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# Differences in motivational dynamics between experienced cyclists and untrained participants during an incremental endurance exercise task

Izzy. G. Wellings *, Richard Ferguson, Ian M. Taylor

*School of Sport, Exercise & Health Sciences, Loughborough University, Leicestershire, LE11 3TU, UK*

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ABSTRACT

*Purpose:* The conflict between the desire to reduce effort during exercise and the performance goal of the exercise task contributes to explaining endurance exercise performance. However, whether the trajectories of these two motivational responses systematically differ across individuals with different characteristics is poorly understood. The present study examined whether changes in desire to reduce effort and performance goal value across moderate, heavy, and severe exercise intensity domains differed between cyclists and untrained, but active participants.

*Methods:* Fifty participants (14 cyclists and 36 untrained) completed an incremental step test on a cycle ergometer, in which work rate was increased by 25 W every 4 min until voluntary exhaustion. Desire to reduce effort, performance goal value, and blood lactate concentration (for determination of exercise intensity domains) were measured every 4 min and the data were analysed using multilevel modelling.

*Results:* Desire to reduce effort increased quicker for untrained participants in the moderate exercise intensity domain ($b = 1.66$, $p < .001$) and across the whole trial ($b = 1.64$, $p < .001$), compared to cyclists ($b = .69$, and $b = 1.14$, respectively, both $p < .001$). Untrained participants reported similar performance goal value at the beginning of the trial ($b = 16.02$, $p < .001$), compared to cyclists ($b = 17.25$, $p < .001$). Beyond moderate intensities, the performance goal value decreased significantly for the untrained participants ($b = -.70$, $p < .001$) but significantly increased for cyclists ($b = .45$, $p = .01$). This pattern was also observed when focusing solely on the severe intensity domain (cyclists: $b = .90$, $p < .001$; untrained: $b = -.84$, $p < .001$).

*Conclusion:* There are distinct differences in the desire to reduce effort and performance goal value between cyclists and untrained athletes. Identifying these systematic differences enhances the credibility of the desire-goal conflict framework in explaining endurance performance and provides insight into the type and timing of interventions that might be successful in improving performance.

## 1. Introduction

Endurance and persistence are essential abilities in various sports and athletic endeavours. During these activities, the decision to reduce effort or terminate endurance acts is impacted by both psychological and physiological factors. The latter help characterise potential limits of human endurance, but partial or complete disengagement from exercise often occurs prior to reaching these physiological parameters (Marcora et al., 2009). Psychological influences are, therefore, often the mitigating factor in endurance performance. Despite this significance, the underlying psychological dynamics during endurance performance are poorly understood. The present study aims to tackle this issue by examining whether dynamic motivational factors during endurance efforts differ between experienced cyclists and untrained populations.

Physiological changes (e.g., increased heart rate and blood lactate concentration during exercise), are detected by afferent receptors within the muscles which send signals to the central nervous system (Craig, 2003). These signals trigger awareness of whole-body homeostatic disturbance in several brain regions and aversive feelings towards the exercise are experienced (Damasio & Carvalho, 2013; Lambert et al., 2005). Avoiding this sensation and returning to homeostasis by reducing physical effort becomes a tempting and potentially satisfying proximal desire (Taylor, 2021). This largely hedonic desire to reduce effort conflicts against the relatively distal performance goal. The idiographic content of the performance goal varies (e.g., one individual may want to do their best, whereas another might be more focused on winning),

* Corresponding author.
*E-mail address:* i.g.wellings@lboro.ac.uk (Izzy.G. Wellings).

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however, it is the motivational magnitude (i.e., computational value) of the goal which is contrasted with the desire (Westbrook & Braver, 2015). This desire-goal conflict impacts overall endurance exercise performance. Specifically, a greater desire to reduce effort at the start of an endurance effort alongside a more rapid reduction in goal value over time can discriminate relatively poor endurance performance from successful (Taylor et al., 2020).

In line with the underpinning physiological responses to exercise, the desire to reduce effort and performance goal value do not change linearly but shift and accelerate across different exercise intensities, defined by specific physiological thresholds (Taylor et al., 2022). The moderate intensity domain refers to exercise below the intensity after which there is an initial increase in blood lactate concentration above resting values (i.e., first lactate threshold (LT1; Faude et al., 2009). The heavy intensity domain refers to intensities above LT1 but below a second lactate threshold (LT2) characterised by a second rise in blood lactate concentration above resting levels (Valenzuela et al., 2021). A consistent and steady increase in blood lactate concentration is observed in the heavy intensity domain, along with a steady increase in volume of oxygen uptake ($VO_2$), with stabilisation occurring after 20–30 min (Jones et al., 2011). No steady state in physiological variables, such as $VO_2$ and blood lactate, is obtained at intensities above LT2, which is referred to as the severe intensity domain. Over the course of an incrementally difficult endurance trial, the desire to reduce effort typically accelerates during the heavy intensity exercise domain, with further acceleration during severe exercise. Within-person changes in blood lactate concentration and heart rate have been associated with these disturbances in the desire to reduce effort. The trajectory of the performance goal value, however, only typically deviates during the severe intensity exercise domain, when it begins to significantly decrease (Taylor et al., 2022).

Underpinning this existing research (i.e., Taylor et al., 2022) is the implicit assumption that crossing these exercise intensity thresholds impacts the motivation of individuals consistently, however, this is unlikely to be the case. It is well established that trained athletes will cross these thresholds at higher work rates, compared to untrained participants. However, fitness and experience also influence the subjective interpretation of physiological responses (Treasure & Newbery, 1998; Schneider et al., 2009), irrespective of when thresholds are breached. Athletes are likely to interpret physiological responses as task-relevant neutral information, compared to untrained individuals who typically perceive the cues as an indication of physiological strain (e.g., Acevedo et al., 1994). Therefore, in addition to trained athletes' ability to delay breaching physiological thresholds, their psychological responses to crossing these thresholds also differ to untrained participants. These different reactions likely explain why trained individuals typically exhibit a curvilinear decline in affect during exercise (Petruzzello et al., 2001; Boutcher et al., 1997), whereas a linear decline in affect is generally observed in less trained individuals (e.g., Blanchard et al., 2001; Ekkekakis et al., 2011; Welch et al., 2007). Given the significant motivational role of affect (e.g., Berridge & Kringelbach, 2013), this evidence implies that trained athletes suffer less motivational disturbance when entering higher intensity exercise domains, compared to untrained athletes. Nonetheless, this hypothesis is important to test as any differences in motivational reactions to physiological thresholds may provide new opportunities for psychological interventions aimed at improving endurance capability. Any observed differences in motivational dynamics also give the underpinning desire-goal framework credibility in explaining important performance-related phenomena.

Based on the above, the aim of this study was to examine if the trajectories of desire to reduce effort and performance goal value during different exercise intensity domains systematically differ across experienced cyclists and untrained populations. It was hypothesized that cyclists (versus untrained) will have a lower mean level and slower rate of increase in desire to reduce effort in all exercise intensity domains. This will be coupled with a higher mean level and slower rate of decrease in the performance goal value across the exercise intensity domains.

## 2. Methods

### 2.1. Participants

Participants were 18–50 years old, with no history of cardiovascular, metabolic, or haematological disorders, and free of pre-existing medical conditions or family history that made high intensity exercise potentially unsafe. Cycling participants were required to perform > 5 h of cycling per week, whereas untrained participants were required to perform <1.5 h of aerobic exercise per week.

Fifty ($M_{age}$ = 23.52 years; $SD$ = 6.95 years) participants were recruited through word of mouth and social media. This sample size was chosen because 50 level-2 units (i.e., participants in the present study) is recommended for unbiased estimates in regression coefficients, variance components, and standard errors in multilevel modelling (Maas & Hox, 2005). Fourteen (11 males, 3 females; $M_{age}$ = 27.43 years; $SD$ = 12.18 years) experienced cyclists with an average $VO_{2max}$ of 54.0 (9.6) ml/kg/min (i.e., performance level 2/3; De Pauw et al., 2013) and thirty-six (17 males, 19 females; $M_{age}$ = 22.00 years; $SD$ = 2.34 years) untrained participants with an average $VO_{2max}$ of 40.0 (7.3) ml/kg/min (i.e., performance level 1, De Pauw et al., 2013) were recruited.[1]

### 2.2. Procedures

This study was part of a larger project examining the desire-goal conflict during endurance performance; details (i.e., research questions and data analysis strategy) of which were pre-registered on the open science framework (https://osf.io/np6ed). All experimental procedures were approved by a university ethics approval committee and conformed with the Declaration of Helsinki. Participants were fully informed of study details and the risks and discomforts associated with the experimental trial. It was clarified that participation was voluntary, data would be stored anonymously, and they had a right to withdraw at any point during the study without consequences. Participants provided written informed consent and completed questionnaires to establish that they met the inclusion criteria.

Self-selected motives are likely to hold more personal value than externally imposed motives (Ryan & Deci, 2019). Therefore, after participants were informed of the goal to continue cycling for as long as possible whilst the workload increased, they were asked to choose a complementary underpinning reason most salient to them from a list (i.e., to beat other participants; to prove my fitness; to do the best I possibly can; to learn about my mental and physical abilities; to be respected by the experimenters; to demonstrate my cycling ability; to be admired for my performance). These goals were designed to reflect different types of normative and self-referenced exercise goals commonly held by sport and exercise participants (Roberts et al, 1998). The chosen goal was placed on a wall in front of them for the duration of the trial and served as the only reminder of the goal. There was no verbal encouragement during the trial.

Participants then performed an incremental exercise test to voluntary exhaustion on an electronically braked cycle ergometer (Lode-Excalibur Sport, Lode B.V. Gronigen, The Netherlands). Ergometer saddle and handlebar dimensions were set up to suit individual specifications. Depending on experience and personal preference, untrained individuals started from 25 to 75 W and cyclists started from 75 to 150 W. This flexibility was used because absolute time taken to breach thresholds and terminate the trial were not relevant to the study hypotheses. Visual information regarding work rate and time passed was

[1] An anonymous reviewer asked if there were significant differences in age across the two groups, however, an independent samples $t$-test did not provide any evidence ($t = -1.66$, $p = .06$). Given this non-significant finding and that participants' age was not including in our pre-registered data analysis plan, we did not control for age in subsequent analysis.

obscured to avoid participants using this information to regulate their performance. Work rate was increased by 25 W every 4 min. The measures were spread out to avoid overburdening the participants and researchers at any one point. After 90 s of each stage, participants were asked to verbally respond to the measures of desire to reduce effort and performance goal value. Capillary blood samples (20 μL) were taken from the earlobe in the last 30 s of each 4-min stage and analysed within 1 h using a Biosen C-Line Glucose and Lactate analyzer (EKF Diagnostics). A blood lactate/work-rate curve was modelled for each participant using publicly available software (Newell et al., 2007). The work-rate corresponding to an initial increase of 1 mmol $L^{-1}$ above baseline concentration during the initial stage of the exercise test, and fixed blood lactate concentration of 4 mmol $L^{-1}$ were defined as LT1 and LT2, respectively. The moderate intensity domain corresponded to intensities prior to LT1, the heavy intensity domain to intensities between LT1 and LT2 and the severe intensity domain corresponded to all intensities above LT2. Pedal cadence was maintained above 70 rpm with the test terminated when the participant stopped, or cadence dropped below 70 rpm for more than 5 s.

### 2.3. Measures

***Desire to reduce effort and performance goal.*** The desire to reduce effort was measured by verbal responses to the instruction “Please rate to what extent you want to reduce your effort” on a scale ranging from 0 (not wanting to reduce effort at all) to 20 (definitely want to reduce effort immediately). The value of the performance goal was measured by responding to the instruction “Please rate how important is it to achieve your goal” on a scale ranging from 0 (not important at all) to 20 (extremely important). These scales have demonstrated nomological validity in previous research (e.g., Taylor et al., 2022).

### 2.4. Data analysis

To test the hypotheses, two multilevel growth models with desire to reduce effort as the dependent variable were constructed by adding linear time predictor variables (coded as 0, 1, 2, 3, etc.). A dichotomous “LT1” predictor variable was also added, with pre-lactate threshold (i.e., moderate intensity domain) coded as 0, and post-lactate threshold coded as 1 (see Taylor et al., 2022). This operationalisation removed individual variation in the time this threshold was breached, therefore, removing the potential effects of differences in physical fitness and standardizing participants’ underlying blood lactate concentration. A second dichotomous “trained status” predictor variable (0 = cyclists, 1 = untrained) was added. Finally, higher order interaction terms between linear time and LT1 (i.e., the rate of acceleration); linear time and trained status (differences in linear changes across trained status); LT1 and trained status (differences pre/post threshold across trained status); and linear time, LT1 and trained status (differences in the rate of acceleration pre/post threshold across trained status) were integrated. In accordance with guidelines, the highest order statistically significant interaction was interpreted (Aiken & West, 1991). The second model replicated these models but with LT2 replacing LT1 to examine before and after participants entered severe exercise intensities. Any significant interactions were probed using guidelines for simple slopes analysis (Preacher et al., 2006). These two models were then replicated with performance goal value as the dependent variable.

## 3. Results

### 3.1. Descriptive analysis

Descriptive statistics for the study variables at LT1 and LT2, as well as average work rate at these thresholds can be found in Table 1. Untrained participants completed, on average, 8.08 stages ($SD$ = 1.50), which is equivalent to approximately 32 min of work. Cyclists completed, on average, 9.71 stages ($SD$ = 1.68), equivalent to 39 min of work. Average work rate at LT1 and LT2 for untrained participants was 50 % and 73 % of participants’ finishing work rate, respectively. For cyclists, these thresholds occurred at 76 % and 90 % of their finishing work rate, respectively. Intercept only models revealed that 99.6 % of the variance for the desire to reduce effort was at the within-person level and .4 % was at the between person level. Thirty-nine percent of the variance in performance goal value was at the within-person level and 61 % was at the between-person level.

### 3.2. Primary analysis

Table 2 describes the 4 multilevel growth models. Model 1 revealed a significant three-way interaction between trained status, LT1 and time to predict desire to reduce effort. Simple slopes analysis revealed that initial desire to reduce effort was not significantly different from zero in

**Table 2**
Multilevel Growth Models describing Trajectories of Desire to Reduce Effort and Performance Goal Value in Cyclist and Untrained Populations.

| Outcome | Desire to Reduce Effort LT1 Model 1 | Desire to Reduce Effort LT2 Model 2 | Goal Value LT1 Model 3 | Goal Value LT2 Model 4 |
|---|---|---|---|---|
| *Fixed Effects (SE in parentheses)* | | | | |
| Intercept | −.64 (.82) | **−1.46 (.79)** | **17.25 (.85)** | **17.34 (.84)** |
| Linear Time | **.69 (.15)** | **1.12 (.12)** | .10 (.11) | .03 (.08) |
| Lactate Threshold | **−8.23 (1.76)** | −5.20 (3.15) | **−3.18 (1.31)** | **−7.34 (2.21)** |
| Trained/ Untrained | .11(.99) | .58 (.94) | −1.23 (1.01) | −1.24 (1.0) |
| Time × LT | **1.93 (.26)** | **1.26 (.38)** | .35 (.19) | **.87 (.27)** |
| Time × Trained status | **.97 (.26)** | **.54 (.18)** | −.20 (.19) | −.06 (.12) |
| LT × Trained status | **4.17 (1.90)** | 2.57 (3.33) | **5.86 (1.41)** | **10.72 (2.34)** |
| Time × LT × Trained status | **−.86 (.34)** | −.34 (.43) | **−.94 (.25)** | **−1.68 (.30)** |
| *Random Effects* | | | | |
| Level 1 | **6.86 (.51)** | **7.47 (.56)** | **3.75 (.28)** | **3.63 (.27)** |
| Level 2 | **6.20 (1.42)** | **5.51 (1.30)** | **8.24 (1.75)** | **8.31 (1.76)** |

*Note.* Bold figures indicate statistical significance ($p < .05$). Exact values can be calculated from the $Z$ scores ($b/SE$). LT = Lactate Threshold.

**Table 1**
Descriptive statistics of study variables.

| Variable | Untrained Participants | | | | Cyclists | | | |
|---|---|---|---|---|---|---|---|---|
| | LT1 | | LT2 | | LT1 | | LT2 | |
| | Mean (SD) | Range | Mean (SD) | Range | Mean (SD) | Range | Mean (SD) | Range |
| Desire to reduce effort | 9.52 (3.61) | 0–17 | 11.91 (4.30) | 0–20 | 10.43 (4.43) | 0–14 | 12.38 (4.57) | 0–20 |
| Performance goal | 14.86 (3.47) | 8–20 | 14.52 (3.87) | 5–20 | 17.14 (3.43) | 10–20 | 17.54 (2.89) | 10–20 |
| Work rate (watts) | 100 (39) | 50–200 | 147 (42) | 75–225 | 220 (45) | 150–300 | 257 (49) | 200–350 |

*Note.* LT1 and LT2 refer to lactate thresholds 1 and 2.

either cyclists ($b = -.64$, $p = .43$) or untrained ($b = -.54$, $p = .33$) participants. The desire to reduce effort increased quicker prior to LT1 in untrained participants ($b = 1.66$, $p < .001$), compared to cyclists ($b = .69$, $p < .001$). Post-LT1, the desire to reduce effort increased at a similar rate in cyclists ($b = 2.62$, $p < .001$) and untrained ($b = 2.73$, $p < .01$) participants. These trends are graphically illustrated in Figure 1.

Model 2 revealed a non-significant three-way interaction, however, the linear change in desire to reduce effort was different across cyclists and untrained participants (i.e., the interaction between trained status and time was significant). Simple slopes analysis revealed the desire to reduce effort increased quicker in untrained participants ($b = 1.64$, $p < .001$) compared to cyclists ($b = 1.14$, $p < .001$) across the length of the trial. The difference in average desire to reduce effort before and after LT2 were similar in cyclists and untrained participants (i.e., the interaction between trained status and LT2 was non-significant). These trends are graphically illustrated in Figure 2.

In Model 3. a significant three-way interaction occurred between trained status, LT1 and time. Simple slopes analysis revealed that initial performance goal value differed significantly from zero in cyclists ($b = 17.25$, $p < .01$) and untrained participants ($b = 16.02$, $p < .001$). This goal value did not change pre-LT1 in cyclists ($b = .10$, $p = .40$), or in untrained participants ($b = -.12$, $p = .49$). Post-LT1, the performance goal value decreased significantly for untrained participants ($b = -.70$, $p < .001$) but significantly increased for cyclists ($b = .45$, $p = .01$). These trends are graphically illustrated in Figure 1.

In Model 4, a three-way interaction occurred between trained status, LT2 and time. Simple slopes analysis revealed that initial performance goal value differed significantly from zero in cyclists ($b = 17.34$, $p < .01$) and untrained participants ($b = 16.10$, $p < .001$). This goal value did not change pre-LT2 in cyclists ($b = .03$, $p = .76$), nor untrained participants ($b = -.03$, $p = .73$). Post-LT2, the performance goal significantly increased for cyclists ($b = .90$, $p < .001$) but decreased significantly for untrained participants ($b = -.84$, $p < .001$). These trends are graphically illustrated in Figure 2.

## 4. Discussion

The desire-goal conflict has been recognised as a valid framework, contributing towards performance during endurance exercise (Taylor et al., 2020), however, until now it had not been employed to examine potential motivational differences in experienced cyclists and untrained participants. The criterion for experienced cyclists was that they engage in more than 5 h of cycling per week. Untrained participants were healthy individuals who engaged in less than 1.5 h of aerobic exercise per week. Blood lactate thresholds were used as markers to examine changes in desire to reduce effort and performance goal value through the moderate, heavy, and severe exercise intensity domains. It is well established that trained athletes cross lactate thresholds at higher work rates, therefore, taking more time to reach the threshold during incremental endurance exercise tests, compared to untrained athletes. However, in the present study we accounted for this confound by disaggregating the effect of time from each participant's thresholds, allowing us to directly compare participants' motivational responses. As expected, marked differences in trajectories of the desire to reduce effort and performance goal value were observed. These findings provide a motivational basis for trained status-related performance differences and future interventions. That is, the desire to reduce effort or performance goal value could be targeted to alter endurance performance.

Unsurprisingly, the desire to reduce effort was negligible at the beginning of the endurance bouts for both participant groups, however, it increased more rapidly in untrained individuals during the moderate intensity domain (i.e., below LT1). This finding is in line with untrained

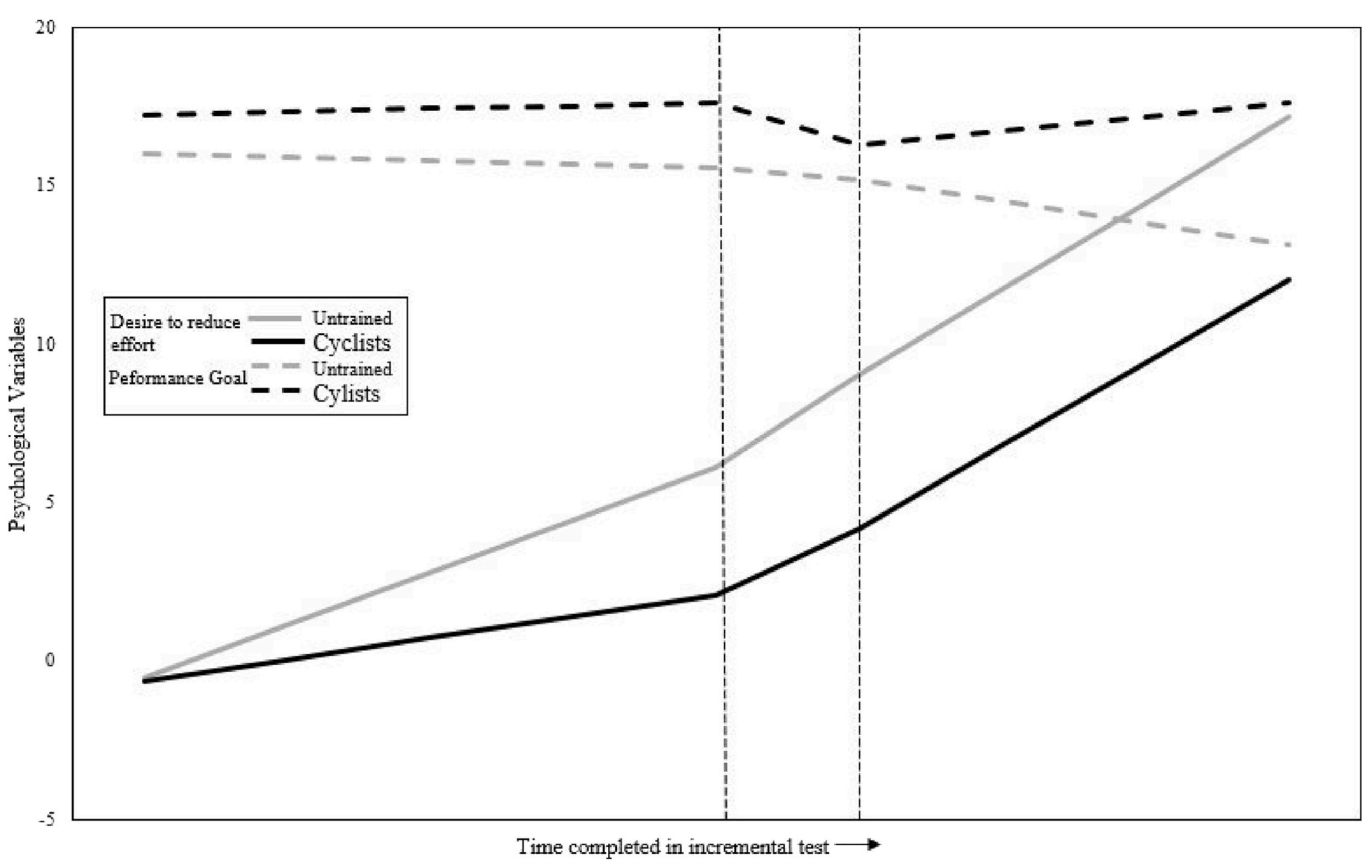


**Figure 1.** Difference in change in desire and performance goal value for cyclists & untrained participants at lactate threshold 1.
Note. Lactate threshold 1 occurs between the two dotted lines.

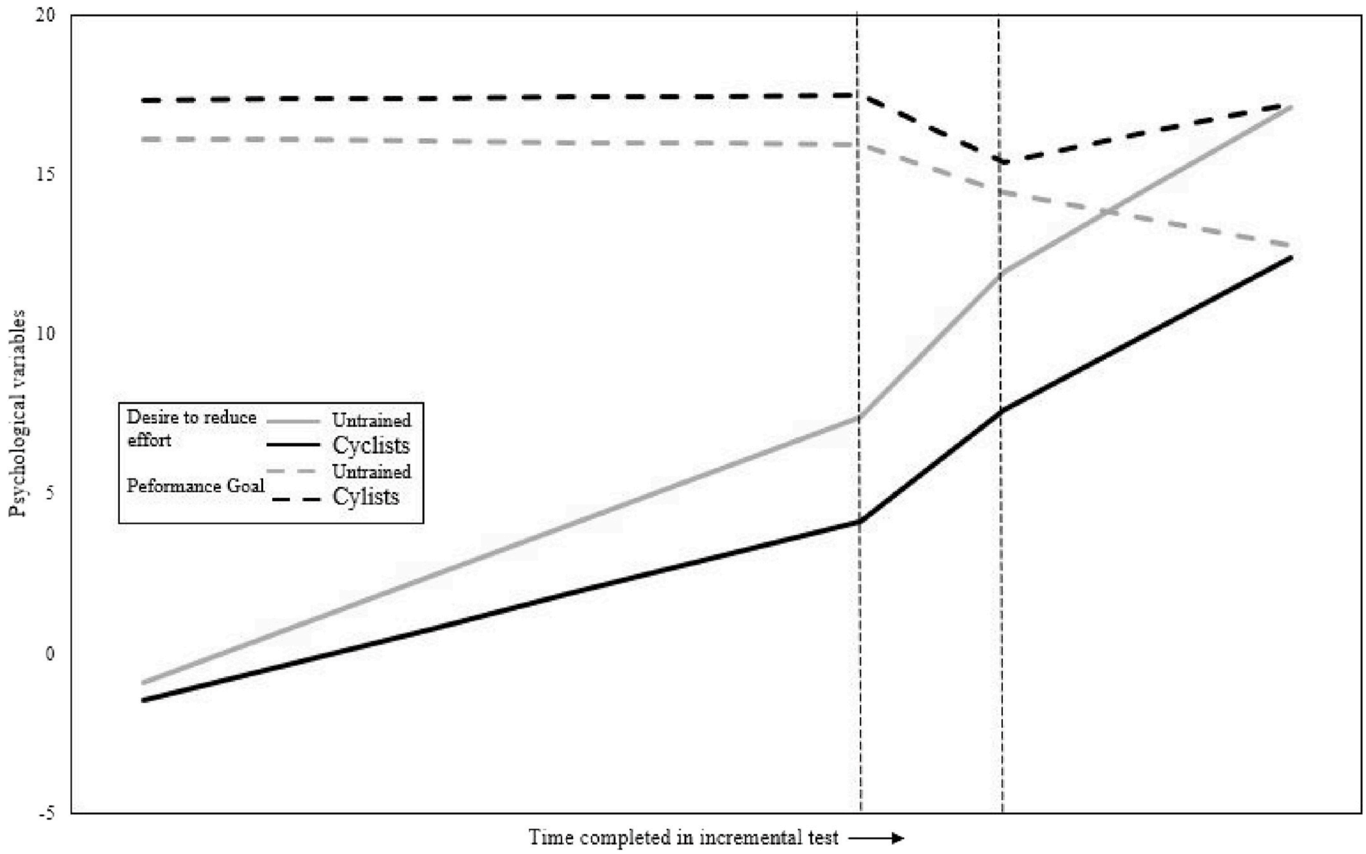


**Figure 2.** Differences in Change in Desire to reduce effort and Performance Goal Value for Cyclists & Untrained Participants at Lactate Threshold 2.
Note. Lactate threshold 2 occurs between the two dotted lines.

participants tendency to experience exercise negatively almost instantly (Boutcher et al., 1997), especially when exercise intensity is imposed on them (e.g., by the experimenter; Rose & Parfitt, 2007). In contrast, trained athletes are more accustomed to exercise at this intensity, therefore, their feelings tend to be positively valenced (Boutcher et al., 1997; Olney et al., 2018; Petruzzello et al., 2001). Relatedly, more experienced athletes may develop a greater value of exerting effort (Inzlicht et al., 2018) or more willing to pay the 'cost' of exerting effort (Chong et al., 2018), therefore, a desire to reduce it manifests more slowly. In the present study, the experienced cyclists' desire to reduce effort also increased in the moderate intensity domain, but the effect size was relatively small ($b = .69$, compared to $b = 1.66$ in untrained participants). The underpinning physiological responses to exercise (e.g., blood lactate concentration) are typically stable at this intensity with little homeostatic disturbance (MacIntosh et al., 2021). Therefore, increases in desire to reduced effort in both groups are likely to be explained by other factors, such as boredom (Wolff et al., 2021) or the rising costs of effort over time (Kurzban et al, 2013). Alternatively, increasing desire to reduce effort could also be explained by neurological factors given that the varying activation of various brain structures underpins effort- and goal-based decision making (Müller & Apps, 2019).

As participants crossed LT1 and moved beyond moderate intensity exercise, the desire to reduce effort increased similarly for cyclists and untrained. This motivational disturbance is likely due to a significant departure from physiological homeostasis (Ekkekakis et al., 2005), yet it was somewhat unexpected that the rate of change was similar across cyclists and untrained participants. Although, results were in line with expectations when inspecting the linear change across the whole trial, where the desire to reduce effort increased more steeply for untrained participants. Trained individuals are likely better prepared to cope with the uncomfortable sensations associated with the endurance test. For example, experienced athletes tend to use problem focused coping strategies which involve increasing effort when difficulty rises (Cosma et al., 2020). In contrast, less experienced athletes typically have maladaptive coping strategies and have not developed the necessary skills to cope effectively under pressure (Rose et al., 2023). It is also possible that trained individuals view the performance-related discomfort as a necessary part of the exercise, whereas untrained participants focus more on the physiological strain causing their desire to reduce effort to increase more rapidly (Acevedo et al., 2003).

Overall, these results demonstrate that important differences in avoidance motivation first manifest within the moderate intensity domain and continue to be observed at higher intensities. However, interventions to delay increases in desire to reduce effort might differ according to the exercise domain. In the moderate intensity domain, interventions should focus on the cognitive underpinnings of increases in the desire to reduce effort (e.g., relieving worry or dread) because physiological responses to exercise are relatively stable in both trained cyclists and untrained participants. For example, these strategies could focus on reappraising thoughts about effort and exertion during endurance activity (Meijen et al., 2020). Alternatively, interventions could target improvements in self-regulation and management of the increasing effort costs as intensity increases (McCormick et al., 2019). In contrast, psychosomatic interventions may be more suited to the severe intensity domain when physiological responses are extremely unstable. Such interventions might include tackling irrational beliefs about the meaning of significant physiological disturbances and discomfort (Stevens et al., 2018).

In addition to differences in the desire to reduce effort, the performance goal trajectory also varied across cyclists and untrained individuals. The motivational magnitude of the performance goal was similar across cyclists and untrained participants at the beginning of the exercise test. This contrasts with the lay notion that trained athletes are universally more motivated than non-athletes. Indeed, in the moderate intensity domain, the performance goal value did not change for the cyclist population or in the untrained population. Beyond moderate intensities, performance goal value reduced for the untrained population but increased for the cyclists. These differences in trajectory were also observed when focusing specifically on severe intensity exercise (i.e., Model 4). A greater ability to deal with performance demands and the need to avoid failure in trained performers (Liew et al., 2019; Šmela et al., 2017) may explain why the performance goal value increases by a small amount in these individuals. In fact, it's possible that the small increases in performance goal value are reflective of mental toughness in trained athletes (Gucciardi, 2010). Moreover, trained individuals have more experience setting goals, which may help them to choose personal goals which are more resilient (Sheehan et al., 2018). It is likely that trained individuals identify with being an athlete and the goal of performing well is congruent with that identity, hence, the goal is robust to increasing task difficulty (cf. Ntoumanis et al., 2014). In contrast, untrained participants may reduce their goal value to safeguard their self-worth as the work rate gets more difficult. Past research has often presumed that physiological factors primarily determine performance success during severe intensity exercise (e.g., Ament & Verkerke, 2009; Midgley et al., 2007). However, the different performance goal trajectories between the cyclists and untrained populations, despite ostensibly the same physiological underpinnings (as reflected by blood lactate concentration), implies that psychological factors also impact on success during exercise. This implies that less trained participants should set more resilient identity-congruent goals and receive education on effective coping strategies to help to improve performance.

### 4.1. Limitations & future directions

The present study determined important differences in motivational dynamics across experienced cyclists and untrained individuals. However, some limitations and future directions are noteworthy. First, we instructed participants that the goal of the task was to cycle for as long as possible. However, distinct goals have different effectivity, with normative-referenced goals (e.g., performing well to impress others) potentially becoming more fragile when exercise becomes increasingly difficult, relatively to self-referenced goals (e.g., performing well to improve fitness; Duda, 2004). Moreover, process and performance goals potentially enhance performance, lower anxiety, and improve confidence and motivation, compared to ego and outcome goals (Williamson et al., 2022). Therefore, further research is necessary that formally manipulates goal content and examines the trajectories of differing performance goal content. Second, our untrained group consisted of individuals who were relatively high fitness, compared to the general population. A relatively unfit population would presumably have a more unstable desire to reduce effort and performance goal. Relatedly, our cyclists were more experienced in endurance exercise and had higher fitness, compared to the untrained participants. Future research may wish to separate potentially different effects of fitness and experience on desire-goal trajectories. Finally, future research should aim to test interventions that educate individuals on their motivational responses across the different intensity domains. For example, interventions that improve performance goal setting by making the goals congruent with one's identity or advice on managing performance-related discomfort might hold value.

### 4.2. Summary and conclusion

The present study established clear differences between the trajectories of the desire to reduce effort and the performance goal value between experienced cyclists and untrained but active individuals. The desire to reduce effort increased more steeply for the untrained population in the moderate and severe intensity exercise domains. The performance goal stayed constant for the untrained population in relatively early stages of exercise, but then decreased sharply in the severe intensity domain. The performance goal remained robust for the cyclist population throughout the exercise task with small increases occurring after each lactate threshold. These results demonstrate that there are important motivational differences between these two populations and provides insight into the type of interventions that might be successful in improving performance. Moreover, the ability of the desire-goal conflict framework to distinguish between experienced cyclists and untrained individuals enhances its credibility.

## CRediT authorship contribution statement

**Izzy. G. Wellings:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Richard Ferguson:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization. **Ian M. Taylor:** Writing – review & editing, Supervision, Resources, Methodology, 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

The data and multilevel models have been added to the OSF website.

## References


Acevedo, E. O., Kraemer, R. R., Haltom, R. W., & Tryniecki, J. L. (2003). Perceptual responses proximal to the onset. *The Journal of Sports Medicine and Physical Fitness, 43*, 267–273. PMID: 14625505.

Acevedo, E. O., Rinehardt, K. F., & Kraemer, R. R. (1994). Perceived exertion and affect at varying intensities of running. *Research Quarterly for Exercise & Sport, 65*(4), 372–376. https://doi.org/10.1080/02701367.1994.10607643

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Sage Publications, Inc. https://doi.org/10.2307/2348581

Ament, W., & Verkerke, G. J. (2009). Exercise and fatigue. *Sports Medicine, 39*(5), 389–422. https://doi.org/10.2165/00007256-200939050-00005

Berridge, K. C., & Kringelbach, M. L. (2013). Neuroscience of affect: Brain mechanisms of pleasure and displeasure. *Current Opinion in Neurobiology, 23*(3), 294–303. https://doi.org/10.1016/j.conb.2013.01.017

Blanchard, C. M., Rodgers, W. M., Spence, J. C., & Courneya, K. S. (2001). Feeling state responses to acute exercise of high and low intensity. *Journal of Science and Medicine in Sport, 4*(1), 30–38. https://doi.org/10.1016/s1440-2440(01)80005-0

Boutcher, S. H., McAuley, E., & Courneya, K. S. (1997). Positive and negative affective response of trained and untrained subjects during and after aerobic exercise. *Australian Journal of Psychology, 49*(1), 28–32. https://doi.org/10.1080/00049539708259847

Chong, T. T. J., Apps, M. A., Giehl, K., Hall, S., Clifton, C. H., & Husain, M. (2018). Computational modelling reveals distinct patterns of cognitive and physical motivation in elite athletes. *Scientific Reports, 8*(1), Article 11888. https://doi.org/10.1038/s41598-018-30220-3

Cosma, G., Chiracu, A., Stepan, R., Cosma, A., Nanu, C., & Păunescu, C. (2020). Impact of coping strategies on sport performance. *Journal of Physical Education and Sport, 20*(3), 1380–1385. https://doi.org/10.7752/jpes.2020.03190

Craig, A. D. (2003). Interoception: The sense of the physiological condition of the body. *Current Opinion in Neurobiology, 13*(4), 500–505. https://doi.org/10.1016/S0959-4388(03)00090-4

Damasio, A., & Carvalho, G. (2013). The nature of feelings: Evolutionary and neurobiological origins. *Nature Review Neuroscience, 14*, 143–152. https://doi.org/10.1038/nrn3403

De Pauw, K., Roelands, B., Cheung, S. S., De Geus, B., Rietjens, G., & Meeusen, R. (2013). Guidelines to classify subject groups in sport-science research. *International Journal of Sports Physiology and Performance, 8*(2), 111–122. https://doi.org/10.1123/ijspp.8.2.111

Duda, J. L. (2004). Goal setting and achievement motivation in sport. *Encyclopedia of applied psychology, 2*, 109–119. https://doi.org/10.1016/B0-12-657410-3/00804-7

Ekkekakis, P., Hall, E. E., & Petruzzello, S. J. (2005). Variation and homogeneity in affective responses to physical activity of varying intensities: An alternative perspective on dose-response based on evolutionary considerations. *Journal of Sports Sciences, 23*(5), 477–500. https://doi.org/10.1080/02640410400021492

Ekkekakis, P., Parfitt, G., & Petruzzello, S. J. (2011). The pleasure and displeasure people feel when they exercise at different intensities. *Sports Medicine, 41*(8), 641–671. https://doi.org/10.2165/11590680-000000000-00000

Faude, O., Kindermann, W., & Meyer, T. (2009). Lactate threshold concepts: How valid are they? *Sports Medicine, 39*(6), 469–490. https://doi.org/10.2165/00007256-200939060-00003

Gucciardi, D. F. (2010). Mental toughness profiles and their relations with achievement goals and sport motivation in adolescent Australian footballers. *Journal of Sports Sciences, 28*(6), 615–625. https://doi.org/10.1080/02640410903582792

Inzlicht, M., Shenhav, A., & Olivola, C. Y. (2018). The effort paradox: Effort is both costly and valued. *Trends in Cognitive Sciences, 22*(4), 337–349. https://doi.org/10.1016/j.tics.2018.01.007

Jones, A. M., Grassi, B., Christensen, P. M., Krustrup, P., Bangsbo, J., & Poole, D. C. (2011). Slow component of VO2 kinetics: Mechanistic bases and practical applications. *Medicine & Science in Sports & Exercise, 43*(11), 2046–2062. https://doi.org/10.1249/MSS.0b013e31821fcfc1

Kurzban, R., Duckworth, A., Kable, J. W., & Myers, J. (2013). An opportunity cost model of subjective effort and task performance. *The Behavioral and brain sciences, 36*(6), 661–679. https://doi.org/10.1017/S0140525X12003196

Lambert, E. V., St Clair Gibson, A., & Noakes, T. D. (2005). Complex systems model of fatigue: Integrative homeostatic control of peripheral physiological systems during exercise in humans. *The Journal of Sports Medicine, 39*, 52–62. https://doi.org/10.1136/bjsm.2003.011247

Liew, G. C., Kuan, G., Chin, N. S., & Hashim, H. A. (2019). Mental toughness in sport. *German Journal of Exercise and Sport Research, 49*(4), 381–394. https://doi.org/10.1007/s12662-019-00603-3

Maas, C. J., & Hox, J. J. (2005). Sufficient sample sizes for multilevel modeling. *Methodology, 1*(3), 86–92. https://doi.org/10.1027/1614-1881.1.3.86

MacIntosh, B. R., Murias, J. M., Keir, D. A., & Weir, J. M. (2021). What is moderate to vigorous exercise intensity? *Frontiers in Physiology, 12*, Article 682233. https://doi.org/10.3389/fphys.2021.682233

Marcora, S. M., Staiano, W., & Manning, V. (2009). Mental fatigue impairs physical performance in humans. *Journal of applied physiology, 106*(3), 857–864. https://doi.org/10.1152/japplphysiol.91324.2008

McCormick, A., Meijen, C., Anstiss, P. A., & Jones, H. S. (2019). Self-regulation in endurance sports: Theory, research, and practice. *International Review of Sport and Exercise Psychology, 12*(1), 235–264. https://doi.org/10.1080/1750984X.2018.1469161

Meijen, C., Turner, M., Jones, M. V., Sheffield, D., & McCarthy, P. (2020). A theory of challenge and threat states in athletes: A revised conceptualization. *Frontiers in Psychology, 11*, 126. https://doi.org/10.3389/fpsyg.2020.00126

Midgley, A. W., McNaughton, L. R., & Carroll, S. (2007). Physiological determinants of time to exhaustion during intermittent treadmill running at $VO_{2max}$. *International Journal of Sports Medicine, 28*(4), 273–280. https://doi.org/10.1055/s-2006-924336

Müller, T., & Apps, M. A. (2019). Motivational fatigue: A neurocognitive framework for the impact of effortful exertion on subsequent motivation. *Neuropsychologia, 123*, 141–151. https://doi.org/10.1016/j.neuropsychologia.2018.04.030

Newell, J., Higgins, D., Madden, N., Cruickshank, J., Einbeck, J., McMillan, K., & McDonald, R. (2007). Software for calculating blood lactate endurance markers. *Journal of Sports Sciences, 25*(12), 1403–1409. https://doi.org/10.1080/02640410601128922

Ntoumanis, N., Healy, L. C., Sedikides, C., Duda, J., Stewart, B., Smith, A., & Bond, J. (2014). When the going gets tough: The "why" of goal striving matters. *Journal of Personality, 82*(3), 225–236. https://doi.org/10.1111/jopy.12047

Olney, N., Wertz, T., LaPorta, Z., Mora, A., Serbas, J., & Astorino, T. (2018). Comparison of acute physiological and psychological responses between moderate-intensity continuous exercise and three regimes of high-intensity interval training. *The Journal of Strength & Conditioning Research, 32*(8), 2130–2138. https://doi.org/10.1519/JSC.0000000000002154

Petruzzello, S. J., Hall, E. E., & Ekkekakis, P. (2001). Regional brain activation as a biological marker of affective responsivity to acute exercise: Influence of fitness. *Psychophysiology, 38*(1), 99–106. https://doi.org/10.1111/1469-8986.3810099

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interaction effects in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics, 31*, 437–448. https://psycnet.apa.org/doi/10.3102/10769986031004437.

Roberts, G. C., Treasure, D. C., & Balague, G. (1998). Achievement goals in sport: The development and validation of the perception of success questionnaire. *Journal of Sports Sciences, 16*(4), 337–347. https://doi.org/10.1080/02640419808559362

Rose, S., Burton, D., Kercher, V., Grindley, E., & Richardson, C. (2023). Enduring stress: A quantitative analysis on coping profiles and sport well-being in amateur endurance athletes. *Psychology of Sport and Exercise, 65*, Article 102365. https://doi.org/10.1016/j.psychsport.2022.102365

Rose, E. A., & Parfitt, G. (2007). A quantitative analysis and qualitative explanation of the individual differences in affective responses to prescribed and self-selected exercise intensities. *Journal of Sport & Exercise Psychology, 29*(3), 281–309. https://doi.org/10.1123/jsep.29.3.281

Ryan, R. M., & Deci, E. L. (2019). Brick by brick: The origins, development, and future of self-determination theory. In *Advances in motivation science, 6* pp. 111–156). Elsevier. https://psycnet.apa.org/doi/10.1016/bs.adms.2019.01.001.

Schneider, M., Dunn, A., & Cooper, D. (2009). Affect, exercise, and physical activity among healthy adolescents. *Journal of Sport & Exercise Psychology, 31*(6), 706–723. https://doi.org/10.1123/jsep.31.6.706

Sheehan, R. B., Herring, M. P., & Campbell, M. J. (2018). Associations between motivation and mental health in sport: A test of the hierarchical model of intrinsic and extrinsic motivation. *Frontiers in Psychology, 9*, 707. https://doi.org/10.3389/fpsyg.2018.00707

Šmela, P., Pačesová, P., Kraček, S., & Hájovský, D. (2017). Performance motivation of elite athletes, recreational athletes and non-athletes. *Acta Facultatis Educationis Physicae Universitatis Comenianae, 57*(2), 125–133. https://doi.org/10.1515/afepuc-2017-0012

Stevens, C. J., Mauger, A. R., Hassmèn, P., & Taylor, L. (2018). Endurance performance is influenced by perceptions of pain and temperature: Theory, applications and safety considerations. *Sports Medicine, 48*, 525–537. https://doi.org/10.1007/s40279-017-0852-6

Taylor, I. M. (2021). A motivational model of endurance and persistence. In C. Englert, & I. M. Taylor (Eds.), *Motivation & self-regulation in sport and exercise* (pp. 87–101). London: Routledge.

Taylor, I. M., Boat, R., & Murphy, S. L. (2020). Integrating theories of self-control and motivation to advance endurance performance. *Psychology of Sport and Exercise, 13*(1), 1–20. https://doi.org/10.1080/1750984X.2018.1480050

Taylor, I. M., Smith, K., & Hunte, R. (2020). Motivational processes during physical endurance tasks. *Scandinavian Journal of Medicine & Science in Sports, 30*(9), 1769–1776. https://doi.org/10.1111/sms.13739

Taylor, I. M., Whiteley, S., & Ferguson, R. A. (2022). The disturbance of desire-goal motivational dynamics during different exercise intensity domains. *Scandinavian Journal of Medicine & Science in Sports, 32*(4), 798–806. https://doi.org/10.1111/sms.14129

Treasure, D. C., & Newbery, D. M. (1998). Relationship between self-efficacy, exercise intensity, and feeling states in a sedentary population during and following an acute bout of exercise. *Journal of Sport & Exercise Psychology, 20*(1), 1–11. https://doi.org/10.1123/jsep.20.1.1

Valenzuela, P. L., Alejo, L. B., Montalvo-Pérez, A., Gil-Cabrera, J., Talavera, E., Lucia, A., & Barranco-Gil, D. (2021). Relationship between critical power and different lactate threshold markers in recreational cyclists. *Frontiers in Physiology, 828*. https://doi.org/10.3389/fphys.2021.676484

Welch, A. S., Hulley, A., Ferguson, C., & Beauchamp, M. R. (2007). Affective responses of inactive women to a maximal incremental exercise test: A test of the dual-mode model. *Psychology of Sport and Exercise, 8*(4), 401–423. https://doi.org/10.1016/j.psychsport.2006.09.002

Westbrook, A., & Braver, T. S. (2015). Cognitive effort: A neuroeconomic approach. *Cognitive, Affective, & Behavioral Neuroscience, 15*, 395–415. https://doi.org/10.3758/s13415-015-0334-y

Williamson, O., Swann, C., Bennett, K. J., Bird, M. D., Goddard, S. G., Schweickle, M. J., & Jackman, P. C. (2022). The performance and psychological effects of goal setting in sport: A systematic review and meta-analysis. *International Review of Sport and Exercise Psychology*, 1–29.

Wolff, W., Bieleke, M., Martarelli, C. S., & Danckert, J. (2021). A primer on the role of boredom in self-controlled sports and exercise behavior. *Frontiers in Psychology, 12*, Article 637839. https://doi.org/10.3389/fpsyg.2021.637839