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Exercise pain and alexithymia: exploring the relationship

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Abstract

Alexithymia, a psychological trait characterized by impaired emotional awareness and regulation, has been linked to altered pain perception and emotional processing. Despite its established role in chronic pain and psychological disorders, little is known about its influence on exercise-induced pain. To investigate the relationship between alexithymia and exercise-induced pain perception, differences in pain intensity, perceived exertion, heart rate, and task endurance were measured during isometric exercise in alexithymic and control participants. Sixty participants were categorized into alexithymic and control groups based on the Alexithymia Scale. Participants performed an isometric contraction task, holding a mass of 20% of their one-repetition maximum (1RM) at a 90° elbow flexion for as long as they could, during which pain intensity, perceived exertion, and heart rate were recorded. Statistical analyses, including MANOVAs and correlation analyses, evaluated the effects of alexithymia on these outcomes. Alexithymic participants reported significantly higher pain intensity compared to controls across all time points. However, no significant differences were found between groups for perceived exertion, heart rate, or task endurance. These findings suggest that exercise-induced pain is increased in alexithymia, but without limiting muscular endurance. Targeted pain management interventions focusing on emotional processing deficits may benefit individuals with alexithymia. Future research should explore adaptive mechanisms over prolonged exposure and the development of tailored therapeutic interventions to improve emotional resilience and quality of life. This study is the first to demonstrate that alexithymia is associated with heightened pain perception during exercise, independent of exercise intensity and physiological response. These findings offer novel insights into the interplay between emotional processing and pain sensitivity, highlighting the need for targeted pain management interventions in alexithymic individuals. The results have potential implications for both psychological and physical rehabilitation strategies, improving therapeutic approaches for populations with emotional processing deficits.

Key words: alexithymia; pain; exercise induced pain; subjective pain perception.

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Introduction

Emotional awareness and regulation are vital to mental well-being, enabling individuals to recognize, manage, and respond to emotions effectively. When these processes are disrupted, as seen in alexithymia, individuals face challenges that affect daily functioning and responsiveness to treatment across psychological and somatic disorders.[1] Affecting approximately 13% of the population,[2] alexithymia is characterized by difficulty identifying and describing emotions, a tendency toward externally oriented thinking, and reduced interoception.[3]

Pain is defined as a subjective sensory and emotional experience.[4] Recent research has emphasized alexithymia's influence on pain perception.[5,6] Alexithymia's deficits in emotional processing amplify pain perception, with individuals reporting greater pain intensity and increased interference in daily activities.[5] This heightened sensitivity likely stems from difficulties in identifying and regulating emotions, making physical sensations like pain more overwhelming.

Alexithymia is also linked to various chronic pain and psychosomatic conditions.[7-9] Alexithymic individuals often report greater pain intensity and are more prone to maladaptive health behaviors, such as treatment avoidance and substance use.[10,11] Coupled with elevated rates of anxiety and depression, these behaviors complicate treatment and highlight the need for interventions targeting emotional deficits.[12,13]

Alexithymia can also influence exercise behaviors, with affected individuals gravitating toward high-intensity or high-risk activities, such as extreme endurance sports or skydiving, to manage emotional discomfort by externalizing focus.[14,15] This preference for external cognitive focus temporarily distances individuals from internal emotional states.[16] However, these activities can lead to dependency, as seen in exercise addiction and issues like orthorexia nervosa.[17] While exercise may offer temporary relief, it also poses risks, especially for those prone to maladaptive behaviors.[18]

Although alexithymia's effects on pain perception and exercise behaviors have been studied independently, research on exercise-induced pain in alexithymic individuals is limited. This is relevant because their emotional processing difficulties may heighten discomfort or alter exercise capacity, which could have implications for exercise adherence and/or performance. Structured exercise programs, such as aerobic interventions, may reduce alexithymia symptoms and pain perception,[19] but interventions must address risk factors like eating disorders to prevent maladaptive behaviors.[18] Exploring alexithymia's role in exercise-induced pain could inform personalized therapies integrating physical activity with emotional and cognitive support.

This study investigates alexithymia's relationship with exercise-induced pain perception, assessing psychological and physiological factors. Specifically, it assesses whether individuals with high alexithymia differ from controls in terms of pain intensity ratings during exercise, subjective emotional appraisal of exertion, physiological response (*e.g.*, heart rate), and muscular endurance performance (*i.e.*, time to task failure). These dimensions collectively reflect how alexithymia may influence both the perception and interpretation of physical discomfort during high-intensity physical exertion. To guide this investigation, the study addresses the following research questions and hypothesis:

- **RQ1:** Does alexithymia influence individuals' subjective perception of exercise-induced pain during high-intensity resistance exercise?
  - *H1: Individuals with alexithymia will report significantly greater exercise-induced pain intensity compared to individuals without alexithymia, due to deficits in emotional awareness and regulation that heighten sensitivity to emotional and sensory discomfort.*
- **RQ2:** Is alexithymia associated with differences in physiological responses to exercise, such as heart rate?
  - *H2: Individuals with alexithymia will not exhibit significantly different heart rate responses during exercise compared to individuals with no alexithymia, as autonomic physiological reactivity is not consistently altered by emotional awareness deficits.*
- **RQ3:** Does alexithymia affect perceived exertion or muscular endurance performance during high-intensity exercise?
  - *H3: Individuals with alexithymia will report significantly lower ratings of perceived exertion compared to individuals without alexithymia, due to reduced interoceptive awareness and a tendency to under-detect physical effort, despite experiencing elevated pain intensity.*

Material and Methods

Ethics

The study was approved by the University of Kent SSES Research Ethics & Advisory Group (ref. Prop. 50_2016_17). All participants signed a consent form prior to the study and the study was performed in accordance with the Declaration of Helsinki.

Participants

This study employed an observational design to investigate the relationship between alexithymia and exercise-induced pain perception and performance. Participants were recruited through university-wide advertisements and voluntary sign-up, using convenience sampling among healthy university students.

A total of 60 (males=13, females=47) university students, with a mean age of 22.83 years (SD=5.15), participated in the study. Participants' one-repetition maximum (1RM*), for 90° of motion of the dominant arm ranged from 5 to 30 kg, with a mean at 11.33 kg (SD=5.77). More than half of the participants reported not engaging in regular (3 to 7 days per week), structured resistance or aerobic exercise (41/60) during the testing week. Participants who reported engaging in regular structured exercise (19/60) had a weekly mean workout time of 5.37 hours per week (SD=3.69).

All participants were healthy, with no disability that could affect their performance in the exercise task. In addition, no participant reported taking any chronic medication or having any cardiovascular, mental, or brain condition that could affect their performance. Therefore, inclusion criteria were: i) being a currently enrolled university student aged 18-25; ii) absence of any health conditions that would interfere with exercise performance; and iii) ability to provide informed consent. Exclusion criteria included: i) any medical contraindications to resistance training; ii) regular use of medications affecting mood or pain perception; or iii) previous diagnosis of mental or neurological illness.

Participants were split into two groups based on their alexithymia levels: the control/non-alexithymia group and the alexithymia group. The control/non-alexithymia group included those with an alexithymia level of 50 or lower, while the alexithymia group consisted of those with levels ranging from 51-60 (possible diagnosis of alexithymia) and 61 or more (diagnosis of alexithymia). The control group (M=40.02, SD=6.74), which did not exhibit alexithymia, consisted of 45 participants, while the alexithymia group (M=60.67, SD=5.54) included 15 participants. Among those in the alexithymia group, 9 exhibited borderline alexithymia, and 6 were diagnosed with alexithymia. These findings support the idea that approximately 13% of the general population is affected by alexithymia.[2] Table 1 presents the relevant descriptive data for each condition.

Procedure

Upon arrival at the laboratory, participants were informed about the nature and procedures of the study and provided written informed consent. They were then given a questionnaire packet comprising demographic questions and the Alexithymia Scale Questionnaire (TAS-20).

**i.e.*, the heaviest weight they could lift.

Table 1. Descriptives statistics per group.

Group	n	Sex		Age		1RM		Regular exercise	
		Males	Females	M	SD	M	SD	Aerobic	Resistance
Control	45	10	35	23.42	5.32	11.34	5.64	19/45	16/45
Alexithymia	15	3	12	21.07	4.28	11.27	6.37	8/15	7/15

Following questionnaire completion, participants underwent a strength assessment to determine their one-repetition maximum (1RM). Standing upright with their back against a wall and their dominant arm fully extended (elbow and wrist at 180°), participants performed biceps curls through a full range of motion (to 90° flexion). Weight was incrementally added until the participant could no longer complete the movement. A rest period of 2 min was provided between each 1RM attempt to ensure adequate recovery and consistency. The heaviest successfully lifted mass was recorded as their 1RM.

A weight equal to 20% of each participant's 1RM was then calculated and designated as the Baseline Mass for the endurance task. Participants subsequently rested for 10 minutes before proceeding to the experimental session.

During the experimental task, participants were seated with their elbow resting on a cushioned surface (a yoga mat placed on a table) for comfort and stabilization. They were instructed to hold the baseline mass in an isometric contraction at 90° elbow flexion for as long as possible (Figure 1). At 60-s intervals, participants were prompted to verbally report two measures: pain intensity rating (PIR) and rating of perceived exertion (RPE). No verbal encouragement or feedback was provided during the task.

The endurance task had a maximum time limit of 15 minutes to ensure standardization and participant safety. Task termination occurred either upon volitional fatigue or completion of the full 15-min duration, depending on individual capacity. Figure 2 illustrates the experimental process.

Instruments

During the two sessions of the study (*i.e.,* the familiarization and intervention sessions), the following data were collected:

Alexithymia scale questionnaire (TAS-20). Participants were asked to complete the TAS-20 upon arrival to the laboratory. TAS-20 is a self-report measure of alexithymia, comprised of 20 items rated on a 5-point Likert scale with 3 subscales (difficulty describing feelings, difficulty identifying feelings, and externally oriented thinking). Cut-off scoring of the model results in three groups scored out of 100: ≤50=no alexithymia, 51-60=borderline alexithymia, and ≥61=alexithymia. The scale has been extensively used and tested for reliability and validity when examining alexithymia with multiple populations.[19-21]

Heart rate (HR). HR was measured continuously with a telemetric device (Polar Electro, N2965, Finland). HR provides a measure of the psychological anticipation of and physiological response to exercise and has been used in several previous studies relating to pain.[22-24]

Pain intensity rating (PIR). Participants were asked to verbally report their level of perceived pain every 60 s, using the 0-10 Cook Scale that ranged from 0 (no pain at all) to 10 (extremely intense pain, almost unbearable). Participants were instructed to report their pain intensity according to feelings of pain during exercise, rather than compared to other non-exercise type pain (*e.g.*, dental pain). The PIR scale has been previously shown to have high reliability and validity.[25] Our analysis supports previous findings, with a high degree of reliability, measured by Cronbach alpha, α=0.920.

Rating of perceived exertion (RPE). Participants were asked to verbally provide a rating of perceived exertion, using the 6-20 Borg Scale that ranged from 6 (No exertion at all) to 20 (Maximal

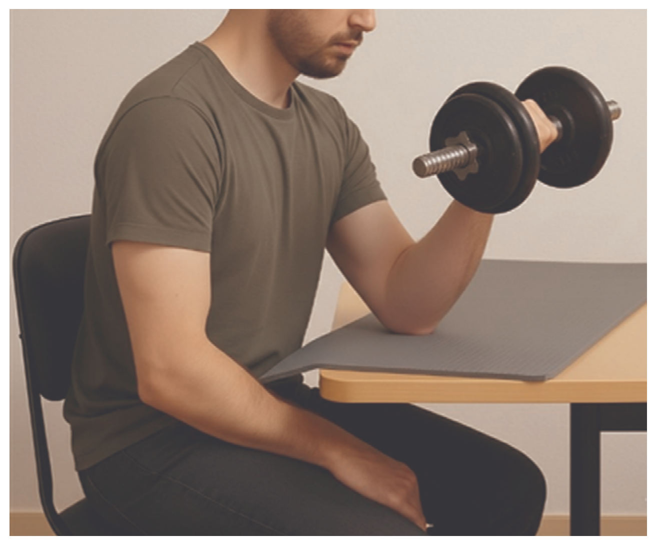

Figure 1. Experimental setup.

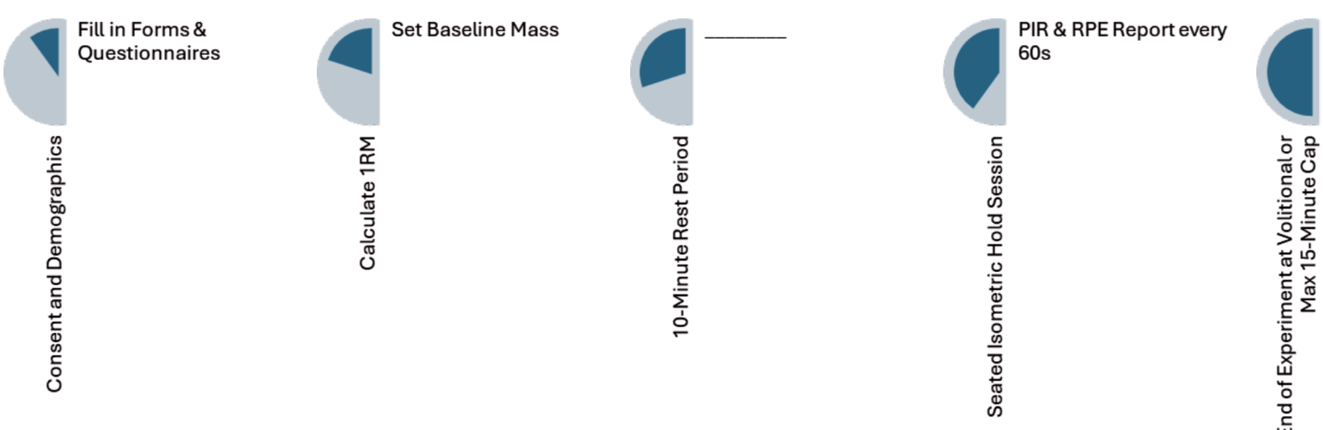

Figure 2. Illustration of the study procedure.

exertion), every 60s during the exercise task. Specifically, participants were asked to report how much effort they had to exert to keep their arm in a 90º flexion, independent of feelings of discomfort. The RPE scale has also been shown to have high reliability and validity.[26] Our results support previous findings, revealing high reliability, α=0.886.

Time to task failure (TTF). TTF was defined as the amount of time participants spent holding the mass. For health and safety reasons, the maximum experimental time was set to 15 min.

Statistical analysis

A *post-hoc* power analysis using G*Power indicated that a total sample size of 42 participants would be sufficient to detect medium effects (Cohen's d=0.5) with 80% power at α=0.05. Our final sample of 60 participants therefore provides adequate power for the primary analyses.

The data analyses focused on time-based measures such as PIR, RPE, and HR, using ISO time-points that were consistent across all participants. The shortest time to task failure for all participants was 3 min. Therefore, the ISO time analysis was conducted for the first, second, and third min of the exercise task, denoted as PIR1-3, RPE1-3, and HR1-3. The final data point at task failure was also analyzed for PIR, RPE, and HR (fPIR, fRPE, fHR). The average PIR, RPE, and HR (mPIR, mRPE, mHR) were calculated for each participant throughout the exercise task.

To explore the relationships between alexithymia and performance or perceptual variables, Pearson correlation coefficients (r) were first computed between alexithymia scores and PIR, RPE, HR, and TTF values.

To test the main hypotheses, namely, whether individuals with alexithymia differ from controls in pain perception, perceived exertion, heart rate response, and endurance, a one-way Multivariate Analysis of Variance (MANOVA) was conducted. This analysis included all performance and perceptual variables (*e.g.*, PIR1–3, mPIR, and fPIR; RPE1–3, mRPE and fRPE; HR1–3, mHR and fHR; TTF) as dependent variables, with alexithymia group (alexithymia vs. control) as the fixed factor. Univariate ANOVAs were used as follow-up tests for individual outcomes.

Prior to analysis, the assumptions for MANOVA were tested. The Shapiro-Wilk test was used to assess the normality of the dependent variables, and Box's M test was conducted to evaluate the homogeneity of variance-covariance matrices. All assumptions were satisfied.

Partial eta-squared (η^2) values were reported to indicate the effect sizes for each MANOVA.

Results

In the initial stage of our analysis, we performed a correlation analysis to investigate the potential connection between alexithymia and perceived pain, TTF, or heart rate. The findings, which are detailed in Table 2, indicated a positive correlation between alexithymia and the perception of pain, but no significant correlations with the other variables.

MANOVA was conducted to examine the overall effect of Alexithymia group (alexithymia *vs* control) on the set of time-based outcome measures (PIR, RPE, HR, and TTF). The multivariate analysis indicated no statistically significant overall effect of the alexithymia factor on the combined dependent variables, Wilks' Λ=0.712, F(16, 43)=1.23, p=0.288, η^2=0.288.

Despite the non-significant multivariate effect, follow-up univariate ANOVAs were examined to explore group differences in specific outcomes, in line with prior research. A more detailed analysis showed that alexithymia had a significant effect on pain for the PIR1 (F(1, 58)=9.96, p=0.003, η^2=0.147), PIR2 (F(1, 58)=4.65, p=0.035, η^2=0.074), PIR3 (F(1, 58)=4.06, p=0.049, η^2=0.066). Alexithymia also showed a marginally significant effect on the mean PIR (mPIR) (F(1, 58)=3.94, p=0.052, η^2=0.064). In general, as shown in Figure 3 and Table 3, the effect of alexithymia was significant, with non-alexithymic/control participants reporting lower pain levels than alexithymic individuals.

Table 2. Alexithymia, pain perception, perceived exhaustion, heart rate: correlations (n=60).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.Alexithymia	-	0.39**	0.28*	0.26*	0.25	0.25	0.11	0.06	0.03	0.14	0.12	-0.11	-0.18	-0.14	-0.06	-0.11
2.PIR1		-	0.79**	0.61**	0.39**	0.69**	0.70**	0.57**	0.48**	0.26*	0.50**	-0.13	-0.18	-0.08	-0.18	-0.15
3.PIR2			-	0.88**	0.47**	0.82**	0.59**	0.65*	0.66**	0.34*	0.54**	-0.03	-0.02	0.09	-0.07	-0.02
4.PIR3				-	0.59**	0.81**	0.50**	0.66**	0.73**	0.39**	0.54**	0.01	0.05	0.18	-0.02	0.04
5.fPIR					-	0.82**	0.27*	0.34**	0.40**	0.62**	0.56**	0.07	0.12	0.17	0.11	0.10
6.mPIR						-	0.50**	0.55**	0.57**	0.57**	0.66**	-0.01	0.03	0.12	-0.01	0.02
7.RPE1							-	0.85**	0.68**	0.35**	0.71**	-0.13	-0.06	-0.07	-0.16	-0.12
8.RPE2								-	0.91**	0.48**	0.83**	-0.17	-0.01	-0.03	-0.22	-0.13
9.RPE3									-	0.55**	0.81**	-0.06	0.10	0.11	-0.10	0.00
10.fRPE										-	0.84**	-0.02	0.07	0.01	0.06	0.06
11.mRPE											-	-0.11	0.01	-0.04	-0.09	-0.05
12.HR1												-	0.86**	0.90**	0.88**	0.95**
13.HR2													-	0.93**	0.87**	0.96**
14.HR3														-	0.89**	0.97**
15.fHR															-	0.94**
16.mHR																-

*p<0.05; **p<0.01.

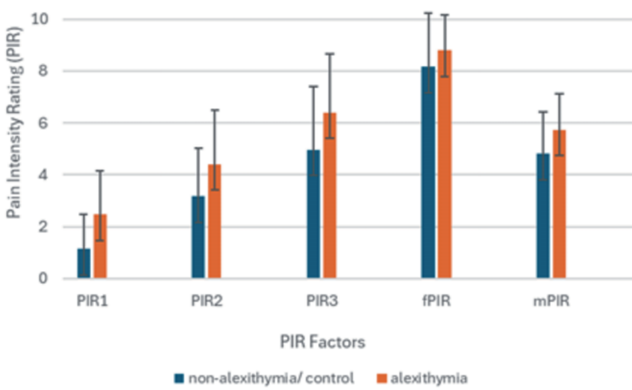

Figure 3. Effect of alexithymia on pain intensity ratings (PIR1, PIR2, PIR3, fPIR, mPIR).

The analysis revealed that alexithymia had no significant effect on the dependent variables of RPE and HR (Table 4). Regarding RPE, the findings suggest that although alexithymic participants reported significantly higher pain, they did not experience a parallel increase in perception of effort. Further, participants with alexithymia and control participants displayed a similar HR response to the exercise. Alexithymia did not have a significant effect on time to task failure. Both alexithymic individuals and non-alexithymic/control participants were able to maintain the muscle contraction for approximately the same amount of time.

Discussion

The results of this study provide important insights into the relationship between alexithymia and various physiological and psychological parameters during exercise, including exercise-induced pain,

Table 3. Effects of alexithymia on pain.

Dependent	df	df error	F	η²	Alexithymia factor	M	SD	95% Confidence interval Lower bound	Upper bound	*p*
PIR1	1	58	9.96	0.147	Non-alexithymia/ control	1.13	1.33	0.72	1.53	0.003**
					Alexithymia	2.47	1.68	1.53	3.40	
PIR2	1	58	4.65	0.074	Non-alexithymia/ control	3.16	1.86	2.59	3.73	0.035*
					Alexithymia	4.40	2.10	3.24	5.56	
PIR3	1	58	4.06	0.066	Non-alexithymia/ control	4.97	2.42	4.23	5.70	0.049*
					Alexithymia	6.40	2.26	5.15	7.65	
fPIR	1	58	1.26	0.021	Non-alexithymia/ control	8.16	2.06	7.53	8.78	0.265
					Alexithymia	8.80	1.37	8.04	9.56	
mPIR	1	58	3.94	0.064	Non-alexithymia/ control	4.82	1.59	4.34	5.30	0.052
					Alexithymia	5.73	1.39	4.97	6.50	

$^*p \leq 0.05$; $^{**}p < 0.01$.

Table 4. Effects of alexithymia on heart rate and perceived exhaustion.

Dependent	df	df error	F	η²	Alexithymia factor	M	SD	95% Confidence interval Lower bound	Upper bound	p
RPE1	1	58	0.650	0.011	Non-alexithymia/ control	7.89	2.01	7.28	8.49	0.423
					Alexithymia	8.40	2.44	7.05	9.75	
RPE2	1	58	0.226	0.004	Non-alexithymia/ control	9.86	2.69	9.05	10.68	0.636
					Alexithymia	10.27	3.24	8.47	12.06	
RPE3	1	58	0.053	0.001	Non-alexithymia/ control	11.75	3.60	10.65	12.85	0.819
					Alexithymia	12.00	3.76	9.92	14.08	
fRPE	1	58	1.113	0.019	Non-alexithymia/ control	16.09	3.70	14.98	17.20	0.296
					Alexithymia	17.20	2.93	15.58	18.82	
mRPE	1	58	0.834	0.014	Non-alexithymia/ control	11.78	2.56	11.01	12.55	0.365
					Alexithymia	12.47	2.45	11.11	13.82	
HR1	1	58	0.714	0.012	Non-alexithymia/ control	88.93	12.22	85.26	92.61	0.402
					Alexithymia	85.80	13.09	78.55	93.05	
HR2	1	58	1.82	0.030	Non-alexithymia/ control	87.75	11.14	84.36	91.14	0.183
					Alexithymia	83.27	11.07	77.13	89.40	
HR3	1	58	1.11	0.019	Non-alexithymia/ control	88.70	11.28	85.28	92.13	0.297
					Alexithymia	85.00	13.16	77.71	92.29	
fHR	1	58	0.201	0.003	Non-alexithymia/ control	89.27	11.38	85.85	92.69	0.656
					Alexithymia	87.67	13.65	80.11	95.23	
mHR	1	58	0.767	0.013	Non-alexithymia/ control	88.69	11.10	85.36	92.02	0.385
					Alexithymia	85.73	11.99	79.09	92.37	
TTF	1	58	0.236	0.004	Non-alexithymia/ control	5.14	1.33	4.46	5.42	0.629
					Alexithymia	05.29	2.00	4.22	6.35	

$^*p \leq 0.05$; $^{**}p < 0.01$.

perceived effort, and heart rate. The primary findings demonstrate a significant positive correlation between alexithymia and exercise pain perception, indicating that individuals with higher levels of alexithymia report experiencing more intense exercise-induced pain. However, no significant relationships were observed between alexithymia and the other variables, such as perceived effort or heart rate, suggesting that alexithymia has a specific effect on exercise-induced pain perception rather than a broad influence on physiological responses or subjective measures of exertion.

The primary statistical approach, a one-way MANOVA, indicated no significant overall effect of the Alexithymia factor on the entire combined set of physiological and perceptual measures, including pain, RPE, HR, and TTF. However, this omnibus non-significant finding must be interpreted with caution. The MANOVA simultaneously tests a large number of dependent variables (16 in this case), which can reduce statistical power to detect differences in a subset of closely related variables, especially in studies with smaller sample sizes. Given the a priori theoretical interest and the significant results found in the follow-up univariate ANOVAs for pain intensity ratings (PIR1, PIR2, PIR3), we proceeded to interpret these individual analyses. The significant differences observed specifically in the pain perception measures suggest that alexithymia's influence is highly specific to the subjective reporting of nociceptive input, supporting the psychophysiological decoupling hypothesis (as noted below), even if the combined effect across all physiological and perceptual variables was not robust enough to pass the stringent multivariate test.

In response to RQ1, the findings indicated that alexithymia was significantly associated with elevated exercise-induced pain perception, with alexithymic individuals reporting higher pain intensity across all iso-time points. These findings support H1. The analysis revealed that participants with alexithymia experienced higher exercise-induced pain perception across all iso-time points (PIR1, PIR2, PIR3), aligning with prior studies suggesting that alexithymic individuals often struggle with emotional regulation, which may heighten their sensitivity to physical sensations, particularly during exercise.[27] This is consistent with the idea that alexithymia exacerbates subjective discomfort through impaired emotional processing,[28] potentially supporting a psychophysiological decoupling, where the cognitive and emotional processing of exercise-induced pain is disrupted in alexithymic individuals.[29,30] It is intriguing that task performance was not impaired by the increased exercise-induced pain experienced, given that such an effect has been consistently shown before.[31] One explanation for this may be that given that alexithymia disrupts emotional processing, and that behavior change arising from pain is largely driven by the affective components of pain, the alexithymic participants might have experienced more sensory pain (pain intensity) but that the affect (unpleasantness) of this was the same or less (so disengagement from the task was not different). Future research utilizing scales which measure pain affect would help confirm this notion.

The gender imbalance in our sample (47 out of 60 participants were female) may have influenced the study outcomes, particularly given well-established sex differences in both pain perception and emotional processing. Females typically report greater pain sensitivity and lower pain thresholds across experimental modalities, influenced by hormonal fluctuations (*e.g.*, estrogen-mediated pain modulation), reduced activation of endogenous opioid systems, and higher interoceptive awareness.[32,33] In parallel, cognitive and social factors contribute to differential emotional regulation between sexes. Women are generally socialized to be more emotionally expressive and attuned to internal states, whereas men are more likely to down-regulate or externalize emotional experience.[34,35] Recent meta-analytic evidence supports the notion that men tend to report higher alexithymia scores overall, particularly in traits associated with externally focused attention and reduced emotional awareness.[36] However, these differences are small and appear to be modulated by cultural context and age, suggesting a role for socialization and shifting gender norms. These physiological and cognitive distinctions suggest that sex may moderate the relationship between emotional regulation difficulties and pain experience. Thus, the heightened pain responses observed in individuals with alexithymia may partly reflect an interaction between emotional dysregulation and female-typical physiological sensitivity to nociceptive input. Future research should use gender-balanced or stratified samples to more accurately assess whether sex-specific mechanisms shape the link between alexithymia and exercise-induced pain.

In response to RQ3, the findings indicated that alexithymia was not significantly associated with perceived exertion or time to task failure, with no observed differences in RPE (RPE1-3, mRPE, fRPE) or muscular endurance between groups. These findings do not support H3. The lack of a significant effect of alexithymia on perceived effort (RPE) suggests that, while alexithymic individuals report higher exercise-induced pain, this does not translate to increased perceptions of exertion. It may be that alexithymic individuals are less attuned to physical effort cues, just as they are with emotional states.[37] This differential response to pain and effort suggests an understanding within alexithymic individuals of the distinction between subjective pain experience and effort, perhaps even to a greater degree than seen in the general population (particularly given that there was no observed difference in TTF). Additionally, higher exercise pain sensitivity might necessitate increased motivation to engage in and maintain physically demanding tasks, as heightened discomfort typically correlates with the need for greater motivational thresholds.

The absence of an effect of alexithymia on perceived effort could also stem from the complex interplay between psychological and physiological factors in alexithymic individuals. While exercise-induced pain perception is highly subjective and influenced by emotional processing, exertion is more directly tied to physiological factors such as the effort to contract the muscle and muscle fatigue, which may not be as readily impacted by alexithymia. This interpretation is further supported by the lack of significant differences in TTF, as both alexithymic and control participants displayed comparable levels of muscular endurance.[38]

In response to RQ2, the findings indicated that alexithymia was not significantly associated with heart rate responses during exercise, as both alexithymic and non-alexithymic participants exhibited similar cardiovascular patterns throughout the trials. These findings support H2. This suggests that while alexithymic individuals experience higher levels of exercise-induced pain, their cardiovascular response remains consistent with those of non-alexithymic individuals during physical tasks (although the cardiovascular response to a submaximal, single limb, sustained contraction is limited). These findings are consistent with the broader literature, indicating that while alexithymia can amplify subjective sensory and emotional experiences, it does not necessarily alter autonomic responses, such as heart rate.[39]

The lack of significant differences in heart rate further supports the notion that alexithymia's primary effect lies in the cognitive and emotional appraisal of physical sensations, rather than in the regulation of physiological responses by the autonomic nervous system. In other words, alexithymic individuals may "feel" more exercise-induced pain, but their cardiovascular response remains comparable to that of non-alexithymic individuals, implying a purely perceptual rather than physiological difference in response.[40]

Given the rising use of exercise interventions within populations susceptible to or experiencing alexithymia,[19,41] and the increased risk of exercise addiction among alexithymic individuals, understanding the variations in exercise pain experience related to alexithymia is critical for designing effective intervention protocols. The findings from this study reinforce the need for large-scale investigations to further explore the nuanced relationships between exercise, pain perception, and alexithymia, with the aim of tailoring therapeutic approaches to address the specific emotional processing challenges associated with alexithymia.

In conclusion, this study demonstrates a significant impact of alexithymia on exercise pain perception, with alexithymic individuals reporting higher pain intensity across all measured time points. Crucially, this effect was observed independently of perceived effort, heart rate, or muscular endurance in this sample. The core insight of this research is that alexithymia's influence is highly specific to the subjective cognitive and emotional appraisal of physical sensations. This supports the notion of psychophysiological decoupling, where heightened sensory discomfort in alexithymic individuals is not paralleled by altered physiological or performance metrics. These findings highlight the need for targeted pain management interventions focusing on emotional processing deficits, which may help alleviate the heightened pain sensitivity experienced by individuals with alexithymia during physical activity.

Limitations and future directions

Several limitations of this study warrant consideration. First, the use of a university sample may introduce sampling bias, thereby restricting the generalizability of the findings to broader and more diverse populations. Second, the sample was markedly gender-imbalanced, with a predominance of female participants. Given the well-established sex differences in both pain perception and emotional processing, this imbalance may have influenced the results and underscores the need for replication in gender-balanced or stratified cohorts.

Third, pain was assessed solely in terms of intensity, without accounting for its affective or unpleasantness dimensions. This is a notable limitation, as alexithymia may differentially influence the sensory and emotional aspects of pain. Future studies should incorporate multidimensional pain assessment tools that capture both intensity and affective responses to provide a more nuanced understanding of the pain-emotion interface.

Fourth, although the primary analyses revealed robust group differences, the analytical model did not include potentially influential covariates such as gender, baseline physical activity, or exercise frequency. While preliminary checks suggested these factors did not significantly moderate the main effects, future research should formally test their influence using larger and more heterogeneous samples.

Finally, a key limitation is the absence of psychological variables such as depression, anxiety, and pain catastrophizing, factors that are frequently elevated in individuals with alexithymia and could confound interpretations of pain perception and exertion. The lack of these measures limits our ability to isolate the specific contributions of alexithymia. Future studies should integrate standardized psychological instruments (*e.g.*, HADS, DASS-21) to better differentiate the independent and interactive effects of emotional dysregulation, mood disturbances, and maladaptive pain-related cognitions.

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Availability and data and material: the data that support the findings of this study are available upon reasonable request from the corresponding author. The data are not publicly available due to confidentiality and ethical restrictions.