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Impact of a structured recreational sports program on physiological, psychological, and lifestyle outcomes in individuals with substance use disorders: a convergent mixed- methods pilot study from the West Bank, Palestine

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Abstract

Background

Substance use disorders (SUDs) impose a complex burden of physiological deterioration, neuropsychiatric comorbidity, and social disintegration. Despite growing evidence supporting physical activity as an adjunctive rehabilitative strategy, structured recreational sports programs remain virtually unexplored in the Palestinian and broader Middle Eastern context.

Methods

A convergent mixed-methods pilot design was employed. Six adult males with narcotic SUD (mean age 40.7 ± 7.0 years) were purposively recruited from the Palestinian National Rehabilitation Center (PNRC), Bethlehem, West Bank. A four-week, multimodal recreational sports program (16 sessions; aerobic exercise, resistance training, balance activities, group interactive games, and mindfulness-based relaxation) was implemented as an adjunct to standard inpatient rehabilitation. Pre- and post-intervention fasting blood samples were analysed for hepatic enzymes, lipid profile, metabolic markers, renal function, and complete blood count. Depressive symptoms were assessed using the Beck Depression Inventory-II (BDI-II). Given the non-normally distributed small sample, the Wilcoxon Signed-Ranks Test was applied to all paired comparisons ($\alpha = 0.05$). Semi-structured interviews with participants and ten rehabilitation specialists provided qualitative data, analysed via conventional content analysis.

Results

Statistically significant reductions were observed in total cholesterol ($Z = 1.99$, $p = 0.046$; mean reduction ~ 0.90 mmol/L) and serum bilirubin ($Z = 2.20$, $p = 0.028$; mean reduction ~ 5.65 µmol/L). BDI-II scores declined markedly: all six participants (100%) attained no-depression status post-intervention. Six qualitative themes emerged: mood stabilisation, reduction in substance cravings, enhanced self-esteem and self-efficacy, improved social connectedness, improved sleep quality, and broader lifestyle restructuring.

Conclusions

A structured recreational sports program can serve as a clinically meaningful adjunct to standard inpatient addiction rehabilitation, producing early improvements in lipid metabolism, hepatic function, psychological well-being, and lifestyle organisation. These pilot findings, generated within a single-group pre-post design without a control condition, warrant confirmation through adequately powered randomised controlled trials with extended follow-up and diverse samples.

Background

Substance use disorders (SUDs) constitute one of the most pressing public health challenges of the twenty-first century, imposing substantial physiological, neuropsychiatric, and socioeconomic burdens on affected individuals and health systems worldwide [1, 2]. In the West Bank, Territory of Palestinian Authority, escalating rates of narcotic use among adults have been documented in the context of prolonged political instability and socioeconomic strain, placing considerable pressure on limited rehabilitation infrastructure [1]. Massad et al. reported alarmingly high prevalence of high-risk drug use among Palestinian males in a nationally representative cross-sectional study, underscoring the urgency of developing contextually appropriate, evidence-based treatment models [1].

Chronic narcotic use profoundly disrupts dopaminergic and serotonergic neurotransmission — circuits governing mood, motivation, reward processing, and executive function — with clinical consequences including anhedonia, impaired impulse control, emotional dysregulation, and elevated risk of major depressive disorder [3, 4]. Sustained substance use additionally produces measurable physiological harm, including dyslipidaemia, hepatic dysfunction, impaired renal regulation, and systemic oxidative stress, compounding the complexity of recovery and elevating long-term morbidity [5]. Progressive social isolation, family disintegration, and occupational marginalisation further entrench the addictive cycle [2, 3].

Standard addiction rehabilitation has historically emphasised pharmacological detoxification and psychosocial counselling [4]. An expanding body of evidence, however, demonstrates the adjunctive therapeutic value of structured physical activity. Exercise modulates monoaminergic and endocannabinoid neurotransmission, attenuates hypothalamic-pituitary-adrenal axis hyperactivity, stimulates endogenous opioid release, improves lipid metabolism, and promotes hippocampal neuroplasticity — effects that collectively support physiological recovery and psychological resilience [6, 7, 8, 9]. Group-based exercise additionally fosters social cohesion, behavioural accountability, and a sense of belonging — relational qualities severely eroded by addiction [10, 11].

Despite this evidence base, few empirical investigations have examined structured recreational sports programs within formal inpatient addiction rehabilitation facilities, and virtually none have been conducted in the Palestinian or broader Arab Middle Eastern context. Furthermore, most existing studies address physiological or psychological outcomes in isolation, rarely integrating biomarker assessment with qualitative exploration of lived experience within a single mixed-methods framework.

The present study aimed to evaluate the impact of a purpose-designed, four-week recreational sports program on selected physiological biomarkers, depressive symptom severity, and lifestyle-related behavioural outcomes in adult males with narcotic SUDs receiving inpatient rehabilitation at the PNRC, Bethlehem. By adopting a convergent mixed-methods design, the study provides both quantitative evidence and experiential depth, contributing novel insights to the literature on exercise-based adjunctive rehabilitation in resource-limited, conflict-affected settings.

Methods

Study design

This study employed a convergent mixed-methods pilot design [12], integrating quantitative pre-post assessment of physiological and psychological outcomes with qualitative phenomenological inquiry. Quantitative and qualitative data were collected concurrently and integrated at the interpretation stage using a triangulation merging protocol [13]. The term 'impact' is employed throughout as appropriate for a single-group pre-post exploratory design and does not imply causal attribution, which requires a randomised controlled design with a comparator group. This study is explicitly positioned as a pilot investigation to inform the design of future confirmatory trials. Reporting follows the Good Reporting of A Mixed Methods Study (GRAMMS) framework.

Setting

The study was conducted at the Palestinian National Rehabilitation Center (PNRC), Bethlehem, West Bank, Territory of Palestinian Authority — the principal national inpatient addiction treatment facility in the West Bank. The PNRC provides comprehensive inpatient rehabilitation integrating pharmacological management, daily psychiatric and social work consultations, nursing monitoring, and structured therapeutic activities.

Participants

Participant group (n = 6)

The eligible study population comprised all 15 male inpatients at the PNRC who were actively undergoing treatment for narcotic SUD during the data collection period (January–February 2024) and who met pre-specified eligibility criteria. Inclusion criteria: (a) confirmed narcotic SUD diagnosis per ICD-10 criteria; (b) age 30–55 years; (c) medical clearance for physical activity, confirmed by the treating physician; and (d) written informed consent. Exclusion criteria: any acute medical condition contraindicating physical exertion, severe psychiatric comorbidity requiring intensive management, or participation in a structured exercise programme within the preceding six months.

Of 15 initially eligible individuals, nine withdrew prior to programme commencement, predominantly due to early voluntary discharge — a characteristic and documented feature of the PNRC's voluntary treatment structure. The final analytical sample comprised six participants (n = 6) who completed all 16 sessions. Programme completion itself constitutes a meaningful engagement indicator: treating staff confirmed that participants in the sports programme demonstrated markedly superior treatment adherence relative to contemporaneous non-participants.

Given the exploratory pilot design, the small eligible population within a single centre, and qualitative saturation principles applicable in mixed-methods research, a final sample of n = 6 is methodologically defensible for generating preliminary insights while precluding broad statistical generalisation [12]. No a priori power calculation was conducted, as the primary aim was exploratory. Baseline demographic and clinical characteristics are presented in Table 1.

Table 1 Baseline demographic and physiological characteristics of participants (n = 6)

Characteristic	P1	P2	P3	P4	P5	P6
Age (years)	34	42	38	51	46	33
Body mass (kg)	78	85	71	90	83	68
Height (cm)	172	176	169	180	174	167
BMI (kg/m²)	26.4	27.4	24.9	27.8	27.4	24.4
Substance	Opioids	Opioids	Opioids	Opioids	Opioids	Opioids
Medical comorbidities	None	None	None	HTN*	None	None
Prior structured exercise	No	No	No	No	No	No

HTN hypertension (controlled pharmacologically); BMI body mass index. All participants reported no prior structured physical activity. Duration of narcotic use was not systematically recorded and is acknowledged as a study limitation.

Specialist group (n = 10)

Ten rehabilitation specialists employed at the PNRC — three social workers, three clinical psychologists, and four physicians — participated in qualitative interviews. All held a minimum of five years of clinical experience in addiction rehabilitation.

Intervention

The recreational sports programme was purpose-designed for this study, informed by a systematic synthesis of the literature on physical activity interventions in SUDs and comorbid psychiatric conditions [6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19]. The programme incorporated: aerobic exercise, resistance training, balance and coordination activities, cardiovascular conditioning, guided mindfulness and breathing exercises, progressive muscle relaxation, and group-based interactive activities. Group formats were deliberately included to address social isolation endemic to SUD rehabilitation.

Core design principles included: age- and health-status-appropriate activity selection; progressive overload with graduated increases in session duration and intensity; individualised modifications for

baseline fitness variation; deliberate activity variety to sustain engagement; and strict injury prevention protocols. Social interaction and cultivation of mutual accountability were embedded as explicit therapeutic objectives.

The programme was implemented over four consecutive weeks, comprising four sessions per week (16 sessions total), each lasting 40–70 minutes. Sessions comprised three phases: (1) Warm-up (10–15 min): brisk walking and dynamic stretching; (2) Main activity (25–40 min): rotating combination of aerobic exercises, resistance training, balance drills, cardiovascular conditioning, and group interactive games; (3) Cool-down (10–20 min): guided deep breathing, progressive muscle relaxation, and mindfulness-based reflection. A representative weekly plan is provided in Additional file 1 (Table A1). The programme was implemented as an adjunct to — not a replacement for — the PNRC's standard inpatient protocol (pharmacological management, nursing assessment, psychiatric consultations, and social work).

Data collection

Physiological measures

Pre- and post-intervention fasting venous blood samples were collected by qualified clinical laboratory personnel under standardised conditions. Analyses included: hepatic function (alanine aminotransferase [ALT], aspartate aminotransferase [AST], serum bilirubin); lipid profile (total cholesterol [TC], triglycerides [TG]); metabolic markers (fasting plasma glucose, serum uric acid); renal function (serum creatinine, blood urea); and complete blood count (white blood cells [WBC], red blood cells [RBC], haemoglobin [HGB], platelets [PLT], lymphocytes, monocytes, granulocytes). Blood pressure was recorded at both time points using a calibrated aneroid sphygmomanometer. All values are reported in SI units.

Psychological measure

Depressive symptom severity was assessed using the Beck Depression Inventory-II (BDI-II) [20], a validated 21-item self-report instrument with established psychometric adequacy across clinical and cultural populations. The BDI-II assesses the severity of cognitive, affective, and somatic depressive symptoms over the preceding two weeks. Scores are classified as: 0–13 (minimal/no depression), 14–19 (mild), 20–28 (moderate), and ≥ 29 (severe). The BDI-II is a symptom severity monitoring tool, not a diagnostic instrument.

Qualitative data collection

Semi-structured interviews were conducted individually with each participant before and after the intervention to explore subjective experiences, perceived benefits, challenges, and recovery attitudes.

Separate semi-structured interviews were conducted with all ten treating specialists to elicit professional observations of participants' behavioural, motivational, and clinical changes. All interviews were audio-recorded with prior informed consent and transcribed verbatim in Arabic, then translated to English by a bilingual researcher. Interview guides were piloted with one specialist not included in the analytical sample.

Data analysis

Quantitative analysis

Data were analysed using IBM SPSS Statistics version 25. Descriptive statistics (mean ± standard deviation [SD]) were computed for all continuous variables. Given the small sample size (n = 6) and inability to robustly verify normality assumptions, the non-parametric Wilcoxon Signed-Ranks Test was applied to all paired pre-post comparisons — an approach more appropriate than the paired t-test when sample sizes fall below 30 [21]. Statistical significance was set at $\alpha = 0.05$ (two-tailed). Individual participant data are presented alongside group-level statistics to enable assessment of response heterogeneity.

Qualitative analysis

Interview transcripts were analysed using conventional (inductive) content analysis [22], an approach appropriate for exploratory health research in which a priori theoretical frameworks are withheld to allow themes to emerge directly from the data. Analysis proceeded through four stages: (1) repeated reading and immersion; (2) identification of meaning units and open coding; (3) grouping into categories and higher-order themes; and (4) interpretive synthesis of shared experiential patterns. Rigour was ensured through investigator triangulation (two researchers independently coded all transcripts, with disagreements resolved by consensus) and member checking (key preliminary findings were shared with participants for confirmatory feedback).

Mixed-methods integration

Quantitative and qualitative data were integrated at the interpretation stage following a merging triangulation approach [13]. Statistical findings guided the selection of qualitative themes for deeper exploration, while qualitative narratives contextualised and mechanistically elaborated observed patterns in the quantitative data.

Results

Physiological outcomes

Group-level descriptive and inferential statistics

Table 2 presents pre- and post-intervention group means (± SD) and Wilcoxon Signed-Ranks Test results for all physiological variables. Of 16 variables examined, two achieved statistical significance: TC and serum bilirubin.

Table 2 Group-level pre- and post-intervention physiological measurements (n = 6), Wilcoxon Signed-Ranks Test

Measure (units)	Pre-test Mean ± SD	Post-test Mean ± SD	Z	p-value
ALT (U/L)	25.18 ± 14.85	26.10 ± 17.18	0.11	0.917
AST (U/L)	16.25 ± 8.00	16.85 ± 6.05	0.31	0.753
Total cholesterol (mmol/L)	5.63 ± 1.21	4.73 ± 0.85	1.99	**0.046***
Fasting glucose (mmol/L)	5.16 ± 1.06	6.17 ± 1.12	1.78	0.075
Serum bilirubin (μmol/L)	11.46 ± 3.08	5.81 ± 1.88	2.20	**0.028***
Triglycerides (mmol/L)	2.18 ± 1.13	1.65 ± 0.56	1.36	0.173
Uric acid (μmol/L)	296 ± 58	309 ± 60	1.15	0.249
Creatinine (μmol/L)	91.9 ± 14.1	95.4 ± 15.9	0.31	0.753
Blood urea (mmol/L)	4.57 ± 0.70	4.83 ± 0.61	1.15	0.249
WBC ($\times 10^9$/L)	9.70 ± 1.35	9.55 ± 2.64	0.52	0.600
RBC ($\times 10^{12}$/L)	5.10 ± 0.56	5.57 ± 1.61	0.31	0.753
Haemoglobin (g/L)	156.5 ± 8.8	153.2 ± 9.1	1.26	0.207
Platelets ($\times 10^9$/L)	290 ± 54	261 ± 119	1.15	0.249
Lymphocytes (%)	37.83 ± 7.11	36.00 ± 6.29	0.63	0.528
Monocytes (%)	3.83 ± 0.75	4.00 ± 1.10	0.38	0.705
Granulocytes (%)	58.33 ± 7.81	60.00 ± 7.16	0.53	0.596

**p < 0.05 (Wilcoxon Signed-Ranks Test, two-tailed). SI unit conversions: TC from mg/dL ÷ 38.67; bilirubin from mg/dL × 17.1; creatinine from mg/dL × 88.4; urea from mg/dL × 0.357; glucose from mg/dL × 0.0555. ALT alanine aminotransferase; AST aspartate aminotransferase; WBC white blood cells; RBC red blood cells.*

Individual participant data for statistically significant variables

Table 3 presents individual pre- and post-intervention values for TC and serum bilirubin — the two statistically significant variables. For TC, reductions were observed in five of six participants (P2–P6),

with P1 showing negligible change (pre: 4.71; post: 4.73 mmol/L). P2, with the highest baseline TC (7.48 mmol/L), demonstrated the largest absolute reduction (−3.26 mmol/L). This pattern — most pronounced improvement in participants with highest baseline values — is consistent with the dose-response relationship documented in exercise-lipid research and argues against an outlier-driven group result. For serum bilirubin, reductions were distributed across five of six participants, with the largest improvements in P4 and P6 (−10.26 and −11.62 μmol/L, respectively), who also had the highest baseline values.

Table 3 Individual participant pre- and post-intervention values for total cholesterol (mmol/L) and serum bilirubin (μmol/L)

Participant	TC pre (mmol/L)	TC post (mmol/L)	TC Δ	Bilirubin pre (μmol/L)	Bilirubin post (μmol/L)	Bilirubin Δ
P1	4.71	4.73	−0.02	8.72	5.64	−3.08
P2	7.48	4.22	−3.26	9.41	9.23	−0.18
P3	6.34	6.03	−0.31	9.41	5.30	−4.11
P4	4.86	4.37	−0.49	14.54	4.28	−10.26
P5	6.08	5.35	−0.73	10.43	5.64	−4.79
P6	4.29	3.67	−0.62	15.90	4.28	−11.62

Δ = post minus pre (negative values indicate reduction). TC total cholesterol.

Psychological outcomes: depressive symptoms (BDI-II)

Table 4 presents individual BDI-II scores and severity classifications pre- and post-intervention. Prior to the programme, four participants met criteria for moderate depression (P1, P3, P5, P6), one for severe depression (P2), and one was in the no-depression range (P4). Post-intervention, all six participants (100%) attained scores in the no-depression category. P2, with the highest pre-test score (37), achieved the largest improvement (Δ = −28). These changes represent self-reported symptomatic improvement within the context of a concurrent multimodal rehabilitation programme and cannot be attributed exclusively to the exercise component.

Table 4 Individual BDI-II scores and depression severity classifications, pre- and post-intervention

Part.	Pre score	Pre classification	Post score	Post classification	Δ score
P1	28	Moderate depression	2	No depression	−26
P2	37	Severe depression	9	No depression	−28
P3	19	Mild depression	0	No depression	−19
P4	8	No depression	2	No depression	−6
P5	23	Moderate depression	1	No depression	−22
P6	20	Moderate depression	11	No depression	−9

Δ = post minus pre (negative values indicate improvement). BDI-II Beck Depression Inventory-II. Classification thresholds: 0–13 = no/minimal depression; 14–19 = mild; 20–28 = moderate; ≥ 29 = severe.

Qualitative results: participant and specialist interviews

Six themes emerged from inductive content analysis of participant and specialist interviews.

Theme 1: mood stabilisation and emotional regulation

All participants reported marked improvements in mood and emotional regulation during the programme. Participant 3 described: "Before I started the programme, I was always feeling low, but after a few weeks, I began to feel more energetic. The combination of physical activity and social interaction has made a huge difference in how I feel every day." Participant 4 noted: "There is a noticeable shift in my mood. I feel more upbeat and positive about my life." Treating specialists corroborated these observations, reporting reduced behavioural agitation and greater emotional stability in programme participants relative to non-participants.

Theme 2: reduction in substance cravings

Participants consistently reported reduced substance cravings and diminished preoccupation with drug-seeking ideation. Participant 5 stated: "Before the programme, I could not stop thinking about using. Now, when I exercise, I do not crave it as much. It is like the exercise fills the void that I used to fill with substances." This aligns mechanistically with evidence that aerobic exercise activates mesolimbic reward circuitry and attenuates the salience of substance-related cues [6].

Theme 3: enhanced self-esteem and self-efficacy

Participants consistently reported gains in self-confidence and perceived competence. Participant 2 reflected: "I feel much better about myself. The programme has made me feel more capable and

confident. I have started seeing positive change in my life." Specialists observed that programme participants increasingly volunteered for responsibilities within the centre and demonstrated greater initiative in therapeutic activities.

Theme 4: improved social connectedness

Social isolation is a well-characterised feature of active and recovering SUD. The group-based exercise format directly challenged this pattern. Participant 6 noted: "I used to isolate myself, but now I feel much more connected with others. The group exercises helped me interact with people in a way I had not before." Participant 1 added: "The programme made me realise how important it is to have others around you, especially during recovery."

Theme 5: improved sleep quality and daily routine

Multiple participants and all ten specialists reported improvements in sleep quality and regularity of daily routines. Participants described improved sleep onset, fewer nocturnal disturbances, and enhanced daytime alertness. Specialists noted that improved sleep correlated with more productive morning engagement in therapeutic sessions.

Theme 6: enhanced treatment adherence and motivational engagement

All ten specialists unanimously reported substantially higher treatment adherence and motivational engagement in programme participants compared to non-participating contemporaneous patients. Specialists attributed this to the structured routine, social rewards, and experiential reinforcement generated by the exercise programme.

Lifestyle-related outcomes

Qualitative data revealed substantial restructuring of participants' daily living patterns, extending beyond discrete psychological or physiological changes. Participants described a transition from unstructured, sedentary, socially withdrawn routines to organised, purposive, and socially engaged behavioural patterns. Participant 2 summarised: "This programme gave me a structure for my day. Before, I did not know what to do with myself. Now I look forward to the sessions and I feel like I have a purpose." Specialists observed reduced sleep medication reliance, improved appetite regulation, decreased substance-seeking ideation, and greater willingness to engage in leisure activities — consistent with the theoretical construct of embodied capital in recovery [23].

Discussion

Summary and principal findings

This pilot study provides preliminary evidence that a structured, purpose-designed recreational sports programme, implemented as an adjunct to standard inpatient addiction rehabilitation, yields early clinically meaningful improvements across physiological, psychological, and lifestyle domains in adult males with narcotic SUDs in the West Bank, Palestine. The convergence of significant biomarker findings with consistent qualitative evidence of psychological and behavioural benefit supports a biologically and psychologically coherent narrative: structured physical activity, when introduced early within a comprehensive rehabilitation context, initiates metabolic and neurochemical adaptations experienced subjectively as improved mood, motivation, and social connection, which in turn reinforce treatment adherence.

Physiological outcomes

The statistically significant reduction in TC over four weeks (mean group reduction: ~0.90 mmol/L) is consistent with established evidence that even short-duration aerobic exercise programmes can initiate favourable lipid modification in previously sedentary individuals. Kodama et al., in a meta-analysis of 25 randomised trials, confirmed that aerobic exercise alone produces significant increases in high-density lipoprotein cholesterol independently of dietary change [27]. Yalın et al. similarly documented significant TC and triglyceride reductions in sedentary subjects following a four-week structured programme [26]. The exercise-lipid response observed here is biologically plausible given that all participants were physically inactive prior to enrolment — a status associated with heightened lipid responsiveness to initial exercise exposure. Individual data demonstrate that the group-level result reflects broadly distributed reductions most pronounced in participants with the highest baseline TC, consistent with regression-to-the-mean effects well-documented in exercise-lipid research.

The significant reduction in serum bilirubin has plausible mechanistic underpinnings: hepatic bilirubin metabolism is modulated by splanchnic blood flow and hepatocellular transport capacity, both of which respond positively to regular aerobic exercise. Exercise-induced reductions in systemic oxidative stress may additionally enhance hepatic conjugation efficiency [24]. The pronounced reductions in participants with highest baseline values reinforce the interpretation of a genuine hepato-physiological effect [24].

The absence of significant changes in hepatic enzymes (ALT, AST) and renal function markers should not be interpreted as evidence of intervention failure. These biomarkers reflect longer-latency structural adaptations: hepatocellular enzyme normalisation typically requires sustained exercise over weeks to months [24], and renal function adaptations similarly unfold over extended timeframes [25]. The four-week window was sufficient for sensitive early metabolic markers but insufficient for longer-latency variables. Future studies employing 8–12 week programmes with post-intervention follow-up are needed.

The non-significant elevation in fasting glucose (pre: 5.16 to post: 6.17 mmol/L; p = 0.075) warrants cautious attention. Potential explanations include dietary changes within the inpatient setting, individual pharmacological effects on glucose metabolism, or within-person biological variability. This variable should be prospectively monitored in future studies with dietary control. All observed physiological changes must be interpreted within the context of concurrent pharmacological and psychosocial treatment at the PNRC; they reflect the additive contribution of the sports adjunct within a multimodal rehabilitative environment.

Psychological outcomes

The magnitude of BDI-II score reductions — all six participants (100%) attaining no-depression status at post-test — warrants careful interpretation. Several converging mechanisms can account for the rapidity and scale of early symptomatic improvement. First, the transition from isolation and inactivity to structured daily group-based physical activity constitutes a powerful environmental and behavioural change independently of any direct neurobiological effect. Suterwala et al. established that subjective affective responses to a single exercise session predict subsequent treatment response in depression [28], indicating that early psychological benefits emerge rapidly. Second, neurobiological mechanisms through which exercise exerts antidepressant effects — enhanced monoaminergic neurotransmission, increased brain-derived neurotrophic factor expression, and hippocampal neurogenesis [29, 30] — may be potentiated in the SUD context where pre-intervention neurochemical depletion is pronounced. Third, for individuals recovering from SUDs, the experience of physical accomplishment and group belonging may rapidly restore personal agency severely eroded by addiction. Fourth, concurrent pharmacological and psychosocial support within the PNRC reinforced these gains. BDI-II reductions represent early self-reported symptomatic change and should not be construed as clinical remission.

Comparison with existing literature

The present findings are broadly consistent with the international literature while extending it into a context — Palestinian inpatient addiction rehabilitation — almost entirely absent from prior empirical work. Wang et al., in a meta-analysis of 22 studies, confirmed that physical exercise produces significant improvements in lipid profiles and psychological well-being among individuals with SUDs [5]. Roessler reported improvements in mood and drug use following an exercise programme for individuals with drug abuse in a Danish pilot study [25] — a directly comparable design without a control group. The convergent mixed-methods design of the present study, integrating multi-domain biomarker assessment with validated psychological measurement and qualitative phenomenological inquiry, constitutes a methodological advance distinguishing it from most comparable regional work, which has relied predominantly on descriptive or survey methods [24, 25].

Lifestyle impact and embodied capital

A distinctive feature of this study is its explicit operationalisation of lifestyle change as an outcome domain. Qualitative data revealed substantial restructuring of daily living patterns encompassing improved sleep hygiene, reduced substance-seeking ideation, enhanced self-regulatory capacity, and greater social participation. These changes map directly onto Fitzgerald's [23] conceptual framework of 'embodied capital' — the accumulation of health-promoting behaviours and self-identities that reduce vulnerability to relapse — and underscore the importance of retaining lifestyle as a rigorously measured outcome in future research.

Strengths and limitations

This study possesses several strengths. It represents, to the authors' knowledge, one of the first mixed-methods investigations of a recreational sports programme within addiction rehabilitation in the Palestinian context. The integration of multi-domain biomarker assessment, a validated psychological instrument, and inductive qualitative inquiry achieves a degree of evaluative comprehensiveness rarely attained in comparable studies. The programme is low-cost, contextually accessible, and replicable in similarly resource-constrained settings.

Limitations must be transparently acknowledged. The small final sample (n = 6) substantially restricts statistical power and precludes generalisation. The absence of a concurrent control group means that observed changes cannot be unequivocally attributed to the exercise programme; concurrent standard rehabilitation care likely contributed to improvements, and these effects cannot be statistically disaggregated. Medication details were not systematically recorded, representing an important confounding variable. The four-week intervention was insufficient for evaluating longer-latency physiological adaptations. The exclusively male sample restricts applicability to women and gender-diverse populations. Duration of narcotic use was not documented. No follow-up assessments were conducted. Qualitative themes may be subject to social desirability response bias in the rehabilitation context. The voluntary treatment structure of the PNRC introduced substantial attrition constraining the final sample size.

Clinical and policy implications

As a pilot study, these findings carry tentative practical implications requiring confirmation through larger controlled research. The positive trends observed — early symptomatic improvement in depression, favourable lipid response, and consistent qualitative evidence of behavioural benefit — provide a preliminary rationale for Palestinian rehabilitation centres to pilot and formally evaluate exercise-based adjunctive programmes. These findings are directionally aligned with the World Health Organization's Global Action Plan on Physical Activity 2018–2030, which advocates integrating physical activity into mental health and addiction recovery systems. Confirmation through future controlled trials would provide a stronger evidence base for investment in exercise infrastructure, trained exercise physiologists

within rehabilitation teams, and intersectoral partnerships between health ministries and sports organisations.

Future research

Future studies should employ: (1) randomised controlled designs with parallel control groups receiving standard care alone, and sample sizes determined by a priori power calculations; (2) extended intervention periods of 8–12 weeks with follow-up at 3, 6, and 12 months; (3) inclusion of female participants and individuals with diverse substance use profiles; (4) neurobiological outcome measures including brain-derived neurotrophic factor and cortisol; (5) systematic prospective documentation of concurrent pharmacological treatment as a covariate; (6) objective physical fitness assessments (e.g., maximum oxygen uptake); and (7) exploration of community-based and digital delivery models to extend programme access.

Conclusions

This exploratory pilot study provides preliminary evidence that a structured recreational sports programme, implemented as an adjunct to standard inpatient addiction rehabilitation, can yield early, clinically relevant improvements in lipid metabolism, hepatic bilirubin handling, depressive symptom severity, and lifestyle organisation in adult males with narcotic SUDs in the West Bank, Palestine. These findings are appropriately contextualised within the inherent constraints of a small, single-group, non-randomised design. They provide a biologically and psychologically plausible, convergent mixed-methods foundation to justify and guide the design of larger, adequately powered randomised controlled trials. If replicated at scale, these findings could support the recognition of structured exercise as an evidence-based component of addiction rehabilitation in Palestinian and comparable regional health systems — a cost-accessible intervention with meaningful public health potential.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki (World Medical Association, 2013). Ethical approval was obtained from the Palestinian Ministry of Health, the primary national ethics oversight authority for clinical research in Palestinian health and rehabilitation facilities, in the absence of a separate centralised institutional review board (Approval No: M.T, 101,101). Written informed consent was obtained from all participants prior to enrolment, including explicit consent for publication of de-identified data. Participants were informed of their unconditional right to withdraw without consequence to their ongoing treatment.

Consent for publication

Written consent for publication of anonymised data and interview excerpts was obtained from all participants.

Availability of data and materials

The datasets generated and analysed during the current study are not publicly available due to participant privacy protections and ethical restrictions, but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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This research received no external funding.

Authors' contributions

NA and RM led the design and implementation of the recreational sports programme, conducted primary fieldwork, and directed qualitative data collection. RA and TR contributed to research design, participant assessment, and manuscript drafting. MK supervised the overall project, contributed to methodological design and quantitative analysis, and served as corresponding author. IT contributed to data analysis, statistical interpretation, and manuscript revision. All authors read and approved the final manuscript.

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