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Running improves mental health symptoms and pain catastrophising in adults with chronic low back pain: a secondary analysis of the ASTEROID randomised controlled trial

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ABSTRACT

Objectives: This pre-planned secondary analysis examined the effects of a running intervention on mental health symptoms and pain catastrophising in adults with chronic low back pain.
Design: Two-arm parallel individual randomised (1:1) controlled trial.
Methods: This study randomised 40 adults (mean [standard deviation] age: 33 [6] years, female: 50 %) with non-specific chronic low back pain to a 12-week running (progressive run–walk interval exercise training) intervention (n = 20) or waitlist control (n = 20). Outcomes were mental health symptoms (21-item Depression, Anxiety, and Stress Scale) and pain catastrophising (Pain Catastrophising Scale). Data were collected at baseline, six, and 12 weeks post-baseline. Separate linear mixed models with random effects (participants) evaluated within- and between-group changes.
Results: At 12 weeks post-baseline, running improved overall mental health symptoms (estimated marginal mean net difference [95 % confidence interval] points: −4.35 [−7.73, −0.97], P = 0.012), depression symptoms (−1.75 [−3.42, −0.08], P = 0.040), stress symptoms (−1.65 [−3.01, −0.29], P = 0.017), and pain catastrophising (−7.85 [−11.98, −3.72], P < 0.001), yet not anxiety symptoms (−0.95 [−2.16, 0.26], P = 0.122), compared with control.
Conclusions: Running improved mental health symptoms and pain catastrophising among adults with non-specific chronic low back pain when compared to waitlist control. Differences in pain catastrophising, yet not mental health symptoms, were clinically meaningful. Running appears to be an efficacious treatment for psychological comorbidities common among adults with non-specific chronic low back pain.

Practical implications

- Running improves overall mental health symptoms in adults with chronic low back pain.
- Running improves depression symptoms in adults with chronic low back pain.
- Running improves stress symptoms in adults with chronic low back pain.
- Running improves pain catastrophising in adults with chronic low back pain.

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1. Introduction

Low back pain (LBP) is a leading cause of age-standardised disability, affecting >568.4 million people globally[1] with associated annual healthcare costs of US$134.5 billion in the United States of America[2] and A$4.8 billion in Australia.[3] Whilst many factors contribute to LBP, a multivariate meta-analysis of 33 studies revealed psychosocial factors had greater relative contributions than structural or functional nervous system factors.[4] Another meta-analysis of 20 studies (10,842 patients with LBP) showed psychiatric comorbidities and pain catastrophising were associated with a greater likelihood of worse disability outcomes at one-year follow-up (likelihood ratio [95 % CI]: 2.2 [1.9, 2.3] and 2.5 [2.2, 2.8], respectively).[5] Therefore, identifying strategies to address these comorbid factors among this susceptible population group is critical.

Exercise-based therapies are an effective treatment option for chronic LBP, given moderate efficacy, low injury risk, and low financial cost.[6] A systematic review and network meta-analysis of 89 randomised controlled trials showed aerobic exercise training improved mental health symptoms among adults with non-specific chronic LBP.[7] However, only three studies[8–10] have specifically explored the effect of running in individuals with chronic LBP. A pilot randomised controlled trial of 20 adults with non-specific chronic LBP (mean [SD] age: 42 [13] years) showed 12 weeks of treadmill running for 30–50 min, three times per week led to greater improvements in mental health symptoms (Hospital Anxiety and Depression Scale) compared to electrotherapy, with a within-group reduction of 8.6 points.[9] Notably, between-group analyses were not conducted. The same authors then conducted a non-randomised trial that implemented the same running intervention in 64 adults with non-specific chronic LBP, sub-grouped as having either high- or low-adrenocortical responsiveness (mean [SD] age: 41 [11] and 39 [9] years, respectively).[10] Running was associated with within-group improvements in mental health symptoms (Hospital Anxiety and Depression Scale) of 6.2 and 1.7 points in the high and low response groups, respectively. A greater between-group improvement for participants with high-adrenocortical responsiveness is likely due to the higher levels of depression and anxiety at baseline within this group, suggesting a running intervention may be more beneficial for improving symptoms in individuals with greater mental ill-health. Finally, a randomised controlled trial of 320 retired athletes (mean [SD] age: 38 [5] years) showed no difference in pain intensity between those who engaged in six months of running and a non-exercise control group[8]; however, mental health symptoms were not measured.

The current evidence suggests that running may improve mental health symptoms in adults with chronic LBP[9,10]; however, non-randomised designs in previous trials limit confidence in these findings. Additionally, these studies only reported total scores from the Hospital Anxiety and Depression Scale, and it is therefore difficult to differentiate between subscales of mental health symptoms (i.e. depression, anxiety, and stress). Finally, no studies have explored the impact of running on pain catastrophising, a known treatment confounder in individuals with chronic LBP.[11] Therefore, the current study aimed to assess the effects of running on mental health symptoms (overall, depression, anxiety, and stress) and pain catastrophising in adults with chronic LBP compared to waitlist control.

2. Materials and methods

2.1. Trial design

This pre-planned secondary analysis of a 12-week two-arm parallel individually randomised (1:1) controlled trial examined the effects of a running (progressive run–walk interval exercise training) intervention on mental health symptoms and pain catastrophising compared to waitlist control in adults with non-specific chronic LBP (n = 40).[12] The full study protocol is described in detail elsewhere.[13] This study received ethics approval from the Deakin University Human Research Ethics Committee (ID: 2022-162) on 26 September 2022, was prospectively registered with the Australian New Zealand Clinical Trials Registry (ACTRN12622001276741) on 29 September 2022, and is reported per the CONSORT 2010 Statement as recommended at the time of manuscript preparation (Supplement A).[14]

2.2. Participants

Forty adults aged 18–45 years with non-specific chronic LBP (pain located between the costal margin and above the inferior gluteal folds, with or without leg pain, that is experienced on most days for ≥12 weeks and not attributable to a specific pathology) were recruited via online advertising. Potential participants were screened via phone to assess eligibility. Exclusion criteria relevant to the current study were: (a) the inability to communicate in English, (b) pregnancy, lactating or less than 1-year postpartum, (c) current or prior elite athlete (e.g. member of Australian Institute of Sport, state institutes or academies of sport, or the national squad of any sport), (d) any absolute contraindications for exercise training, (e) participation in running or sport that involves running in the last three months (>1 session per month), and (f) inability to access a smartphone with a cellular internet connection.

2.3. Interventions

2.3.1. Running

Participants randomised to the intervention completed a 12-week run–walk interval exercise training programme consisting of three 20–30-minute weekly sessions detailed elsewhere.[13] In brief, participants completed the intervention in their local community with run data captured via Runkeeper (v14.7, ASICS Runner App, Boston, United States of America) and an online questionnaire (REDCap, Nashville, United States of America).[15,16] In consultation with an Accredited Exercise Physiologist from the research team, participants started with 15–45 s of running, interspersed by 115–120 s of walking, and repeated these run–walk intervals between 6 and 10 times. Once participants completed the upper repeat range in any given week (ten repeats), they progressed to the next stage of the interval training programme, with each successive running interval increasing by 15 s. Participants met for 15 min weekly (weeks 1–4) and then fortnightly (weeks 6–12) via secure video consultation (Zoom Video Communications, California, United States of America) with a member of the study team to discuss the exercise training programme. Throughout the intervention, participants also received educational content via email regarding ideal running speed, footwear selection, the safety of running, and dealing with setbacks. It was recommended that participants complete training sessions on a flat track without large hills and avoid treadmills, yet no other restrictions were provided regarding training surface (e.g. dirt, grass, or paved).

2.3.2. Waitlist control

Participants randomised to control were asked to manage their LBP as usual (e.g. general practitioner management, over-the-counter pharmacotherapy) and avoid commencing a running programme. Otherwise, no restrictions on physical activity were imposed. Following completion of the study, waitlist participants were offered the same exercise training programme and 1-on-1 consultation with an Accredited Exercise Physiologist as per the intervention group.

2.4. Outcomes

All outcomes were measured at baseline, six weeks post-baseline, and 12 weeks post-baseline via an online questionnaire.

2.4.1. Mental health symptoms

Overall, stress, anxiety, and depression symptoms were measured using the 21-item Depression, Anxiety, and Stress Scale (DASS-21).[17] Responses were measured on four-point Likert scales where zero indicated 'never' and three indicated 'almost always'. Higher scores represented worse mental health symptoms. Scores ranged from 0 to 63 points for overall mental health symptoms and 0–21 points for subscales (depression, anxiety, and stress symptoms). The DASS-21 has good to excellent test–retest reliability (ICC = 0.82–0.90).[17]

2.4.2. Pain catastrophising

Pain catastrophising was measured using the 13-item Pain Catastrophising Scale (PCS).[18] Responses were measured on a five-point Likert scale, where zero indicated 'not at all' and four indicated 'all the time'. Higher scores represent worse pain catastrophising. The PCS has good to excellent test–retest reliability (ICC = 0.80–0.93).[18]

2.4.3. Other outcomes

As reported in detail elsewhere,[13] the 101-point visual analogue scale measured average LBP intensity over the last seven days, the 10-item Oswestry Disability Index measured disability due to LBP, and adherence (overall training session adherence and within-session training load completed) was documented throughout the study by members of the research team. Adverse events were defined as any untoward medical occurrence, such as increased pain or injury that resulted in a missed training session, and were classified as study-related if they were deemed definitely, probably or possibly related to the exercise training intervention.

2.5. Sample size

The sample size of 40 participants (n = 20 per group) was based on a priori power calculations to detect the smallest effect size of interest between the intervention and control for each primary outcome (pain intensity, disability, and intervertebral disc T2) detailed elsewhere.[13]

2.6. Randomisation

Participants were randomly assigned to the intervention or waitlist control (1:1) using block randomisation with random block lengths (2–6 per block) and stratification for sex using the 'blockrand' package in R (v4.1.2, The R Foundation, Vienna, Austria). An author (SDT) with no participant contact created and employed the randomisation schedule using sequentially numbered, opaque, sealed envelopes.

2.7. Blinding

Given the nature of the intervention, neither participants nor team members administering the intervention were blinded to treatment allocation. Given that the primary outcomes of interest were subjective, the participant was considered the assessor; therefore, it was also not possible to blind the outcome assessor in the current study.[19]

2.8. Statistical methods

All analyses were conducted using Stata (v17, StataCorp, College Station, United States of America). Separate linear mixed models with random effects (participants) were used to evaluate within- and between-group changes in mental health symptoms and pain catastrophising over time. Linear mixed models adopted an intention-to-treat approach and employed restricted maximum likelihood estimations to account for any missing data (i.e. no missing data were imputed). An α of 0.05 was adopted for all analyses.

3. Results

3.1. Participant flow

Collectively, 155 potential participants were screened for eligibility and 40 participants were randomised to the intervention or waitlist control (Fig. 1). No participants withdrew from the study.

3.2. Recruitment

This study was conducted from December 2022 to May 2023. The trial ended when all recruited participants finished the 12-week intervention period.

3.3. Baseline data

Participant characteristics at baseline are presented in Table 1. As reported elsewhere,[12] total sample mean (SD) age was 32.8 (6.2) years, average LBP intensity over the last seven days was 39.7 (21.1) points, and disability from LBP was 20.0 (9.1) points.

3.4. Numbers analysed

All 40 participants were analysed per the intention-to-treat approach. One participant did not comply with all data collection requirements, and data were missing at six weeks post-baseline.

3.5. Outcomes and estimation

Adherence and pain intensity outcomes are reported in detail elsewhere.[12] In brief, mean (SD) training session adherence was 70.4 % (20.4 %), running speed was 9.5 (1.8) km/h, and running distance was 2.0 (1.2) km per session. From baseline to 12 weeks post-baseline, running improved LBP intensity over the last seven days (−15.30 [−25.33, −5.27] points, P = 0.003).

Within- and between-group changes in mental health symptoms and pain catastrophising are shown in Table 2. From baseline to 12 weeks post-baseline, running improved overall mental health symptoms (estimated marginal mean net difference [95 % CI] points: −4.35 [−7.73, −0.97], P = 0.012), depression symptoms (−1.75 [−3.42, −0.08], P = 0.040), stress symptoms (−1.65 [−3.01, −0.29], P = 0.017), and pain catastrophising (−7.85 [−11.98, −3.72], P < 0.001), yet not anxiety symptoms (−0.95 [−2.16, 0.26], P = 0.122), when compared to waitlist control. Running, yet not waitlist control, was associated with within-group improvements in overall mental health symptoms (estimated marginal mean change [95 % CI] points: −2.65 [−5.04, −0.26], P = 0.030), depression symptoms (−1.20 [−2.38, −0.02], P = 0.047), stress symptoms (−1.30 [−2.26, −0.34], P = 0.008), and pain catastrophising (−5.75 [−8.67, −2.83], P < 0.001). Moreover, running led to between-group improvements in pain catastrophising from baseline to six weeks post-baseline (estimated marginal mean net difference [95 % CI] points: −4.49 [−8.66, −0.33]).

3.6. Harms

As reported in detail elsewhere,[12] nine study-related adverse events were observed in the intervention group: seven lower limb injuries (calf and knee), one cardiac syncope associated with an underlying condition, and one exacerbation of low back pain.

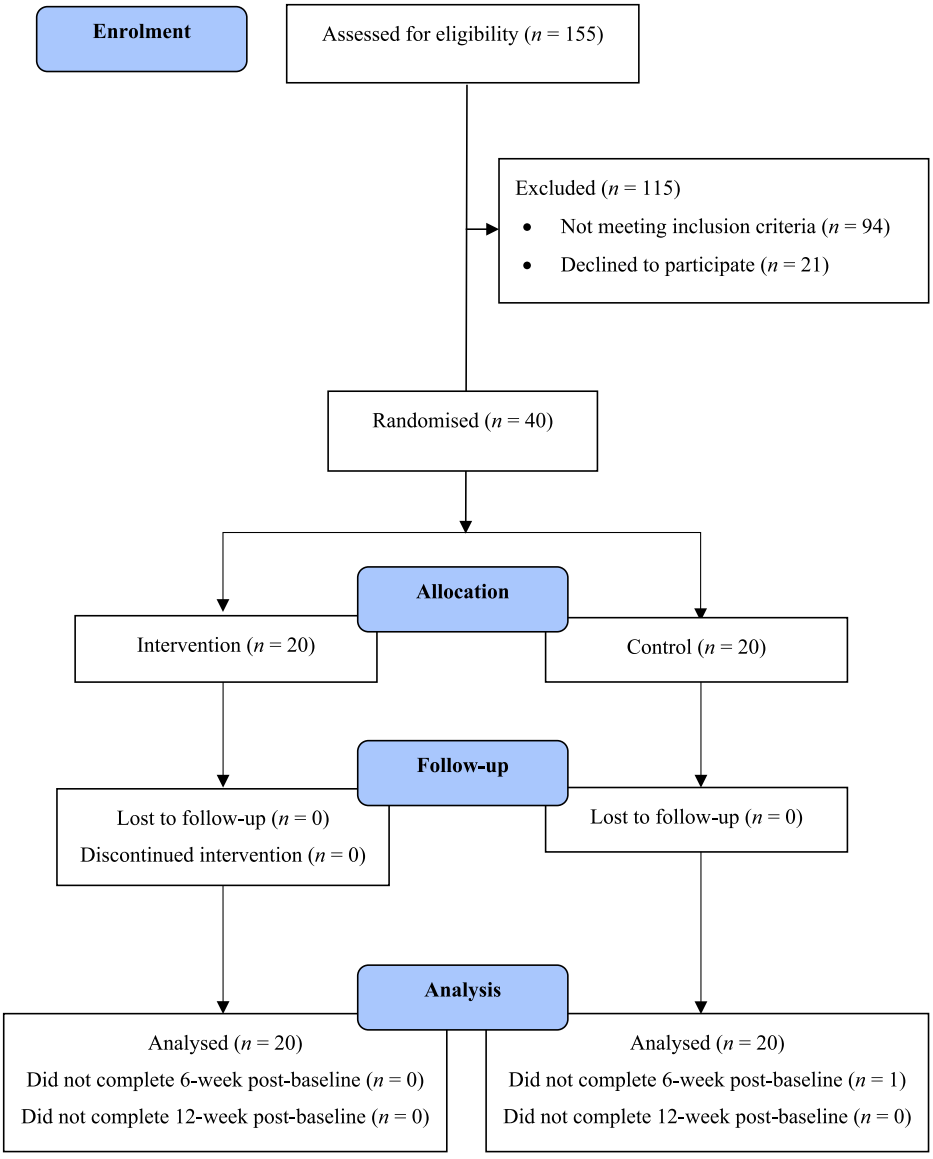

Fig. 1. Protocol per CONSORT diagram guidelines.

4. Discussion

The current study showed that a 12-week running (progressive run–walk interval exercise training) intervention improved overall mental health symptoms, depression symptoms, stress symptoms, and pain catastrophising among adults with non-specific chronic LBP when compared to waitlist control. Notably, reductions in pain catastrophising were detected as early as six weeks post-baseline. No within- or between-group changes were detected for anxiety symptoms.

Table 1
Descriptive characteristics of participants at baseline.

	Intervention (n = 20)	Control (n = 20)
Age, years	33.55 (5.31)	32.15 (6.96)
Female, n (%)	10 (50)	10 (50)
Overall mental health symptoms, points	11.30 (7.03)	16.15 (10.75)
Depression symptoms, points	3.70 (3.37)	5.70 (4.71)
Anxiety symptoms, points	2.05 (2.28)	3.15 (3.22)
Stress symptoms, points	5.55 (3.12)	7.30 (3.76)
Pain catastrophising, points	12.75 (10.75)	12.90 (8.29)

Data are mean (SD) or count (percentage within-group). Potential scores ranged from 0 to 63 points for overall mental health symptoms, 0 to 21 points for subscales (depression, anxiety, and stress symptoms), and 0 to 52 points for pain catastrophising.

Our study demonstrated running can yield a range of psychological benefits among adults with non-specific chronic LBP. Our findings align with a network meta-analysis of randomised controlled trials that showed exercise training, in general, improved mental health symptoms among adults with chronic LBP.[7] Comparison to the only other non-pilot study that examined running in adults with non-specific chronic LBP is difficult due to the use of the Hospital Anxiety and Depression Scale which assesses composite anxiety and depression symptoms.[10] Additionally, the previous study was non-randomised and lacked a non-treatment control.[10] Given we observed a reduction in depression symptoms, yet not anxiety symptoms, it may be plausible that the reductions in composite anxiety and depression symptoms observed in the prior study[10] were driven by improvements in depression symptoms. Mechanistically, exercise training leads to the release of neurohormonal factors, which can elevate mood and alleviate depression symptoms.[20] However, these effects may not be as impactful for reducing the physiological hyperarousal or cognitive patterns associated with anxiety.[20]

Table 2
Changes in mental health symptoms and pain catastrophising over time.

	Intervention (n = 20)			Control (n = 20)			Group-by-time	
	Mean (SE)	Δ mean (95 % CI)	p	Mean (SE)	Δ mean (95 % CI)	P	β (95 % CI)	P
Overall mental health symptoms, points								
Baseline	11.30 (2.37)			16.15 (2.37)				
6-week	10.15 (2.37)	−1.15 (−3.54, 1.24)	0.345	16.64 (2.39)	0.49 (−1.94, 2.93)	0.692	−1.64 (−5.05, 1.77)	0.346
12-week	8.65 (2.37)	−2.65 (−5.04, −0.26)	**0.030**	17.85 (2.37)	1.70 (−0.69, 4.09)	0.163	−4.35 (−7.73, −0.97)	**0.012**
Depression symptoms, points								
Baseline	3.70 (1.08)			5.70 (1.08)				
6-week	3.60 (1.08)	−0.10 (−1.28, 1.08)	0.868	5.66 (1.08)	−0.04 (−1.24, 1.17)	0.950	−0.06 (−1.75, 1.63)	0.943
12-week	2.50 (1.08)	−1.20 (−2.38, −0.02)	**0.047**	6.25 (1.08)	0.55 (−0.63, 1.73)	0.362	−1.75 (−3.42, −0.08)	**0.040**
Anxiety symptoms, points								
Baseline	2.05 (0.68)			3.15 (0.68)				
6-week	1.80 (0.68)	−0.25 (−1.10, 0.60)	0.565	3.81 (0.69)	0.66 (−0.21, 1.53)	0.136	−0.91 (−2.13, 0.31)	0.143
12-week	1.90 (0.68)	−0.15 (−1.00, 0.70)	0.730	3.95 (0.68)	0.80 (−0.05, 1.65)	0.066	−0.95 (−2.16, 0.26)	0.122
Stress symptoms, points								
Baseline	5.55 (0.85)			7.30 (0.85)				
6-week	4.75 (0.85)	−0.80 (−1.76, 0.16)	0.102	7.16 (0.85)	−0.14 (−1.12, 0.84)	0.777	−0.66 (−2.03, 0.71)	0.345
12-week	4.25 (0.85)	−1.30 (−2.26, −0.34)	**0.008**	7.65 (0.85)	0.35 (−0.61, 1.31)	0.474	−1.65 (−3.01, −0.29)	**0.017**
Pain catastrophising, points								
Baseline	12.75 (2.09)			12.90 (2.09)				
6-week	9.65 (2.09)	−3.10 (−6.02, −0.18)	**0.037**	14.29 (2.11)	1.39 (−1.58, 4.37)	0.358	−4.49 (−8.66, −0.33)	**0.035**
12-week	7.00 (2.09)	−5.75 (−8.67, −2.83)	**<0.001**	15.00 (2.09)	2.10 (−0.82, 5.02)	0.159	−7.85 (−11.98, −3.72)	**<0.001**

Data are sample size, estimated marginal mean (SE), within-group mean change from baseline (95 % CI), within-group P-value, group-by-time β coefficient (95 % CI), or group-by-time P-value from linear mixed models. Observed mean (SD) is presented in Supplement B. Potential scores ranged from 0 to 63 points for overall mental health symptoms, 0 to 21 points for subscales (depression, anxiety, and stress symptoms), and 0 to 52 points for pain catastrophising. Bold: $P<0.05$.

Defining clinical meaningfulness is contentious for the DASS-21.[21] When considering the recommended three-distribution clinical significance model,[21] clinically meaningful reductions for raw scores (i.e. prior to multiplying by two for comparability to the DASS-42) within normal range, such as the mean scores observed among the total population of our study, are 1.93 points for depression symptoms, 1.93 points for anxiety symptoms, and 2.45 points for stress symptoms. Subsequently, neither our observed within- nor between-group effects were likely clinically meaningful. Establishing clinically meaningful thresholds for the PCS has received limited attention to date,[22] yet one distribution-based method for drawing conclusions involves establishing decision thresholds at 0.5 SD of baseline values.[23] Using this method, we defined a decision threshold of 4.80 points, which suggests that both the within- and between-group effects for running were clinically meaningful. Notably, these thresholds were only exceeded at 12 weeks post-baseline, despite statistically significant changes detected as early as six weeks post-baseline.

Our findings have several implications for clinical practice. First, running is a form of aerobic exercise that can be considered in treatment plans for patients with chronic LBP as a complementary intervention that can address both physical and psychological symptoms. Highlighting the psychological benefits of exercise training, such as mood improvement, may help motivate patients to adhere to exercise programmes, particularly among those hesitant to engage in physical activity due to pain or fear of exacerbation.[24] In addition, encouraging patients to continue running beyond 12 weeks could foster lasting lifestyle modifications and benefits associated with long-term running.[25] Furthermore, the observed improvements in depression symptoms suggest that exercise training may foster a sense of accomplishment and control (self-efficacy), which is critical in managing chronic pain.[26]

Strengths of the current study include being the first randomised controlled trial to compare running to a non-treatment control among adults with non-specific chronic LBP, the lack of attrition, and investigation of an intervention that could viably be scaled at the population level due to accessibility, low financial costs and non-reliance on specialised equipment. However, limitations warrant consideration. First, the study likely attracted individuals interested in exercise training. Whilst we employed exclusion criteria regarding running in the last three months, historical experience or exposure may have impacted participation in the current study and/or adherence to our intervention. Second, participants allocated to waitlist control did not receive the same level of contact as the intervention group; therefore, we cannot determine the potential magnitude of non-specific effects borne from the coaching and support elements of the intervention.[27] Third, the current study was a pre-planned secondary analysis; thus, the original sample size calculation was not based on mental health symptom or pain catastrophising outcomes. Finally, participants tended to have low levels of mental health symptoms and pain catastrophising at baseline. In line with the exercise training principle of initial values,[28] running may yield greater effects than observed in the current study among individuals with severe psychological comorbidities, yet this remains speculative and warrants further investigation given the compromised recovery trajectories associated with mental ill-health in this susceptible population group.

5. Conclusion

A 12-week running (progressive run–walk interval exercise training) intervention led to improved mental health symptoms and pain catastrophising among adults with non-specific chronic LBP when compared to waitlist control. Changes in pain catastrophising, yet not mental health symptoms, were clinically meaningful. Running appears to be an efficacious treatment for psychological comorbidities common among adults with non-specific chronic LBP.

CRediT authorship contribution statement

Conceptualisation: SDT, DLB, UHM, and PJO
Data curation: CLS and CN
Formal Analysis: PJW
Funding acquisition: DLB, UHM, and PJO
Investigation: CLS, CN, and PJO
Methodology: All
Project administration: CLS, CN, SDT, and PJO
Resources: PJO

Software: PJW and PJO
Supervision: PJO and GEV
Validation: PJO
Visualisation: PJW and PJO
Writing – original draft: PJW
Writing – review & editing: All.

Confirmation of ethical compliance

Ethics approval was provided by the Deakin University Human Research Ethics Committee (ID: 2022-162) on September 26, 2022.

Trial registration

Australian New Zealand Clinical Trials Registry: ACTRN12622001276741. Registered on September 29, 2022.

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Declaration of interest statement

The authors declare no conflicts.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsams.2025.08.001.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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