.

5. Conclusion

This randomised controlled trial demonstrates that hydrothermal recovery modalities can produce significant psychological benefits in university-level athletes. However, the effects vary considerably between intervention types sauna and steam therapies provided comprehensive psychological recovery through substantial improvements in both mood states and fatigue perception. Whirlpool therapy demonstrated selective benefits for reducing fatigue, while also producing unexpected mood deterioration.

These findings have important implications for sports psychology practice and athlete care. Practitioners should consider the differential psychological effects of recovery modalities when developing individualised recovery protocols. Heat-based therapies appear to be optimal for comprehensive psychological recovery, while water-based interventions may be more suitable for fatigue-specific concerns.

The substantial effect sizes observed suggest that hydrothermal recovery represents a valuable addition to psychological recovery strategies for competitive athletes. The accessibility and cost-effectiveness of these interventions make them practical options for diverse athletic populations seeking to optimise psychological well-being and performance.

Future research should examine optimal dosing strategies, individual difference moderators, and long-term effects of hydrothermal recovery on psychological adaptation and athletic performance. Understanding the mechanisms underlying differential psychological responses will inform the development of personalized recovery protocols that maximize benefits while minimizing potential adverse effects.

The integration of physical and psychological recovery strategies represents the future of athletic care. These findings contribute to the growing body of evidence supporting holistic approaches to athlete well-being, which address both physiological and psychological needs for optimal performance and long-term athletic success.

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