Optimization of Endurance Performance Through Psychological Self-Regulation Strategies

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“The best rides are the ones where you bite off much more than you can chew, and live through it.”

Doug Bradbury, MTB pioneer

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Abstract

This thesis investigated the efficacy of the self-regulatory strategy of if-then planning on endurance performance. Self-regulation is deemed a fundamental aspect in endurance sports, which pose a multiplicity of complex demands on athletes. Thus, this thesis aims to establish a self-regulation strategy that is precisely tailored to the challenges of endurance sports. Further, it is illustrated how self-regulatory strategies like if-then planning should be optimally applied to support athletes in succeeding. To that end, the possible contents of if-then plans regarding inner obstacles (if-component) and goal-directed behaviors (then-component; research paper I), their formulation and application in cycling contexts (research paper II), and their possible moderating factors (research paper III) have been investigated.

To create if-then plans that effectively enhance performance, sufficient knowledge about the obstacles (if-components) that might jeopardize athletes’ goal attainment and possible goal-directed behaviors (then-components) is needed. Thus, the first research paper employed a qualitative survey to elicit the perceptions of elite and youth-level athletes (Study 1) and coaches (Study 2). They were asked to identify inner obstacles that athletes face in cycling competitions and the goal-directed behaviors they apply to deal with these obstacles. The most frequently highlighted inner obstacles were dealing with challenging situations, pressure, and maintaining concentration. Preparation, self-encouragement, relaxation (athletes), and concentration (coaches) were the most frequently reported goal-directed behaviors. To sum up, these studies showed that elite and youth-level athletes and coaches have substantial knowledge of inner obstacles and goal-directed behaviors, which should facilitate the formulation and application of effective if-then plans.
The first research paper explored possible inner obstacles and goal-directed behaviors of elite and youth-level athletes without applying them in an if-then plan in an endurance performance task. Building on this, the second research paper examined whether recreational exercisers are able to identify inner obstacles and goal-directed behaviors using structured interviews. Furthermore, it was investigated whether the composition of these two elements in if-then plans can be used to improve performance in two cycling ergometer tests. In both tests, perception of effort was the most frequently mentioned obstacle, while motivation to do well, self-encouragement, and a clear focus on the body and on cycling were the most reported goal-directed behaviors. Although if-then planning had no effects on performance in either of the cycling ergometer tests, important insights were gained on how recreational exercisers apply if-then plans.

Finally, the third research paper investigated the circumstances under which recreational exercisers can optimize their performance using if-then plans in an experimental laboratory study. After completing a static-muscular endurance task, exercisers chose whether they terminated the task due to effort or pain. Then, they applied a corresponding if-then plan before repeating the task (e.g., 'And if my effort/pain gets too high, then I tell myself: I can still keep going!'). It could be shown that exercisers’ implicit theories about athletic performance (i.e., lay theories about whether performance is generally limited versus changeable), more specifically about performance limitations (physical or mental) moderated effects of if-then planning on muscular endurance performance. If-then plans that were congruent with exercisers’ implicit theories and perceived performance limitations improved their performance.

Taken together, this project provides novel insights into the use of if-then plans within both elite and recreational sports. While Research Paper III found statistical evidence to support the notion that measurable improvement in athletic performance is possible, Research Paper II did not yield the same conclusion. This implies that the self-regulatory strategy of if-then planning cannot be used in a “one-size-fits-all” manner. Nevertheless, this thesis explores key considerations for effective self-regulatory interventions in endurance sports, including psychoeducation, assisted self-reflection, and autonomous formulation. Hence, it lays the groundwork for designing further sport psychology interventions and offers valuable contributions to research in the area of if-then planning in sports.
Zusammenfassung

In dieser Arbeit wurde die Wirksamkeit der Selbstregulationsstrategie der Wenn-dann-Pläne auf die Ausdauerleistung untersucht. Selbstregulation kann als eine Schlüsselkomponente im Ausdauersport angesehen werden, der Athlet:innen mit einer Vielzahl von komplexen Anforderungen konfrontiert. Ziel dieser Arbeit ist es daher, eine Selbstregulationsstrategie zu entwickeln, die genau auf die Herausforderungen des Ausdauersports zugeschnitten ist. Darüber hinaus soll veranschaulicht werden, wie selbstregulatorische Strategien wie Wenn-Dann-Pläne optimalerweise angewendet werden sollten, um Athlet:innen bestmöglichst zu unterstützen. Zu diesem Zweck wurden die möglichen Inhalte von Wenn-dann-Plänen hinsichtlich innerer Hindernisse (Wenn-Komponente) und zielgerichteter Verhaltensweisen (Dann-Komponente; Forschungsarbeit I), ihre Formulierung und Anwendung im Radsportkontext (Forschungsarbeit II) und ihre möglichen moderierenden Faktoren (Forschungsarbeit III) untersucht.

Um Wenn-Dann-Pläne zu erstellen, die die sportliche Leistung effektiv steigern, ist ausreichendes Wissen über die Hindernisse (Wenn-Komponente), welche die Zielerreichung der Sportler:innen gefährden könnten, und über mögliche zielgerichtete Verhaltensweisen (Dann-Komponente) erforderlich. In der ersten Forschungsarbeit werden daher anhand einer qualitativen Umfrage Elite- und Jugendathlet:innen (Studie 1) und Trainer:innen (Studie 2) untersucht. Diese wurden gebeten, innere Hindernisse zu identifizieren, mit denen sich die Athlet:innen bei Radrennen konfrontiert sehen, sowie die zielgerichteten Verhaltensweisen, die sie anwenden, um mit diesen Hindernissen umzugehen. Die am häufigsten hervorgehobenen inneren Hindernisse waren der Umgang mit herausfordernden Situationen, Druck und Konzentration. Vorbereitung, Selbstmotivation, Entspannung (Athlet:innen) und Konzentration (Trainer:innen) waren die am häufigsten genannten zielgerichteten Verhaltensweisen. Zusammengenommen zeigten diese Stu-
dien, dass Elite- und Jugendathlet:innen und Trainer:innen über ein umfangreiches Wissen bezüglich innerer Hindernisse und zielgerichteter Verhaltensweisen verfügen, was die Formulierung und Anwendung effektiver Wenn-Dann-Pläne erleichtern sollte.


Schließlich untersuchte die dritte Forschungsarbeit die Umstände, unter denen Freizeitsportler:innen ihre Leistung in einer experimentellen Laborstudie mithilfe von Wenn-Dann-Plänen optimieren können. Nach Beendigung einer statisch-muskulären Ausdaueraufgabe wählten die Trainierenden aus, ob sie die Aufgabe aufgrund von Anstrengung oder Schmerz abbrachen. Dann wendeten sie einen entsprechenden Wenn-Dann-Plan an, bevor sie die Aufgabe erneut absolvierten (z.B. "Und wenn die Anstrengung/Schmerzen zu groß werden, dann sage ich mir: Ich kann trotzdem weitermachen!"). Es konnte gezeigt werden, dass die impliziten Theorien der Trainierenden (d.h., implizite Annahmen darüber, ob Leistung im Allgemeinen begrenzt oder veränderbar ist), genauer gesagt über (körperliche oder geistige) Leistungsgrenzen, die Wirksamkeit des Wenn-Dann-Plans auf muskuläre Ausdauerleistung beeinflussten. Wenn-dann-Pläne, die mit den impliziten Theorien und den wahrgenommenen Leistungsgrenzen der Freizeitsportler:innen übereinstimmten, verbesserten deren Leistung.

Zusammenfassend bietet dieses Projekt neue Einblicke in den Einsatz von Wenn-Dann-Plänen sowohl im Spitzen- als auch im Freizeitsport. Während die dritte Forschungsarbeit statistische
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1 Synopsis

In the realm of competitive endurance sports, the thin margin between triumph and defeat hinges on every passing second, deciding between success and failure. Beyond the imperative of being in peak physical condition, mental abilities, especially self-regulatory control, emerge as a decisive factor. Also in recreational endurance sports, exercisers need self-regulation to keep going, to challenge their own limits, and to resist giving up. Still, are both elite and recreational athletes able to use self-regulatory strategies to effectively improve endurance performance? Furthermore, what factors contribute to optimizing the effects of self-regulatory interventions, propelling athletes toward peak athletic performance? The present thesis addresses these questions using if-then planning, a well-researched self-regulation strategy (also known as implementation intentions; Gollwitzer, 1993, 1999, 2014, Bieleke, Keller, and Gollwitzer, 2021) in different contexts across three research papers. Implementation intentions support the achievement of a goal (e.g., 'I want to achieve X') by linking a goal-critical situation and a goal-directed behavior to form an if(situation) - then(behavior) plan. The positive effects of if-then planning on athletic performance have been substantiated across various disciplines, such as tennis (Achtziger et al., 2008) and golf (Stern et al., 2013), as well as in the domain of implementing physical activity (Bélanger-Gravel et al., 2013; Rhodes & de Bruijn, 2013). Consequently, it has been widely postulated that if-then planning can serve as a beneficial strategy in sports (e.g., Brick et al., 2016; McCormick et al., 2018a). However, contrary to this assumption, previous investigations in the realm of endurance performance have yielded mixed results (Bieleke, Wolff, et al., 2021). It remains equivocal how if-then planning can be applied successfully in endurance sports. Hence, this thesis seeks to understand if and how if-then planning can be used to enhance endurance performance. To comprehensively investigate the efficacy of if-then plans in endurance sports, a
diverse array of methodological approaches has been employed. For one, a range of samples was examined, spanning recreational exercisers, elite cyclists, (semi-) professional cyclists, and elite coaches. Studies on athletic performance used repeated measures (time point: pre-intervention (T1) vs. post-intervention (T2)) comparing two samples (condition: goal intention vs. implementation intention). Finally, multimethodological investigations were applied consistently across studies to fully capture athletic experience and behavior (e.g., self-reports, laboratory experiments).

Table 1
Overview of the presented publications

<table>
<thead>
<tr>
<th>Contribution of the Study</th>
<th>Study Type</th>
<th>Publication</th>
</tr>
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The goal of this synopsis is to present the three research articles within a unified framework, elucidating their respective contributions to the overarching theme of this dissertation. The following sections will elaborate on the high relevance of self-regulation in endurance performance. Building on this, it will be displayed what is missing from previous research on sport psychological interventions targeting self-regulatory abilities. Then, I will explain the self-regulation strategy of if-then planning, illustrate its beneficial effects and mechanisms, and delineate prior research on the efficacy of if-then planning in the domain of sports. Having established the theoretical framework of this thesis, I will turn to the first research paper, which qualitatively
investigates the possible contents of if-then plans. Then, I’ll focus on the formulation and application of if-then planning in cycling contexts (research paper II) and their possible moderating factors (research paper III). In the concluding segment of this synopsis, I will discuss possible implications for research of if-then planning in endurance sports and extract key points for practice. Additionally, this section will outline potential future directions of research in the area of if-then planning and endurance sports.

1.1 Self-Regulation in Endurance Sports

Athletes need to optimize themselves in every aspect to pursue excellence in their discipline. Besides keeping up rigorous training routines and balanced nutrition, athletes constantly battle their mental barriers to perform better. A crucial facet in fighting this battle is an athlete’s ability to self-regulate, a perspective substantiated by various research (e.g., Englert, 2016). Self-regulation can be defined as 'the capacity of organisms (here, human beings) to override and alter their responses' (Baumeister & Vohs, 2007, p. 116). Especially in endurance sports, self-regulation has been shown to be a fundamental component, as performance needs to be kept up over longer periods of time (see Wolff et al., 2021). The longer a particular level of performance has to be continued (e.g., determined pacing while cycling), the higher accompanying side effects rise (e.g., feelings of exertion) and the more self-regulatory efforts have to be invested (Wolff et al., 2018). This assumption aligns with neuroscientific models like the expected value of control theory (i.e., self-regulatory control is distributed to reduce the necessary mental effort and to magnify the anticipated outcome, Shenhav et al., 2013; for a detailed description of the concept and its relation to self-regulatory control in sports, please see this overview of my colleagues and me, Wolff et al., 2021).

Endurance athletes, in particular, have to overcome intensifying sensations of pain (Mauger, 2019), fatigue (Enoka & Duchateau, 2016), and perceptions of exertion (Marcora, 2008; Marcora et al., 2008). The psychobiological model of endurance performance identifies perceived effort (i.e., a psychological sensation) as the primary performance-limiting factor (Marcora, 2008, 2009; Marcora et al., 2008), a notion widely supported empirically (Blanchfield, Hardy, de Morree,
et al., 2014; Blanchfield, Hardy, & Marcora, 2014; Marcora, 2010; Marcora et al., 2009). It opposes the idea that depleted physiological resources alone are causal for the termination of endurance performance (e.g., Allen et al., 2008; Amann and Calbet, 2008; Burnley and Jones, 2007; Secher et al., 2008). Psychologically grounded in motivational intensity theory (Brehm & Self, 1989; Richter et al., 2016), the model asserts that individuals adapt effort to increasing task difficulty until the application of additional effort is no longer perceived as justified or seen as impossible. At this point, additional effort is no longer exerted, resulting in performance termination. Following this logic, athletes quit an exercise if the effort needed for task continuation exceeds the maximum effort that they are willing to exert in order to succeed, or when an athlete’s maximum has been reached and continuing the exercise seems impossible. Thus, performance termination corresponds to a conscious act of self-regulation rather than a mere product of physiological exhaustion (Pageaux, 2014). Presumably, psychological strategies improve endurance performance when they either lower perceptions of effort or increase motivation to invest effort (Blanchfield, Hardy, de Morree, et al., 2014; Blanchfield, Hardy, & Marcora, 2014). The ability to self-regulate emotions (e.g., sensations of pain), thoughts (e.g., wanting to give up), or behaviors (e.g., adapting pacing) emerges as a pivotal determinant to keep up or to excel in exercising, especially at a competitive level.

**Self-Regulation in Sport Psychological Interventions**

Recognizing the importance of boosting self-regulatory abilities in order to excel in endurance sports, it seems logical that numerous sport psychological interventions aim to foster this competence (e.g., self-talk, Hatzigeorgiadis et al., 2011; attentional focus, Brick et al., 2014, or goal setting, Williams, 2013). Regrettably, they have so far lacked specific adaptation to the intricate requirements of endurance sports, with studies assessing their efficacy tending to be isolated and methodologically limited (McCormick et al., 2015). Most of the studies considered the effectiveness of strategies within psychological skills training packages (e.g., providing a variety of different strategies, sometimes in combination) where evaluating the effectiveness of an individual intervention is inherently limited. It seems that in sports practice, there is a dearth of specific, scientifically based, and practically tested self-regulation strategies designed to max-
imize endurance performance, especially in the field of elite sports and competitive scenarios. In light of this, a comprehensive investigation appears particularly meaningful. It is reasonable to surmise that recreational and competitive athletes differ in their self-regulatory abilities, for example, in terms of skills (Beckford et al., 2016; Englert et al., 2021; Morgan & Pollock, 1977) or neural processing of self-regulatory demands (Li & Smith, 2021). Hence, one major objective of this thesis is to provide a thoroughly investigated self-regulation-based intervention tailored to the distinctive characteristics of recreational and elite sports alike.

1.2 If-Then Planning: Bridging the Gap Between Intention and Behavior

In contrast to the aforementioned research, self-regulation strategies have been researched extensively in the field of psychology. Across domains, they are tested for their effectiveness (see Forgas et al., 2009; Vohs and Baumeister, 2016 as an overview), among them the strategy of implementation intentions, commonly known as if-then planning (Gollwitzer, 1999, 2014). When using if-then planning, a potentially critical situation or an opportunity is linked with a corresponding goal-directed behavior (i.e., emotional, behavioral, or cognitive reaction). These two elements are then combined to form an if(situation) - then(behavior) plan. Therefore, if-then plans address the gap that often arises between intention and action (Sheeran, 2002), effectively bridging and closing it, for example in the area of physical activity (Bélanger-Gravel et al., 2013; Silva et al., 2018).

The reflection of goal-relevant situations and potential goal-directed behaviors leads to a mental connection of these two components. This conditions the response to the instance of a critical cue, heightening its accessibility and recognizability (Gollwitzer, 1999; Janczyk et al., 2015). Going beyond mere goal setting, following and realizing the desired goal is more probable (Adriaanse et al., 2011; Bélanger-Gravel et al., 2013; Gollwitzer & Sheeran, 2006; Toli et al., 2016): If-then planning enhances the ability to recognize opportune moments for action (Achtziger et al., 2012) and support dealing with potential obstacles, as options to act
are predefined when obstacles arise (Gollwitzer et al., 2010; Sniehotta et al., 2006). As for these beneficial effects, forming if-then plans has been found to have a medium-to-large effect size of $d = .65$ on the rate of goal attainment (Gollwitzer & Sheeran, 2006) and to facilitate goal achievement in various areas and domains (Gollwitzer, 2014; Gollwitzer and Sheeran, 2006; see Bieleke, Keller, and Gollwitzer, 2021 for a review).

**Application and Beneficial Mechanisms of If-Then Planning for Endurance Sports**

As both consistent (e.g., improving a certain finishing time) and varying (e.g., reacting to a change in strategy) goal attainment are crucial in endurance sports, demanding the application of self-regulation (Englert, 2016; Wolff et al., 2021), if-then planning emerges as a beneficial strategy for optimizing endurance performance. When creating an if-then plan, two key elements are crucial: identifying a critical situation that could jeopardize the achievement of the goal (e.g., an internal obstacle) and determining a goal-directed behavior that can be employed to overcome that situation (e.g., a specific reaction that needs to be triggered). Applied to endurance sports, consider the goal of winning a leg in the Giro d’Italia, which could be threatened by the onset of fear of failure: cyclists, in response, might uplift their spirits by recalling their rigorous training (e.g., "If I feel fear of failure, then I tell myself: I trained well!").

But why exactly are if-then plans supposed to be helpful during endurance sports, which are often characterized by swift decision-making under high levels of physical stress (e.g., cardiovascular demands, exertion)? As previously mentioned, if-then planning automates the recognition of critical situations and the initiation of goal-directed actions (Gollwitzer, 2014). This transforms behavior from a consciously chosen, intentional course of action to a cue-dominated, automatic process (Martiny-Huenger et al., 2017). The assumption of strategic automaticity can also be illustrated by neural dynamics: functional magnetic resonance imaging studies indicate that if-then plans function through bottom-up information processing because action control is delegated to pre-specified situational cues (Gilbert et al., 2009; Hallam et al., 2015). In contrast, goal intentions (i.e., defining a desired outcome or a wanted behavior, Triandis, 1977) lack the direct connection between situational cues and behavior, relying on more purposeful, top-down self-regulative processes. Especially important for endurance sports might be that if-then plan-
ning is more successful than goal setting when carrying-out of the goal-directed behavior is seen as unpleasant (Milne et al., 2002) and when continuation becomes difficult (e.g., Legrand et al., 2017). Furthermore, if-then planning makes it possible to perform desired behavior with less reliance on information-processing resources (e.g., Webb and Sheeran, 2003), and neutralizes spontaneous reactions (e.g., Thürmer et al., 2020). This could be crucial when a cyclist avoids reacting to every overtaking maneuver but stays focused on pacing, thus guarding herself against premature fatigue. In the same context, it is useful that if-then plans are supportive in coping with adverse feelings, for instance, possible fears of failure (Schweiger Gallo et al., 2009). Should the same cyclist need to change her strategy in the race to still achieve a good placement, if-then plans help in the initiation of conscious processes (Martiny-Huenger et al., 2017) and in the systematic acquisition of information (Bieleke et al., 2020).

Considering these beneficial mechanisms of if-then planning, it seems plausible that they enhance endurance performance by supporting athletes in their challenges. As a result, various experts and institutions, including sporting federations (Calder, 2009), sport psychologists (Brick et al., 2016; McCormick et al., 2018b), and the media (Gregoire, 2016), propose it as a valuable strategy. Given the strong theoretical foundation of if-then plans in the field of self-regulation, they appear to be an appropriate strategy for the purpose of this thesis, aiming to investigate the extent to which athletes can use self-regulatory strategies to improve their performance.

1.3 Striving for an Efficient Application of If-Then Plans in Endurance Sports

Given the scientific base of if-then plans, they have already been explored in other studies as a possible intervention in the sports domain. Looking at studies from the athletic field, if-then plans have been successful in helping athletes recognize favorable opportunities for fluid intake (Hagger & Montasem, 2009) and in enhancing the success rate in golf (Stern et al., 2013). A study with tennis players demonstrated that if-then plans targeting intrusive thoughts, emotions, and physiological states during a competitive match increased performance (Achtziger
et al., 2008). This indicates that they are also effective in the context of stressful competitive situations. However, further research focused on endurance sports paints an inconclusive picture (as my colleagues have displayed in detail; Bieleke, Wolff, et al., 2021). In group-weight holding tasks (e.g., Thürmer et al., 2017) and posture-holding tasks (e.g., Wang et al., 2019), if-then planning improved performance. Conversely, static muscular endurance tasks (e.g., Bieleke et al., 2017; Wolff et al., 2018) or cycling tasks (e.g., Latinjak et al., 2018) failed to demonstrate similar effects, prompting questions about why positive results could not be replicated.

To sum up, the efficacy of if-then planning in concrete sporting performance contexts has not yet been sufficiently investigated: regarding the evidence on a macro level, their efficacy in sports is already researched (e.g., regarding the initiation of regular athletic activity) but comprehensive, micro-contextual investigations as in individual performance situations have not yet taken place (e.g., in competitive sports) or remained inconclusive (e.g., in recreational endurance sports). To fully address this research question in the course of this thesis, it was deemed purposeful to approach it from the ground up. Therefore, the first step was a detailed understanding of the obstacles (possible if-parts) and goal-directed behaviors (strategies that could compose possible then-parts) of those who are most confronted with these components: professional athletes and coaches (research paper I). This endeavor aims to accumulate sufficient knowledge about the obstacles that might jeopardize athletes’ goal attainment and about possible effective goal-directed behaviors, a key prerequisite to creating effective if-then plans.

1.3.1 Research Question I: What Inner Obstacles and Goal-Directed Behaviors Are Identified by Elite and Youth-Level Cyclists and Elite Coaches?

To reiterate, exceptional sports performance relies on self-regulation (e.g., Englert, 2016), given the array of demanding sensations athletes have to deal with. Ergo, an athlete’s performance hinges on the capability to respond to inner obstacles (e.g., exhaustion) with appropriate self-regulatory behaviors (e.g., cheering oneself on; Wolff et al., 2018). Implementation intention theory (Gollwitzer, 1993, 1999, 2014) as a conceptual framework would offer a possible intervention strategy but necessitates sufficient knowledge regarding relevant obstacles and goal-directed behaviors (comp. Keller et al., 2019). Hence, the first paper aimed to consult experts in the
field of endurance sports, especially cycling, in a qualitative survey to generate this knowledge and thus lay the foundation for an effective sports psychology intervention. Experts (in our case elite and youth-level athletes) outshine sub-elite and recreational athletes in crucial mental skills (e.g., self-control, Englert et al., 2021; mental toughness, Beckford et al., 2016; imagery skills and use of associative techniques, Morgan and Pollock, 1977), a proficiency also reflected in what is termed neural efficiency (e.g., Li and Smith, 2021). These distinctions make it plausible that handling exercise-related self-regulatory requirements is facilitated (Wolff et al., 2021). Given their frequent exposure to athletic challenges, they are likely more accustomed to the feelings accompanying competitive settings (e.g., Birrer et al., 2012) and adept at managing these demands with suitable strategies (e.g., Taylor et al., 2008). Overall, this population appeared ideally suited to investigate inner obstacles in cycling competitions and the goal-directed behaviors applied to overcome the challenges that arise. Inner obstacles and goal-directed behaviors of elite and youth-level athletes were examined using a self-designed questionnaire (Study 1). It entailed an assessment of how helpful proposed goal-directed behaviors are perceived by athletes to gain an impression of their usefulness. To gain a comprehensive view of obstacles and goal-directed behaviors, we also asked elite cycling coaches with an adapted questionnaire (Study 2). The samples of these two studies were recruited independently from each other.

**Study 1: Inner Obstacles and Goal-Directed Behaviors Named by Elite and Youth-Level Cyclists**

The findings from the survey revealed a spectrum of inner obstacles frequently faced by athletes during competitions. The most frequently named inner obstacles encompassed dealing with demanding situations during competition, pressure, and concentration difficulties. Athletes also reported being demotivated due to arising challenges, having trouble adhering to cycling strategies, and struggles with estimating their performance (under-/overestimation). Upcoming tension, mental exhaustion, and goal pursuit amid mental or physical challenges were further inner obstacles for athletes. Regarding goal-directed behaviors, the most frequently stated goal-directed behaviors were preparation, self-encouragement, relaxation, and imagination. Athletes also highlighted visualization, fun with the athletic activity, and seeking social support.
tration, external aids (e.g., music), and focusing (which was rated as most helpful) were further goal-directed behaviors. However, a few athletes acknowledged lacking adequate goal-directed behaviors to overcome mental challenges. On average, goal-directed behaviors were rated as rather helpful by athletes.

**Study 2: Inner Obstacles and Goal-Directed Behaviors Described by Elite Coaches**

Coaches predominantly mentioned dealing with demanding situations, difficulties in concentration, adherence to cycling strategies, and self-assessment of capabilities as inner obstacles faced by athletes. Further, coaches identified emotions of insecurity and fear, demotivation stemming from difficult situations, tension, and a lack of willpower. According to their perspective, athletes also struggled with planning and flexibility, as well as with distraction and pressure. The most frequently stated goal-directed behaviors from the coaches’ viewpoint were preparation (even if rated as partly useful), social support, and concentration. Coaches further named self-encouragement, motivation (which was rated most helpful), a positive mindset, and willpower. Relaxation and imagination were also mentioned. Some coaches also noted that athletes assimilated inner obstacles negatively or showed heightened tension as a reaction to mental obstacles. One-sixth of the coaches’ statements were too general to be classified. On average, coaches rated goal-directed behaviors as only partly helpful, suggesting a varied perception of these behaviors among coaches.

**Key Insights From Identified Inner Obstacles and Goal-Directed Behaviors**

In Research Paper I, both athletes and coaches identified a range of inner obstacles and goal-directed behaviors with substantial overlap, providing an extensive overview for designing effective interventions based on implementation intention theory. Notably, intriguing differences surfaced between athletes and coaches: athletes frequently emphasized the demands of dealing with external circumstances, whereas coaches described obstructive emotions such as fear and insecurity. The alignment of these findings with existing literature suggests that elite (youth-level) athletes and coaches possess extensive knowledge, making them excellently suited for formulating and applying effective if-then plans. Furthermore, these findings contribute to the
foundation of sport psychological interventions based on implementation intention theory. It can be suggested that potential future studies focus more strongly on negative affective reactions as obstacles (possible if-part) and on relaxation, concentration, preparation, or self-encouragement as goal-directed behaviors (possible then-part).

The first paper aimed primarily at the theoretical underpinning of if-then plan content in endurance sports. However, it left the question unanswered whether if-then plans can be formulated for and applied under actual athletic performance and whether they can be used to enhance endurance performance. Investigating this aspect comprehensively seems pivotal, considering that previous research paints an inconclusive picture when it comes to the efficacy of if-then planning on endurance performance. Consequently, the second research paper delved into the investigation of formulating and applying if-then plans, employing both qualitative and quantitative approaches in two cycling ergometer tests.

1.3.2 Research Question II: Does Identifying and Thinking of Obstacles and Strategies in Terms of If-Then Plans Improve Endurance Performance in Cycling Tests?

Exercise-related obstacles that athletes face during performance (e.g., perceived exertion, Marcora, 2008; Marcora et al., 2008; perceived fatigability, Enoka and Duchateau, 2016; exercise-induced pain, Mauger, 2019) and the strategies athletes apply (e.g., imagery, self-talk or goal-setting, McCormick et al., 2015) vary as well with exercisers’ athletic level and experience as with the demands of the athletic task. In the same vein, physiological demands respond to divergent requirements and levels (e.g., concerning neural blood circulation and metabolism, Secher et al., 2008; decreased oxygen distribution, Amann and Calbet, 2008; ionic and metabolic adjustments in the active muscle, Fitts, 2008). Consequently, these physiological demands also affect the psychological reaction to exercise (e.g., moderate exercise intensities elicit positive affective responses, Ekkekakis, 2003). Therefore, it seems only logical that the exercise-related obstacles and applied strategies also vary with the given sport. This makes it crucial that interventions are tailored to the demands exercisers face. To account for this prerequisite, the second research paper investigated whether recreational exercisers could identify inner obstacles
and goal-directed behaviors during two diverging tasks, an anaerobic and an aerobic cycling test. In a qualitative approach, exercisers were questioned about the obstacles exercisers face during the tests, the strategies they used to deal with these obstacles, and the potential strategies for future performances of the test. To see whether reflecting these obstacles and strategies in the formation of if-then plans improved performance in the anaerobic and aerobic cycling test compared to goal intentions, a quantitative approach examined whether tailored if-then plans help exercisers to deal better with the obstacles they face. Using a two-within (time point: T1 vs. T2) and two-between (condition: goal intention vs. implementation intention) mixed-factorial design, exercisers performed the anaerobic (Wingate test) and the aerobic (incremental exercise test) cycling test twice in two separate sessions. In the first session, interviews were conducted to elicit exercisers’ obstacles and strategies, which constituted the formulation of if-then plans in the second session. The two cycling tests chosen are frequently used in exercise science and offer the opportunity to capture the range of athletes’ emergent obstacles and strategies used with their distinct characteristics (anaerobic test: very short and focusing on peak power, Bar-Or et al., 1980 vs. aerobic test: measuring aerobic endurance performance, Sjödin and Jacobs, 1981).

**Obstacles, Strategies, and If-Then Plans and Their Efficacy on Endurance Performance**

In both tests, exercisers identified a range of exercise-related obstacles and applicable strategies. They also considered a variety of potential strategies to apply in future performances of the tests. Primary themes concerning exercise-elicited obstacles comprised cycling strategy, discomfort (e.g., regarding the ergometer), goals (e.g., achieving a predefined goal), missing drive (e.g., demotivation, wanting to stop), negative sensations (especially exertion) and challenges in meeting the demands of the test (in the anaerobic test). Exercisers thought of strategies targeting performance pressure (e.g., feeling a sense of duty), attentional focus (either on the body or cycling), comfort (e.g., adjusting cycling position), distancing (e.g., distracting oneself from the task), drive (e.g., the motivation to excel and self-encouragement), goals, and planning.

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1To facilitate a more comprehensive understanding: In Research Paper I, these were referred to as inner obstacles and goal-directed behaviors.
The spectrum of potential strategies entailed attentional focus and drive as well as distancing, goals, performance, and planning.

Exercisers in the implementation intentions condition adeptly recognized and reflected the distinctive demands posed by the aerobic and anaerobic test within their if-then plans. In the anaerobic test, if-parts predominantly encompassed exertion, pressure-related thoughts at the start and finish, and distraction by information on the screen. Self-encouragement, ambition, and planning were prevalent in the then-parts. Conversely, in preparation for the aerobic test, if-parts primarily centered around exertion, demotivation at critical moments, and demotivation in general, while then-parts were characterized by a focus on goal setting and distraction.

Contrary to our initial assumption that reflecting obstacles and strategies in terms of if-then plans would enhance the performance of recreational exercisers, analyses indicated that if-then plans did not effectively improve performance (i.e., anaerobic power) compared to goal intentions in the anaerobic test in T2. Despite an overall performance improvement (i.e., higher time to exhaustion) in the aerobic test from T1 to T2, if-then planning did not significantly enhance the performance of the implementation intention condition compared to goal intentions in T2. Time to exhaustion was neither affected by the time point of measurement nor by the intervention applied.

Key Insights From If-Then Planning Formulation and Efficacy on Endurance Performance

The findings of Research Paper II findings reveal that recreational exercisers successfully identified exercise-related obstacles and useful strategies, offering valuable insights into the range of possible plan contents. Even though performance improvements in the aerobic test suggest that exercisers benefited from applying this information using if-then plans, their application did not lead to any further performance improvement. Nevertheless, the study offers essential practical implications for the implementation of if-then planning in athletic settings. Given that exercisers in this study were rather inexperienced with the specific athletic format (i.e., cycling tests), there may be a need to educate athletes about potential obstacles and strategies to make them more anticipatable. Furthermore, ensuring familiarity with the sport could boost the confidence of recreational exercisers when working out (e.g., in terms of self-efficacy, Wieber
et al., 2010). The use of multiple if-then plans might have led to interference effects between the individual plans (e.g., Verhoeven et al., 2013), suggesting to use one if-then plan in practice. Furthermore, allowing sufficient interim time for exercisers to test the intervention’s suitability for themselves (so-called calibration time, Weinberg and Williams, 2010), could be critical.

The second paper, therefore, implies the circumstances which might enable recreational exercisers to effectively use if-then planning in performance contexts. However, a more in-depth exploration of potential moderating factors influencing if-then plans might shed more light on the question as to why if-then planning effects on (endurance) performance are inconsistent. Therefore, the third research paper aims to investigate the circumstances under which exercisers are able to optimize their performance with the help of if-then plans in a static-muscular endurance task.

1.3.3 Research Question III: What Moderates If-Then Planning Efficacy in Muscular Endurance Performance?

The third study delved into the examination of potential moderators that may influence the effects of if-then planning on performance in a static muscular endurance task (i.e., "hot rings task"); Bieleke and Wolff, 2017). Prior research on if-then planning has already examined other moderating factors (e.g., social anxiety, Webb et al., 2010; conscientiousness, Webb et al., 2007; perfectionism, Powers et al., 2005; or mindset, Weber et al., 2014). In this study, we investigated whether recreational exercisers’ limiting factors of performance, more concretely perceptions of exertion or pain, impact the effects of if-then planning. Exertion, defined as “the conscious sensation of how hard, heavy, and strenuous a physical task is” (Marcora, 2010), pertains to mental processes (e.g., wanting to stop). In contrast, pain is described as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage” (Pageaux, 2016) reflecting bodily processes (e.g., muscle fatigue). Unlike previous research on muscular endurance performance tasks where the same plan was handed to every participant (i.e., perceptions of pain,

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2In the "hot rings task", participants are supposed to hold two aluminum bars which are kept together by intertwined rings for as long as possible by avoiding contact of those rings. This allows to measure time-to-failure and error rate in one task. For a visual illustration, see Bieleke and Wolff (2017), Wolff et al. (2018) or Hirsch et al. (2020).
Thürmer et al., 2017; or perceptions of effort, Bieleke and Wolff, 2017; Wolff et al., 2018), this approach allows us to assess whether individual differences in the sensation of these limiting factors overshadow the effects of if-then planning. Furthermore, we examined whether if-then planning effects are influenced by exercisers’ general beliefs about athletic ability. Specifically, it was explored whether they are perceived as changeable by effort and training (incremental belief) or as fixed and stable (entity belief, Biddle et al., 2003). Additionally, we were interested whether performance is understood as ultimately limited by mental or physical factors (mind-over-body beliefs). This approach enabled us to investigate whether the efficacy of if-then plans focused on the perception of exertion versus pain could be dependent on exercisers’ beliefs about their athletic ability, their understanding of what sensations limit them during a task, and the interaction of these factors. It was hypothesized that performance can be improved by if-then plans tailored to perceived limits of performance (exertion vs. pain) and that implicit beliefs on athletic ability (entity, incremental, and mind-over-body) influence the efficacy of so-built if-then plans. To address this aim, a two-within (time point: T1 vs. T2) and two-between (condition: goal intention vs. implementation intention) design was employed to investigate the effects of if-then planning on performance indicators (time to failure and errors). The content of the if-then plan was based on the perceived limits of exercisers in T1 (“And if my exertion [pain] becomes too high, then I tell myself: I can still keep going!”). Implicit theories on athletic ability were assessed post-intervention.

**The Effects of Implicit Beliefs on Athletic Ability and Experienced Limits of Endurance Performance on If-Then Planning Efficacy**

The analyses of differences between conditions regarding performance indicators did not reveal significant performance divergences. Interestingly, further analyses of the effects on time to failure indicated that if-then planning interacts with implicit theories of athletes and their perceived limits of performance. Exercisers who held high entity beliefs and low mind-over-body beliefs in the if-then planning condition performed better, showing longer time to failure when applying an if-then plan based on exertion. In contrast, exercisers with low entity beliefs and high mind-over-body beliefs in the if-then planning condition enhanced their performance with a
pain-focused if-then plan. Therefore, the findings suggest that individual divergences in implicit theories act as moderating factors.

**Key Insights From Moderators of If-Then Planning Efficacy in Muscular Endurance Performance**

Even though if-then planning was tailored to previously endured limits of endurance performance in Research Paper III, no performance differences between the goal intention and the if-then planning condition could be observed. Nevertheless, the findings underscore the importance of adapting if-then plans to exercisers’ individual limits of performance and their implicit beliefs regarding athletic abilities: when exercisers who perceived to be ultimately limited by mental factors terminated the task pre-intervention due to a mental factor (i.e., exertion), it can be assumed that they interpreted this exertion as a signal to stop. Under this prerequisite, an if-then plan encouraging them to disregard this signal might simply be thwarted. However, if exercisers stopped the task pre-intervention for the same reason, but did not perceive performance as restricted by mental processes (i.e., weak mind-over-body beliefs), exertion was not seen as a stop signal, and the effects of an if-then plan could come into play. Therefore, the results impressively demonstrate the intricate interplay of factors that must align for if-then plans to realize their potential in endurance performance contexts. What is more, they highlight areas requiring further exploration to enhance the applicability of if-then plans as a low-threshold intervention strategy. However, they also suggest that congruence between if-then plans and internal assumptions (such as individual limits of performance and implicit beliefs about athletic abilities) can lead to significant performance enhancements.

**1.4 General Discussion**

The three research papers presented in this thesis reveal that the efficacy of if-then planning as a self-regulatory strategy for improving athletic performance is not consistent across various disciplines and athletic levels. While it may not serve as a universal performance enhancer, this work provides valuable insights into the nuanced factors that should be taken into account
when implementing self-regulatory strategies in elite and recreational sports. Additionally, it offers practical guidance for applying if-then planning in the context of endurance sports. This research yields a plethora of implications, individually discussed in the preceding publications and sections. Hence, the following section aims to present a comprehensive overview of the implications arising from this body of work, encompassing directions for future research on if-then planning in endurance sports as well as practical considerations for implementing such interventions.

1.4.1 Implications and Future Directions for Research on If-Then Planning in Endurance Sports

The findings presented in this thesis offer valuable insights into the use of if-then plans in both elite and recreational sports. They also shed light on key considerations for further research on if-then planning in endurance sports, especially concerning the potential influence of underlying moderators. Research Paper I and II have contributed significantly by revealing that elite cycling athletes, coaches, and recreational exercisers can identify a diverse range of inner obstacles and goal-directed behaviors. This wealth of knowledge provides a strong foundation for future if-then planning studies and other sport-psychological interventions. Importantly, the findings from the first research paper suggest that targeting negative affective reactions (e.g., demotivation, fear, insecurity) as if-parts and relaxation, concentration, preparation, and self-encouragement as then-parts, could be a promising approach. Interestingly, exercisers were not able to enhance performance using if-then plans in the second research paper. Among other factors, this indicates that if-then plans might not universally improve performance, especially in populations with little experience in performance-based cycling. This observation may be extrapolated to inexperienced athletes in other disciplines within the domain of endurance sports.

Especially the findings of Research Paper III underscore the complexity of athletes’ demands, emphasizing the need for a more individualized approach (as an alignment with central inner beliefs and perceived limits of performance) next to the effective combination of obstacles and goal-directed behaviors in the if-then format. In line with the results from the scoping review conducted by my colleagues (Bieleke, Wolff, et al., 2021), the significant performance enhance-
ment in the static muscular endurance task highlights the importance of considering personal and situational factors when creating if-then plans. For instance, having a goal that is perceived as important at the time appears to be necessary (Sheeran et al., 2005) which may not have been the case for the less experienced exercisers in Research Paper II.

When comparing the inner obstacles and goal-directed strategies identified in Research Paper I (elite and youth-level athletes) and Research Paper II (recreational exercisers), it may seem that there is little difference on the surface: for example, both parties name difficulties with keeping up concentration and identify preparation or self-encouragement as possible strategies to overcome obstacles. However, given the differences between the two populations, it is reasonable to assume that the intended objective—enhanced endurance performance—may be perceived and pursued differently. This potential factor should not be dismissed as a moderating influence when implementing if-then planning. Considering research on motives, for example, studies by Smith et al. (2010) indicate that if-then planning might not be imperative when the goal at hand (e.g., enhanced endurance performance) is based on autonomous motives, as the individual’s intrinsic motivation ensures that the goal is achieved. Raising reason to caution are the findings regarding controlled motives and if-then planning: as Elbe and Schüler (2020) conclude, if-then planning focusing on goals that are elicited through internal or external pressure may exacerbate the strain on the exerciser (Smith et al., 2010). If an exerciser explicitly plans for better performance and (as in Research Paper II) is prompted to do so by an experimenter (external pressure), she may tend to react more aversively to the demands placed on her, such as performing an aerobic cycling task. In a similar vein, Bieleke and Keller (2021) assume that the failure to meet goals that are set using if-then planning may generate heightened discomfort, particularly among individuals predisposed to employing if-then planning strategies. In such instances, failing goal attainment might be more readily attributed to one’s own shortcomings. As already revealed by the results of Research Paper III, these examples highlight the intricate interplay of individual moderating factors that can either facilitate or hinder beneficial effects of if-then planning in the area of endurance performance.
Beyond Enhancing Endurance Performance

As previously emphasized, a range of inter-individual differences serves as moderating factors for the effects of if-then planning. Therefore, it becomes imperative to incorporate these aspects in future research and leverage them for the ongoing development of if-then plan content and application. Drawing inspiration from the approach in Research Paper I, where elite and youth-level athletes rated the helpfulness of goal-directed behaviors, it is crucial to evaluate whether exercisers or athletes perceive the intervention as beneficial. More specifically, an in-depth examination of which specific aspects or components of if-then plans they find more (or less) helpful might shed more light onto the possible composition of effective if-then plans. In general, it is reasonable to assume that exercisers regard the application of practical interventions like if-then planning as advantageous (Meijen et al., 2022). Nevertheless, gaining a more precise understanding of the aspects of if-then planning that are widely considered helpful could enable more comprehensive and generalized recommendations for the application of if-then planning in endurance sports.

Expanding beyond the core focus of this thesis, it is essential to consider the broader implications of if-then planning, beyond its role in achieving measurable performance improvements in terms of time to exhaustion. Interventions such as if-then plans have the potential to provide valuable psychological support for athletes facing challenging situations. Equipping athletes with a plan they can rely on to navigate difficult situations or to better manage emotions that are challenging for them might enhance their readiness and resilience. Lane et al. (2016) showed that if-then planning enhanced emotional control and performance contentment. This aspect holds significance for elite athletes and exercise newbies alike: elite athletes encounter a myriad of stressful situations, while recreational exercisers may struggle with unfamiliar sensations that exercise induces. Merely reflecting on possible obstacles and strategies to deal with them can instill athletes with a greater sense of confidence and coping ability. This alone may enhance athletes’ satisfaction and self-confidence (as proposed by McCormick and Meijen, 2019), ultimately contributing to improved athletic performance over the long term. Intriguingly, a study by Meijen et al. (2022) found that participants reported a greater sense of stress controllabil-
ity when applying an online if-then planning intervention before competing. Naturally, if-then planning could be applied in various areas that implicitly have a detrimental effect on athletes’ performance, such as difficulties in recovery initiation, as proposed by Balk and Englert (2020). Particularly in elite sports, using if-then plans to ease athletes’ initiation of other self-regulatory interventions (e.g., breathing exercises, imagery) might be highly beneficial. This facilitation, enabling athletes to draw upon familiar techniques during stressful moments (e.g., tension at the start of a competition), may lead to overall enhanced performance outcomes.

In summary, the findings presented in this thesis constitute a valuable contribution to the heterogeneous empirical findings within the domain of if-then planning research in endurance sports. Altogether, they offer insights into the effective utilization of if-then planning in endurance sports among diverse athletic populations. Furthermore, the implications derived from these comprehensive studies can extend to the application of self-regulatory interventions in other endurance sports. Nonetheless, the outcomes of this thesis emphasize the necessity for more extensive research into the complex interplay of personal (e.g., level of experience, proneness to plan, implicit beliefs) and situational factors (e.g., externally imposed demands). This deeper exploration is crucial to make a more nuanced recommendation regarding the creation and application of if-then plans in the realm of endurance sports. Hence, several promising avenues for future research within the context of if-then planning in athletic contexts emerge.

In the following section, the most viable directions for advancing research on if-then planning in (endurance) sports will be outlined.

**Outlook: Efficacy of If-Plans in a Multimethod Experiment Involving Behavioral, Psychophysiological, and Neuronal Parameters**

In the present thesis, the application of if-then plans in endurance sports was approached from two distinct perspectives. First, qualitative evaluations of if- and then-parts were conducted in Research Papers I and II. Second, the measurement of observable improvements in athletic endurance performance was the focus of Research Papers II and III. When contemplating future research, one multimethodological expansion appears to be particularly noteworthy, one that can build upon the methodologically comprehensive investigations presented in this thesis: the
investigation of neural changes in experienced athletes (i.e. elite, competitive athletes) as they employ if-then plans to enhance their performance. This approach is ideally positioned to align with existing research. Encouragingly, previous results of Wolff et al. (2018) have indicated that if-then planning can affect critical neural correlates of endurance performance, like the activation of prefrontal cortex areas. A conceivable next step would involve a multimethod experiment that encompasses behavioral, psychophysiological, and neuronal parameters. This expanded approach could further advance our understanding of the efficacy of if-plans in endurance sports by exploring their effects on parameters that are not directly observable, such as neuronal activity, heart rate, or breathing rate.

For this purpose, a virtual mountain time trial on a bicycle simulator (for example, as described in more detail in Dahmen et al., 2011) would lend itself. Amateur and/or elite cyclists using either if-then plans or no plans (control group) could be investigated. Individual creation of if-then plans with a reflection of inner obstacles and goal-directed behaviors between two trials (time point: T1 vs. T2) would be preferred to optimally combine the findings from the three research papers. Ideally, neuronal activity in the dorsolateral prefrontal cortex (dIPFC) would be assessed using functional near-infrared spectroscopy, analogous to Wolff et al. (2018). The dIPFC is essential for studying the efficacy of if-then plans in sports for two main reasons. First, the lateral PFC (lPFC) is associated with self-regulatory processes (Cohen & Lieberman, 2010; Miller & Cohen, 2001) and cortical activity might reflect effects of self-regulatory strategies that are not necessarily visible in observable behavior (e.g., Wolff et al., 2016). Second, in previous studies, if-then planning led to comparatively lower activity in the lPFC (e.g., Hallam et al., 2015; Huppert et al., 2006; also during the course of a muscular endurance exercise, Wolff et al., 2018). Thus, it is conceivable that if-then plans could also lead to reduced involvement of the lPFC during mountain time trials, as automation diminishes the need for conscious behavioral control. Additionally, potential moderating factors such as experienced coping and efficacy of if-then plans could be assessed to map participants’ subjectively higher satisfaction with the athletic session following the use of if-then plans. The proposed research design presents a myriad of opportunities for a thorough exploration of the questions raised, aligning seamlessly with a research trend that has gained momentum in recent years. (Wolff et al., 2021).
1.4.2 Implications and Future Directions for Practice

Even though the application of if-then plans is endorsed by multiple sources (e.g., Brick et al., 2016; Calder, 2009; Gregoire, 2016; McCormick et al., 2018b) and has been integrated into real-world scenarios (e.g., Meijen et al., 2022), providing a universal recommendation for their effective practical implementation is challenging, as seen in the practical implications outlined in each research paper. Nevertheless, selected general considerations for elite athletes and recreational exercisers can be identified for the application of if-then planning interventions in endurance sports.

As indicated by Research Paper I and III, no one-size-fits-all templates can be applied when it comes to elite athletes. Initially, it may be beneficial to step back and teach elite athletes and coaches alike what a functioning if-then plan might entail and what components it might comprise. Second, through close collaboration between coach and athletes, it may be essential to determine which obstacles athletes can overcome on their own, which goal-directed behaviors are relevant and beneficial, and the specific situations where an if-then plan would be most effective. Third, athletes should be encouraged to formulate if-then plans that feel coherent and authentic. Regular evaluations can ensure athletes remain committed to using if-then planning, as goal achievement is enhanced when goals targeted with if-then planning are personally close to the individual (Koestner et al., 2002). These three components (psychoeducation, assisted self-reflection, autonomous formulation) offer elite athletes and coaches an avenue to enhance endurance performance, be it on a psychological or even on a physical level. It is advisable for a sport psychologist to lead or at least be involved in these processes, as simply possessing knowledge of sports psychology techniques is often inadequate for athletes and coaches to implement these strategies effectively (e.g., Gould et al., 1990; Zakrajsek and Zizzi, 2007). Importantly, elite athletes (and coaches) need to be taught about the variability in the effectiveness of interventions among athletes. As discussed earlier, several factors interplay, making an intervention beneficial for one athlete and less so for another. At an intrapersonal level, factors such as situational variables (e.g., time of day) and personal characteristics (e.g., level of experience) need to be considered. Therefore, elite athletes should receive guidance to explore which inter-
vention suits them best. It is also essential to keep in mind the calibration effects observed in Research Paper II. Elite athletes should regularly incorporate the use of if-then plans into their training routines to become accustomed to their use. By doing so, when cognitive resources are reduced during competition, they can effortlessly turn to their prepared if-then plans. When these conditions are met, if-then plans can be effectively utilized by elite athletes.

A somewhat similar implication can be derived for the application of if-then planning by recreational exercisers, albeit at a more fundamental level. Elite athletes don’t require an introduction to physical sensations like exertion or pain since they are accustomed to handling strenuous demands. Most recreational exercisers, on the other hand, approach endurance performance from a different perspective, especially concerning their willingness to exert themselves during exercise. Even if the results of Research Paper II are based on an inexperienced population in the given sport, a careful assumption might be made: If the demands of exercise become more predictable (e.g., through education), it might facilitate coping with them. For instance, if physical signals that emerge during exercise (and they do at some point) are better understood as non-threatening (since individuals vary in their interpretation of physical sensations; see mal-adaptive/adaptive effects of interoceptive awareness, Farb et al., 2015; or how they interpret signs of exertion, Research Paper III), this understanding could either help individuals stay on track or boost their willingness to exert themselves.

This reasoning aligns with the findings of Research Paper III, where exercisers’ individual limits of performance and their beliefs about athletic abilities influenced the efficacy of a given intervention. When underlying beliefs and perceptions become more transparent to exercisers, they can potentially use interventions like if-then planning to their advantage. To facilitate this process, smartphone apps can guide through similar processes, translating wishes and obstacles into practical if-then plans (e.g., WOOP, Oettingen, 2023). Based on the concept of mental contrasting with implementation intentions (Oettingen, 2014; Oettingen & Gollwitzer, 2010), the WOOP (wish-outcome-obstacle-plan) app supports the identification and fulfillment of prioritized wishes while allowing users to monitor their progress. Taking this concept further, apps like WOOP could be enhanced by proposing inner obstacles and goal-directed behaviors observed in other users since recreational exercisers typically lack access to sport psychologists or
coaches. This user-friendly support could assist exercisers in overcoming their everyday athletic challenges using if-then plans.

1.5 Summary and Conclusion

This thesis delved into the efficacy of if-then planning on endurance performance and shed light on the optimal application of self-regulatory strategies to enhance athletes’ success. Based on the first paper, it was possible to ascertain that elite and youth-level athletes and coaches have extensive knowledge regarding internal obstacles and applicable goal-directed behaviors. This knowledge should facilitate the formulation and application of effective if-then plans. In the second research paper, though no additional performance improvements were evident as a result of using if-then plans, the study yielded valuable insights for applying these if-then plans with recreational exercisers. Finally, the third research paper demonstrated that exercisers’ implicit theories about performance limitations (physical or mental) moderated the efficacy of if-then plans. When if-then plans aligned with exercisers’ implicit theories and perceived performance limitations, the performance of exercisers improved. Taken together, this project contributes to our understanding of how if-then plans can benefit both elite athletes and recreational exercisers, serving as a foundation for the development of future sport psychology interventions. Moreover, it underscores the factors that aid athletes in achieving athletic success through self-regulatory interventions. The results suggest that the application of if-then planning in endurance sports cannot adhere to a one-size-fits-all approach, emphasizing potential moderators and paving the way for future research in the field of if-then planning in endurance sports.
2 Eigenabgrenzung


**Forschungsartikel I**

Konzeptualisierung der Fragebögen, Datenerhebung und -analyse, Erstellung des Manuskripts inklusive theoretischen Rahmens, Interpretation und konzeptuelle Einordnung der Ergebnisse, Mitwirken an Konzeption und Entwicklung der übergeordneten Fragestellungen.

**Forschungsartikel II**


**Forschungsartikel III**

3 References


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4 Research Papers Summarized in This Thesis

This thesis entails three research papers of which I am first author. They are either published or accepted for publication.

Research Question I: What Inner Obstacles and Goal-Directed Behaviors Are Identified by Elite and Youth Level Cyclists and Elite Coaches?


Research Question II: Does Identifying and Thinking of Obstacles and Strategies in Terms of If-Then Plans Improve Endurance Performance in Cycling Tests?


Research Question III: What Moderates If-Then Planning Effectivity in Muscular Endurance Performance?

Inner Obstacles and Goal-Directed Behaviors of Elite and Youth-Level Cyclists:

A Qualitative Analysis From the Perspective of Athletes and Coaches

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Abstract

As self-regulation is crucial in top-level performance, prior investigations aimed at the efficacy of the self-regulatory strategy of implementation intentions (i.e., if-then plans) on athletic performance. We investigated the inner obstacles (if) that athletes face in competitive situations and assessed the corresponding goal-directed behaviors (then) to design effective implementation-intention-theory-based interventions. We asked elite and youth-level cyclists (Study 1; \( N = 34; \) age: \( M = 23.7 \pm 9.9 \) years) with a self-designed questionnaire and used a reworded version for assessing these research questions from a coaches’ perspective (Study 2; \( N = 42; \) age: \( M = 50.2 \pm 9.8 \) years). Dealing with demanding situations, pressure, and concentration were most frequently named inner obstacles, while goal-directed behaviors were preparation, self-encouragement, relaxation (athletes), and concentration (coaches). The results highlight the emotional-psychological challenges that elite and youth-level cycling athletes face and provide insights for sport psychological research with implementation intentions.

**Keywords:** obstacles and goal-directed behaviors in cycling, elite athletes, elite coaches, implementation intention theory, thematic analysis.
Inner Obstacles and Goal-Directed Behaviors of Elite and Youth-Level Cyclists:
A Qualitative Analysis From the Perspective of Athletes and Coaches

Top-level cycling inspires millions of people. The Tour de France is the world’s largest annual sporting event (sport1.de, 2016) and captures the attention of millions of spectators annually. To succeed in such an event, racing cyclists not only need outstanding physical fitness but also an extensive collection of excellent mental skills (Orlick & Partington, 1988). One broad mental faculty that is particularly relevant for optimal sports performance is self-regulatory control (e.g., Englert, 2016), which refers to “the set of mechanisms required to pursue a goal, especially when distraction and/or strong (e.g., habitual) competing responses must be overcome” (Shenhav et al., 2013, p. 217). The relevance of these mechanisms for endurance performance is intuitively apparent: During an endurance competition, athletes frequently have to cope with intensifying sensations of pain, fatigue, and exertion that create and amplify the urge to quit rather than continue the race (Enoka & Duchateau, 2016; Marcora & Staiano, 2010; Mauger, 2019). Accordingly, endurance performance is critically dependent on how effectively athletes apply self-regulatory strategies to address such inner obstacles (Wolff et al., 2018). For example, an athlete might employ self-talk or imagery as goal-directed self-regulatory behaviors to cope with exercise-induced obstacles (McCormick et al., 2015). To shed light on the nature of these obstacles and the behaviors employed to overcome them, the present research takes a qualitative approach to analyze the inner obstacles elite and youth-level cyclists face during competitions and the goal-directed behaviors they use to overcome them.

Implementation intention theory (Gollwitzer, 1999, 2014) provides a conceptual framework for such an analysis: It explicates the role of obstacles and goal-directed behaviors in goal striving. Specifically, the theory proposes that attaining a goal (e.g., “I want to achieve X”) is facilitated by making self-regulatory if-then plans. If-then planning involves thinking about two key elements: a critical situation that might jeopardize goal attainment (e.g., an inner obstacle standing in the way) and a goal-directed response that might be used to deal with this situation (e.g., a behavior to overcome the obstacle). These two elements are then linked to an if (situation)-then (response) plan. Take for example professional cycling. Here, the goal to win a sprint stage in the
Tour de France could be threatened by the fear of being badly positioned in the closing kilometers of the stage which often can be very hectic. To address this obstacle, an athlete might engage in self-talk to keep focused on the goal to stick with their lead-out rider in the closing kilometer. Making if-then plans is an important component of successful goal attainment across different domains (e.g., physical exercise, Bélanger-Gravel et al., 2013; health, Adriaanse et al., 2011; Bélanger-Gravel et al., 2013; Orbell & Sheeran, 2000; see Gollwitzer & Sheeran, 2006 for a meta-analysis, and Bieleke, Keller, & Gollwitzer, 2021 for a recent review). Accordingly, it has been suggested that if-then planning might also be a relevant self-regulatory strategy in sports in general and in endurance sports in particular (Bieleke, Wolff, et al., 2021). Indeed, the beneficial effects of if-then planning rest primarily on automating both the detection of critical situations and the initiation of goal-directed behaviors (Gollwitzer, 2014) – processes that are likely crucial for effective self-regulatory control in endurance sports (e.g., to deal efficiently with the urge to quit even under high levels of stress; Wolff et al., 2019).

Considering the suitability of implementation intention theory as a conceptual framework and its well-established effectiveness as a self-regulatory strategy, interventions based on the theory have so far produced surprisingly inconsistent results in endurance sports and other sports domains (Bieleke, Wolff, et al., 2021). Concerning endurance, for example, if-then planning has been observed to enhance performance in some tasks (e.g., group weight-holding tasks, Thürmer et al., 2017; posture-holding tasks, S. Wang et al., 2019), but not in others (e.g., static muscular endurance tasks, Bieleke & Wolff, 2017; Hirsch et al., 2020; Wolff et al., 2018; cycling tasks, Hirsch et al., 2021; Latinjak et al., 2018). One possible explanation for these heterogeneous findings is that the bulk of studies investigated the effectiveness of if-then plans in inexperienced exercisers who might not have sufficient insight into the inner obstacles that limit their performance and the goal-directed behaviors that would be suitable to overcome them (Hirsch et al., 2021). Other studies used predetermined if-then plans which targeted obstacles (e.g., pain, effort) and behaviors (e.g., task continuation) that turned out to be unsuitable for improving endurance performance. For instance, it has been demonstrated that the obstacles specified in an if-then plan (e.g., physical pain versus perceived effort) must correspond to exercisers’ beliefs about whether these obstacles limit their
performance (Hirsch et al., 2020). Thus, making an if-then plan to cope with exercise-induced pain during a static muscular endurance task was effective only when exercisers felt that such a physical obstacle limited their performance (in contrast to believing that performance was limited by mental factors). In another study using a static muscular endurance task, participants made if-then plans specifying that sensations of effort should be ignored; however, this plan inadvertently intensified rather than attenuated the perceived effort and thus failed to enhance performance (Bieleke & Wolff, 2017). Taken together, the heterogeneity of findings regarding the effects of if-then planning might be due to inexperienced samples with too little or no insight into relevant obstacles and goal-directed behaviors, reliance on obstacles that are at odds with athletes’ beliefs about what limits their performance, and/or use of goal-directed behaviors that failed to improve performance. Thus, to facilitate the design of effective interventions based on implementation intention theory, it is important to take one step back and investigate which obstacles highly experienced athletes face in their sports, and what kind of goal-directed behaviors they employ to deal with those obstacles.

Accordingly, we turned to two independent samples of elite and youth-level cyclists and cycling coaches, respectively. In comparison to sub-elite and recreational athletes, elite and youth-level athletes excel in a variety of essential mental skills (e.g., most importantly self-control, Englert et al., 2021; but also mental toughness, Beckford et al., 2016; imagery skills and use of associative strategies, Morgan & Pollock, 1977) and seem to possess higher neural efficiency (e.g., Li & Smith, 2021) which might allow them to deal more efficiently with the self-regulatory demands of sports (Wolff et al., 2021). Additionally, they are likely familiar with a broad range of challenging sensations that commonly arise in competitions (e.g., fear of failure, negative emotions, and dysfunctional thinking; Birrer et al., 2012) and with applying various skills that help them deal effectively with these challenges (e.g., imagery, emotion control, and automatic skill performance in Olympic medalists, Taylor et al., 2008). Meanwhile, coaches play an important role in the development and performance of their athletes, as their experience, including their competitive activity and skills, enables them to optimally adapt to athletes’ needs (Jowett et al., 2005; Jowett & Poczwardowski, 2007). Feedback from coaches can give athletes important input about their abilities, willingness to exert effort, and an assessment of their expectation of success (Amorose &
Smith, 2003). Through their position from the outside, their deep insights into processes, and their own competition and training experiences, coaches offer a valuable perspective on the specific obstacles and possible goal-directed behaviors of athletes. Obtaining their perspective to triangulate athletes’ responses is therefore a logical step in gaining an overall picture of athletes' obstacles and goal-directed behaviors. Taken together, elite and youth-level athletes and coaches are ideally suited for studying the inner obstacles associated with endurance performance and behaviors that help to overcome these obstacles, which promises to provide a foundation for developing more effective interventions based on implementation intention theory.

Here, we report two studies that set out to identify the inner obstacles that athletes face in cycling competitions and the goal-directed behaviors they apply to overcome these obstacles. As the mere naming of goal-directed behaviors is little informative in gaining an impression of their usefulness, we asked athletes and coaches how helpful these behaviors were perceived. We recruited two samples: one sample of elite and youth-level athletes who actively competed in cycling events (Study 1) and a sample of elite cycling coaches (Study 2). To increase the sample size with a limited number of elite and youth-level athletes that could be surveyed, these two samples were recruited independently from each other (i.e., the athletes and coaches did not work with each other) and thus provided unique answers to our research question. Due to the explorative nature of our research, we capitalized on a qualitative, data-driven approach to identify relevant themes of obstacles and behaviors.

**General Method**

Our research approach was shaped by an essentialist perspective. Essentialism postulates that “all objects and concepts can be defined by reference to certain core properties that make them what they are” (Rolfe, 2008, p. 269). This perspective had implications for our sampling strategy. Elite and youth-level athletes as well as their coaches are experts for the inner obstacles and goal-directed behaviors associated with endurance performance. Hence, they constitute an ideal sample for addressing our research question, and we sampled them for our study.

The surveys were carried out as part of a larger research project which focused on developing self-regulatory interventions for elite athletes (among other target groups). For this
reason, athletes and coaches were asked to provide several other information besides the reporting of inner obstacles, goal-directed behaviors, and estimated helpfulness (i.e., naming optimized handling of inner obstacles, strategies to mentally prepare for a step test, self-assessments on self-control, boredom proneness, and planning propensity). As only the first part of the questionnaires was relevant for answering our research question, we focused on the presentation of these results in this article. The questionnaires took about 25 minutes to complete and were developed together with an amateur and an elite cyclist to ensure comprehensibility and suitability for the target group. Furthermore, we based the structure and phrasing on established methods from if-then plan research, for example by explicitly asking for inner obstacles first and then focusing on possible goal-directed behaviors. Next to guiding our sampling strategy, the essentialist approach also shaped our approach to eliciting the relevant themes for the analysis. Specifically, to identify and extract fundamental aspects of inner obstacles and goal-directed behaviors, we captured the experiences and perspectives of the athletes and coaches by encouraging them to give answers as freely as possible (i.e., with open-ended questions). The athlete survey was conducted online (Qualtrics, 2005/2021), while the coach survey was conducted in a paper-and-pencil format at the beginning of an in-person workshop. At the beginning of the questionnaire, athletes and coaches were informed about the purpose of the study and their participation rights. Data were collected anonymously. Neither the athletes nor the coaches received financial compensation for participating in the study. The surveys were conducted according to the 1975 Declaration of Helsinki and were approved by the Ethics Committee at the University of Konstanz. For all supplementary materials (study materials, Figures), please see https://osf.io/2bqtx/.

**Questionnaires**

**Study 1: Athlete Sample.** After they had given informed consent, the athletes provided demographic information (age, gender) and information about their cycling experience (e.g., years of cycling, competition experience). Athletes were then asked to name and describe inner obstacles they encounter in a typical competition (“Please describe your central inner obstacles in a typical competition in few words”) that keep them from turning a race into a successful race. It was emphasized that athletes should focus on obstacles they could in principle overcome by themselves.
(as opposed to external obstacles, like a crash). Afterward, the athletes specified the behaviors they commonly apply to deal with these obstacles (“How do you typically deal with these inner obstacles?”) and indicated the extent to which these goal-directed behaviors help them to overcome them (on a scale from 1 = not at all to 5 = very much).

**Study 2: Coach Sample.** The coach questionnaire was analogous to the athlete questionnaire but differed in two ways: First, the coaches provided information about their coaching experience rather than their cycling experience (e.g., highest coaching qualification, main coaching discipline). Second, we asked the coaches about their views on the inner obstacles and goal-directed behaviors of the athletes they coached.

**Data Analysis**

Data resulting from the questionnaires were analyzed with thematic analysis on a semantic level (Braun & Clarke, 2006; Braun et al., 2016) individually for the athlete and the coach sample. Epistemologically, the analysis can best be allocated as essentialist-realist, being of inductive nature, meaning that relevant themes were derived from participants' answers in a data-driven manner (Braun & Clarke, 2006). In the first step, the lead author of this paper conducted an initial review of the data to familiarize herself with the data, noted first ideas to code the data, and then created codes for all data extracts. These codes were then grouped into possible themes. Data extracts that were related to more than one theme were assigned to multiple themes. These themes were then re-evaluated by the researcher regarding the homogeneity of context and content overlaps, and to ensure that they reflected the data accurately and parsimoniously. Finally, each theme was defined and labeled. In the second step, two independent raters assigned all data extracts to the previously defined themes for reexamination. The interrater reliability was between κ = .66 and κ = .75 in the athlete sample and κ = .54 and κ = .62 in the coach sample, which is adequate and suggests that the themes represented the data extracts in a meaningful way (Altman, 1999; Landis & Koch, 1977). Mutual agreement was achieved by discussion (see Sarkar & Fletcher, 2014) except for two data extracts in the athlete sample, which were accordingly assigned to the other theme.

Finally, the theme labels developed from the athlete and the coach data were compared to align theme names to establish coherent wording across both studies. Figure 2 provides an overview
of the extracted themes and their frequencies. Tables 2 and 3 provide an overview of themes and their definitions. Illustrative data extracts in the results section were translated to English from the original language. Figure 3 shows how helpful the handling of mental obstacles was rated in Study 1 and Study 2. In addition to the data analysis presented here, further insights into the distribution of themes regarding inner obstacles and goal-directed behaviors by discipline and performance level are visualized in Figure S1 and Figure S2. Because of the unbalanced sampling due to limited access to elite samples, the interpretability of these additional aspects is limited. For the analyses and illustrations, the statistical software environment R (4.1.0; R Core Team, 2021) and the package ggplot2 (3.3.5; Wickham, 2016) were used.

**Study 1: Athlete Sample**

**Participants**

\[ N = 34 \] elite (world team, continental (pro) team, (elite) amateurs) and youth (under age 19) level cyclists took part in the study (age: \[ M = 23.7 \pm 10.0 \] years; gender: 7 female, 27 male). The recruitment took place through the coaches of the German Cycling Federation, who sent the questionnaire to their cyclists. As can be seen in Table 1 and Figure 1, our sample covered a wide range of experience levels concerning cycling and cycling competitions. Participants reported preparing themselves for licensed races such as the national league (\( N = 10 \)), German (\( N = 7 \)) or state championships (\( N = 3 \)), or the sighting race of the German Cycling Federation (\( N = 5 \); only the most frequently mentioned listed here). Twenty-seven athletes completed the questionnaire in full, the remaining athletes dropped out before reaching the end of the questionnaire (athletes’ level: \( N = 1 \) elite, \( N = 2 \) elite amateur, \( N = 1 \) elite woman, \( N = 1 \) junior, and \( N = 2 \) other). We used all the available answers in the analyses.

**Results**

**Inner Obstacles.** Athletes reported a variety of inner obstacles they experience during typical competitions. These were assigned to a total of 10 themes comprising between 1 and 10 data extracts per theme (see Table 2 for an overview of themes and their definitions and Figure 2 for a visualization of frequencies). The most frequent obstacle athletes stated was pressure, in terms of “pressure to succeed” or “pressure to perform” well. Athletes described to be pressured by
Table 1.

Descriptive information regarding athletes’ cycling experience and training status (Study 1) and coaches’ training experience (Study 2).

<table>
<thead>
<tr>
<th>Athletes (Study 1)</th>
<th>M</th>
<th>SD</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycling experience (years)*</td>
<td>10.2</td>
<td>5.1</td>
<td>[8.4, 12.0]</td>
</tr>
<tr>
<td>Competitive experience (years) *</td>
<td>6.9</td>
<td>4.5</td>
<td>[5.4, 8.5]</td>
</tr>
<tr>
<td>No. of competitions (in the last 6 months)</td>
<td>5.6</td>
<td>5.7</td>
<td>[3.7, 7.6]</td>
</tr>
<tr>
<td>Watts step test**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>351.7</td>
<td>105.4</td>
<td>[304.3, 399.1]</td>
</tr>
<tr>
<td>f</td>
<td>302.0</td>
<td>49.2</td>
<td>[258.9, 345.1]</td>
</tr>
<tr>
<td>Cycling training (h/week)</td>
<td>12.1</td>
<td>3.9</td>
<td>[10.8, 13.4]</td>
</tr>
<tr>
<td>Training overall (h/week)</td>
<td>14.4</td>
<td>4.0</td>
<td>[13.1, 15.7]</td>
</tr>
</tbody>
</table>

| Coaches (Study 2)                                      |       |     |             |
| Coaching experience (years)                            | 25.6  | 10.7 | [22.2, 29.0] |

Note. *Athletes that indicated more than thirty years (cycling experience N = 1; competition experience N = 1) or less than one year experience (competition experience N = 1) were not included in the mean value calculation.

**Watts of the last stage cycled through in athletes’ most recent stage test of the Federation of German Cyclists.

Figure 1.

Illustration A visualizes athletes’ main competitive discipline and their overall competition experience per discipline as well as coaches primarily coached disciplines and coached disciplines in general. Illustration B displays athletes’ performance levels.

Note. Abbreviations: MTB = Mountain biking, MTBO = Mountain bike orienteering, WT = World Tour, KPT = Continental Professional Team, KT = Continental Team. It was possible to select multiple disciplines when indicating competition experience (athletes), coached disciplines (coaches), and level of athletes (coaches).
“expectations”, such as the “prior year placement” or their “competition”. Dealing with demanding situations during the competition (e.g., unforeseen situations like “crashes”, “hectic pace”) challenged athletes, they named examples such as a “bad starting position”, “technical passages” or “getting poor nutritional intake”. Concentration difficulties (e.g., when making decisions under stress) were also identified as a major obstacle that athletes encounter during competitions: Athletes emphasized the struggle to “keep a clear head”, “focus on the race”, or to “always stay alert in a 200km race (…) and to go beyond the limit at the end”. Being demotivated due to difficult competitive situations was perceived as an obstacle as well, for example when it is demanding “not losing motivation especially when being overtaken” or “not to be dragged down by a probably unsatisfactory result”. Also, athletes mentioned difficulties with sticking to their cycling strategies, like “restraining oneself during long bike marathons, even though the legs seem to be able to give more”. Related to this latter obstacle was self-assessment such as the adversity of “assessing your

Figure 2.

Visualization of the frequencies of (A) inner obstacles and (B) goal-directed behaviors from the perspective of athletes (Study 1) and coaches (Study 2).
strength and attacking at the right moment”. Upcoming tension (e.g., “excitement before the competition” or “playing down excitement”) or mental exhaustion – for example feeling mentally depleted due to increased mental demands, as one athlete puts it more specifically “moving clever in the field costs mental energy, because of permanent concentration” – were further inner obstacles. Pursuing the goal when being mentally exhausted or lagging behind was also stated, as it is challenging to “believe from the beginning to the end that the goal can still be achieved”.

**Goal-Directed Behaviors.** Goal-directed behaviors that were used to overcome the stated inner obstacles were assigned to 12 themes with 1 to 7 data extracts per theme (see Table 3 and Figure 2). Preparation (i.e., any way of preparing to face possible mental obstacles) was the most frequent goal-directed behavior, which was estimated between rather helpful and very much helpful. Athletes stated to prepare “regarding food and drink: develop routine + logic regarding carbohydrate turnover and calorie consumption and maximum carbohydrate intake as well as fluid supply” or with “pacing strategies”. Self-encouragement was the second most frequent goal-directed behavior in terms of verbalizing statements to cheering oneself up (e.g., “I tell myself that it is only a momentary state and will get better abruptly in the next rounds”, “not to give up talking to myself”) which athletes perceived as partly helpful. Maintaining a calm, relaxed inner attitude in the face of mental obstacles or calming down (e.g., through breathing) was stated by athletes as well, they described behaviors like “regarding riding in the field, concentration, and tactics: Try to stay relaxed, don't tense up” or “try to stay calm and tell myself that I trained well. Have fun”. Imagination in the sense of using motivating pictures or ideas and repression (i.e., “ignoring” the mental challenge) was also named. One athlete described his imagination more in detail: “About going to the limit: Thinking about why you are doing it, playing music in your head or certain motivating phrases. Create feelings that release performance, e.g., euphoria, anger.” Athletes also described to cope inadequately with inner obstacles due to excessive demands through mental obstacles. For example, they stated to feel “overwhelmed” or simply answered to deal “bad[ly], I rise to the challenge”. Visualization (e.g., “Visualization of the race situation, the attack, the victory in the head prior to the race”) and focusing on themselves - as they reported “I do my own thing” or “I focus on myself” - was a possible goal-directed behavior, which was perceived as between
rather and very much helpful. Social support, in terms of “talk[ing] with parents or coach” for support, and concentration (e.g., “trying to think logically as much as possible, retrieve learned and also use more and more feeling and routine”) were estimated as quite helpful. Fun with the athletic activity and external aids like “music” were also stated. Goal-directed behaviors were on average rated as rather helpful ($M = 3.7 \pm 0.8$), with focusing being estimated as most helpful ($M = 4.5 \pm 0.7$). Figure 3 illustrates how helpful athletes rated each of the goal-directed behaviors.

**Table 2.**

**Themes of inner obstacles reported by athletes (Study 1) and coaches (Study 2) and their definitions.**

<table>
<thead>
<tr>
<th>Theme</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dealing with Demanding</strong></td>
<td>Difficulties to deal with particularly demanding situations. This includes unforeseen events such as falls as well as difficult environmental conditions (unfavourable weather conditions, disadvantageous starting position, etc.) and personal situational difficulties such as experiencing pain.</td>
</tr>
<tr>
<td><strong>Concentration</strong></td>
<td>It is difficult for athletes to make a focused decision under high physical stress or to maintain concentration under distracting, irrelevant environmental factors, distractions that may arise internally or externally.</td>
</tr>
<tr>
<td><strong>Pressure</strong></td>
<td>Influenced from outside or by the person him/herself. Can be caused by different factors such as competition, own attitude of entitlement or the individual situation as well as by the lack of competence to distance oneself internally and can be perceived as a threat.</td>
</tr>
<tr>
<td><strong>Cycling Technique / Strategy</strong></td>
<td>This includes everything that is related to the applied tactical strategy in a broader sense. Applying/maintaining the strategy even when the situation might lead one to do otherwise. Recognizing and assessing the right moment in a race situation for certain strategic moves, but also having difficulty using these moments to one's advantage.</td>
</tr>
<tr>
<td><strong>Demotivation</strong></td>
<td>Difficult to keep up motivation and not being able to motivate oneself despite/because of a negative situation occurring.</td>
</tr>
<tr>
<td><strong>Self-Assessment</strong></td>
<td>A correct self-assessment as a challenge. This includes, for example, not overestimating oneself prematurely and then collapsing, but also not underestimating oneself and possibly risking too little. Overcoming a negative self-assessment or achieving a positive self-assessment also falls into this category.</td>
</tr>
<tr>
<td><strong>Tension</strong></td>
<td>High nervousness or an increased state of arousal (due to stress, hectic, excitement) hinder athletes from being able to deliver the best performance or to prepare well for the competition.</td>
</tr>
<tr>
<td><strong>Mental Exhaustion</strong></td>
<td>A decrease in mental strength due to increased mental stress. This can show itself, for example, in increased distractibility / diminishing focus.</td>
</tr>
<tr>
<td><strong>Goal Pursuit</strong></td>
<td>The constant pursuit of the goal and the belief in the goal as a mental challenge. Continuing to pursue the goal even when (mentally) exhausted or lagging behind as a challenge.</td>
</tr>
<tr>
<td><strong>Insecurity</strong></td>
<td>Athletes react with insecurity to demanding situations in competition.</td>
</tr>
<tr>
<td><strong>Willpower</strong></td>
<td>Athletes cannot always maintain their will to go to the limit of performance.</td>
</tr>
<tr>
<td><strong>Fear</strong></td>
<td>Athletes suffer from anxiety concerning their performance and competition, are afraid to fail.</td>
</tr>
<tr>
<td><strong>Planning</strong></td>
<td>Athletes still have difficulties to plan the correct dealing with certain challenges.</td>
</tr>
<tr>
<td><strong>Distraction</strong></td>
<td>Athletes are too distracted prior to competition to prepare themselves well.</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>It is difficult for athletes to react safely and quickly to changing conditions.</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Not classifiable</td>
</tr>
</tbody>
</table>

*Note.* 1 refers to obstacles only stated in Study 1, while 2 indicates obstacles reported only in Study 2.
Table 3.

Themes of goal-directed behaviors reported by athletes (Study 1) and coaches (Study 2) and their definitions.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>Athletes prepare intensively for the competition and plan how to deal with difficult or critical situations.</td>
</tr>
<tr>
<td>Self-Encouragement</td>
<td>Any form of speaking to oneself. Mental (for outsiders not audible) self-promotion like speaking aloud with oneself.</td>
</tr>
<tr>
<td>Calming / Relaxation</td>
<td>Maintaining a calm, serene inner attitude when mentally challenged. Also, actions that promote relaxation or reduce hectic/stress.</td>
</tr>
<tr>
<td>Concentration</td>
<td>Athletes concentrate and blank out everything else.</td>
</tr>
<tr>
<td>Social Support</td>
<td>Support from people in the social environment, such as family members, friends, coaches, etc.</td>
</tr>
<tr>
<td>Imagination</td>
<td>Athletes use motivational images or imagery.</td>
</tr>
<tr>
<td>Repression(^1)</td>
<td>The mental challenge is ignored, blanked out or repressed by athletes.</td>
</tr>
<tr>
<td>Visualization(^1)</td>
<td>Something is pictured to deal with the mental challenge. This can be a past training as well as a future race. The visualization can happen before or in the situation.</td>
</tr>
<tr>
<td>Excessive Demand(^1)</td>
<td>Athletes have inadequate strategies to deal with mental obstacles. Implies that athletes are impaired in their performance by their mental obstacles.</td>
</tr>
<tr>
<td>Focusing(^1)</td>
<td>Focus (concentration) on the own person. The actions of other people and the situation recede into the background.</td>
</tr>
<tr>
<td>Fun(^1)</td>
<td>Athletes try to meet the mental challenge by having fun with the activity (in this case, cycling) or use fun that does not come from the activity itself as coping.</td>
</tr>
<tr>
<td>External Aids(^1)</td>
<td>These include technical aids that are external to the person, such as special apps, etc. These categories also include aids that the person uses before or during the stress situation, such as certain drinks, food, or music.</td>
</tr>
<tr>
<td>Undifferentiated(^2)</td>
<td>No specific handling can be derived from the answer.</td>
</tr>
<tr>
<td>Negative Assimilation(^2)</td>
<td>Athletes process mental obstacles negatively and may react irritably or withdraw themselves.</td>
</tr>
<tr>
<td>Mindset(^2)</td>
<td>Athletes deal with mental obstacles with a certain attitude.</td>
</tr>
<tr>
<td>Motivation(^2)</td>
<td>Athletes are highly motivated for the competition.</td>
</tr>
<tr>
<td>Tension(^2)</td>
<td>Athletes react nervously to mental challenges.</td>
</tr>
<tr>
<td>Willpower(^2)</td>
<td>Athletes use their will (e.g., to win).</td>
</tr>
</tbody>
</table>

Note: \(^1\) refers to goal-directed behaviors only stated in Study 1, while \(^2\) indicates goal-directed behaviors reported only in Study 2.

Study 2: Coach Sample

Participants

\(N = 42\) coaches (age: \(M = 50.2 \pm 9.8\) years, gender: 38 male, 3 female, and 1 coach where no gender was specified), participated in the paper-pencil survey during an in-person workshop for level-A cycling coaches. They reported a coaching experience of \(M = 25.6 \pm 10.7\) years, most had a level-A license in competitive sports (i.e., the second-highest coaching license in Germany) and three coaches had the highest German coaching license. Table 1 maps the experience of cycling training in years, while Figure 1 shows which disciplines coaches stated to train overall, their mainly
trained cycling discipline, and what levels their coached athletes compete on.

**Results**

**Inner Obstacles.** Coaches’ answers regarding central inner obstacles that are demanding during athletes’ competitions were assigned to a total of 14 themes which comprised between 1 and 8 data extracts per theme (see Table 2 for an overview of themes and their definitions and Figure 2 for a visualization of frequencies). The most frequently stated inner obstacle was *dealing with demanding situations*, such as “course conditions” or “surviving the mass start situation (riding as far ahead as possible)”. Difficulties to *concentrate* were identified as a challenge by coaches, as trouble to “make thoughtful decisions under high physical stress” or to stay “100% focused but not tense”. From their point of view, athletes struggled with adhering to their *cycling strategies* like “rolling along in the main field to save energy” or “completing difficult technical sections without...”

**Figure 3.**

*Perceived helpfulness of goal-directed behaviors to overcome inner obstacles rated by athletes (Study 1) and coaches (Study 2; scale from 1 = “not at all” to 5 = “very much”).*
crashing”. Self-assessment, such as “not to become arrogant”, “self-assessment of tactical-technical performance”, or “self-doubt” was also mentioned. Coaches seemed to perceive their athletes as emotionally challenged by insecurity (e.g., “there are so many strong/better athletes”, “not knowing about strength of competition”) and fear (e.g., “fear of failure, of not performing up to expectations”, “the higher the level, the more existential fears”). Demotivation due to difficult competitive situations, like “motivation problems when the pace of the field cannot be followed” or “to finish the race, not to give up even in a hopeless situation”, high tension (e.g., “nervousness at start (and prior)”) and pressure, such as “pressure of expectations (internal + external)” were further performance-reducing obstacles. A lack of willpower, that the athlete cannot always maintain the will to push to the limit (e.g., “perseverance”, “overcoming limitations”) was described as an inner obstacle as well. Athletes’ difficulty in planning how to address certain obstacles (e.g., “1. Warm up 2. Start of the race, Pedalling 3. Contact with escapees”) was also addressed, while flexibility appeared as athletes’ difficulty in responding safely, including their “reactions to [a] changed competition situation (keyword Plan B)”. Distraction in the sense that athletes “focus too much on external factors (forgetting about eating)” was also observed as an inner obstacle.

Goal-Directed Behaviors. Goal-directed behaviors (i.e., how coaches perceive that athletes overcome inner obstacles) were assigned to 12 categories in total with 2 to 11 data extracts per theme (see Table 3 and Figure 2). Preparation (i.e., planning how to cope with difficult or critical information, like regarding their competition, conditions), was named most frequently but rated as partly useful. As one coach describes it: “They require an extremely large amount of information on the competition requirement, competition, extra[ordinary] conditions, etc.”. It is emphasized to “talking through individual actions in your head (line choice, riding actions, self-motivation)”. Social support, such as “cooperation with trainer (encouragement, strategy, cheering)” or the “team meeting”, and concentration were also mentioned frequently but estimated as partly helpful. One coach stated the “focus on [the] own pre-start process”, and another the importance to “hide own weaknesses, concentrate on strengths”. It was brought up that athletes assimilated inner obstacles negatively by showing “introverted, sometimes aggressive behavior”, are “irritable, unresponsive” or “overact, distract”, which was deemed as an important aspect. Tension as a
reaction to mental obstacles was also stated as a (maladaptive) goal-directed behavior which was rated as little useful. Coaches reported their athletes to be “nervous, talking [themselves] out of it” or that “nervousness is projected onto various trivialities (e.g., supposedly "bad" food). They then get caught in a spiral of discomfort and are then unable to ride optimally activated.” Self-encouragement like motivational phrases (especially illustrative examples being “Only the good ones stay [-] The losers leave”, “If you can win[,] win[,] If you lose[,] then you lose [-] but never give up”) as goal-directed behavior was estimated between partly and quite useful as well as motivation (one coach named it “high intrinsic motivation”). A positive mindset (e.g., a “positive basic attitude”) and willpower – for example, labeled as “will to fight, will to win (winning rider)” - were also considered between partly and quite useful. Further goal-directed behaviors to handle mental obstacles were relaxation in the sense of “sufficient rest (active) before the competition, sufficient sleep”, as well as imagination. One detailed imagination entailed “You see yourself in the race, you've trained for it, the weather doesn't matter. You can do this, the road is one with you, and imagine how you ride the track. And ride ahead. You are one with yourself”. One-sixth of the coaches’ statements could not be classified in a differentiated way because the statements were too general (e.g., “different, some very good, others rather bad”). Goal-directed behaviors on average were rated as partly helpful \((M = 3.3 \pm 0.9)\), with motivation being estimated as most helpful \((M = 5.0)\), only one estimation provided; Figure 3 illustrates the helpfulness of each goal-directed behavior.

**Discussion**

We investigated the inner obstacles that athletes face in cycling competitions and assessed the goal-directed behaviors they use to deal with these obstacles. To this end, we recruited a sample of athletes (Study 1) and a sample of coaches (Study 2) to obtain two nonaligned perspectives on these questions. These analyses revealed substantial overlaps between the two perspectives (i.e., athletes and coaches) concerning obstacles and goal-directed behaviors. Pressure, dealing with demanding situations, and maintaining concentration were the most frequently experienced obstacles reported by athletes. Coaches reported dealing with demanding situations, concentration, and cycling technique as the most common challenges. However, some particularly interesting
differences were observed too: for example, athletes frequently named dealing with external circumstances as demanding (e.g., crashes, weather, course), while coaches were more likely to specify obstructive emotions such as fear and insecurity. To overcome these obstacles, athletes relied on preparation, self-encouragement, and relaxation. Preparation was also a goal-directed behavior mentioned by the coaches, who additionally mentioned concentration and social support.

All in all, athletes and coaches presented an extensive overview of the obstacles recurring in cycling competitions and the goal-directed behaviors they would apply to address them. In the following, we will first outline how the findings of this qualitative assessment fit into existing sport psychology literature and then deduce how future research on implementation intention theory in sports might incorporate the present findings to develop better if-then plans for the sports domain to arrive at more effective interventions.

**Inner Obstacles and Goal-Directed Behaviors**

Regarding the inner obstacles, the central role of perceived pressure in both the athlete and the coach sample is consistent with existing literature (e.g., McKay et al., 2008; Thelwell et al., 2007). For instance, the importance of pressure and competitive stressors was also emphasized in a study focusing on young elite athletes across sports disciplines (Kristiansen & Roberts, 2010). Athletes in this study reported being challenged by pressure exerted by others and themselves, as well as by being intimidated by more experienced competitors in the field. These athletes also found it difficult to adhere to rituals before competitions, which was also mentioned by the coaches in Study 2 as a potential obstacle (e.g., athletes forget to eat because they are distracted by environmental factors). Especially negative emotions like insecurity and fear were mentioned by the coaches, which have been observed to interfere with focus and concentration similar to demotivation (Lazarus, 2000). The mention of mental exhaustion by athletes fits into the large research body of ego depletion (e.g., Englert, 2016) and mental fatigue (e.g., Marcora et al., 2009), respectively, and reflects the presumed impairment of athletic performance well studied in the theoretical framework (for an overview, see Giboin & Wolff, 2019).

Concerning goal-directed behaviors, athletes and coaches in our studies mentioned a broad range of behaviors that could be used as mental strategies to deal with inner obstacles, indicating
their importance for optimum performance in elite competition (e.g., Orlick & Partington, 1988). For instance, *self-encouragement* that might occur in the form of self-talk was mentioned as a strategy by both athletes and coaches, in line with findings that athletes use self-talk routinely (L. Wang et al., 2003) and consider it as performance enhancing (Masciana et al., 2001). Similarly, research revealed that young elite athletes find it useful to engage in self-talk; moreover, they emphasized maintaining concentration and focus as well as controlling their nervousness as further helpful behaviors (Kristiansen & Roberts, 2010). The importance of emotion regulation is also evident in the coaches’ mentions that an accumulation of negative emotions (e.g., anxiety, self-doubt) occurred as a maladaptive reaction in dealing with inner obstacles. The necessity to keep up cognitive control, reflected by the categories *concentration* and *focus* in our data, is known to enhance performance (Brick et al., 2014) and facilitate performance improvement (Clingman & Hilliard, 1990). Indeed, the appropriate use of mental strategies has been linked to superior athletic performance in several studies. For example, ultramarathon runners use mental strategies like self-talk, attention strategies, imagery, and goal setting to master their race (Simpson et al., 2014).

Finally, both athletes and coaches identified the relevance of *social support* to improve performance, which is assumed to aid in coping with stress in competitive contexts (Rees et al., 2007) and to protect from stress (Rees & Hardy, 2004). Coaches particularly emphasized the importance of their athletes’ *willpower* and *motivation* in dealing with challenges, reflecting the complex discourse and interplay between these two factors (e.g., Ainslie, 2020) and also raising questions for further research, such as whether athletes have a higher overall motivation to overcome effort or fundamentally experience it as more justified.

**Implications for If-Then Planning Research in Sports**

We addressed our research question through the lens of implementation intention theory. Interventions based on the theory commonly take one of two forms (e.g., Keller et al., 2019): (1) participants are either instructed to specify obstacles and goal-directed behaviors on their own or (2) they are given plans with predetermined obstacles and behaviors. In the first case, the assumption is that participants have sufficient insight into the obstacles that might jeopardize their
goal attainment as well as sufficient knowledge about effective goal-directed behaviors. Based on our data, we addressed this assumption and established that athletes’ and coaches’ answers converge with findings in the sport psychology literature. The present research suggests that elite and youth-level athletes and coaches have substantial insights into the obstacles associated with cycling competitions and the goal-directed behaviors they could use to deal with them. This puts them in the ideal position to devise effective if-then plans to enhance their performance, which might not have been the case with the less experienced exercisers that have been investigated in previous research on implementation intention theory in sports (Bieleke & Wolff, 2017; Hirsch et al., 2021; Hirsch et al., 2020; Latinjak et al., 2018; Wolff et al., 2018).

In the second case of interventions based on implementation intention theory, it is important to know the relevant obstacles and goal-directed behaviors. This is where our findings make an important contribution. One possibility to capitalize on the results of the present studies in future research is to combine the assessed obstacles and goal-directed behaviors into if-then plans to examine whether these if-then plans support athletes in optimizing performance (e.g., in analogy to previous studies on the effects of implementation intentions in sports where tennis players were provided with lists of negative inner states and coping responses to create effective if-then plans, Achtziger et al., 2008). For instance, future studies might focus more strongly on negative affective reactions as obstacles (e.g., tension, nervousness, pressure, anxiety) than previous if-then planning interventions in endurance tasks did, whose focus was mainly on muscle pain (e.g., Hirsch et al., 2020; Thürmer et al., 2017; S. Wang et al., 2019) and perceived effort (e.g., Bieleke & Wolff, 2017; Wolff et al., 2018). This seems particularly promising as, under some conditions, negative affective reactions have been associated with improved performance (Hanin, 2010; Lane et al., 2011). For instance, when exercisers associate nervousness with a good performance. Regarding the goal-directed behaviors specified in previous if-then planning research, a stronger focus could be on relaxation, concentration, preparation, or self-reassurance. Especially the focus on self-encouraging statements would reflect the importance of self-talk in sport psychology literature (e.g., McCormick & Hatzigeorgiadis, 2019). Indeed, while previous if-then planning research has often specified task continuation (“Keep going”; e.g., Hirsch et al., 2020) as a goal-directed behavior and failed to
observe enhanced performance, one study found positive effects of if-then planning on endurance performance when using self-encouragement as a goal-directed behavior (“I can do it”; e.g., Thürmer et al., 2017). Although this latter study relied on a student sample, its findings lay credence to the promise of self-encouragement as a goal-directed behavior that is suitable for implementation intention theory-based interventions and that is deemed relevant by athletes and coaches alike. In addition, it might be promising to combine implementation intentions with mental contrasting (for a detailed description, see Oettingen, 2015) to design more effective implementation intention interventions in the sports context. Connecting mental contrasting with implementation intentions (MCII; Oettingen, 2014; Oettingen & Gollwitzer, 2010) successfully employs a similar formulation of wishes, optimal outcomes, possible obstructive obstacles, and plans, for example in the area of health (Stadler et al., 2010), or physical activity (Marquardt et al., 2017).

**Further Considerations and Practical Implications**

Some limitations of the present research should be noted. First, we relied on data sets from athletes and coaches who were not matched to each other (even though we cannot rule out that some of them already worked together). While this provided us with more diverse perspectives than dyadically matched data, it also limits our ability to directly compare the answers and to triangulate the data appropriately. For instance, future research might investigate whether athletes differ in their views on obstacles and goal-directed behaviors from their coaches. Furthermore, recruiting matching samples would also allow for a more precise evaluation of the usefulness of employed goal-directed behaviors, in accordance with both perspectives. Second, while the responses from coaches were collected via a paper-pencil questionnaire with a researcher on site, the athlete data were collected with an online survey which might explain the higher dropout rate among athletes. This might limit the generalizability of our results (e.g., athletes who dropped out might have named other obstacles and behaviors) but the online format allowed us to recruit a larger number of athletes in general. In the future, generalization of the results for endurance sports could further be expanded by investigating comparative samples with amateur athletes to figure out whether they perceive the same or different inner obstacles and goal-directed behaviors. Additionally, due to the accessibility of our samples, it was not possible to collect balanced samples in several aspects (e.g., age,
performance level, cycling discipline). For example, our sample of athletes who completed the whole questionnaire consists of a disproportionately large number of young cyclists, which makes it little informative about certain patterns in answers within specific age groups, for example. This analytical aspect could receive more attention in future research.

Also, with regard to the obstacles and goal-directed behaviors mentioned, further questions arise that go beyond the scope of this study. For example, athletes and coaches appeared to mention pressure differently: pressure is perceived as the most common obstacle by athletes, while coaches often see pressure as an important factor in achieving the best performance. Considering that a very controlling, pressure-building training style can be associated with demotivation (e.g., Haerens et al., 2018), this might be a factor to consider when training coaches in sport psychology interventions. One could speculate that the pressure that athletes named is also captured by the negative affect that coaches mentioned. Linking this to the factor of willpower (which only coaches mentioned), it could be assumed that coaches tend to build up pressure when they suspect that their athletes have too little willpower, while on the other hand, the athletes might choke precisely because of this pressure. This assumption might be supported by the goal-directed behaviors mentioned by athletes and coaches: For example, athletes mentioned relaxation, possibly to reduce pressure, while coaches emphasized concentration, motivation, and social support to increase willpower and thus athletic performance. However, this could create even more pressure for athletes.

Moreover, future investigations might consider interviews with athletes and coaches to allow a more in-depth exploration (e.g., in terms of connections or context) of the findings compared to the questionnaires used. First, inner obstacles and goal-directed behaviors could be set in direct relation to each other. Given the data collection format used, no follow-up questions could be made to athletes or coaches about the extent to which the described inner obstacles or goal-directed behaviors directly relate to each other. For example, one goal-directed behavior was reported after naming three different inner obstacles. While it can be assumed that this goal-directed behavior could be used to overcome all three inner obstacles, this cannot be said with certainty and thus cannot be analyzed in relation to each other in our case. In future exploratory studies, this would be crucial to recognize and examine relevant connections between inner obstacles and goal-
directed behaviors. In addition, hypothesized mechanisms for effective behavior could be extracted in further analytical approaches. Secondly, interviews would also allow to assess the extent to which athletes and coaches speak a different language for similar inner obstacles and goal-directed behaviors or where they might misunderstand each other. On a small scale, this would reduce the likelihood of unclear or overly general statements (as occurred in Study 2), and on a large scale could improve athlete-coach communication, thereby increasing athlete satisfaction. Finally, beyond bridging linguistic discrepancies in working together, guided interviews would have other benefits as well: To overcome inner obstacles using goal-directed behaviors, athletes must first recognize and identify them. To do so, they must have or develop, respectively, a deeper understanding of their thought patterns and emotional responses, as well as the external factors that may add to their struggles. This is necessary to choose the appropriate goal-directed behaviors but might be an ability that athletes are likely to have difficulties with. In interviews, one can react to any noticeable difficulties and assist athletes. This probably optimizes study results, which will facilitate even better theory-practice transfer in terms of acceptance and applicability of interventions. It is conceivable, aside from methodological considerations, that when experimenting with if-then plans in practice (as suggested by Bieleke, Wolff, et al., 2021), similar training effects could occur for this skill as for visualization skills (which are more highly developed in top athletes; Murphy & Martin, 2002; Weinberg, 2008). Potentially reinforcing effects are also found when implementation intentions are applied on a regular basis (Gollwitzer & Sheeran, 2006). In further research, an interplay of these two factors would certainly be worth considering, and in practice, athletes could benefit from visualizing and then formulating relevant inner obstacles and goal-directed behaviors.

Despite the difficulties associated with endurance performance, the implementation and training of self-reflective and self-regulatory strategies seems worthwhile for athletes and coaches. Our study provides insights into a multitude of potential inner obstacles and goal-directed behaviors. These insights can be used, for example, to facilitate and refine the application of if-then plans. While definitive conclusions and authoritative recommendations are beyond the scope of the present research, some tentative suggestions for the use of if-then planning can be derived from
previous research. For instance, studies in endurance sports suggest that if-then plans should not be formulated too close to the planned behavior to allow sufficient time for the if-then plan to consolidate (e.g., Hirsch et al., 2021). To facilitate memorizing and internalizing the content of the plans, it can be helpful to repeat them in one's mind's eye (e.g., Bieleke et al., 2018). Reinforcing effects occur when they are applied regularly (Gollwitzer & Sheeran, 2006). On the other hand, if-then plans should be reviewed on a regular basis as their impact varies depending on different factors, such as the type of behavior, motivation, and context (Gollwitzer & Sheeran, 2006). Finally, it is important to ensure the personal relevance of if-then plans to facilitate their effectiveness (Bieleke, Wolff, et al., 2021).

**Conclusion**

This study explored athletes' inner obstacles and goal-directed behaviors in a competitive context from the perspective of elite and youth-level athletes (Study 1) and elite coaches (Study 2). The qualitative analysis provided a comprehensive picture of inner obstacles (e.g., pressure, dealing with demanding situations, maintaining concentration, cycling technique) and goal-directed behaviors (e.g., preparation, self-encouragement, relaxation, concentration, social support). The results of this study contribute to sport psychological research with implementation intentions by providing new approaches regarding the mixed literature in this area (e.g., through new plan content) and underline the variety of emotional-psychological obstacles that elite and youth-level cycling athletes face.

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**Conflict of Interest**
The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Data Availability Statement**
Questionnaires available at https://osf.io/2bqtx/.

**Author Contribution**
A.H., M.B., W.W., and J.S. contributed to the design of the survey. A.H. carried out the data collection. The first draft of the paper was written by A.H. Data analysis was performed by A.H.; M.B., W.W., and J.S. revised and edited the manuscript which was then finalized by A.H. All authors approved of the submitted version of the manuscript.

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References


Struggles and strategies in anaerobic and aerobic cycling tests: A mixed-method approach with a focus on tailored self-regulation strategies

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Abstract

Endurance sports pose a plethora of mental demands that exercisers have to deal with. Unfortunately, investigations of exercise-specific demands and strategies to deal with them are insufficiently researched, leading to a gap in knowledge about athletic requirements and strategies used to deal with them. Here, we investigated which obstacles exercisers experience during an anaerobic (Wingate test) and an aerobic cycling test (incremental exercise test), as well as the strategies they considered helpful for dealing with these obstacles (qualitative analysis). In addition, we examined whether thinking of these obstacles and strategies in terms of if-then plans (or implementation intentions; i.e., "If I encounter obstacle O, then I will apply strategy S!") improves performance over merely setting performance goals (i.e., goal intentions; quantitative analysis). 

N = 59 participants (age: M = 23.9 ± 6.5 years) performed both tests twice in a 2-within (Experimental session: 1 vs. 2) × 2-between (Condition: goal vs. implementation intention) design. Exercisers’ obstacles and strategies were assessed using structured interviews in Session 1 and subjected to thematic analysis. In both tests, feelings of exertion were the most frequently stated obstacle. Motivation to do well, self-encouragement, and focus on the body and on cycling were frequently stated strategies in both tests. There were also test-specific obstacles, such as boredom reported in the aerobic test. For session 2, the obstacles and strategies elicited in Session 1 were used to specify if-then plans. Bayesian mixed-factor ANOVA suggests, however, that if-then plans did not help exercisers to improve their performance. These findings shed novel light into the mental processes accompanying endurance exercise and the limits they pose on performance.

Introduction

The specific psychological obstacles that exercisers face during an endurance performance and the strategies they apply to deal with them requires more research as this topic is of great scientific and practical importance [1, 2], for example when it comes to enhancing motivation on continuous athletic activity or exercisers’ athletic performance in general. To understand the
limits of endurance performance (i.e., factors that hamper or disrupt endurance performance) and design effective sport psychological interventions, knowledge about the various exercise-related psychological obstacles that might affect performance is crucial [3]. Accordingly, a growing body of research focuses on the obstacles that endurance athletes have to deal with during performance (e.g., [1, 4]) and comprehensive reviews shed light on the characteristics of psychological interventions in sport that allow them to improve endurance performance (e.g., [5]).

According to the psychobiological model of exercise tolerance [6, 7], the perceived exertion (referred to as “the conscious sensation of how hard, heavy, and strenuous a physical task is”; [8]) plays a critical role: When the application of additional effort appears unreasonable or not possible, endurance performance (i.e., cycling) is terminated [6, 7]. Other frameworks like the taxonomy of fatigue argue that perceived fatigability (referred to as “the sensations that regulate the integrity of the performer based on the maintenance of homeostasis and the psychological state of the individual”; [9]) is impacted by exercise-induced sensations like exertion or pain and thus influences performance fatigability (i.e., muscle and nervous system capacity to generate a sufficient response for a given exercise; [9]). Exercise-induced pain itself is also an important determinant of endurance performance, as higher pain tolerance is associated with enhanced endurance performance (see [10] for a detailed overview). This is consistent with observations that former Olympic cyclists report successful coping with pain to be the greatest psychological challenge [11], and that being occupied with physical discomfort impaired performance [4]. Corroborating the assumptions made in these theoretical frameworks, a focus group study with recreational endurance exercisers revealed that exercise-related sensations like exertion, pain, fatigue, or discomfort were the most common challenges [1]. Beyond dealing with these bodily sensations, staying focused and motivated after difficult situations are further obstacles recreational exercisers report. However, sport-specific obstacles differ between athletes and non-athletes: For example, non-athletes are more likely to process physiological signals during sports negatively (e.g., sensations of exertion and pain) which might in turn trigger negative affective reactions [12]. Also, non-athletes reported more pain, discomfort, or articulated irrelevant information for the exercise than athletes [13]. Thus, lack of experience creates critical obstacles in sport.

Beyond focusing on perceived obstacles, it is also crucial to know which strategies exercisers spontaneously apply to deal with them. Deliberately implemented strategies and programs have been studied extensively (e.g., [2, 14]) and show that endurance performance can be enhanced by mental imagery, self-talk, and goal setting [2]. For instance, self-talk interventions can reduce perceptions of effort as one determinant of endurance performance [15]. Active distraction at low training intensities was perceived as helpful in a sample of recreational runners to reduce boredom and increase positive emotions [16]. Accordingly, metacognitive skills -pertaining to “planning and reviewing one’s attentional focus” [4], seem to be helpful for athletes in order to gain knowledge about the use of cognitive strategies. As with exercise-related obstacles, expertise and fitness level affect the kind of strategies exercisers use [17]. Thus, a key characteristic of a strategy to enhance endurance performance is the adaptability to requirements and demand levels of different sports and athletes’ abilities. To our knowledge, research that elicits the specific obstacles exercisers face during a single bout of exercise, and that assesses the strategies exercisers use to cope with these challenges is lacking.

**Obstacles and strategies might depend on exercise characteristics**

Exercise-induced obstacles and strategies to deal with them vary not only as a function of the exercisers’ training level and experience but also as a function of the task demands associated
with an exercise. Within a given sport, physiological demands vary in terms of changes in neural blood circulations and metabolism [18], reduced oxygen distribution [19], and ionic and metabolic modifications in the concerned muscle [20]. Consequently, these effects also affect our psychological response to athletic activities. For instance, our affective response is modulated by the intensity of an exercise [21]: At moderate intensities (i.e., up to the aerobic threshold) exerciser tend to have positive affective response, whereas at very high intensities (i.e., above the anaerobic threshold) the affective response tends to be negative. This difference in affective response has been explained (among others) by the different interoceptive sensations created by these intensities [21]. The three-dimensional framework of perceived fatigability further highlights the differential contributions of sensory-discriminatory (i.e., perception of strain), affective-motivational (i.e., key emotion), and cognitive-evaluative components (i.e., mindset) to endurance performance [22]. For example, a short anaerobic test can be completed by most exercisers, as it covers an exercising time of only 30 seconds, which might lead to a higher sense of achievability. However, the short duration of the test means that there is little time to adjust performance strategies. An aerobic test, on the other hand, is open ended and will therefore lead to complete exhaustion of the exerciser, likely leading to negative affective reactions. It is each participant’s decision when to terminate the test, which also makes performance dependent on motivation and attitude. Due to the steady increase in power output, the aerobic test probably requires significantly more self-control from the exerciser (see [23] for a similar reasoning). Due to its longer duration, however, participants might also have more opportunities to adapt their strategies in order to last longer. Thus, different exercises (within one type of sport, as well as across sports) vary in the physiological and psychological demands they impose, which in turn might create obstacles that are very exercise-specific. To account for these differences, strategies need to be tailored to the obstacles an exerciser faces [24].

Optimizing performance with tailored self-regulatory interventions

Optimal performance hinges on effective self-regulation (i.e., “the capacity of organisms (here, human beings) to override and alter their responses” [25]), the importance of which for sports performance is well established (e.g., [26]). Beyond relying on their intuitive lay knowledge, exercisers might benefit from employing targeted self-regulatory strategies to deal more effectively with their exercise-induced obstacles. One promising self-regulatory strategy is if-then planning (often referred to as implementation intentions; [27]). Implementation intentions are an effective self-regulation strategy in a variety of contexts [28, 29], like in the context of physical exercise [30], health (e.g., [31–33]), and researchers have started to investigate its effects on endurance performance (e.g., [34]). If-then planning is based on establishing links between goal-relevant situations (e.g., obstacle: experiencing the urge to stop) and goal-directed behaviors (e.g., overcoming the obstacle: cheering yourself on) in an if-then format: “If I encounter obstacle X, then I will perform behavior Y!” (e.g., “And if I feel the urge to stop, then I tell myself: You can do it!”; [35]). The structure of if-then plans is assumed to facilitate goal attainment by strengthening the mental representation of the goal-relevant situation, making it more accessible and easier to recognize [27, 36]. Moreover, if-then planning is assumed to automate the initiation of the goal-directed behavior [37].

If-then planning is typically contrasted with forming goal intentions, which refers to merely specifying a desired outcome or a desired behavior (e.g., “I want to keep going as long as possible!”; [38]). Because such goals comprise no specific link between a situation and a behavior, they are conducive to more deliberative, top-down ways of self-regulation than if-then planning, which facilitates automatic, bottom-up ways of self-regulation. Importantly, research
shows that when it comes to staying on track, even when performing the goal-directed behavior is perceived as aversive, if-then planning is a more effective self-regulation strategy than goal setting [39]. Moreover, if-then plans are effective for counteracting impulsive reactions [40], which can be helpful for example when an athlete has to control the impulse to follow every acceleration of her opponents (because not controlling this impulse would eventually wear out the athlete, reducing the chance to win the race). Their desirable cognitive mechanisms (e.g., automaticity) and their effectiveness across various domains (e.g., health, exercise) render if-then plans a promising self-regulatory strategy in endurance sports [41]. However, prior research in this domain has so far produced mixed results (see [34] for a comprehensive overview): plans focusing on one or two obstacles defined by the experimenter have been investigated [42–44] and observed inconsistent results. Bieleke et al. [34] argue that the effectiveness of if-then plans might be enhanced by tailoring if-then plans to athletes—that is, instructing exercisers to generate their own plan contents geared towards their personal obstacles and strategies to deal with them. For example, studies in which if-then plans were used without providing a particular obstacle in non-endurance domains (e.g., tennis, [45]; or golf and darts, [46]) found positive effects on performance. Thus, the heterogeneity of prior findings might be due to a lack of adequately tailoring if-then plans to the challenges an exerciser faces during the exercise [47].

The present study
Taken together, the first aim of this study is to use a qualitative approach to investigate 1) the specific obstacles exercisers face during two different exercises, 2) the strategies they use spontaneously to deal with these obstacles, and 3) the strategies they consider helpful for future performances of the test. These obstacles and strategies were assessed after a first session with an anaerobic (Wingate test) and an aerobic cycling test (incremental exercise test). The second goal is to investigate whether if-then plans can help exercisers to better deal with the obstacles they face during an anaerobic and an aerobic cycling test. To this end, we used the obstacles and strategies that participants reported in the first session to help them generate individually tailored if-then plans for a second session with the same two tests. In line with previous research [45, 46], we expected improved performance in the if-then plan condition compared to a goal intention condition. As control variables, we assessed ratings of perceived exertion (RPE; [48]) and goal commitment in both sessions.

Methods
Participants and design
We recruited a sample of N = 59 participants (age: M = 23.9 ± 6.5 years) for a 2-within (Session: 1 vs. 2) × 2-between (Condition: goal intention vs. implementation intention) mixed-factorial study. Study participants were recruited throughout the semester until a large enough sample was tested. The sample size was determined in accordance with other implementation intention research in sports, following recommendations to enhance power in this type of research (e.g., employing a within-subject design; for a systematic review, see [34]). A sample size of N = 54 participants is sufficient to detect a medium effect of f = 0.25 [49] in a mixed-factorial ANOVA to find a within-between interaction (α = .05) with a power of .95 (calculated with G*Power; [50]). Participants were randomly assigned to conditions. Seven participants were excluded from quantitative data analysis because they did not participate in the second session (N = 3), due to technical difficulties (N = 3), or because they did not comply with instructions (N = 1). This left 27 participants in the goal intention condition and 25 participants in the implementation intention condition.
The participants included in the quantitative analyses were $M = 169.4 \pm 16.1$ cm tall and weighed $M = 66.2 \pm 16.9$ kg. They reported to exercise $M = 5.4 \pm 2.9$ hours per week (endurance training: $M = 2.2 \pm 2.2$; strength training: $M = 2.4 \pm 2.2$) and to be engaged in a variety of sport activities (most frequently reported were jogging 21.1%, fitness 9.6%, soccer, weight training 7.7%), having performed their main sport activity for an average of $M = 7.3 \pm 7.0$ years. No participant reported cycling as their primary sport. Overall, participants stated to ride a bike for $M = 2.3 \pm 2$ hours per week as a physical activity (e.g., to commute to work), and to spend $M = 0.3 \pm 0.7$ hours per week with cycling as a sports activity. Participants in the goal and the implementation intention condition did not differ in their weekly training duration, $p = .370$, or the duration of performing their main sport, $p = .340$. There were no specific exclusion criteria for participation in the study, except that participants should have no injuries that prevented them from cycling. Moreover, we asked to avoid alcohol and strenuous exercise one day before each session and on the day of the session itself, as well as to refrain from consuming caffeine in the two hours before each session. Only marginal non-compliance from these requirements was recorded, with no differences between the goal and the implementation intention condition, $ps > .130$. All participants signed an informed consent and were compensated with 30 Euro and course credit when they completed both study sessions. The study protocol and measurements were approved by the Ethics Committee at the University of Konstanz (approval #24/2016). For all supplementary materials (Tables, Figs, study materials), please see https://osf.io/mq6kt/.

**Procedure**

The study comprised two individual sessions in the laboratory that followed a very similar procedure (see S1 Fig). We kept the order of tests constant (i.e., the anaerobic test followed by the aerobic test) because for relatively untrained participants it would be very difficult to perform well in the anaerobic after completing the aerobic test. The second session took place 7 to 14 days after the first session at the same time as the first session (if possible for participants). Each session was carried out by a researcher who explained the study protocol and guided participants through the anaerobic and the aerobic test. To ensure standardization, the study was always conducted by the same two researchers who followed a prepared experimental protocol.

**First session.** After anthropometric measurements were taken, the ergometer settings were adjusted until participants were comfortable on the bike. Then, participants completed a standardized warm-up protocol (a three-minute ride with a resistance of 1.5 watt (W)/kg, a five-second sprint with a resistance of 10 W/kg, and a two-minute ride with a resistance of 1.5 W/kg), were given the opportunity to adjust their position on the bike, and were introduced to the procedure of the anaerobic test and asked to set a performance goal ("I want to reach maximum power as fast as possible and hold it for as long as possible."). To assess perceived exertion, participants reported their RPE on the category ratio 10 (CR10) scale [48, 51] prior to the test (to familiarize themselves with the use of the scale) and immediately after they completed it (a continuous measurement during the anaerobic test was not possible due to cycling at maximum power output). In the following fifteen-minute break, goal commitment was assessed, and a structured interview was conducted which explored perceived obstacles of participants, the strategies they spontaneously employed to deal with these obstacles, and the strategies they deemed helpful in future performances of the test (see study materials in S1 Appendix). After the break, participants were introduced to the aerobic test and asked to set a performance goal ("I want to cycle as long as possible."). During the test, RPE was repeatedly assessed every three minutes ± 15s (i.e., when resistance increased). Concluding Session 1,
another structured interview was performed to explore obstacle and strategies and participants completed a final questionnaire. During both tests, the researcher did not interact with participants and stayed outside their field of vision.

Second session. Except for the random assignment of participants to the goal intention or the implementation intention condition, Session 2 followed the same general procedure as Session 1. Participants in the goal intention condition wrote down their respective performance goals (“I want to reach maximum power as fast as possible and to hold it as long as possible.” / “I want to cycle as long as possible.”). They were also instructed to reflect on the situations, thoughts, and actions they had stated in the structured interview conducted in the first session, which were listed on an instruction sheet. Participants in the implementation intention completed the same steps but were afterwards instructed to explicitly link their stated obstacles with goal-directed actions or thoughts in an if-then format. These were individual if-then plans and thus varied between participants (e.g., “If I have some power left, then I will pedal once again with maximum force!”; “If exertion gets too high, then I will cheer myself on once more!”). Participants could formulate and write down as many if-then plans as they needed, then they were asked to reflect those if-then plans for the upcoming test. The formulation of several plans should allow participants to prepare effectively for different obstacles (cf. [45]).

Tests and measures

Performance tests. Participants performed two different cycling tests that are frequently used in exercise science and which are typical in the context of endurance performance: the Wingate test (referred to as the anaerobic test; [52]) and an incremental exercise test (referred to as aerobic test). The Wingate test is a very short test (max. 30 seconds) that is used to measure peak power in a seated sprint on a cycling ergometer [53]. It is the most commonly used test when it comes to measuring anaerobic performance [54], is associated with a positive influence on endurance performance [55], and can also be used to predict endurance performance [56]. The incremental exercise test can be used to measure aerobic endurance performance [57]. Both cycling tests were performed on a Cyclus2 ergometer [58] that was equipped with Look Keo Sprint clipless pedals.

Anaerobic test. Participants were instructed to cycle at a frequency of 70 revolutions per minute (rpm) and to accelerate then: At a frequency of 80 rpm, the program activated the anaerobic test which lasted 30 seconds. Resistance during the test was dependent on cadence and determined relative to participants’ body weight [53]. Anaerobic exercise (maximum power) is generally reached after several seconds and decreases shortly (1–2 s) thereafter until the end of the test [59]. Participants were instructed to attempt to reach their maximum power after three to five seconds, and were asked to remain in a seated position, riding in the drops. As a measure of performance, the maximal performance in watts divided by bodyweight was used.

Aerobic test. Participants were instructed to cycle (seated and riding on the hoods) for as long as possible. The initial resistance was set to 60 W [60] and increased by 20 W every three minutes. Participants were instructed to keep a constant cadence between 75 and 95 rpm. On the Cyclus2 screen, participants could see the time until the next power increase, their cycled distance in kilometers, work in kilojoules, and their cadence. The test was terminated when participants’ cadence dropped below 65 rpm, and they were prompted by the experimenter when the cadence came down to 70 rpm. Time-to-exhaustion was used as a measure of aerobic performance.

Rating of Perceived Exertion (RPE). To measure the effort associated with performance of the anaerobic and the aerobic test, we assessed participants’ ratings of perceived exertion.
(RPE) with the CR10 scale [48, 51]. RPE was described to participants as “the conscious sensation of how hard, heavy, and strenuous a physical task is” [8]. We printed a scale for RPE on a sheet of paper that was placed in front of participants. The scale ranged from 0 (“nothing at all”) to 10 (“maximal”) / 11 (“even more than max”); [61]).

Questionnaires and structured interviews. Participants stated their goal commitment (adapted goal commitment scale [62]; e.g., “The goal was important to me.”; four items in total) after both the anaerobic test (Session 1: Cronbach’s $\alpha = 0.96$, Session 2: Cronbach’s $\alpha = 0.92$) and the aerobic test (Session 1: Cronbach’s $\alpha = 0.96$, Session 2: Cronbach’s $\alpha = 0.92$) in both sessions on seven-point Likert scales (1: does not apply, 7: fully applies). Additionally, participants provided demographic information (e.g., age, physical activity, main sports) once after the first session and they reported on their compliance with the study requirements (e.g., abstaining from caffeine) after both sessions.

In the structured interview, participants were asked to name any thoughts, emotions, and behaviors that they considered as obstacles for performing optimally in the test. Furthermore, they were asked to report any strategies they had used or that they deemed useful in future performances of the test. The experimenter explicitly stated that participants should focus on sensations and behaviors on which they have influence and that they could change. They were asked to answer as spontaneously as possible. Following these open questions, more detailed questions were asked by the experimenter (e.g., "Did a thought occur to you during the test, which you regard as helpful right now? When did this thought occur?" or "Were there any situations in which a hindering thought occupied your mind?"; analogous questions were asked regarding emotions and behavior). Only when participants struggled with answering these questions, examples were provided by the experimenter (e.g., “many athletes report encouraging themselves if the test becomes strenuous”) and participants indicated whether these examples applied to them. If participants still did not address the question, the experimenters moved on to the next question.

Data analysis

Qualitative data. Thematic analysis was used to analyze the structured interviews [63]. We used an inductive approach where the data were not assigned to any pre-determined categories and its level was semantic, i.e., it was not intended to identify underlying assumptions of participants [63]. One researcher first familiarized herself with the data to gain an initial impression of participants’ individual obstacles and strategies. Then, all interview items were coded, meaning that they were grouped first into broad topics and then into more specific categories. These categories were then re-evaluated to make sure that they presented the dataset accurately. Items that related to more than one category were assigned to multiple categories. Concluding this first step of the qualitative analysis, each category was clearly defined and named. Then, the second step of the analysis followed, in which two independent raters categorized the interview items into the defined categories. A blind rating format was used, meaning that the two independent raters did not know the first coder’s assignment and were only informed about the purpose of the interviews, the names of the categories and their definitions. If one item was coded to more than one category, raters were indicated to rate this item with multiple categories or to comment if they did not support multiple assignment. Then, the initial coder and the two raters discussed disagreements in assignment of categories until mutual agreement was achieved (see [64]) which was the case for all items. Categories were then grouped into general themes (see Table 1). S1A–S1C Table show the main results of the thematic analysis and give an overview over the categories, their definitions, and example statements, while Fig 1A–1C visualizes the frequencies of the general themes for both tests. S2
Quantitative data. First, we controlled if goal commitment in both tests and RPE finish in the anaerobic test differed between the goal intention and the implementation intention group and between sessions with a 2 (Condition: goal vs. implementation intention condition) × 2 (Session: 1 vs. 2) Bayesian mixed-factor ANOVA. For testing if RPE increased during the aerobic test and whether these increases differentiate between both conditions and sessions, we performed an analogous analysis with RPE as dependent variable, where we added test duration as additional within-participants factor for the aerobic test (to account for differences in test duration in the aerobic test, RPE values were standardized from 0 to a 100 percent and then aggregated across 20% intervals).

In addition, we checked for any performance differences between both groups in Session 1 conducting Bayesian t-tests, for which we report Bayes factors (BF10). The Bayes factor allows

<table>
<thead>
<tr>
<th>Obstacles</th>
<th>Strategies used</th>
<th>Potential strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Theme</td>
<td>Category</td>
<td>General Theme</td>
</tr>
<tr>
<td>Missing focus</td>
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<td>Distancing</td>
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<td></td>
<td>Distraction</td>
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<td>Missing drive</td>
<td>Attentional focus</td>
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<td></td>
<td><strong>Body</strong></td>
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<td>Frustration</td>
<td>Technique</td>
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<td></td>
<td><strong>Failure</strong></td>
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<td></td>
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<td></td>
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<td><strong>Pressure to perform</strong></td>
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<td>Test demands</td>
<td>Surprised by test demands</td>
<td>Performance</td>
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<td><strong>Acceleration</strong></td>
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<td></td>
<td><strong>Power management</strong></td>
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<td></td>
<td><strong>Slowing down</strong></td>
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<tr>
<td></td>
<td><strong>Riding behavior / technique</strong></td>
<td>Comfort</td>
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<tr>
<td>Discomfort</td>
<td>Ergometer</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td></td>
<td><strong>Miscellaneous</strong></td>
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<tr>
<td></td>
<td><strong>Posture</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>Body</strong></td>
<td></td>
</tr>
<tr>
<td>Goal</td>
<td>Goal achievement</td>
<td>Goal achievement</td>
</tr>
<tr>
<td></td>
<td><strong>Aimlessness</strong></td>
<td>Goal</td>
</tr>
</tbody>
</table>

Table shows if- and then components (clustered in subcategories) used in the anaerobic and the aerobic test.

Quantitative data. First, we controlled if goal commitment in both tests and RPE finish in the anaerobic test differed between the goal intention and the implementation intention group and between sessions with a 2 (Condition: goal vs. implementation intention condition) × 2 (Session: 1 vs. 2) Bayesian mixed-factor ANOVA. For testing if RPE increased during the aerobic test and whether these increases differentiate between both conditions and sessions, we performed an analogous analysis with RPE as dependent variable, where we added Test duration as additional within-participants factor for the aerobic test (to account for differences in test duration in the aerobic test, RPE values were standardized from 0 to a 100 percent and then aggregated across 20% intervals).

In addition, we checked for any performance differences between both groups in Session 1 conducting Bayesian t-tests, for which we report Bayes factors (BF10). The Bayes factor allows
To aid the interpretation of these Bayes factors, we relied on the evidence categories suggested by Jeffreys [66] and Lee & Wagenmakers [67]. When data were not normally distributed, Bayesian Mann-Whitney-tests were used.

To test whether the implementation intention intervention improved performance in the second session compared to the first session, we ran 2 (Condition: goal vs. implementation intention condition) × 2 (Session: 1 vs. 2) Bayesian mixed-factor ANOVA. For anaerobic performance, peak power in watts divided by bodyweight was used as the dependent variable. Time-to-exhaustion was used as the dependent variable in the aerobic test.

Analyses were run in the statistical software environment R (3.3.6; [68]), using the BayesFactor package [69], and in JASP [70]. Plots were created using GGPOLOT2 (3.2.1; [71]).
Results

Qualitative analysis: Obstacles, strategies, and if-then plans

The qualitative analysis covered the obstacles participants encountered during the anaerobic and the aerobic tests as well as the strategies they already used or that they considered useful for dealing with the obstacles in future test performances. As an overview, the resulting general themes and categories across tests are presented in Table 1. Fig 1A–1C provides an overview of the general themes and their frequencies, separately for each test. See S1A–S1C Table for the definitions of each category and examples of statements and S2 Table for if- and then components (clustered in subcategories) applied in the anaerobic and the aerobic test.

Obstacles experienced during performance. Obstacles experienced in both the anaerobic and the aerobic test. Effort was the most reported obstacle in both tests (e.g., “it’s getting harder and harder”). Participants stated that frustration or anger about their own performance was obstructive (e.g., “frustrated when resistance was higher than expected”). Some participants reported discomfort regarding the ergometer, were occupied with their physical reactions (e.g., “getting nauseous”), or their position during the test, which they considered hindering. Demotivation to exert oneself was perceived as an obstacle as well. Some reported to have been distracted by information on the screen or by negative thoughts. Especially in the aerobic test, not being able to distract oneself was perceived as an obstacle. Some participants stated the test was not important to them and indicated a lacking incentive for the task.

Specific obstacles in the anaerobic test. The feeling of failure was reported to be hindering as well as shame during physical exercise. Specific periods of time of the test put some participants under pressure (e.g., “last 10 seconds”). As the test continued, exhaustion was an obstacle (e.g., “the urge to quit”). Further obstacles concerned difficulties with acceleration or not having used maximum power during the test. Most of them regarded the moment when their cadence dropped as critical. Finally, some participants were surprised about resistance during the test, what led them to stop pedaling or to feel demotivated to keep going as goal achievement was harder than expected. Test duration was also perceived as demotivating.

Specific obstacles in the aerobic test. Feeling bored was reported to be hindering (e.g., “How long do I have to sit here”) as was pain. Also, pressure to perform was perceived as aversive for some participants, especially when they compared themselves to others. Participants also reported riding technique to be a challenge or reported the information on the display to be demotivating. Being able to terminate the test anytime was reported as an obstacle, too. Specific time periods of the test (e.g., “always second half of the interval”) demotivated participants as well as the perception of decreasing performance. Not being able to reach one’s goal or not having an exact goal because the test had no fixed ending was also stated as obstacle.

Strategies used to deal with obstacles. Strategies used in both the anaerobic and the aerobic test. A majority of participants reported that motivation for the test in general was helpful during the test, especially motivation through self-encouraging statements (e.g., “give your best”). Also, participants perceived joy for exercise and exertion as helpful as well as the anticipation of being proud of oneself and of the own performance. Some stated to be motivated by feeling their own exertion (e.g., “exertion is progress”) or by imagining cycling in other contexts. Many participants reported ambition to be helpful and motivating (e.g., “as fast as possible”). In general, concentration on information about the current ride presented on the screen was perceived as helpful.

Specific strategies in the anaerobic test. Rationalization of the test was helpful to keep performing (e.g., “I wanted to exercise more anyways”). Concentration on the screen was reported as beneficial as well, specifically regarding information about time and on cadence. Focusing on certain body parts or movements was also perceived as helpful as well as focusing on the...
Few participants stated that it was beneficial to not put pressure on themselves (e.g., "it's ok to cycle like that") or that they felt obliged to follow the study protocol. Finally, some participants reported that it was helpful to cut out everything during the test.

Specific strategies in the aerobic test. Motivation through a positive attitude towards the test (e.g., "exercise makes you happy"), motivation through focusing on one's self-worth, and achieving a cycling flow (like a rhythm) were all perceived as helpful. It was helpful for participants to focus on themselves, on their technique (e.g., "pedaling constantly"), or to focus on the screen. Distraction was perceived as beneficial as well as focus on proximal goals or setting a goal. Few participants stated that it was helpful to adjust their posture during the test or to plan ahead. The category "Miscellaneous" contains items that were not applicable with the other categories.

Potential strategies for dealing with the obstacles. Potential strategies in both the anaerobic and the aerobic test. A lot of participants considered self-encouragement as being an effective behavior in critical situations, primarily through cheering themselves on. Also, ambition and a positive attitude was reported to be a potential strategy. Similar to the applied strategies, imagination of a motivational context (e.g., "doing a final sprint") or rationalization of the test was stated to be an effective thought. Specific goal setting was also reported as being potentially useful after both tests (e.g., "cycling at least 15 minutes, reaching a cadence of 75 one last time"). In general, concentration on the screen and on the body was reported. Finally, some participants stated distraction by thinking consciously of something else (e.g., "imagine song in my mind"), cutting out all thoughts, or imagining another environment or motivational things.

Specific potential strategies in the anaerobic test. Some participants reported that thoughts about something positive or goal achievement could be used to motivate them. Planning certain (tricky) parts of the test in advance was regarded as being potentially helpful (e.g., "control breathing, do not breathe hectically when resistance hits"). Optimizing performance through concentration on cadence or on time (e.g., "looking at the timeline, half is already done") on the screen was more prominent after the aerobic test, but also mentioned after the anaerobic test. Concentration on certain techniques was perceived as an effective measure to optimize performance.

Specific potential strategies in the aerobic test. Goal focus and feeling pride of oneself (e.g., "thinking about the success") was mentioned as potentially effective. Concentration in general, on cadence or on time, or on riding technique was proposed as an effective measure. Some participants stated that using screen information to adjust performance, taking off pressure (e.g., "cadence is alright, just as good as a faster one") and avoiding failing could be effective reactions to critical situations.

Combining obstacles and strategies: Which if-then plans did exercisers form?. In the second session, participants formed on average $M = 2.7 \pm 1.3$ ($Min = 1, Max = 5$) implementation intentions for the anaerobic test and $M = 3.1 \pm 1.5$ ($Min = 1, Max = 5$) for the aerobic test. About one third of the specified goal-related obstacles (if-components) pertained to exertion (e.g., "If I think about my tired legs."). The second most specified if-component concerned the start/finish of the test (e.g., "If I reach the last 10 seconds of the test."). Concerning the then-components, strategies comprising self-encouragement (e.g., "...then I’ll smile and tell myself: everything’s ok!") and ambition (e.g., "...then I’ll stay ambitious and be better than the others!") were most frequently chosen. For the aerobic test, more than 40 percent referred to if-components concerning exertion (e.g., "If I nearly cannot go on any longer.") or certain periods of time during the test (e.g., "If the test begins.") while around 36 percent of then-components targeted goal setting (e.g., "...then I’ll finish the end of this step!") and distraction (e.g., "...then I’ll distract myself by singing songs in my head!") as strategies.
Quantitative analysis: If-then plans and performance

Preliminary analyses. Goal commitment and RPE. A comparison of participants in the goal and implementation intention condition regarding their goal commitment (see Table 2 for descriptive statistics) provided most support for the null model, suggesting no condition differences in both tests and in both sessions (i.e., 1 and 2), with all BF10 ≤ 0.45 (anaerobic test) and all BF10 ≤ 0.61 (aerobic test). The analysis of RPE finish in the anaerobic test indicated that our data provided most support for the null model, suggesting no differences in RPE finish between conditions and sessions, all BF10 ≤ 0.26. Mean values of RPE finish indicate exertion after the aerobic test. As expected, RPE substantially increased in the aerobic test (all BF10 ≤ 0.26).

Performance in the first session. Comparing the goal (M = 8.3 ± 0.8) and the implementation intention condition (M = 8.9 ± 2.0) in the anaerobic test at the first session (Fig 2A) provided little evidence for differences between conditions, BF10 = 0.58. In regard to the aerobic test (Fig 2B), we found slight evidence (BF10 = 1.38) for higher time-to-exhaustion in the implementation intention (M = 24.0 ± 7.5) than in the goal intention condition (M = 19.9 ± 7.4).

Performance in the second session. Anaerobic test. The analysis revealed that the data provided strongest support for a model with the main effect of Session, reflecting that performance improved from the first to the second session (see Table 4). In comparison, a model with the main effects of Session and Condition, BF10 = 0.81, and a model with both main effects and their interaction, BF10 = 0.23, received less support. This corresponds to slight and moderate evidence in favor of the Session main effect model, respectively. A model with the main effect of Condition received considerably less support, BF10 = 5.52e-3, which constitutes extreme evidence in favor of the Session main effect model. Together, these findings suggest that the implementation intention intervention did not improve performance in the second session compared to the goal intention condition (for descriptive statistics, see Table 3).

Aerobic test. The analysis revealed that our data provided most support for the null model (see Table 4). In comparison, the model with the main effect of Condition received less

Table 2. Descriptive statistics of goal commitment and RPE in the anaerobic / aerobic test for each condition (N = 25 for the goal intention condition (GI), N = 27 for the implementation intention condition (II)).

<table>
<thead>
<tr>
<th>Test</th>
<th>Measurement</th>
<th>Session</th>
<th>M</th>
<th>SD</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic</td>
<td>Goal commitment</td>
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<td>GI</td>
<td>5.9</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>GI</td>
<td>5.6</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>II</td>
<td>6.3</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>II</td>
<td>6.6</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>RPE finish</td>
<td>1</td>
<td>GI</td>
<td>7.0</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>GI</td>
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<tr>
<td></td>
<td></td>
<td>1</td>
<td>II</td>
<td>7.1</td>
<td>1.7</td>
</tr>
<tr>
<td>Aerobic</td>
<td>Goal commitment</td>
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<td>GI</td>
<td>6.0</td>
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</tr>
<tr>
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<td></td>
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<tr>
<td></td>
<td></td>
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<td>RPE</td>
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<td>1</td>
<td>II</td>
<td>5.1</td>
<td>0.7</td>
</tr>
</tbody>
</table>

RPE in the anaerobic test refers to RPE at finish, RPE in the aerobic test is a mean value of reported RPE.

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support, BF_{10} = 0.62, which corresponds to little evidence in favor of the null model. The model with the main effect of Session, BF_{10} = 0.20, and the model with both main effects, BF_{10} = 0.16, received less support as well. This corresponds to moderate evidence in favor of the null model. Finally, the model with both main effects and their interaction received considerably less support, BF_{10} = 0.04, suggesting strong evidence in favor of the null model. Together, these findings suggest that time-to-exhaustion in the aerobic test was not influenced by Session (i.e., no learning effects) or Condition (i.e., no intervention effects).

**Discussion**

We assessed the obstacles exercisers with little or no prior cycling training experience faced during two different cycling tests, along with the strategies they spontaneously applied to deal with these obstacles and strategies they considered helpful for future performances of the tests.
Building on this qualitative approach, we then tested whether combining the perceived obstacles and the identified strategies into self-regulatory if-then plans helped exercisers improve their performance in a second exercise session.

**Experienced obstacles, applied strategies, and potential strategies**

For both tests, participants identified multiple exercise-induced obstacles (Fig 1A), spontaneously applied a diverse range of strategies (Fig 1B) and considered several strategies helpful for

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**Table 3.** Summary of means, standard deviations and 95% confidence intervals for anaerobic power (in W/kg) and mean power (in W) in the anaerobic test / time-to-exhaustion (in minutes) and maximum power (in W) in the aerobic test for each condition (N = 25 for the goal intention condition (GI), N = 27 for the implementation intention condition (II)).

<table>
<thead>
<tr>
<th>Test</th>
<th>Measurement</th>
<th>Session</th>
<th>M</th>
<th>SD</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic</td>
<td>Anaerobic power (in W/kg)</td>
<td>1</td>
<td>8.3</td>
<td>0.8</td>
<td>[8.0, 8.7]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>II</td>
<td>8.9</td>
<td>2.0</td>
<td>[8.1, 9.7]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>8.7</td>
<td>1.2</td>
<td>[8.2, 9.2]</td>
</tr>
<tr>
<td>Mean power (in W)</td>
<td></td>
<td>1</td>
<td>405.6</td>
<td>97.8</td>
<td>[365.2, 445.9]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>II</td>
<td>484.6</td>
<td>137.7</td>
<td>[430.2, 539.1]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>412.4</td>
<td>87.0</td>
<td>[376.5, 448.3]</td>
</tr>
<tr>
<td>Aerobic</td>
<td>Time-to-exhaustion (in minutes)</td>
<td>1</td>
<td>19.9</td>
<td>7.4</td>
<td>[16.9, 23.0]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>II</td>
<td>24.0</td>
<td>7.5</td>
<td>[21.1, 27.0]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>20.0</td>
<td>6.2</td>
<td>[17.4, 22.5]</td>
</tr>
<tr>
<td>Maximum power (in W)</td>
<td></td>
<td>1</td>
<td>495.6</td>
<td>135.3</td>
<td>[442.0, 549.0]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>II</td>
<td>412.4</td>
<td>87.0</td>
<td>[376.5, 448.3]</td>
</tr>
</tbody>
</table>

**Table 4.** Model comparisons with Bayesian mixed factor ANOVA: Dependent variables were anaerobic power (maximal performance in watts divided by weight) for analysis of performance in the anaerobic test / time-to-exhaustion (in minutes) and maximum power (in W) in the aerobic test. Each model was compared against the best model.

**Anaerobic test**

| Models                        | P(M) | P(M|data) | BFₘ | BF₁₀ | error % |
|------------------------------|------|---------|-----|------|---------|
| Session                      | 0.20 | 0.49    | 3.81| 1.00 |         |
| Session + Condition          | 0.20 | 0.40    | 2.63| 0.81 | 5.39    |
| Session + Condition + Session * Condition | 0.20 | 0.11 | 0.50 | 0.23 | 4.60 |
| Null model (incl. subject)   | 0.20 | 2.70e-3 | 0.01| 5.53e-3 | 2.02 |
| Condition                    | 0.20 | 2.69e-3 | 0.01| 5.52e-3 | 3.13 |

**Aerobic test**

| Models                        | P(M) | P(M|data) | BFₘ | BF₁₀ | error % |
|------------------------------|------|---------|-----|------|---------|
| Null model (incl. subject)   | 0.20 | 0.49    | 3.89| 1.00 |         |
| Condition                    | 0.20 | 0.31    | 1.77| 0.62 | 5.60    |
| Session                      | 0.20 | 0.10    | 0.45| 0.20 | 1.03    |
| Session + Condition          | 0.20 | 0.08    | 0.34| 0.16 | 8.71    |
| Session + Condition + Session * Condition | 0.20 | 0.02 | 0.08 | 0.04 | 8.28 |

**Note.** All models include subject. Prior and posterior model probabilities are depicted in the column P(M) and P(M|data), respectively. BFₘ illustrates the change from prior to posterior model odds, BF₁₀ the Bayes factor for each model, and Error % the precision of the Bayes factor calculations.
future performance of the tests (Fig 1C). Regarding obstacles, participants in the implementation intention condition most often specified perceived exertion, pressure-related thoughts at the start and finish, and distraction by information on the screen in the if-part of their plans in preparation for the anaerobic test. Regarding strategies, the most frequently used then-parts referred to self-encouragement, ambition, and planning. Interestingly, plan content was different in the aerobic test. Here, the obstacles specified in the if-part mostly referred to exertion, demotivation at critical moments, and demotivation in general. The goal-directed behaviors specified in the then-parts mainly referred to seeking distraction or focusing on riding technique. Accordingly, participants recognized and considered differences in the specific demands posed by the aerobic and anaerobic test in their if-then plans.

The emphasis on exercise-related sensations like exertion, pain, discomfort, or the urge to stop as obstacles replicates the findings of McCormick et al. [1]. Likewise, the difficulties to remain concentrated, to be negatively affected by distractions, and to respond with frustration to stressors during the test is in line with this prior research. In general, the identified obstacles and strategies during performance fit well into and further expand existing frameworks, like the distinction between associative and dissociative cognitions [72]. Interestingly, while McCormick et al. [1] interviewed endurance athletes, only a small portion of our sample were active in endurance sports (n = 16) and even these athletes had negligible experience with cycling tests. This attests to the universality of the sensations associated with the performance of endurance sports. The importance of perceived exertion as a major performance-limiting obstacle aligns well with predictions of the psychobiological model [6, 7], supporting the crucial role perceived exertion plays for endurance performance. Furthermore, the relevance of reported exertion, pain, and discomfort seems to be characteristic of less experienced samples (e.g., [13]) and it can be assumed that a majority of our sample was overwhelmed by the external demands of the task (e.g., riding on an ergometer, staying in a seated cycling position) and their physical challenges (e.g., heat stress in the laboratory, muscle pain) that their concentration on the performance test objectives was limited. Especially during the anaerobic test, technical aspects of cycling like acceleration, power management, and slowing down were reported as critical by participants, which converges with findings that less experienced athletes experience greater difficulty in regulating their efforts [73] and in dealing with their physiological sensations compared to more experienced athletes [13]. In practice, it might be helpful to educate less experienced athletes about possible physiological sensations in advance and to suggest several effective then-strategies for dealing with common if-obstacles (e.g., effort, muscle pain) in order to create a helpful if-then plan (as effectively applied in other if-then planning studies in sport [45]).

Besides corroborating previous research about obstacles in endurance sports, the participants in our study also identified obstacles that have so far received little attention in sport psychological research. Most notably, a consistently stated obstacle in the aerobic test was boredom, which also was the fourth most frequently used if-component in the implementation intention condition. This suggests that participants not only got bored frequently during the aerobic test and attached great importance to boredom as an obstacle, but also searched for ways to deal with it. This is particularly important as boredom has long been overlooked as a potential obstacle in endurance sports [74]: Recent evidence points towards the relevance of boredom in elite [75] and recreational sports alike [76]. Considering boredom as an obstacle for endurance performance also aligns well with theoretical considerations, as recent work has highlighted that boredom can directly act as a self-regulatory challenge to goal pursuit [77], thereby making it harder for an athlete to perform optimally.

In contrast to prior research that took a broader view on the challenges of endurance sports (e.g., comprising competitions and training; [1]), we decided to take a more narrow view by
focusing on the obstacles faced during two very specific cycling performances (i.e., an anaerobic and an aerobic tests). In doing so, we answered calls for an in-depth exploration of the demands associated with specific performances [1]. This allowed us to present a detailed analysis of exercise-induced obstacles (e.g., identifying boredom as an obstacle in the aerobic test but not in the anaerobic test), which can be used as a starting point for developing more tailored sport-psychological trainings.

The strategies reported by participants in our study also align well with the existing literature. Particularly, the frequent use of self-encouraging statements seems to be an adaptive choice, as research has shown that self-talk can be beneficial for performance [78]. In addition, many of the reported strategies can be understood as emotion-regulation strategies, which also seems to be adaptive because such strategies can enhance positive emotions [79]. For example, participants found it helpful to imagine the feeling of being done with the test, to remind themselves of being able to finish the test, or to be proud about having achieved half of the test because of their own ambitions.

The (lack of) efficacy of self-generated if-then plans
We found that performance was not enhanced by the use of if-then plans, neither in the aerobic nor in the anaerobic test. Prior research has shown that improving endurance performance with ready-made self-regulatory strategies that focus on one or two pre-defined obstacles is unlikely [42–44, 47]. Therefore, we instructed participants to generate individual plans, capitalizing on the information about obstacles and strategies we had elicited in structured interviews after the first session. Similar approaches are known to be effective in other domains; for example, when making if-then plans is combined with the self-regulation strategy of mental contrasting (i.e., mental contrasting with implementation intention, MCII, [80,81]). An MCII intervention has parallels to our approach because it emphasizes the need to elicit desires and goals and to contrast them with the obstacles of attaining these goals. MCII supports has been shown to facilitate short-term and long-term goal pursuit attainment across various domains of life, such as academic accomplishments [82], relationships [83], health [84], and physical activity [85]. MCII is also known to be effective in the domain of sports: In a study investigating the use of MCII among dance sport athletes, the use of MCII was related to better performance [86]. It thus seems worthwhile to examine whether an MCII procedure would be more effective in enhancing endurance performance than an if-then planning intervention.

Limitations
One drawback of relying on self-generated if-then plans is that researchers have little control over the plans participants specify. Consequently, it is possible that participants generate plans that do not affect their performance or even have detrimental effects. For instance, in one study on improving volleyball service performance [87] if-then plans were generated based on coaches’ feedback regarding the performance of their athletes. The authors of this study argue that the resulting if-then plans might have directed attention too much on the execution of well-learned motor behaviors, which might have interfered with performance. It is conceivable that participants in our study also planned behaviors that they thought would help them perform better, while in fact these behaviors might have been ineffective or even detrimental in some cases. In addition, critical situations were sometimes specified in vague terms (e.g., “If it becomes exhausting”) or did not pertain to an obstacle or opportunity (e.g., “If I am cycling”). This might be due to a lack of experience with cycling training, which required participants to base the specified obstacles and strategies on a single test performance. Consequently, it might be that if-then planning is a more effective strategy among experienced athletes (see [34], for a
similar argument). With this assumption in mind, the results of the qualitative analysis must be considered carefully. A generalization to more (e.g., athletes) or less (e.g., physically inactive) experienced populations can only be made to a limited extent. Future research should investigate the extent to which these findings hold in other populations as well.

A closer look on our qualitative findings provides additional insights into the question of why if-then plans might have been ineffective in our study. In both tests, participants were able to identify obstacles and spontaneously applied several strategies that have shown to be useful by prior research (e.g., emotional regulation, attention regulation). This alone might have helped participants in the goal intention condition to improve their performance. Tentative support for this reasoning comes from the observation that participants substantially improved their performance in the aerobic test between the first and the second session, irrespective of whether they belonged to the goal or the implementation intention condition. Thus, participants might have been very effective in finding ways to deal with the challenges posed by the tests, making it difficult for the if-then planning intervention to further improve performance. Similar effects have been observed in a study investigating the influence of self-talk on performance in a time-to-exhaustion ergometer test, in which the expected effects of self-talk were masked by learning effects through task repetition and concomitant reflection of participants [88]. Subsequent studies might resort to a less rigorous control condition in which participants do not engage in interviews about obstacles and strategies. Nevertheless, comparing an implementation intention condition with a goal intention condition is a standard approach in if-then planning research [35] and differences between conditions are commonly observed despite the possibility that participants in the goal condition might form spontaneous if-then plans. Furthermore, plan effects in future studies might be enhanced by asking subjects to make one plan pertaining to the most critical obstacle (or opportunity) and the best goal-directed strategy. Rather than helping subjects prepare for different stressors in the cycling tasks, there might have been interference between the different if-then plans [89]. Indeed, the majority of subjects in the implementation intention condition used more than one plan to prepare for the tests, which might have thwarted the beneficial effects of if-then planning. Finally, it is possible that the type of goals that participants set (e.g., process-related: keep going, ignore pain; outcome-related: target time) might have had an influence on endurance performance (see [90] about recommendations on effective goal setting in sports). We did not address this issue here because our focus was primarily on if-then planning rather than on goal setting. Still, future research should focus on how various types of exercise-related goals affect endurance performance. Also, future studies should consider the possible interaction of (un-)specificity of goals and if-then planning, as studies indicate that specific goals lead to better performance than vague, general or no goals [91] and goal specificity alone trumps the effects of merely ‘do your best’ goals [92]. It is plausible that forming specific goals already improve endurance performance and thereby reduce implementation intention effects.

Another reason for the lack of efficacy of our intervention could pertain to the characteristics of the sample. None of our participants performed cycling as their main sport, meaning that they had little to no experience with the specific task demands. Research indicates that there could be differences between participants who regularly engage in a certain activity compared to inexperienced participants in terms of their motivation to perform well [93]. With regard to sport psychological interventions, it has been argued that inexperienced samples lack the intrinsic motivation to perform the task, therefore obscuring any effects of self-regulatory strategies that are based on sufficient motivation [3]. The results of our qualitative analysis mirror this argument, as many participants reported missing drive and motivation as obstacles for performing well. However, our participants reported to be well committed in both conditions. Nevertheless, these results should be interpreted with care because they might reflect...
social desirable responding. This underlines the necessity to conduct future experiments testing if-then planning in endurance sports with experienced athletes who are presumably much more intrinsically motivated to perform as good as possible and master the metacognitive skills and attentional strategies necessary to implement strategies during performance [4]. Furthermore, given the lack of task-specific cycling experience in our sample, it might have been especially difficult to apply if-then planning in an immediately following test: the effective use of psychological skills requires people to try whether the corresponding strategy is suitable for them [94]. This calibration time constitutes one reason for the recommendation to not make use interventions shortly before an event (like the performance tests for the participants; [3]). Future research could benefit from probing the efficacy of self-generated if-then plans prior to a test and to adapt the plans if necessary.

In addition, there are a number of factors that potentially determine endurance performance but are beyond the scope of the present investigation. For example, future studies should take the influence of self-efficacy into account, a widely studied determinant of sports performance (e.g., [95]) with beneficial effects on effort perception [96] and pain tolerance [97]. Moreover, high self-efficacy is associated with improved implementation intention effects in complex tasks [98], suggesting that it might be crucial to ensure that participants feel confident in performing the athletic task to reap the potential benefits of forming if-then plans. In the same vein, it can be discussed whether a different performance test could have been more appropriate to show effects of if-then plans. As the aerobic test requires a steady increase in power output and thus poses increasing self-regulatory demands, a test that feels more achievable (e.g., a time trial) could have heighted participants’ perceptions of self-efficacy. However, as a self-paced time trial would induce further self-regulatory demands (e.g., constantly having to adjust one’s power output to what one believes one can sustain for the expected ride time), this would be a less pure measure of aerobic performance—as pacing errors can substantially affect overall performance—compared to the aerobic test. A difference in mean power between conditions in Session 1 makes the elicitation of if-then planning effects even more intricate. On the one hand, as participants in the implementation condition already presented higher power output, additional enhancement of performance might have been difficult which could obscure potential if-then planning effects. On the other hand, performance parameters do not indicate that further improvement through if-then planning is not possible, which again raises the question of the appropriateness of the tests to illustrate performance enhancements. Future studies should investigate which tests are optimally suited to reflect if-then planning effects on endurance performance. Additionally, conducting both performance tests on the same day is a limitation of this study from an exercise physiology and psychology perspective: Perceptual and physiological processes in the first test might have influenced those in the second test (e.g., in terms of residual fatigue; see [99] for a detailed review).

Conclusions

In this study, we investigated the obstacles exercisers face during an anaerobic and an aerobic cycling test, as well as the strategies they considered helpful for dealing with these obstacles. We further investigated whether if-then plans based on these obstacles and strategies lead to improved performance. Qualitative analyses of interviews conducted with participants immediately after the tests revealed substantial insights into diverse sets of obstacles and strategies. The quantitative analyses suggest that an if-then planning intervention did not improve anaerobic performance or time-to-exhaustion. These findings indicate that participants were able to identify exercise-related obstacles and useful strategies; moreover, performance improvements
in the aerobic test suggest that they could use this information to their advantage. However, if-
then planning provided no additional benefits. When using if-then planning for less experi-
enced athletes in practice, it might be helpful to educate exercisers about potential obstacles
(e.g., muscle soreness) and to suggest potential strategies (e.g., self-encouragement), to use one
if-then plan that is rehearsed with a sufficient time lag before use, and to ensure that exercisers
are familiar with the sport so that they feel more self-efficient per se. Future research should
complement our study with a focus on more experienced athletes and other intervention tech-
niques. Nevertheless, our findings shed novel light onto the complex interplay of perfor-
mance-related factors when investigating the impact of psychological interventions designed
to help athletes in dealing with determinants of endurance performance.

Supporting information

S1 Table. A. Obstacles the participants reported to have experienced during the anaerobic /
aerobic test. Note. * refers to obstacles that were only mentioned after the anaerobic test, while
** refers to obstacles that were only mentioned after the aerobic test. B. Strategies used (thoughts, sensations or behaviors) during the anaerobic / aerobic test. Note. * refers to strategies
that were only mentioned after the anaerobic test, while ** refers to strategies that were only mentioned after the aerobic test. C. Potential strategies reported by participants after the
anaerobic / aerobic test. Note. * refers to potential strategies that were only mentioned after
the anaerobic test, while ** refers to potential strategies that were only mentioned after the
aerobic test.

S2 Table. If- and then-components in categories (incl. frequency) used by participants to
enhance performance in the anaerobic / aerobic test.

S1 Fig. Flowchart, visualizing the protocol of session one (a) and session two (b). Manipu-
lation means the random assignment to either the goal intention / implementation intention.
condition.

S1 Appendix. Study materials.

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References


Implicit Theories about Athletic Ability Modulate the Effects of If-Then Planning on Performance in a Standardized Endurance Task

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Abstract: Muscular strength has a strong positive impact on cardiometabolic health and fitness. However, building up strength endurance requires effortful exercises. From a health perspective, it is important to understand which psychological strategies help people deal with straining exercise. Self-regulation strategies like if-then planning (also known as implementation intentions) appear particularly promising because they might directly alter how people deal with exercise-induced sensations. However, research on the effects of if-then planning on exercise performance has yielded mixed results so far. One possible reason for these inconsistent results is the lack of tailored interventions and the neglect of potential moderators. To address this, we investigated the efficacy of if-then plans that were tailored to perceived limits of endurance performance (i.e., perceptions of exertion versus pain). In addition, we investigated the effects of these tailored if-then plans while taking into account the potentially moderating effects of individual differences in implicit theories. Specifically, we were interested in the role of implicit theories about athletic performance (i.e., entity versus incremental beliefs) and about the limitation of athletic performance by mental versus physical factors (i.e., mind-over-body beliefs). N = 66 male students (age: M = 25.8 years, SD = 3.2) performed a static muscular endurance task twice (measurement: baseline task vs. main task) and were randomly assigned to a goal or an implementation intention condition. They were instructed to hold two intertwined rings for as long as possible while avoiding contacts between them (measure of performance: time-to-failure and errors). After the baseline task, participants were either given an implementation intention or were simply asked to rehearse the task instructions. The content of the instruction depended on whether they ascribed ultimate baseline task termination to perceptions of exertion or pain. After the main task, implicit theories on athletic ability were assessed. No differences in performance emerged between conditions. In the implementation intention condition, however, stronger entity beliefs were associated with increasing time-to-failure when participants planned to ignore exertion but with decreasing time-to-failure when they planned to ignore pain. This pattern of results was reversed with regard to mind-over-body beliefs. These findings indicate that the efficacy of psychological strategies hinges on recreational athletes’ beliefs regarding athletic performance.

Keywords: muscular endurance performance; self-regulation; implementation intentions; psychobiological model; Borg scales; implicit theories; limits of athletic performance
1. Introduction

Research shows that physical fitness contributes strongly to the current and future health of adults and children alike [1,2]. Even though most work has focused on the importance of cardiorespiratory fitness for health outcomes, muscular fitness is increasingly recognized as a relevant factor as well [3]: it is linked to lower cancer mortality risk in men [4], lower overall mortality [5], as well as enhanced bone health, boosted self-esteem, and reduced adiposity in children [3,6]. Although these benefits are widely known and despite recommendations by major health organizations to engage in muscular endurance training [7] to enhance cardiometabolic health and fitness [8], a large number of people is still not active: an estimated 77% of U.S. citizens do not fulfill physical activity recommendations on cardiovascular and strength training [9]. To complicate matters further, building up muscular strength requires to endure muscular exercises for a sufficient time at an optimal intensity, which might be perceived as too effortful and encourage premature termination of an ongoing exercise. From a health perspective, it is therefore paramount to understand which factors influence and eventually limit muscular endurance performance and whether there are strategies to effectively deal with these factors.

A large body of research investigated physiological limits to exercise tolerance [10–13] and suggests that people might not fully deplete their physiological resources in straining exercise [14,15]. This points toward an important role of psychological factors in exercise termination. For example, according to the psychobiological model of exercise tolerance [16,17], perceived exertion critically limits endurance performance. The model states that endurance exercises are terminated when applying additional effort seems either unjustified or impossible [16,17]. Applied to muscular endurance performance, this suggests increasing self-regulatory demands [18]: as upholding certain levels of performance becomes more and more difficult (i.e., the perception of exertion rises), self-regulatory challenges rise as well (e.g., enduring increasing sensations of pain).

One strategy that might help to deal with these challenges is the self-regulatory strategy of if-then planning (also referred to as forming implementation intentions [19,20]), which has already been investigated in the context of health (i.e., [21–23]) and various other domains [24]. In an if-then plan, a person specifies how to achieve a goal (e.g., enduring an effortful task). It comprises selecting a goal-relevant situation (e.g., upcoming sensations of muscle pain) and linking it to a goal-directed behavior (e.g., ignoring the pain and continuing the exercise) in an if-then format: “If I encounter Situation S, then I will perform Behavior B!” (e.g., “And if my pain becomes too great, then I tell myself: I can still keep going!”). Making if-then plans is assumed to activate the mental representation of the situation which thereby becomes easier to remember and to recognize [25,26]. Research further indicates that if-then planning automates the initiation of the goal-directed behavior [19,20]. Accordingly, implementation intentions are seen as an efficient bottom-up form of action control compared to goal intentions, which merely specify what to do but not how to do it (e.g., “I want to ignore the pain and continue the exercise!”) [27] and are thus less conducive to automatic behavior initiation. This is an essential aspect especially in complex health behaviors like exercising that confront people with various barriers to perform successfully and to keep exercising.

In support of this notion, one study showed that implementation intentions help athletes to recognize opportunities for hydration and to increase the intake of carbohydrate-electrolyte solutions during a cycling exercise by over 50% [28]. In a study with tennis players, implementation intentions on how to deal with intrusive thoughts, emotions and physiological states led to improved performance during matches [29]. More relevant for our present purposes, however, are investigations of the effects of if-then planning in muscular endurance tasks. This research is scarce, though, and has so far produced inconsistent results. On the one hand, if-then plans helped participants deal with perceptions of pain in a ball-holding task: Planning to direct attention away from muscle pain and to initiate self-affirmative speech (“And if my muscles hurt, then I will ignore the pain and tell myself: I can do it!”) led to an increase in time-to-failure compared to a condition with a corresponding goal intention [30]. On the other hand, two similar studies focusing on time-to-failure in a rod-holding task found no effects of if-then planning on performance. In one study [31], planning to ignore perceived...
exertion did not alter performance and actually increased exertion. Such a null-finding also emerged in the second study [18] in which participants planned to ignore perceptions of pain (as in the ball-holding study)—although functional near-infrared spectroscopy (fNIRS) during task performance showed lower lateral prefrontal cortex activity among participants in the implementation intention condition, indicating lower activation in an area that is critical for effortful self-regulatory control. Taken together, these results indicate that if-then planning affects the correlates of muscular endurance performance but not necessarily performance itself. Furthermore, it suggests that neither targeting perceptions of exertion nor targeting perceptions of pain yields consistent effects of implementation intentions.

This poses the question of what might cause the inconsistent findings. It seems worthwhile to investigate whether the effects of if-then planning are moderated by factors that were not yet accounted for. Here, we focus on two of these factors: First, it might matter whether people experience perceptions of exertion or perceptions of pain as limits to their own performance. Exertion refers to “the conscious sensation of how hard, heavy, and strenuous a physical task is” [32] and therefore reflects mental processes (e.g., the urge to quit). Pain, on the other hand, is defined as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage.” [33] and thus reflects bodily processes (e.g., locomotor muscle fatigue or accumulation of lactic acid). Previous research provided the same plan to all participants (i.e., dealing with pain or dealing with exertion) and therefore does not provide information on whether and how individual differences in experiencing mental versus bodily limits obscure implementation intention effects.

Second, it might matter to which degree participants believe that performance is generally limited versus improvable, and whether potential limits pertain to the mind versus the body. Such beliefs are commonly referred to as implicit theories that people may hold regarding attributes like intelligence [34]. These beliefs are commonly divided into two categories that describe how people judge the malleability of an attribute [35–37]: People are said to hold entity beliefs if they think that an attribute is fixed and stable, while they are said to hold incremental beliefs if they think that an attribute is flexible and changeable. These beliefs influence decisions, for example regarding what goals to pursue [36], but are usually unconscious [38]. People holding entity beliefs seek positive appraisals of their expertise and thus favor performance-oriented goals, while people holding incremental beliefs try to enhance their ability through acquisition and thus favor learning-oriented goals [35]. Learning-oriented goals are often (but not necessarily) associated with more beneficial outcomes than performance-oriented goals because they are conducive to using negative feedback as a means for further development rather than interpreting it as a mere sign of lack of ability. Considering research on implicit theories about willpower, it is implied that failing self-regulation after a short execution of self-control does not originate in people’s actual self-control resources but is defined by their beliefs on how much self-control they are able to exert [39]. This research underlines the important role which implicit theories have on behavior, as they for example disclose failures in self-control [40].

This theorizing can be transferred to the exercise context, in which implicit theories pertain to the malleability of athletic abilities and thus influence exercise behavior [41,42]. Specifically, people holding incremental beliefs see athletic ability as changeable by learning, effort, and training, whereas people holding entity beliefs see it as innate and stable, and thus unchangeable by training and effort [42,43]. Interestingly, a person can hold both incremental and entity beliefs at the same time, thinking of athletic ability as an inherited capability that can still be enhanced through commitment and effort [43]. Incremental beliefs about athletic ability are connected to higher self-driven motivation, enjoyment and grit as they are accompanied by expectations of improved performance [42,44]. Entity beliefs, on the other hand, are more likely to lead to frustration and discouragement because they render failure as feedback on a lack of ability [42,44].

It is therefore plausible that entity and incremental beliefs moderate implementation intention effects in various ways. For instance, entity theorists could undermine their effects due to doubts that planning improves a performance that one deems unchangeable. Alternatively, people holding entity beliefs might be more likely to respond well to an external strategy (i.e., if-then plans) as means to avoid
failure in the upcoming performance (and thus avoid feedback on a lack of ability [45]). People with incremental theories might, in contrast, be amenable to if-then plans because they consider changes in performance as generally possible and might be more receptive to learning for improvement [46]. They may, however, perform better regardless of external self-regulatory strategies, as they are shown to be more persistent in challenging exercise tasks compared to entity theorists [47]. Given these considerations, it is plausible that implicit theories affect implementation intention efficacy. To our knowledge, this interaction has not been addressed so far.

Moreover, the interaction between beliefs and implementation intentions could be even more intricate when we consider that participants might perceive exertion or pain as limit to their performance. As we have argued above, exertion and pain serve as signals that mental or bodily limits have been reached, respectively. To understand the (lack of) implementation intention effects, it might therefore be important to know whether people believe that performance is ultimately limited by mental (mind) rather than by physical factors (body)—which we refer to as mind-over-body beliefs. For instance, people who perceive the body as limiting factor in athletic performance (i.e., low mind-over-body beliefs) might interpret pain as a signal that this limit is reached and deem further attempts to improve futile. This might undermine the effectiveness of planning to simply ignore pain as a means to endure longer. This could be different for people who believe that performance is ultimately limited by mental factors (i.e., high mind-over-body beliefs). To them, pain does not signal that a performance limit is reached, rendering plans targeting the regulation of pain more auspicious. Analogous arguments can be constructed with respect to exertion: people holding low (versus high) mind-over-body beliefs might not (versus might) identify perceptions of exertion as a limiting signal, which might increase (versus decrease) the efficacy of planning to ignore exertion. In sum, the effectiveness of plans targeting the regulation of exertion versus pain might depend on people’s beliefs about athletic ability (entity, incremental, mind-over-body), their perception of limiting sensations during an endurance task (pain, exertion), and the interaction of beliefs and limits.

Taken together, the aim of this study was twofold. First, we wanted to improve upon previous research designs. In previous studies, all participants received the same if-then plan that targeted either perceived exertion [31] or pain [18,30]. These studies did not take into account whether these sensations were in fact limiting the performance of individual participants. To address this shortcoming, we asked participants to state whether they had terminated the baseline task because of exertion or pain and then gave them an if-then plan that was tailored to their individual reason for task termination. Second, we wanted to investigate whether the efficacy of if-then planning is influenced by participants’ implicit theories about athletic ability. While there are studies on the influence of entity and incremental beliefs on the motivation in physical activity and enjoyment of sports (e.g., [42,44,48]), we are not aware of studies on the importance of implicit theories for the effectiveness of self-regulation strategies. As we have outlined above, there are several ways in which the beliefs resulting from implicit theories might interact with plan effects and with sensations of exertion or pain. For instance, entity and incremental beliefs could be differentially conducive to planning effects. Moreover, beliefs about physical versus mental limits of performance could affect implementation intention effects depending on whether people struggle with sensations of pain or exertion.

Beyond these two major aims, studies on if-then planning effects on endurance performance were so far afflicted by a high inter-individual variability especially with regard to time-to-failure (which is common in endurance performance research, see [49,50]). This variability might have obscured potential differences between goal and implementation intention conditions. We therefore added a baseline measure that allowed us to account for preexisting differences in endurance performance. These changes—increased statistical power with a baseline measure and if-then plans tailored to perceived limits of endurance performance (i.e., perceptions of exertion versus pain) in combination with potentially moderating effects of participants’ individual beliefs about athletic ability (entity, incremental, mind-over-body)—should further advance our understanding of when and how if-then planning affects endurance performance.
2. Materials and Methods

2.1. Participants and Design

We recruited an all-male sample of $N = 66$ participants (age: $M = 25.8$ years, $SD = 3.2$) to minimize gender-related variance in endurance performance [31,50]. This sample size allows us to detect medium-to-large differences ($d = 0.70$; a typical effect size of implementation intentions is $d = 0.65$, see [19]) between the goal and the implementation intention condition in two-sided t-tests ($\alpha = 0.05$). The study adopted a 2-within (measurement: baseline task vs. main task) × 2-between (condition: goal intention vs. implementation intention) design; participants were randomly and equally assigned to conditions. As third factor, we measured whether participants identified perceived exertion or pain as limiting their performance in the baseline task (limit: exertion versus pain). More participants named exertion (48 in total, including 23 in the implementation intention condition) than pain (18 in total; including 10 in the implementation intention condition) as their limit, with a similar distribution across conditions, $\chi^2 (1, N = 66) = 0.782$, $p = 0.782$. Six participants (five in the implementation intention condition) were excluded from data analysis due to deviations from study protocol (the exclusion of those six participants did not change the pattern of results in terms of significance). The remaining participants reported exercising $M = 6.7$ hours per week ($SD = 4.7$), of which 33.3% were related to strength training. Fifty-seven participants stated to be engaged in a variety of sport activities, having performed their main sport activity for an average of $M = 7.8$ years ($SD = 6.2$), while 3 participants reported to be physically inactive (2 in the goal condition). Participants in the goal and the implementation intention condition did not differ in regard to their weekly training hours, $p = 0.448$, or the duration of performing the main sport, $p = 0.306$. When we advertised the study online, we emphasized that no current or recently healed injuries in shoulders, arms, or the back should be present to be eligible for participation. Moreover, we asked to avoid alcohol and strenuous exercise the day before the experiment and to refrain from consuming caffeine in the two hours before. Most participants complied with these requests with no differences between conditions, $p > 0.545$. Specifically, 16 participants (nine in the implementation intention condition) reported injuries that had happened some time ago (three in the last 6 months, four in the last 7–12 months, nine more than 12 months ago). And while all participants complied with the instruction not to consume caffeine, 18 participants exercised (eight in the implementation intention condition) and 16 consumed alcohol (nine in the implementation intention condition) the day before the experiment. All participants signed an informed consent and were compensated with 5 Euro and course credit. The study protocol and measurements were approved by the Ethics Committee at the University of Konstanz (approval #24/2016).

2.2. Static Muscular Endurance Task

We used the “hot rings task” (HRT; [31]) to measure static muscular endurance performance. Participants were instructed to hold two aluminum bars connected by intertwined rings for as long (time-to-failure) and with as few contacts between the rings (errors) as possible. As shown in Figure 1, participants stand in an upright position with their arms outstretched to form a 90° angle with their torso. A connector element links participants’ arms with the aluminum rods via a holding device with a recording box for reliably measuring time-to-failure and errors. The recording box measures ring contacts at 50 Hz. The holding device is fastened at the ceiling of the laboratory and can be flexibly adjusted to each participant’s individual height while the connector element is still locked. This way, participants were able to rest their arms during the adjustment period. Before the HRT begins, the connector element is unlocked. It unplugs as soon as participants lower their arms below the preset 90° angle. Time-to-failure is recorded simultaneously with a stopwatch. The HRT allows measuring muscular endurance performance in terms of time-to-failure and errors simultaneously. The total duration of ring contacts (measured by the recording box in milliseconds) was added up to an error score in seconds.
2.3. Ratings of Perceived Exertion (RPE) and Pain (RPP)

While performing the HRT, participants were prompted by a recorded computer voice to state RPE and RPP every 25 ± 10 s using Category Ratio 10 (CR10) scales [51,52]. In order to make sure that participants differentiated on what sensation (exertion vs. pain) to focus on [33], RPE was described to them as “the conscious sensation of how hard, heavy, and strenuous a physical task is” [32]. RPP was supposed to be rated according to individual discomfort but was not separately defined to the participants. We printed individual scales for RPE and RPP on sheets of paper, hung on the wall in front of the participants. Each scale ranged from 0 (“nothing at all”) to 10 (“maximal”) or 11 (“even more than max”) [33].

2.4. Questionnaires

After both the baseline and the main task, participants stated whether they currently felt several negative (exhausted, uncomfortable, annoyed, tense; Cronbach’s $\alpha = 0.73$) and positive emotions (happy, energetical, content, relieved; Cronbach’s $\alpha = 0.78$) on seven-point Likert scales (1: does not apply, 7: fully applies). For the analyses, emotional states were aggregated to positive / negative feelings. Then, they declared their reason for baseline task termination (exertion vs. pain, other reasons). Additionally, they indicated their performance motivation (e.g., “It was important for me to persist for as long as possible in the endurance task.”, Cronbach’s $\alpha = 0.90$), task satisfaction (e.g., “I am satisfied with how precisely I performed in the endurance task.”, Cronbach’s $\alpha = 0.74$), and self-efficacy (e.g., “I am convinced of my ability to perform endurance tasks like this for as long as possible.”, Cronbach’s $\alpha = 0.86$) with respect to both time-to-failure and errors on seven-point Likert scales (1: does not apply, 7: fully applies).

After the main task, we measured participants’ implicit theories about athletic ability using the Conceptions of the Nature of Athletic Ability Questionnaire 2 (CNA AQ-2; [42]). It comprises 12 items (Table 1), with a subscale of six items pertaining to entity beliefs (Cronbach’s $\alpha = 0.75$) and another subscale of six items pertaining to incremental beliefs (Cronbach’s $\alpha = 0.76$). We averaged the six items of each subscale into composite scores with higher values indicating a stronger belief that athletic ability is either fixed and stable (entity) or improvable and trainable (incremental), respectively. Following the authors of the questionnaire [42] and considering that incremental and entity beliefs are no orthogonal constructs, we used the two scales separately in the analyses. We generated three additional items...
(Table 1, Items 13–15) to measure mind-over-body beliefs (Cronbach’s α = 0.55). These three items were averaged into a composite score with higher values indicating that the mind rather than the body is seen as limiting athletic ability. Answers were given on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Finally, participants reported a number of demographic information (i.e., age, physical activity, main sports).

Table 1. Items used for measuring entity and incremental beliefs (CNAAQ-2; [42]), complemented by three items measuring implicit theories about the body versus the mind as limiting factors of athletic performance (i.e., mind-over-body beliefs).

<table>
<thead>
<tr>
<th>First-Order Variable</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entity</strong></td>
<td>1. You have a certain level of ability in sport and you cannot really do much to change that level.</td>
</tr>
<tr>
<td></td>
<td>2. Even if you try, the level you reach in sport will change very little.</td>
</tr>
<tr>
<td></td>
<td>3. It is difficult to change how good you are at sport.</td>
</tr>
<tr>
<td></td>
<td>4. You need to have certain ‘gifts’ to be good at sport.</td>
</tr>
<tr>
<td></td>
<td>5. To be good at sport, you need to be born with the basic qualities which allow you success.</td>
</tr>
<tr>
<td></td>
<td>6. To be good at sport you need to be naturally gifted.</td>
</tr>
<tr>
<td><strong>Incremental</strong></td>
<td>7. To be successful in sport you need to learn techniques and skills and practice them regularly.</td>
</tr>
<tr>
<td></td>
<td>8. You need to learn and to work hard to be good at sport.</td>
</tr>
<tr>
<td></td>
<td>9. To reach a high level of performance in sport, you must go through periods of learning and training.</td>
</tr>
<tr>
<td></td>
<td>10. In sport, if you work hard at it, you will always get better.</td>
</tr>
<tr>
<td></td>
<td>11. How good you are at sport will always improve if you work at it.</td>
</tr>
<tr>
<td></td>
<td>12. If you put enough effort into it, you will always get better at sport.</td>
</tr>
<tr>
<td><strong>Mind-over-body</strong></td>
<td>13. The body sets limits to athletic performance that cannot be overcome.</td>
</tr>
<tr>
<td></td>
<td>14. Mental attitude does not play a role in sports, if the physical preconditions are not met.</td>
</tr>
<tr>
<td></td>
<td>15. One can always enhance one’s athletic performance through mental processes.</td>
</tr>
</tbody>
</table>

2.5. Procedure

Each session was carried out by a researcher who first explained the study and the muscular endurance task to participants. Importantly, they were not informed at this point that they would have to perform the task twice to avoid strategic allocations of resources. After adjusting the holding device to participant’s height, the researcher explained the experimental procedure and the CR10 scale. A demonstration trial was provided to give participants a feeling for the sensitivity of the connector element by having them lower their arms below a 90° angle. Then, after participants had stated their initial level of RPE and RPP, the baseline task started. The researcher did not interact with participants during the task and stayed outside their field of vision. Participants were prompted by a recorded voice played by a computer to state their RPE and RPP, while the experimenter documented the answers. As soon as the connector element unplugged, the baseline task ended, and participants stated their final RPE and RPP. They also indicated whether they terminated the baseline task due to exertion or pain. Participants now learned that they would perform the task again after a five-minute resting period. During this time, they answered a questionnaire about their current emotional state, task performance motivation and self-efficacy.

Participants were then given instruction to form a goal or an implementation intention for the upcoming main task. In both conditions, the content of the instructions depended on whether participants terminated the baseline task due to sensations of exertion or pain. In the goal condition, participants rehearsed the task (“Even if my exertion [pain] becomes very high, the task requires to persist for as long as possible while avoiding contacts between the rings!”). In the implementation intention condition, participants instead set a goal (i.e., “I want to persist for as long as possible while avoiding contacts between...
the rings!") and added an if-then plan: “And if my exertion [pain] becomes too high, then I tell myself: I can still keep going!”. After that, participants started with the main task following the same procedure as in the baseline task. The task concluded with questionnaires regarding their current emotional state, performance motivation and self-efficacy. Finally, we measured their implicit theories on athletic performance and assessed demographic information. Figure A1 illustrates the study procedure in a flowchart.

3. Results

3.1. Data Analysis

As preliminary analyses, we compared goal and implementation intentions regarding task experience and baseline endurance performance. These comparisons were conducted with regression analyses. Correlations between the implicit theories (entity, incremental and mind-over-body) were calculated using Pearson correlations. Homogeneity of variance and normality assumption were tested using the Levene’s test and the Shapiro-Wilk test, respectively.

To address our main research question, we ran a series of regression models. We specified time-to-failure and errors in the main task as dependent variables indicating endurance performance, always adjusting for the corresponding baseline values. We specified Condition (0 = goal, 1 = implementation intention) and Limit (0 = exertion, 1 = pain) as dummy predictors and beliefs (entity, incremental, mind-over-body) as continuous predictors. There were no significant differences between the group variances of time-to-failure and errors in the baseline and the main task, all ps ≥ 0.123. The dependent variables were not normally distributed, all ps < 0.001.

All analyses were run in the statistical software environment R (3.3.6, [53]). Plots were created using GGPILOT2 (3.2.1, [54]), sjPlot [55] and the graphical elements of the University of Konstanz [56]. The regression analyses were conducted with the robcov function of the rms package [57], which provides robust estimates of the standard errors. Regression tables were designed using texreg [58]. Significance is assumed when p < 0.05.

3.2. Preliminary Analyses

3.2.1. Task Experience and Beliefs

There were no differences between goal and implementation intention condition regarding performance motivation, self-efficacy, task satisfaction, or positive and negative feelings, all bs ≤ 0.46 ps ≥ 0.134. More importantly, participants in both conditions displayed similar levels of incremental beliefs, b = –0.09, p = 0.529, entity beliefs, b = 0.005, p = 0.978, and mind-over-body beliefs, b = −0.18, p = 0.381. Entity and incremental beliefs were negatively associated, r(58) = −0.35, p < 0.006, as were entity and mind-over-body beliefs, r(58) = −0.31, p = 0.015. Incremental and mind-over-body beliefs were positively correlated, r(58) = 0.44, p < 0.001. We found no condition differences regarding average RPE in the baseline task, b = 0.34, p = 0.417, or in the main task, b = 0.19, p = 0.681. Analogously, there were no differences between conditions in the average RPP in the baseline task, b = 0.20, p = 0.685, or in the main task, b = 0.66, p = 0.240.

3.2.2. Baseline Performance

There were no differences in time-to-failure (in minutes) between the goal (M = 10.5, SD = 5.5) and the implementation intention condition (M = 10.6, SD = 6.3), b = 0.14, p = 0.925. Similarly, no differences between the goal (M = 15.2, SD = 39.4) and the implementation intention condition (M = 16.3, SD = 66.9) emerged with respect to errors (in seconds), b = 1.03, p = 0.942. Figure 2 illustrates time-to-failure (Figure 2a) and errors (Figure 2b) in the baseline and the main task as a function of Condition and Limit.
Figure 2. Violin plots and boxplots of (a) time-to-failure and (b) errors as a function of Condition (goal vs. implementation intention) and the reason for T1 task termination (Limit: exertion vs. pain).

In general, time-to-failure was significantly longer in the baseline task ($M = 10.6, SD = 5.8$) than in the main task ($M = 7.7, SD = 5.2$), $b = -2.87, p < 0.001$. Errors did not differ significantly between the baseline task ($M = 15.7, SD = 53.5$) and the main task ($M = 23.8, SD = 88.3$), $b = 8.06, p = 0.274$.

3.3. Performance in the Main Task

3.3.1. Time-to-Failure

Conditions and Limit

Comparisons of goal versus implementation intention condition and of exertion versus pain as limits revealed no significant effects, $b = 0.07, p = 0.944$ (Table 2, Model 1), and $b = 0.14, p = 0.921$ (Table 2, Model 2), respectively, and there was no significant interaction between Condition and Limit, $b = 0.90, p = 0.759$ (Table 2, Model 3).

Entity Beliefs

We added the entity beliefs to the variables in Model 3 and specified all possible interactions (Table 2, Model 4). This resulted in a significant effect of Condition, $b = -10.57, p = 0.016$, that was...
governed by significant two-way interactions with Limit, \( b = 28.47, p = 0.013 \), and entity beliefs, \( b = 4.67, p = 0.026 \), and by a significant three-way interaction with Limit and entity beliefs, \( b = -14.69, p = 0.020 \). To ease the interpretation this three-way interaction, we plotted time-to-failure as a function of Condition, Limit, and the entity beliefs in Figure 3a. In the goal condition, stronger entity beliefs were associated with decreasing time-to-failure when participants felt limited by feelings of exertion but with increasing time-to-failure when they felt limited by feelings of pain. This was reversed in the implementation intention condition, where stronger entity beliefs were associated with increasing time-to-failure when participants felt limited by feelings of exertion but with decreasing time-to-failure when they felt limited by feelings of pain.

**Incremental Beliefs**

In an analogous fashion, we added the incremental beliefs to the variables in Model 3 and specified all possible interactions (Table 2, Model 5). This revealed no significant effects, \( p_s \geq 0.112 \). However, as can be seen in Figure 3b, the association between Limit and incremental beliefs especially in the implementation intention condition was reversed in comparison to the analysis of entity beliefs.

**Table 2.** Linear regression models for explaining time-to-failure in the main task of the HRT. The intercept represents the expected time-to-failure in the main task when all other predictors equal 0. Numbers in parentheses are robust standard errors. Baseline: Condition = Goal Intention, Limit (reason for baseline task termination) = Exertion.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
<th>Model 7</th>
</tr>
</thead>
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<td>Intercept</td>
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<td>1.68</td>
<td>4.59</td>
<td>2.01</td>
<td>1.97</td>
<td>5.42</td>
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<tr>
<td></td>
<td>(1.81)</td>
<td>(1.52)</td>
<td>(1.88)</td>
<td>(2.03) *</td>
<td>(3.44)</td>
<td>(2.26)</td>
<td>(3.86)</td>
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<tr>
<td>Time-to-failure</td>
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<td>0.57 ***</td>
<td>0.57 ***</td>
<td>0.51 ***</td>
<td>0.48 ***</td>
<td>0.52 ***</td>
<td>0.45 ***</td>
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<td>Baseline Task</td>
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<td>(0.17)</td>
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<td>(0.10)</td>
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<td>(1.03)</td>
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<tr>
<td>Limit = Pain</td>
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<td>3.37</td>
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<td>(1.44)</td>
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<td>(15.84)</td>
<td>(4.15)</td>
<td>(14.66)</td>
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<tr>
<td>II × Pain</td>
<td>0.90</td>
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<td>-38.45 **</td>
<td>-20.44</td>
<td>-14.97</td>
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<td>(24.33)</td>
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<td>15.33</td>
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<td>II × Pain × Incremental</td>
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<td>5.98</td>
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<td></td>
<td></td>
<td>(5.99)</td>
<td>(5.46)</td>
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<tr>
<td>Mind-over-body</td>
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<td>-0.04</td>
<td></td>
<td></td>
<td>(0.54)</td>
<td>(0.54)</td>
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<tr>
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<td>-2.93</td>
<td>-1.09</td>
<td></td>
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<td>(2.20)</td>
<td>(1.42)</td>
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<td>Pain × Mind-over-body</td>
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<td>(1.84)</td>
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<tr>
<td>II × Pain × Mind-over-body</td>
<td>10.32 **</td>
<td>9.20 **</td>
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<td>(3.19)</td>
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<td>(1.21)</td>
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<td>(1.84)</td>
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<td>0.42</td>
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*** p < 0.001, ** p < 0.01, * p < 0.05, ◦ p < 0.1; L.R., likelihood ratio; Num. obs., number of observations; Adj. R², adjusted R²; II = Implementation Intention.
Mind-over-body Beliefs

Next, we added mind-over-body beliefs in the same fashion (Table 2, Model 6). This revealed a significant interaction between Condition and Limit, $b = -38.45$, $p = 0.003$, that was governed by a three-way interaction of Condition, Limit and mind-over-body beliefs, $b = 10.32$, $p = 0.002$ (see Figure 3c). While time-to-failure was not affected by limits and mind-over-body beliefs in the goal condition, stronger mind-over-body beliefs in the implementation intention condition were associated with decreasing time-to-failure when participants felt limited by feelings of exertion but with increasing time-to-failure when they felt limited by feelings of pain.

![Figure 3](image-url)

**Figure 3.** Estimated time-to-failure as a function of Condition (goal vs. if-then plan), Limit (reason for baseline task termination: exertion vs. pain) and (a) entity beliefs, (b) incremental beliefs and (c) mind-over-body beliefs. Higher values of entity beliefs represent a stronger belief that athletic ability is stable and fixed, while higher values of incremental beliefs represent a stronger belief that athletic ability is changeable by effort and training. Finally, higher values of mind-over-body beliefs represent a stronger belief that the mind (i.e., mental factors) rather than the body (i.e., physical factors) limits athletic performance.
Joint Analysis of Beliefs

In a final step, we simultaneously added entity, incremental, and mind-over-body beliefs to examine which beliefs are most important for time-to-failure when controlling for the influence of other beliefs (Table 2, Model 7). We found that the three-way interaction effect involving entity became nonsignificant, \( b = -9.01, p = 0.069 \), while the three-way interaction effect involving mind-over-body beliefs remained significant, \( b = 9.20, p = 0.006 \). The interaction effect involving incremental beliefs remained nonsignificant, \( b = -0.26, p = 0.962 \). This pattern of results suggests that mind-over-body beliefs in concert with perceived limits of performance (exertion vs. pain) were an important determinant of implementation intention effects on time-to-failure.

3.3.2. Errors

Condition and Limit

Comparisons of goal versus implementation intention condition and of exertion versus pain as limiting factors regarding errors revealed no significant effects, \( b = -16.19, p = 0.244 \), and \( b = 7.22, p = 0.530 \), respectively, and there was no significant interaction between Condition and Limit, \( b = -83.49, p = 0.169 \) (Table A1, Models 1–3).

Moderation by Entity, Incremental and Mind-over-body Beliefs

Analogous to the analysis of time-to-failure, we added the beliefs and specified interactions with all variables in Model 3 (Table A1, Models 4–6). These analyses did not yield any significant effects, \( ps \geq 0.073 \). Errors are plotted as a function of Condition, Limit, and the respective beliefs in Figure A2.

Joint Analysis of Beliefs

In a final step, we simultaneously added entity, incremental, and mind-over-body beliefs and their interactions with Condition and Limit, which revealed no significant effects, \( ps \geq 0.055 \) (Table A1, Model 7).

4. Discussion

The aim of this study was to advance research on the effects of forming implementation intentions on muscular endurance performance. Specifically, we investigated the effectiveness of implementation intentions tailored to experienced limits of endurance performance (i.e., perceptions of exertion versus pain) conjointly with potentially moderating effects of individual differences in implicit theories about the stability versus malleability of athletic performance (i.e., entity versus incremental beliefs) and about the limitation of athletic performance by mental versus physical factors (i.e., mind-over-body beliefs).

In line with prior research [18,31], forming goal versus implementation intentions did not improve endurance performance in terms of time-to-failure or errors, even though the if-then plans were tailored to previously experienced limits of endurance performance. However, individual differences in implicit theories emerged as a moderating variable: In the implementation intention condition, stronger entity beliefs were associated with increasing time-to-failure when participants planned to ignore exertion but with decreasing time-to-failure when they planned to ignore pain. In contrast, stronger entity beliefs in the goal condition were associated with decreasing time-to-failure when the goal pertained to exertion but with increasing time-to-failure when the goal pertained to pain. Interestingly, this pattern of results was reversed with regard to incremental beliefs (although this pattern itself was not significant) and even more so with regard to mind-over-body beliefs. This observation makes sense when considering that entity beliefs were negatively correlated with incremental and mind-over-body beliefs, which in turn were positively correlated with each other.

The role of mind-over-body beliefs seems particularly intriguing because beliefs about the nature of limits to athletic performance have so far garnered little or no scientific attention. Our findings might
be tentatively interpreted as follows: Participants who believe that mental factors ultimately limit athletic performance (i.e., strong mind-over-body beliefs) and who had just terminated the baseline task because of such a mental factor (i.e., perceived exertion) likely interpret their exertion as a signal that their personal limit is reached. This might undermine the effectiveness of implementation intentions, especially when the plan requires them to ignore this signal. The very same plan might, however, be viable for participants who likewise had just terminated the baseline task because of exertion but do not believe in the mind’s role in limiting performance (i.e., weak mind-over-body beliefs). These participants are unlikely to interpret exertion as signaling the reaching of a limit, leaving room for implementation intention effects to unfold. By analogy, plans targeting the perception of pain might be more viable for participants who terminated the baseline task because of pain (i.e., a bodily factor) and hold strong rather than weak mind-over-body beliefs. It seems promising for future research to follow this line of reasoning up by using implementation intentions targeting perceptions that were not the reason for previous task termination (e.g., planning to ignore pain after terminating the baseline task due to exertion).

Of course, our reasoning rests on the assumption that exertion and pain are two distinguishable perceptions that people conceive of as representing mental versus bodily factors, respectively. This view is supported by the literature, which describes perceived exertion as an indicator of mental strain [59] and perceived pain as corresponding to bodily processes [33]. Accordingly, our results suggest that the contents of implementation intentions should be aligned with people’s implicit beliefs about the (reaching of) limits of athletic abilities in order to work effectively. In our study, this was particularly important with regard to entity and mind-over-body beliefs.

In contrast to our initial assumptions, we did not observe a direct impact of entity and incremental beliefs on implementation intention effects. As we have argued in the introduction, it was plausible to assume that entity and incremental beliefs about athletic ability have direct (although potentially different) consequences for implementation intentions. However, we found no significant effects of incremental beliefs at all and no direct effects of entity beliefs. Although, the observation that stronger entity beliefs were associated with longer time-to-failure when the implementation intention targeted exertion can be explained with the existing literature on implicit theories: from an entity perspective, exertion signals a deficit because people with talent do not need to invest effort in order to achieve something [35,60]. Therefore, being confronted with sensations of exertion in the baseline task, they probably were more likely to respond well to an implementation intention focused on ignoring exertion. This reasoning can be applied vice versa to an incremental perspective: here, exertion is an unavoidable part of development and necessary for transforming skills into accomplishments [35,61]. Accordingly, participants holding stronger incremental beliefs would presumably be wary using an implementation intention targeting the ignorance of exertion, an allegation that is implied by the visualization of time-to-failure in Figure 3b. However, in our study we assessed implicit theories after the completion of the baseline and the main task to avoid undesired effects of the measurement on performance. Therefore, future research should complement our approach with a design in which implicit theories are assessed prior to the endurance task.

Our study has important implications for the design of implementation intentions in studies investigating athletic performance. It provides guidance on how implementation intentions should be constructed in order to overcome exercise-related obstacles. In former studies, all participants formed the same implementation intention targeting a single obstacle known to be of general relevance (i.e., perceptions of pain or effort; e.g., [18]). This has yielded mixed results, however, and our findings suggest an intricate interplay between beliefs about athletic performance and the (reaching of) limits as possible reason for this inconsistency. It thus seems advisable to tailor implementation intentions specifically to people’s beliefs about performance and its limits, for instance, by avoiding that the implementation intentions requiring to ignore a factor that they interpret as signal that their personal (mental or physical, as the case may be) limits are reached. All in all, the results further the assumption that a generalizable application of if-then plans in exercise contexts is not always effective and provides
an explanation as to why similar studies did not observe positive effects for plans [18,31]. Instead, an individual consideration of exercisers’ implicit beliefs in what limits their performance is necessary in order to improve muscular endurance performance. This study therefore makes a strong contribution for the research on the use of if-then plans in (muscular) endurance performance by specifying how to tailor implementation intentions to exercisers’ needs.

As mentioned above, further studies should provide participants with implementation intentions after having assessed their implicit theories. This would allow, for instance, to rule out the possibility that participants’ expressed believes (i.e., entity, incremental, and mind-over-body) were affected by their earlier experiences of exertion or pain during the task, and/or by the effectiveness of the corresponding if-then plans. Until such data is available, causal interpretations must remain tentative. Another intriguing question pertains to the effects of implementation intentions tailored to perceptions that participants did not attribute to task termination. That is, participants who terminate the baseline task because of exertion would plan to ignore their pain, whereas participants who terminate the baseline task because of pain would plan to ignore their exertion. Such an approach avoids mismatches between the content of implementation intentions and participants’ beliefs, as the plan could no longer target a perception that is seen as signaling the reaching of a limit. Finally, it seems promising to experimentally manipulate participants’ believes about athletic ability rather than measuring it (e.g., [60,62,63]). This would permit stronger causal inferences and therefore provide additional insights in the interplay of implementation intentions and implicit theories.

That said, our findings already contribute to literature on the moderators of implementation intention effects [64]. This literature has mainly focused on individual difference variables like social anxiety [65], conscientiousness [66], and perfectionism [67], but also on situational moderators like mindsets [68]. Here, we combined both approaches by demonstrating an interaction of participants’ general beliefs about athletic ability as a trait (i.e., entity, incremental, mind-over-body) and the limiting factors of their performance as a state (i.e., perceptions of exertion and pain). As such, our research reinforces calls for investigating moderators of implementation intention effects and highlights the importance of considering both traits and states in doing so. This might be particularly relevant with respect to physical exercise and endurance performance, given the currently conflicting sets of findings in this domain.

Finally, and reaching beyond theoretical considerations, our study has implications for designing interventions that help recreational athletes to initiate and maintain regular muscular exercise. Despite common knowledge that physical activity is important for health [1,2], half of the people who want to become (and stay) physically active fail to do so [69]. In the domain of muscular endurance, an important cause for such failures might be that the training is perceived as effortful and is accompanied by uncomfortable sensations like pain [70]. Given their effectiveness across domains, it is therefore not surprising that implementation intentions are frequently recommended as a self-regulation strategy in the sports context [29,70–73] and tailored primarily to the regulation of effort and pain when it comes to improving muscular endurance [18,30,31]. However, our results indicate that conveying implementation intentions to recreational athletes is not without its hooks. For instance, it might seem intuitive to advice recreational athletes to ignore their perceptions of effort when they perceive an exercise as too effortful by means of forming an implementation intention. Our data suggest, however, that this might backfire if these athletes interpret their effort as signaling that an ultimate performance limit has been reached. Against this background and considering the conflicting findings regarding implementation intention effects in the domain of endurance performance, further research seems necessary to develop implementation intentions that effectively enhance muscular endurance in applied settings. As a first and important step, our study showed how individual differences in believes and perceived performance limits could be used to design implementation intentions.

One could argue that the results of this study are not easily applicable to the broad population of frequently exercising recreational athletes, as the study sample consists of students with reasonable variation in regard to exercise motivation and athletic experience. It is possible that the influence of
implicit theories on athletic ability and of beliefs on the limitations of athletic performance is different in populations of more experienced exercisers, as they might already have experienced the boundaries of their bodily resources and thus possess an enhanced body awareness. These experiences might have an effect on self-regulation strategies such as implementation intentions. Future research should extend our results by investigating the impact of individual beliefs about athletic ability and of perceived limits of endurance performance particularly in hobby, amateur, and professional endurance athletes.

Moreover, our results concerning the influence of mind-over-body beliefs should be taken with a grain of salt. On the one hand, we think that these beliefs are important for evaluating the effectiveness of psychological interventions in the exercise domain, and this impression is reinforced by our observation that mind-over-body beliefs played an even more powerful role than entity and incremental beliefs. On the other hand, our findings rest on an ad hoc constructed scale in accordance with and complementing the established CNAAQ-2. The rather weak internal consistency of the three constituent items indicates that we tapped into a rather complex construct that might be difficult to capture in full with only three items. Given the relevance of these items in explaining the effectiveness of if-then plans according to our data, it might be worthwhile to develop and psychometrically test a dedicated scale for assessing mind-over-body beliefs.

5. Conclusions

In this study, we investigated the effects of if-then planning on performance in a static muscular endurance task as well as potential moderators of these effects. Our findings point to an important role of individual beliefs about athletic ability (i.e., entity, incremental, and mind-over-body) as well as the perceived limits of endurance performance (i.e., exertion and pain). The content of an implementation intention needs to be congruent with these beliefs and limits in order to improve performance: if, for instance, people plan to ignore a perception (e.g., exertion) that is interpreted as signaling the reaching of a limit according to their beliefs about athletic ability (e.g., mind-over-body), performance seems to deteriorate. In contrast, planning to ignore a perception that is not interpreted as signaling the reaching of a limit seems to promote performance. The findings of this study increase the current knowledge on moderators of if-then planning and add to the existing research on the efficacy of implementation intentions on exercise performance. We hasten to add that our interpretations remain tentative until further experimental evidence is available that systematically investigates the interplay of plan contents, beliefs, and perceptions. Nevertheless, our data provide solid grounds for suggesting that implementation intentions should be carefully tailored to what recreational athletes believe about athletic performance and their own limits. Such tailoring of implementation intentions might be a powerful tool to assist exercisers with staying on track even during effortful muscular endurance tasks and deal with aching muscles, ultimately helping them to enhance their physical fitness and health. Therefore, this study provides a valuable contribution to research on health-related behavior by providing insights on how to optimize the application of well-researched psychological strategies in the exercise context. Finally, it is important to note that in the health setting, sports and exercise is often performed at low intensities that do not push exercisers to their effort- and pain-related limits. Therefore, low intensity exercise is likely to pose different self-regulatory challenges that threaten long-term exercise adherence: For many people, exercise might simply be boring. Recently, it has been proposed that boredom acts as a powerful motivator for seeking out more rewarding behavioral alternatives [74], and these might be at odds with one’s goal of becoming fit and healthy. Thus, self-regulatory control is required to keep going despite being bored [74]. Therefore, future research should investigate how if-then plans can be tailored to the challenges of low intensity exercise, to help aspiring exercisers deal with these self-regulatory challenges.

**Author Contributions:** W.W., M.B., A.H., and J.S. conceptualized the experimental design. M.B. and W.W. carried out the data collection. Data analysis was performed by A.H. and M.B. The first draft was written by A.H., M.B., W.W. and J.S. revised and edited the manuscript which was then finalized by A.H. All authors have read and agreed to the published version of the manuscript.
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**Conflicts of Interest:** The authors declare no conflict of interest.

**Appendix A**

![Flowchart of the study procedure](image)

**Figure A1.** Flowchart of the study procedure. The procedure of the baseline task and the main task was analogous.
Table A1. Linear regression model for explaining errors in the main task in the HRT. The intercept represents the expected mean value of errors in the main task when all other predictors are equal to 0. Numbers in parentheses are robust standard errors. Baseline: Condition = Goal Intention, Limit (reason for baseline task termination) = Exertion.

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<th>Model 3</th>
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</table>

*** p < 0.001, ** p < 0.01, * p < 0.05, ◦ p < 0.1; L.R., likelihood ratio; Num. obs., number of observations; Adj. R2, adjusted R2; II Implementation Intention.
Figure A2. Estimated errors as a function of Condition (goal vs. if-then plan), Limit (reason for baseline task termination: exertion vs. pain) and (a) entity beliefs, (b) incremental beliefs and (c) mind-over-body beliefs. Higher values of entity beliefs represent a stronger belief that athletic ability is stable and fixed, while higher values of incremental beliefs represent a stronger belief that athletic ability is changeable by effort and training. Finally, higher values of mind-over-body beliefs represent a stronger belief that the mind (i.e., mental factors) rather than than the body (i.e., physical factors) limits athletic performance.

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