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# The effects of self-control exertion on subsequent physical performance in an alexithymic population

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ABSTRACT

Initial self-control exertion can impair subsequent physical performance, with perceptions of pain and motivation proposed as potential mechanisms. Examining state anxiety in this context is critical, as reductions may reflect more adaptive emotional responses to exertion in alexithymic athletes. Whilst yet to be explored, the limited emotional awareness and regulation associated with alexithymia may buffer against the performance-depleting effects of self-control exertion. This study addresses this gap and examines pain, motivation, RPE, and state anxiety as potential mechanisms. Using a within-subject crossover design, 40 participants (aged 18–45 years; 27 male, 13 female; 20 alexithymic, 20 non-alexithymic) completed a wall-sit to exhaustion twice, following either a non-self-control task (congruent Stroop) or self-control task (incongruent Stroop). Pain, motivation, and RPE were recorded at 15-s and every 30-s thereafter during the wall-sit, while state anxiety was measured pre-wall-sit, immediately post-wall-sit, and 10-min post. Self-control exertion influenced performance differently between groups. Non-alexithymic individuals exhibited significant performance decrements, quitting the wall-sit sooner following self-control exertion compared to the non-exertion condition ($p = 0.007$). In contrast, alexithymic individuals performed the wall-sit for significantly longer following self-control exertion compared to the non-exertion condition ($p < 0.001$). Multilevel modelling revealed greater increases in pain and RPE over time, alongside steeper motivation declines, for alexithymic individuals compared to non-alexithymic individuals, particularly under self-control exertion conditions. Despite reporting heightened anxiety, alexithymic individuals did not experience performance declines, indicating a potential adaptive benefit in emotionally challenging situations, which warrants further exploration across different sports.

## 1. Introduction

Alexithymia has been defined as a personality construct characterised by difficulties in identifying and describing emotions (Graham et al., 2025). Research indicates that this trait has a prevalence of approximately 10 % in the general population (Mattila et al., 2006); however, studies suggest that its prevalence may be higher in athletic populations, with estimates ranging from 25 % (Graham et al., 2025) to 30 % (Lopes et al., 2022). Individuals with alexithymia exhibit distinct attentional characteristics due to their atypical emotional processing. Specifically, they are less sensitive to emotional stimuli, which may result in a reduced tendency to shift attention away from task-relevant goals in response to emotional distractions (van der Velde et al., 2013). Research into emotional distractions has shown that emotionally salient stimuli often impair performance by narrowing attentional focus that may lead to task-relevant information being missed (Goodhew & Edwards, 2024). In contrast, alexithymic individuals may be better equipped to ignore such distractions, allowing them to sustain attention on task-relevant cues. Research has speculated that following self-control exertion, individuals with alexithymia may be able to maintain focus on long-term goals, such as optimal performance, rather than succumbing to immediate discomfort (Graham et al., 2025). However, the mechanisms underpinning these advantages remain speculative.

Self-control is a crucial element of self-regulation, involving the conscious inhibition of impulses to achieve long-term objectives (Boat & Cooper, 2019). It is fundamental in various aspects of life, including academic achievement, maintaining relationships, and excelling in physical performance (Baumeister et al., 2007). Within self-control literature, researchers have distinguished between trait and state

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dimensions. Trait self-control reflects a stable characteristic influencing behaviour regulation across time, whereas state self-control refers to a temporary ability that fluctuates based on situational demands (Hunte et al., 2022). This distinction is particularly relevant to performance contexts, where the exertion of state self-control can negatively impact subsequent behaviour requiring self-control. For instance, following a task requiring self-control (e.g., an incongruent Stroop task), participants were unable to sustain a standing wall-sit task as long as after completing a task requiring no self-control (e.g., a congruent Stroop task; Boat & Taylor, 2017; Hunte et al., 2022). Similar performance decrements have been observed across various physical performance tasks, including cycling endurance (Boat, Atkins, et al., 2018; Boat et al., 2017) and skill-based tasks (Boat, Sunderland, & Cooper, 2021). Meta-analytical evidence has reported a medium-sized negative effect of prior self-control exertion on subsequent physical performance (Giboin & Wolff, 2019; Hunte et al., 2021), with effects being more pronounced in isolation tasks (e.g., wall-sit) compared to whole-body endurance tasks (e.g., cycling; Giboin & Wolff, 2019). While these studies provide valuable insights into the effects of self-control exertion on physical performance, researchers have begun to explore *why* performance declines after such exertion (e.g., Boat et al., 2018).

A recent meta-analysis by Hunte et al. (2021) identified increased perceptions of pain as a key mechanism underlying performance decrements following self-control exertion. Consistent with the 'shifting priorities' perspective (Inzlicht & Schmeichel, 2016), self-control exertion leads to an attentional shift towards physical discomfort (e.g., pain), rather than long-term goals (e.g., persisting at the task and performing optimally). For example, Boat and Taylor (2017) demonstrated that following the completion of a task requiring self-control (incongruent Stroop task), participants reported increased perceptions of pain during a subsequent wall-sit task, compared to when they performed a task requiring no self-control (congruent Stroop task). Similar findings have also been corroborated in other studies (e.g., Boat et al., 2018; Hunte et al., 2022). Motivation has been suggested as a mechanism underlying performance decrements following self-control exertion. Self-control exertion may temporarily reduce motivation for sustained effort, particularly when the task's value or outcome is not immediately apparent. Boat et al. (2018) found lower motivation following self-control tasks was associated with poorer wall-sit performance. However, this finding is inconsistent with others reporting motivation remaining stable after self-control exertion (Brown & Bray, 2017). Additionally, perceived exertion is another proposed mechanism. Individuals may experience physical tasks as subjectively more demanding after exerting self-control, even if their physical capacity is unchanged, leading to earlier task disengagement or reduced persistence. It should be noted, RPE findings are difficult to interpret and more research is needed to understand this relationship (Hunte et al., 2021). These findings present challenges to the Shifting Priorities perspective of self-control (Inzlicht & Schmeichel, 2016) and suggest that multiple, possibly interacting, mechanisms may explain post-exertion performance decrements. Furthermore, no research to date has examined the effects of self-control exertion in alexithymic populations, and whether the potential underpinning mechanisms for performance decrements may be different in this population.

Individuals with alexithymia may respond differently to self-control exertion due to motivations related to agentic emotion regulation theory (Willegers et al., 2023). Specifically, alexithymic individuals may use physical activity as a structured means to manage emotions, particularly heightened state anxiety (Woodman & Welch, 2021). Although state anxiety is not a direct measure of emotion regulation, it has been used in previous alexithymia research as an indicator of regulatory processes (Woodman et al., 2008). A reduction in anxiety following physical activity may therefore reflect a purposeful attempt to re-establish emotional balance in response to internal distress. Pain may also be experienced differently in alexithymic individuals as. Evidence suggests reduced interoceptive awareness may attenuate pain sensitivity (Brewer et al., 2016; Kano & Fukudo, 2013), potentially enhancing persistence. Other studies report heightened pain sensitivity amongst alexithymic individuals, likely due to difficulty interpreting bodily signals (Di Tella & Castelli, 2016). These conflicting findings imply that the experience of pain may depend on contextual demands. Similarly, motivation may be less vulnerable to changes for alexithymic individuals following self-control exertion as effort is driven by external rules rather than internal cues, since task structure may compensate for reduced emotional insight (Shalev, 2019). Finally, perceived exertion may be influenced by broader interoceptive disruptions, leading to under- or over-reporting of effort. By focusing on tangible, controllable aspects of a task, alexithymic individuals may be able to persist with physically demanding tasks despite discomfort, thus providing a potential performance advantage,. As such, this may partially explain why alexithymia is more prevalent in athletes, as it may offer a competitive advantage in managing emotional and physical demands (Willegers et al., 2023). However, this remains speculative at present.

The primary aim of the present study was to explore whether self-control exertion differentially affects subsequent physical performance in alexithymia and non-alexithymia populations. Furthermore, a secondary aim was to examine whether self-control exertion affects the time course of pain, motivation, and RPE, to consider whether these may be mechanisms that explain any effects on subsequent physical performance. Finally, a third aim of the study was to investigate whether self-control exertion affects changes in state anxiety following performance on a physical task. Based on previous research (Boat et al., 2020; Graham et al., 2025; Woodman & Welch, 2021), it was hypothesised that following the prior exertion of self-control, individuals with alexithymia will be less susceptible to performance declines (hypothesis 1) as well as changes in pain, motivation, and RPE (hypothesis 2) during a subsequent physical performance task, compared to non-alexithymic individuals. Furthermore, it was hypothesised that alexithymic individuals would show greater reductions in state anxiety following physical performance (hypothesis 3), consistent with the view that exertion may serve a regulatory function. To test these hypotheses, a wall-sit task was used as the performance measure. This task offers a standardised, low-skill physical challenge that is sensitive to motivational and attentional changes following self-control exertion (Boat et al., 2020; Boat & Taylor, 2017). Critically, it allows for in-task measurement of pain, RPE, and motivation, making it well suited for exploring the potential mechanisms through which self-control exertion may influence physical performance (Hunte et al., 2021), and for detecting whether these processes operate differently in individuals with alexithymia.

## 2. Method

### 2.1. Participants

The sample consisted of 40 current athletes (males = 27; females = 13) aged 18–45 years ($M_{age}$ = 24 years, $SD_{age}$ = 4.34 years). Participants were classified as either recreational ($n$ = 29) or elite ($n$ = 11) based on Swann et al. (2015) elite classification and exercised on average 3 days per week ($SD$ = 1 day; e.g., cycling, rowing, rugby, running, and swimming). A priori power analysis using G*Power (version 3.1; Faul et al., 2007) indicated that a minimum sample of $N$ = 34 was required to detect a large interaction effect (0.4) in a repeated measures ANOVA with power = 0.80 and α = 0.05. The final sample exceeded this threshold and was considered adequately powered and is representative of similar previous self-control studies (Giboin & Wolff, 2019). Following approval from a university ethics committee, each participant signed an informed consent form after the study was explained in full and it was described that involvement was anonymous and voluntary. All participants were healthy, as confirmed by a university-approved general health questionnaire, and were asked to refrain from alcohol and vigorous exercise in the 24 h prior to testing. While the sample was adequate in size, it was appropriate for the study's experimental design and recruitment aims. Although caution is warranted when generalising, the sample provides a meaningful foundation for future research.

## 2.2. Measures

### 2.2.1. The Toronto Alexithymia scale (TAS-20)

The TAS-20 (Bagby et al., 1994) assesses the extent to which an individual is alexithymic. The measure comprises 20 items rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The first factor in the three-factor model contains seven items and assesses the ability to identify feelings and distinguish them from somatic sensations (e.g., "I am often confused about what emotion I am feeling"). The second factor contains five items and assesses the ability to describe feelings to others (e.g., "It's difficult for me to find the right words for my feelings"), while the third factor contains eight items and assesses externally oriented thinking (e.g., "I prefer to just let things happen rather than to understand why they turned out that way"). A total alexithymia score was calculated by summing all positively keyed items (after reverse scoring negatively keyed items), with participants categorised as non-alexithymic (≤51), possibly alexithymic (52–60), or alexithymic (≥61). Internal consistency for the total TAS-20 score in the present sample was excellent (Cronbach's $\alpha = 0.91$).

### 2.2.2. Daily stress

Daily stress was measured using the seven stem questions from the Daily Inventory of Stressful Events Questionnaire (Almeida et al., 2002). Participants were asked to report whether any stressful events had occurred today by circling either "yes" or "no" (e.g., "An argument or disagreement with someone"). A total daily stress score was calculated from summing the 'yes' responses. Internal reliability for the 7-item daily measure was acceptable across the full dataset ($\alpha = 0.76$).

### 2.2.3. Perceptions of physical fatigue

Perceptions of physical fatigue was assessed using the combined scores of two items from the fatigue subscale from the Profile of Mood States (McNair et al., 1992; i.e., "I feel physically worn out" and "I feel physically exhausted") on a five-point scale anchored by 1 (not true) to 5 (very true). These items were used as they showed high factor loadings in previous research and acceptable reliability (Beedie et al., 2000). However, internal consistency in the current sample was poor (Cronbach's $\alpha = 0.57$), suggesting that the items may not have functioned as a cohesive scale in this context. This limitation is considered in the interpretation of related findings.

### 2.2.4. State trait anxiety inventory (STAI-6)

The STAI-6 (Marteau & Bekker, 1992) is a 6-item measure of state anxiety adapted from the original 20-item State-Trait Anxiety Inventory (Spielberger et al., 1983). It evaluates participants' subjective feelings of apprehension and tension. Each item (e.g. "I feel calm") is rated on a four-point Likert scale ranging from 1 (not at all) to 4 (very much so). A total state anxiety score is then calculated by summing all positively keyed items (following the reverse scoring of negatively keyed items) and multiplying the overall sum by 3.33 to rescale it to be comparable with the full 20-item version, allowing interpretation against established state anxiety cut-offs. State showed excellent internal consistency in the present sample (Cronbach's $\alpha = 0.89$).

### 2.2.5. Mental exertion

Participants rated their mental exertion during the Stroop task using Borg's single-item CR-10 scale (Borg, 1998, p. 0 = extremely weak; 10 = absolute maximum), with higher scores indicating more perceived mental exertion. This single item measure has successfully been used in previous self-control research (e.g., Boat et al., 2018).

### 2.2.6. Rating of perceived exertion (RPE)

Participants rated their RPE verbally, during the wall-sit task, using the 6-to-20-point Borg scale (6 = no exertion at all; 20 = extremely hard; Borg, 1976).

### 2.2.7. Perceptions of pain and motivation

Participants pain perception and motivation to continue with the wall-sit task were measured using a Visual Analog Scale (VAS), adapted from the short-form McGill pain questionnaire (SF-MPQ; Melzack, 1987). The VAS used to measure participants' pain perception included a 10-cm line, where one end represented "*No Pain*", and the other end represented the "*Worst Possible Pain*". Similarly, the VAS used to measure participants' motivation to continue with the wall-sit task comprised a 10-cm line where one end signified *"I have zero motivation to continue with the wall-sit task"* and the other end signified *"I am fully motivated to continue with the wall-sit task"*. Participants were instructed to make a mark on the 10 cm-line on both VAS's that represented their current perceptions of pain and motivation. The VAS have been used in previous self-control research as a quick method to examine pain and motivation levels during physical performance (Boat & Taylor, 2017) and has demonstrated acceptable reliability and predictive validity in previous research (Wright et al., 2001).

## 2.3. Procedure

Participants completed two laboratory visits in a randomised, crossover design with order counterbalanced and a minimum 48-h washout period between conditions (self-control exertion and no self-control exertion). A 48-h washout period was implemented between sessions, consistent with previous self-control studies (e.g., Boat et al., 2018) and was deemed sufficient to minimise residual muscular fatigue or psychological carryover effects. Prior to the familiarisation trial, participants completed the TAS-20 (Bagby et al., 1994), to categorise participants into alexithymia (≥61, $n = 20$) and non-alexithymia groups (≥51, $n = 20$; . Bagby et al., 1994). Intermediate scorers (52–59; $n = 52$) were excluded to maintain clear group distinctions, following established cut-offs and consistent with previous research (Graham et al., 2025). Stratified randomisation was used to assign participants within each group to condition order via computer-generated sequence (random.org). Each participant completed three lab visits: a familiarisation, followed by two experimental sessions. On arrival, participants completed daily stress (Almeida et al., 2002) and physical fatigue (McNair et al., 1992) questionnaires. Both measures have been used in previous similar self-control studies to control for daily stress and fatigue (e.g., Boat et al., 2020). In addition, participants completed a state anxiety questionnaire (STAI-6; Marteau & Bekker, 1992) to provide a baseline measure of state anxiety. Participants were then required to complete the Stroop task for 4 min (McEwan et al., 2013). In the Stroop task, a word (always a colour) was displayed in the centre of a computer screen, and participants were required to select the correct response using a response pad (RB-740). In the congruent version of the Stroop task (non-self-control experimental condition), the word and the print colour were congruent (e.g., the word "green" was printed in green ink). In the incongruent version of the Stroop task (self-control experimental condition), the word itself and the print colour were incongruent (e.g., if the word "green" is printed in blue ink, the correct keypad response would be the blue button). The incongruent Stroop task requires self-control because participants must inhibit their natural response to name the word rather than the ink colour (McEwan et al., 2013). Stimuli were presented on the screen one at a time and remained until a response was registered. The Stroop task, a widely used self-control manipulation (McEwan et al., 2013), was administered on a laptop using SuperLab 6.0, with participants seated 80–100 cm from the screen. Participants were instructed to respond as quickly and accurately as possible.

Immediately following the Stroop task, mental effort was rated using the Borg CR-10 Scale (Borg, 1998) to confirm successful self-control manipulation (Boat et al., 2020). Participants were unaware of specific study hypotheses to minimise demand characteristics; however, no additional checks were conducted to assess their awareness of the study's purpose. Participants then completed a physical task (i.e., a wall sit task) to volitional exhaustion. The physical task required individuals to lean with their back against a wall, hips and knees bent at 90°, feet shoulder width apart, with their hands crossed again their chest. The physical task instructions were scripted so that they remained the same for each participant. Individuals were directed to hold the position for as long as possible, until volitional exhaustion. Performance was measured using time (in seconds) until participants quit the wall-sit task. This physical performance task and protocol has been used in previous self-control research (e.g., Boat & Taylor, 2017; Hunte et al., 2022). Throughout the wall-sit task, participants' rate of perceived exertion, perception of pain and motivation were recorded initially at 15-s into the wall-sit task, followed by subsequent 30-s intervals for the remainder of the wall-sit task. For instance, participants completed the RPE scale, VAS for pain and the VAS for motivation at 15-s, 45-s, 75-s and so on. Immediately after the wall-sit task, participants were asked to complete the state anxiety questionnaire (STAI-6), before being asked to sit in silence with no distractions for 10-min. Following this, participants were asked to complete a final state anxiety questionnaire (STAI-6). The study's structure and reporting follow the CONSORT guidelines for randomised crossover trials (Dwan et al., 2019) to ensure transparency and replicability. Participants were debriefed fully upon completing all sessions, asked if they had any further questions about the study and thanked for their participation.

### 2.4. Data analysis

Data were analysed using SPSS (IBM corp., version 29.0, Chicago, IL) and R (version 3.5.1). Prior to analysis, data from 40 participants were screened for univariate (*z*-scores≥3.29) and multivariate ($MD_{(3)} \geq 16.27$, $p = 0.001$) outliers. Following this, skewness and kurtosis were assessed for all variables to evaluate the normality of distributions. Skewness values ranged from −5.38 to 6.98, and kurtosis values ranged from −1.96 to 8.63, exceeding recommended thresholds (±2 skewness; ±7 kurtosis; Kim, 2013). Where distributions were non-normal, $\log_{10}$ transformations were applied to achieve acceptable normality. All parameter estimates were "untransformed" prior to reporting for ease of interpretation. Two-way mixed ANOVAs (2 condition: self-control exertion vs non-self-control exertion) x 2 (group: alexithymia vs non-alexithymia) were conducted to evaluate differences in daily stress, perceived physical fatigue, mental exertion, and physical performance (wall-sit duration). Additionally, a three-way mixed ANOVA (3 time: before wall-sit, immediately after, and 10 min post-task) x 2 (condition) x 2 (group) was performed to assess changes in state anxiety. Due to the variable number of within-task observations (initial measure at 15 s, then every 30 s thereafter), multilevel modelling was employed for the repeated measurement of RPE, pain, and motivation using linear mixed-effects models (lme function in R; Hunte et al., 2022). Models included fixed effects for group, condition, and time, and their interactions, with random intercepts to account for participant-level variation. Statistical significance was accepted at $p < 0.05$. Post hoc Monte Carlo simulations were conducted using the simr package in R (Green & MacLeod, 2016) to evaluate the statistical power of multilevel models. These simulations indicated low power to detect key interactions (time*condition) across all models (pain, 19 %, 95 % CI [11.8 %–28.1 %]; RPE, 8 %, 95 % CI [3.5 %–15.2 %]; and motivation, 10 %, 95 % CI [4.9 %–17.6 %]). Even with simulated larger samples ($N = 80$), power improved only marginally for pain (32 %), but remained unchanged for RPE and motivation, suggesting limited power to detect small effects within the trajectories of these measures.

## 3. Results

### 3.1. Descriptive statistics

All descriptive statistics including means and standard deviations for main study variables are shown in Table 1.

### 3.2. Preliminary manipulation checks

Participants did not differ between the condition or groups in levels of perceived physical fatigue ($p = 0.18$) or daily stress ($p = 0.21$) indicating no main effects of condition or group on these variables, therefore it was not necessary to control for physical fatigue or daily stress in the subsequent analyses. A significant main effect of condition on mental exertion was observed ($F_{(1, 38)} = 38.5, p < 0.001, \eta^2 = 0.50$). Participants reported higher levels of mental exertion following the self-control exertion Stroop task ($M = 4.01$, $SD = 2.28$) compared to the non-self-control exertion Stroop task ($M = 2.35$, $SD = 2.01$) demonstrating the successful manipulation of self-control exertion. There were no main effects of group (alexithymia vs non-alexithymia) on mental exertion scores ($p = 0.51$), and no condition*group interaction ($p = 0.11$). Additionally, a significant main effect of condition (self-control exertion vs non-self-control exertion) on correct Stroop responses was observed ($F_{(1, 38)} = 95.3$, $p < 0.001$, $\eta^2 = 0.72$). Participants had more correct responses during the non-self-control exertion Stroop task ($M = 238$, $SD = 33$) compared to the self-control exertion Stroop task ($M = 203$, $SD = 23.1$). There were no main effects of group (alexithymia vs non-alexithymia) on correct Stroop task responses ($p = 0.57$), and no condition*group interaction ($p = 0.95$). In addition, a significant main effect of condition on Stroop reaction time (self-control exertion vs non-self-control exertion) was observed ($F_{(1, 38)} = 20.4$, $p < 0.001$, $\eta^2 = 0.35$). Participants took longer to react to the Stroop Task in the self-control exertion condition ($M = 2552$, $SD = 1217$ ms) compared to the non-self-control exertion condition ($M = 1763$, $SD = 451$ ms). There were no main effects of group (alexithymia vs non-alexithymia) on Stroop reaction time ($p = 0.42$), and no condition*group interaction ($p = 0.17$).

### 3.3. Wall-sit performance

There were no significant main effects for condition ($p = 0.58$) or group ($p = 0.88$). However, there was a large and significant condition*group interaction effect for performance time ($F_{(1, 38)} = 21.5$, $p, < 0.001$, $\eta^2 = 0.36$). Specifically, the non-alexithymia group did not perform the wall-sit task for as long in the self-control exertion condition ($M = 157$, $SD = 89$ s) compared to the non-self-control exertion condition ($M = 171$, $SD = 86$ s; $MD = 14$, $p = 0.007$, 95 %CI [4.23, 24.5], $d = 0.2$). However, the opposite was observed for the alexithymia group, whereby these individuals performed the wall-sit task for longer in the self-control exertion condition ($M = 177$ $SD = 68$ s), compared to the non-self-control exertion condition ($M = 158$, $SD = 62$ s; $MD = -19$, $p < 0.001$, 95 %CI [-28.5, −8.3], $d = 0.3$). Fig. 1).

### 3.4. Mechanistic data

#### 3.4.1. Rate of perceived exertion (RPE)

RPE increased significantly over time ($\beta = 1.32$, 95 % CI [1.19, 1.45], $t_{(403)} = 20.2$, $p < 0.0001$; Table 2a) indicating growing perceived exertion across the task for all participants. A significant group*time interaction ($\beta = 0.53$, 95 % CI [0.32, 0.75], $t_{(403)} = 4.88$, $p < 0.001$) indicated that RPE increased more rapidly in the alexithymia group compared to the non-alexithymia group. Specifically, model estimates showed that RPE increased by 1.32 units every 30-s for the non-alexithymia group and by 1.85 units every 30 s for the alexithymia group. Furthermore, a significant group*condition*time interaction ($\beta = -0.31$, 95 % CI [−0.57, −0.06], $t_{(403)} = -2.30$, $p = 0.022$) indicated that this steeper rate of RPE increase in the alexithymia group was most

**Table 1**
Means and standard deviations for physical fatigue, daily stress, mental exertion, correct Stroop responses, Stroop reaction time and wall-sit performance across conditions and groups.

| Variables | Alexithymia | | | | Non-Alexithymia | | | |
|---|---|---|---|---|---|---|---|---|
| | No Exertion | | Self-control Exertion | | No Exertion | | Self-control exertion | |
| | M | SD | M | SD | M | SD | M | SD |
| Perceptions of Physical Fatigue | 2.13 | 0.97 | 2.08 | 0.97 | 2.25 | 0.87 | 1.85 | 0.95 |
| Daily Stress | 1.10 | 1.77 | 1.10 | 1.07 | 0.70 | 1.03 | 0.20 | 0.52 |
| Mental Exertion | 2.78* | 2.23 | 4.00* | 2.51 | 1.93* | 1.70 | 4.03* | 2.08 |
| Correct Stroop Responses | 235*** | 30 | 201*** | 30 | 241*** | 35 | 206*** | 33 |
| Stroop Reaction Time (ms) | 1800*** | 500 | 2300*** | 600 | 1700*** | 400 | 2800*** | 1600 |
| Wall-sit Performance Time (s) | 158.4$^{\dagger\dagger\dagger}$ | 61.5 | 176.8$^{\dagger\dagger\dagger}$ | 68.1 | 171.1$^{\dagger\dagger\dagger}$ | 85.8 | 156.7$^{\dagger\dagger\dagger}$ | 88.5 |

*Note.* Main effects; *p < 0.05; **p < 0.01; ***p < 0.001. Interaction effects $^{\dagger}$p < 0.05; $^{\dagger\dagger}$p < 0.01; $^{\dagger\dagger\dagger}$p < 0.001.

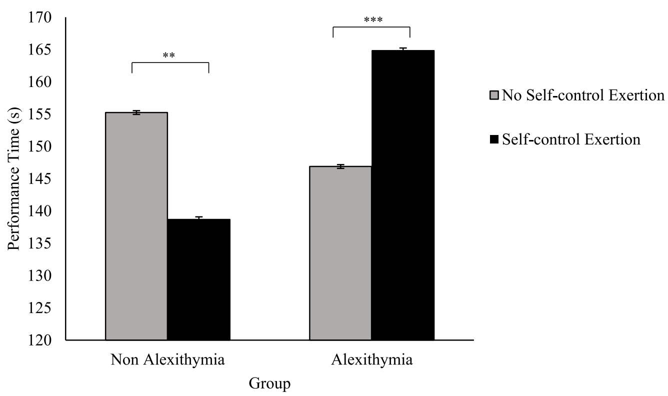


**Fig. 1.** An interaction between condition (non-self-control exertion; self-control exertion) and group (non-alexithymia; alexithymia) on wall-sit performance time.

pronounced under the self-control exertion condition. In this condition, the alexithymia group's RPE increased at an estimated 2.04 units per 30 s, compared to 1.32 for the non-alexithymia group. These findings suggest that individuals with alexithymia may experience physical effort as more taxing when self-control resources have been previously exerted (see Fig. 2). There were no significant main effects for group ($p = 0.87$) or condition ($p = 0.20$). Other interaction effects, including group*condition ($p = 0.41$) and condition*time ($p = 0.46$), were not significant (Table 2a).

### 3.4.2. Perceptions of pain

Perception of pain also increased significantly over time ($\beta = 0.94$, 95 % CI [0.85, 1.02], $t_{(403)} = 21.7$, $p < 0.0001$; Table 2b). A significant group*time interaction ($\beta = 0.24$, 95 % CI [0.10, 0.38], t (403) = 3.36, $p = 0.0009$), indicated that pain increased more rapidly in the alexithymia group (1.18 units per 30 s) than in the non-alexithymia group (0.94 units per 30-s; see Fig. 3). There were no significant main effects for group ($p = 0.49$) or condition ($p = 0.69$).

### 3.4.3. Perceptions of motivation

Motivation declined significantly over time across all participants ($\beta$

**Table 2**
Results of the multilevel models conducted for Rate of Perceived Exertion (a), Perceptions of Pain (b) and Perceptions of Motivation (c).

| Rate of Perceived Exertion (a) | Random Effects | Intercept | Standard Error | 95 % CI | | *t* | *p* |
|---|---|---|---|---|---|---|---|
| Main effect of trial | Intercept | 11 | 0.57 | 9.5 | 12 | 18 | <0.0001 |
| | Group | −1.3 | 0.83 | −2.9 | 0.31 | −1.6 | 0.12 |
| | Condition | −0.40 | 0.41 | −1.2 | 0.39 | −0.99 | 0.32 |
| | Time | 1.3 | 0.065 | 1.2 | 1.5 | 20 | <0.0001 |
| Trial*time interaction | Group*Condition | 0.50 | 0.61 | −0.70 | 1.7 | 0.82 | 0.41 |
| | Group*Time | 0.53 | 0.11 | 0.32 | 0.75 | 4.88 | <0.0001 |
| | Condition*Time | 0.060 | 0.082 | −0.10 | 0.22 | 0.73 | 0.46 |
| | Group*Condition*Time | −0.31 | 0.13 | −0.57 | −0.06 | −2.3 | 0.022 |
| **Perceptions of Pain (b)** | | | | | | | |
| Main effect of trial | Intercept | 2.8 | 0.46 | 1.9 | 3.7 | 6.1 | <0.0001 |
| | Group | −0.46 | 0.66 | −1.8 | 0.84 | −0.69 | 0.49 |
| | Condition | −0.10 | 0.27 | −0.63 | 0.42 | −0.40 | 0.69 |
| | Time | 0.94 | 0.043 | 0.85 | 1.0 | 22 | <0.0001 |
| Trial*time interaction | Group*Condition | 0.10 | 0.40 | −0.68 | 0.88 | 0.25 | 0.80 |
| | Group*Time | 0.24 | 0.07 | 0.10 | 0.38 | 3.4 | 0.0009 |
| | Condition*Time | 0.00044 | 0.05 | −0.10 | 0.10 | 0.0082 | 0.99 |
| | Group*Condition*Time | −0.15 | 0.088 | −0.32 | 0.022 | −1.7 | 0.086 |
| **Perception of Motivation (c)** | | | | | | | |
| Main effect of trial | Intercept | 7.1 | 0.67 | 5.8 | 8.4 | 11 | <0.0001 |
| | Group | −0.16 | 0.96 | −2.0 | 1.7 | −0.16 | 0.87 |
| | Condition | 0.44 | 0.34 | −0.23 | 1.1 | 1.3 | 0.20 |
| | Time | −0.77 | 0.056 | −0.88 | −0.67 | −14 | <0.0001 |
| Trial*time interaction | Group*Condition | −1.1 | 0.52 | −2.1 | −0.091 | −2.1 | 0.033 |
| | Group*Time | 0.0030 | 0.093 | −0.18 | 0.19 | 0.032 | 0.97 |
| | Condition*Time | −0.064 | 0.069 | −0.20 | 0.071 | −0.92 | 0.36 |
| | Group*Condition*Time | −0.30 | 0.11 | 0.079 | 0.52 | 2.7 | 0.0083 |

*Note:* The intercept represents the estimated baseline value of the dependent variable for participants in the control group and baseline condition at Time 0.

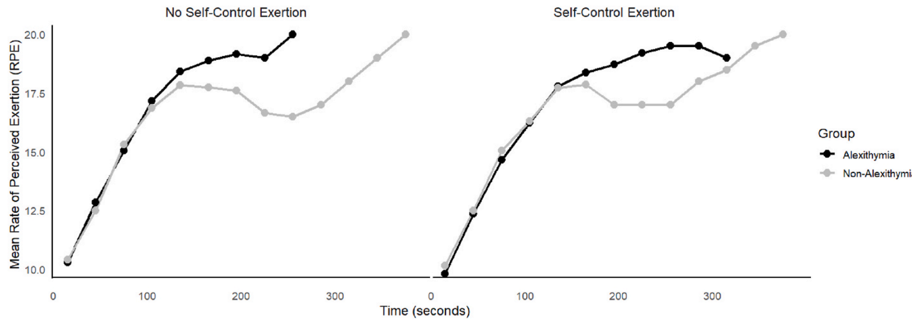


**Fig. 2.** An interaction between group (alexithymia and non-alexithymia), condition (self-control exertion and no-self-control exertion) and time on rate of perceived exertion (group*time interaction, $p < 0.001$; group*time*condition interaction, $p = 0.02$).

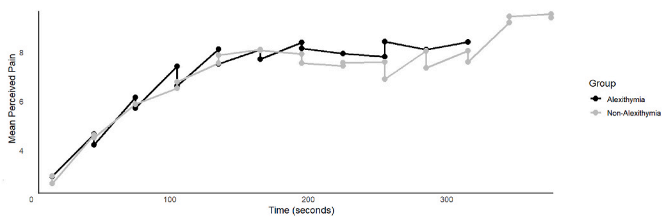


**Fig. 3.** An interaction between group (alexithymia and non-alexithymia) and time on perceived pain (group*time interaction, $p = 0.0009$).

$= -0.77$, 95 % CI [−0.88, −0.67], $t_{(403)} = -13.9$, $p < 0.0001$; Table 2c). A significant group*condition interaction ($\beta = -1.11$, 95 % CI [−2.10, −0.09], $t_{(403)} = -2.14$, $p = 0.033$) indicated that motivation was especially reduced in the alexithymia group under self-control exertion. Moreover, a significant group*condition*time interaction ($\beta = -0.30$, 95 % CI [0.08, 0.52], $t_{(403)} = -2.65$, $p = 0.008$) indicated that motivation declined more quickly over time in the alexithymia group under self-control (−1.07 units per 30 s) compared to the non-alexithymia group (−0.77 units per 30-s; see Fig. 4). There were no significant main effects for group ($p = 0.87$) or condition ($p = 0.20$) and other interaction effects (group*time: $p = 0.97$; condition*time: $p = 0.36$) were not significant.

### 3.4.4. State anxiety

There was a significant main effect of time ($F_{(2, 76)} = 35.8$, $p < 0.001$, $\eta^2 = 0.49$) indicating anxiety levels differed significantly across the three time points. Tukey post hoc tests revealed that anxiety scores significantly increased from before the wall-sit task to after the wall-sit task (32.8 vs 39.4, respectively; $MD = 6.54$, $p < 0.001$, 95 %CI [3.5, 9.6]), but then decreased significantly after 10-min following completion of the wall-sit task (39.4 vs 30.7, respectively; $MD = 8.70$, $p < 0.001$, 95 % CI [-11.3, −6.0]). There were no differences between anxiety scores before the wall-sit task and after 10-min following completion of the wall-sit task ($p = 0.63$). There was a significant main effect of group ($F_{(1, 38)} = 9.54$, $p = 0.004$, $\eta^2 = 0.20$) with the non-alexithymia group reporting significantly lower mean state anxiety scores than the alexithymia group (30.6 vs 38.0, respectively; $MD = 7.33$, $p = 0.004$, 95 %CI [12.1, 2.5]). There were no main effects of condition (self-control exertion) on state anxiety scores. A significant time*condition interaction was found ($F_{(1, 38)} = 4.22$, $p = 0.047$, $\eta^2 = 0.10$), indicating that state anxiety scores differed between the self-control exertion and no-self-control exertion conditions. Tukey post hoc tests revealed that state anxiety scores were significantly higher before the wall-sit task in the no-self-control exertion condition compared to the self-control exertion condition (34.6 vs 31.1, $MD = 3.50$, $p = 0.03$, 95 %CI [0.28, 6.7]). However, this difference did not persist after the wall-sit task ($p = 0.87$) or 10-min following completion of the wall sit task ($p = 0.76$; see Fig. 5). There were no interaction effects between time*group ($p = 0.28$), group*condition ($p = 0.49$) or time*group*condition ($p = 0.91$).

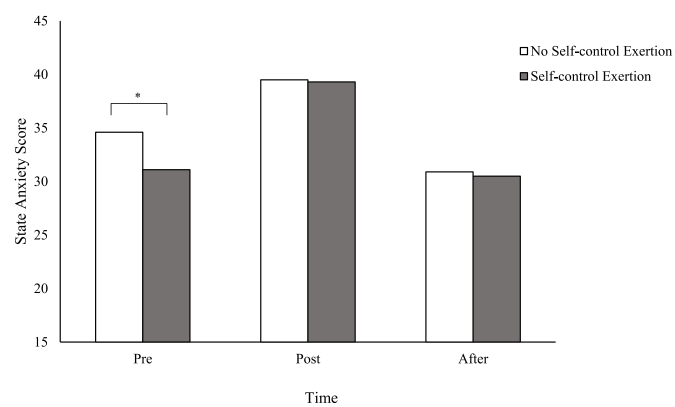


**Fig. 5.** An interaction between time (pre; post; after) and condition (no-self-control exertion; self-control exertion) on state anxiety scores.

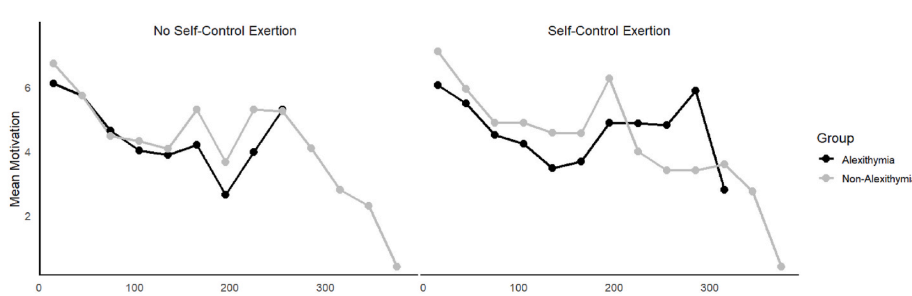


**Fig. 4.** An interaction between group (alexithymia and non-alexithymia), condition (self-control exertion and no-self-control exertion) and time on motivation (group*condition interaction, $p = 0.03$; group*time*condition interaction, $p = 0.008$).

## 4. Discussion

The primary aim of the study was to explore whether self-control exertion influences subsequent physical performance, in individuals with alexithymia, and whether any observed performance decrements could be explained by an individual's perception of pain, motivation, or RPE. In addition, the present study aimed to investigate whether the prior exertion of self-control affects changes in state anxiety, following performance on a physical task (as an indication of emotional regulation). In line with our hypotheses, the prior exertion of self-control did not lead to performance decrements in individuals with alexithymia on a subsequent wall-sit task, contrary to the expected effects seen in non-alexithymic individuals. Although pain increased over time for all participants, there were no significant differences between conditions or between groups. This finding contrasts with previous research (e.g., Boat et al., 2018) suggesting that self-control exertion typically influences pain perception, possibly due to task-specific or timing differences. Interestingly, although there were no main effects for motivation or RPE, interactions revealed that alexithymic individuals experienced a greater increase in RPE and a sharper decline in motivation under self-control exertion conditions. These findings align with previous work highlighting potential for altered interoceptive processing and attentional mechanisms in alexithymia (Pollatos et al., 2015; Graham et al., 2025). Although prior self-control exertion did not influence state anxiety following the physical task, alexithymic individuals consistently reported higher state anxiety across all timepoints, suggesting a generally heightened anxiety state irrespective of self-control exertion.

While self-control depletion typically impairs subsequent physical performance (Hunte et al., 2021), our findings provide novel evidence that individuals with alexithymia may be less susceptible to these effects. Specifically, alexithymic individuals performed better on the wall-sit task following self-control exertion, whereas non-alexithymic individuals showed the opposite pattern. This significant group*condition interaction aligns with proposals that alexithymic individuals may reflect a greater capacity for cognitive resource allocation (Graham et al., 2025). Prior research suggests that self-control depletion effects intensify as fatigue and attentional lapses accumulate (Boat, Williamson, et al., 2021), yet alexithymic individuals in this study showed greater resistance to these declines. This may reflect a cognitive strength (sustained attentional focus) that mitigates the usual performance costs of self-control exertion in physically demanding tasks (Becker et al., 2015).

Our study also found that perceptions of pain, motivation, and RPE were not influenced by prior self-control exertion in terms of main effects; however, notable interaction effects emerged. Specifically, alexithymic individuals exhibited a faster rise in pain and RPE, alongside greater declines in motivation, following self-control exertion. These findings align with recent evidence from Hunte et al. (2024), but contrast with earlier studies that typically reported increased pain perception and RPE alongside decreased motivation (e.g., Boat et al., 2018; Boat & Taylor, 2017). One explanation for these discrepancies involves methodological differences, particularly task duration. Previous studies that employed a shorter 4-min Stroop task, including the present study and those by Hunte et al. (2024) and Boat et al. (2020) found no significant differences in pain perception between self-control and no self-control conditions, even at varied measurement intervals (15 s, 30 s, or 3 min). In contrast, Boat et al. (2020) noted changes in pain perception after longer Stroop tasks (8 and 16 min), suggesting that the extent of cognitive exertion may be critical for influencing pain perception. Furthermore, while increased pain perception might intuitively explain performance decrements following self-control exertion, Hunte et al. (2022) found pain perception insufficient as a sole explanatory factor. Instead, attentional processes may offer a more robust mechanism, particularly within alexithymic populations. In the present study, the alexithymia group showed a sharper decline in motivation over time under self-control exertion. This pattern echoes findings by Brown and Bray (2017), who reported reduced motivation and performance following ego-depletion in tasks requiring sustained effort. They suggested that depleted attentional resources, rather than changes in perception alone, contributed to motivational decline. These effects may interact with individuals differences in attentional focus and interoceptive awareness (Pollatos et al., 2015), potentially making alexithymic individuals more sensitive to task demands when internal motivational cues are ambiguous or weak. It is possible therefore that the Stroop and wall-sit tasks were not sufficiently engaging or challenging to induce noticeable motivational shifts. As such, self-control exertion alone may not be enough to affect motivation in tasks lacking significance or complexity. Future research should investigate when attentional and motivational shifts toward immediate temptations occur to better understand the mechanisms behind self-control exertion's effects on physical performance, particularly with more meaningful and challenging tasks. Extending these findings, the patterns of results for RPE provides additional insight into how alexithymic individuals may respond differently to self-control exertion. Although RPE increased over time for all participants during the physical task, alexithymic individuals reported a significantly steeper increase following self-control exertion than their non-alexithymic counterparts. This heightened perception of effort might suggest distinct interoceptive processing in alexithymia, potentially altering how exertion is internally monitored and interpreted (Pollatos et al., 2015). Crucially, this increased subjective difficulty did not correspond to reduced performance. Instead, alexithymic individuals maintained or even improved performance, supporting the notion that they may sustain attentional focus more effectively during cognitively demanding conditions (Oudejans et al., 2011). This may reflect a tendency to rely more on external task cues than internal states, enabling them to override sensations of fatigue and persist despite perceived effort.

Finally, our findings support previous research showing that individuals with higher alexithymia scores also tend to report heightened levels of anxiety. Across all timepoints and conditions, alexithymia participants reported higher state anxiety than non-alexithymic participants. However, there was no significant group*time interaction, indicating that the wall-sit task did not differentially affect state anxiety between groups. Moreover, state anxiety returned to baseline following a brief rest period, suggesting that the physical task did not produce a sustained regulatory effect for either group. The absence of an anxiolytic effect may reflect the nature of the wall-sit task, which is designed to induce physical discomfort rather than emotional arousal, and therefore may not sufficiently engage emotion regulation processes (Boat et al., 2020). In contrast, emotionally salient environments, such as competitive sports, may offer greater opportunities for emotional regulation. Woodman and Welch (2021) suggest that alexithymic individuals may derive agentic benefits from engaging in sport potentially extending to high-pressure situations. Although we did not observe such effects here, future research could explore more complex tasks to test whether alexithymia offers an emotional advantage in high-stress, performance environments.

### 4.1. Limitations

While this study offers valuable insights, some limitations should be considered. First, while the sample consisted solely of athletes, this focus was intentional to explore alexithymia and self-control within a performance-focused population. However, the relative homogeneity of the sample, with limited diversity in sport type and competitive level, may limit the generalisability of the findings. Future research should consider recruiting athletes from a broader range of sports, competitive standards, and cultural contexts to determine whether the observed effects extend to more diverse populations. Second, while the sample size was adequate to detect large interaction effects in the primary ANOVA analyses and was consistent with previous research in this area (e.g., Boat et al., 2020), it was not large enough to detect smaller effects, particularly in the multilevel models examining changes in pain, RPE, and motivation over time. As noted earlier, post hoc simulations indicated that these models were underpowered to detect key interactions, and increasing the sample size only marginally improved power. Detecting such subtle effects would likely require a substantially larger sample, which was beyond the practical scope of the current repeated-measures design. Future research using larger and more diverse samples will be important to evaluate the reliability of these within-task findings. Third, although the wall-sit task was chosen for its practical strengths and is widely used in self-control research (Hunte et al., 2022), it has limited ecological validity. Specifically, it does not reflect the cognitive and emotional complexity of real-world performance settings, such as competitive sport, which often involve dynamic decision-making and emotion regulation. Future research should consider incorporating more complex and emotionally engaging tasks to better examine how alexithymia interacts with self-control under realistic performance conditions. Finally, the reliance on self-report measures for key variables, such as anxiety and perceived exertion, introduces potential biases, particularly for alexithymic individuals who may struggle with accurately identifying their emotions. While validated, self-report tools are limited in capturing the nuances of emotional regulation (Roos et al., 2022). Future studies would benefit from incorporating objective measures, such as physiological markers like cortisol or heart rate variability, to better assess emotional and physical responses during self-control exertion.

## 5. Conclusion

This study provides novel evidence that individuals with alexithymia are less susceptible to the typical performance impairments associated with prior self-control exertion. Despite reporting heightened anxiety, alexithymic individuals maintained, or even improved, physical performance, suggesting a potential cognitive advantage under prolonged exertion. This may reflect enhanced attentional control or reduced interference from emotional signals, enabling better focus during demanding tasks. From an applied perspective, these findings highlight the potential value of tailoring interventions for athletes high in alexithymic traits, with an emphasis on external focus rather than emotional introspection. While further research is needed, recognising individual differences in interoception, attention, and emotion processing could inform strategies to support athlete performance. Future investigations should attempt to expand on these findings by exploring the effects of prior self-control exertion, in an alexithymic population, across different sports.

## CRediT authorship contribution statement

**Hannah L. Graham:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ruth Boat:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Simon B. Cooper:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Noel P. Kinrade:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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