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Pressure Makes Diamonds?: A Narrative Review on the Application of Pressure Training in High-Performance Sports

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Abstract

There is growing interest for the use of pressure training (PT) in high-performance sports. Although prior reviews have demonstrated the effectiveness of PT to improve performance outcomes, less attention has been directed towards the practical application of PT, including which different psychological or psychosocial functions PT may serve and how contextually relevant pressure-inducing tasks can be designed within practice. The purpose of this paper is to conduct a narrative review to explore and clarify the current knowledge regarding the application of PT within high-performance sports. More specifically, with this paper we aim to contribute to the current literature by discussing common features of PT conceptualisations, the proposed functions of PT, key considerations for the practical implementation of PT, and avenues for future PT research.

Keywords: coping; planned disruptions; pressure inurement; stress exposure; stress inoculation

Pressure Makes Diamonds?: A Narrative Review on the Application of Pressure Training in High-Performance Sports

Participating in high-performance sports is a highly demanding and potentially stressful endeavour. Athletes frequently face a wide range of stressors, which can broadly be classified as performance stressors (e.g., injury, performance expectations), organisational stressors (e.g., leadership, team issues), and personal stressors (e.g., work-life balance, family issues) (Arnold & Fletcher, 2021; Sarkar & Fletcher, 2014). Among others, stress can have subsequent detrimental effects on athletes' (visuomotor) performance (Nieuwenhuys & Oudejans, 2017; Vine et al., 2016), personal and athletic development (Bergeron et al., 2015; Wylleman & Lavallee, 2004), and mental wellbeing (Kegelaers et al., 2022; Rice et al., 2016). Stress management and coping interventions have, therefore, long formed a central feature of sport psychology (Kent et al., 2018; Murdoch et al., 2021; Rumbold et al., 2012). One particular type of intervention that has started to gain attention over the past decade or so is the use of *pressure training* (PT) (Fletcher & Arnold, 2021; Low et al., 2021). Such PT aims to strengthen athletes' stress management skills and ability to perform under pressure by deliberately exposing them to (simulated) stressors within the practice environment.

The notion that athletes may find some benefit within (simulated) stressor experiences is not necessarily new in sports (Collins & MacNamara, 2012), or psychology more broadly (Seery, 2011). This idea can be linked back to theoretical constructs such as stress-related growth (Park et al., 1996), toughening (Dienstbier, 1989), steeling (Rutter, 1987), or antifragility (Taleb, 2012) (for a review of these constructs, see Fletcher & Arnold, 2021). A growing body of research has demonstrated that challenging or adverse (early life) experiences in athletes *can* lead to growth across multiple interpersonal and intrapersonal domains, including superior performance (Fletcher, 2021; John et al., 2019). Although debate exists surrounding the extent to which challenge in and of itself can differentiate performers

of different levels (Collins et al., 2016b), one consistent implication coming from this research line is the notion that potential benefits of challenging experiences may be leveraged by regularly exposing athletes to relatively small, developmentally appropriate stressors (e.g., Collins et al., 2016a; Collins & MacNamara, 2012; John et al., 2019; Sarkar & Fletcher, 2017). The concept of PT is also rooted within traditional cognitive behavioural interventions, such as systematic desensitization (Wolpe, 1961) and stress inoculation training (Meichenbaum, 1985). Analogous to medical inoculation, these approaches have a long history of being used to treat phobias and other anxiety-related disorders via gradual exposure to the anxiety-inducing stimuli, often progressing from imagery or role playing to in vivo exposure (see Fletcher & Arnold, 2021).

Several systematic reviews and meta-analyses have already demonstrated the effectiveness of PT for improving performance in sport and other domains (Gröpel & Mesagno, 2019; Kent et al., 2018; Low et al., 2021). To illustrate, Low et al. (2021) conducted a meta-analysis of 14 studies across both sport and policing, finding moderate to large positive effects on performance outcomes (Hedges' $g = 0.67$). Although insightful and important consolidations of the existing literature, by focussing on performance as the primary outcome of PT these reviews did not directly address the mechanisms of PT or other potential functions of PT in relation to psychological or psychosocial development (Alder et al., 2016; Kegelaers, Wylleman, & Oudejans, 2020; Low, Freeman, et al., 2022). Indeed, Kent et al. (2018) highlighted that future research should develop a better understanding of how contextually relevant pressure-inducing tasks can be designed and through which mechanisms PT contributes to improved performance outcomes. There is, in other words, a need to further examine the *process* of PT in addition to its primary outcome (i.e., performance). At the same time, PT has also been a source of contention and debate in sports (e.g., Fletcher & Arnold, 2021; Howells & Wadey, 2021) as well as broader performance

domains (e.g., Mazzola & Disselhorst, 2019). Scholars have noted that the ill-considered or ineffective implementation of PT could lead to unhealthy and even abusive practice environments. Advancing our understanding of the process of PT is thus not only important to understand how it can be effectively implemented, but equally to gain insight into some of the ethical challenges associated with it and how these may be mitigated.

Following the call by Kent et al. (2018), the purpose of the present paper is to conduct a narrative review to explore and clarify the current knowledge regarding the application of PT within high-performance sports. More specifically, with this paper we aim to contribute to the current literature by discussing common features of PT conceptualisations, the proposed functions of PT, guidelines and additional considerations for PT implementation, and future avenues for PT research.

Conceptualising Pressure Training

Within the sport psychology literature, PT has been presented in many different shapes and forms and under different names, including pressure inurement training (Fletcher & Sarkar, 2016), pressure acclimatisation training (Beseler et al., 2016), anxiety training (Oudejans & Pijpers, 2009), simulation training (Kent et al., 2018), or stress exposure training (Driskell et al., 2014). Some approaches have conceptualised PT as a self-contained intervention, whereas others have considered it as part of larger multimodal interventions (e.g., combined with psychoeducation or skill development; Low et al., 2021). A range of different theoretical frameworks have also been used to underpin its use within sports, including transactional stress and coping theories (Fletcher et al., 2006; Lazarus & Folkman, 1984), the Theory of Challenge and Threat states in Athletes (Jones et al., 2009), or attentional control theories explaining the anxiety-performance relationship (Eysenck et al., 2007; Nieuwenhuys & Oudejans, 2012). This conceptual and theoretical proliferation has led

112 to fragmented and sometimes inconsistent ways scholars have defined and operationalised
113 PT.

114 Although no single approach to PT exists, there are some areas of convergence among
115 different conceptualisations (Fletcher & Arnold, 2021). First, interventions generally include
116 a purposeful manipulation of the practice environment with the intention to expose athletes to
117 increased levels of pressure (Low et al., 2021; Stoker et al., 2016). Within the PT literature,
118 pressure is typically defined in line with Baumeister (1984), who described it as "any factor
119 or combination of factors that increase the importance of performing well on a particular
120 occasion" (p.610; see also Stoker et al., 2016). However, authors have argued that it is not the
121 pressure (i.e., importance to perform one's best) in and of itself, but rather the subsequent
122 stress response, resulting from a subjective evaluation of the situation, which will negatively
123 affect an athlete's functioning (Oudejans & Pijpers, 2009; Vine et al., 2016). Perhaps stated
124 more accurately, PT, thus, involves manipulation of the practice environment with the intend
125 to evoke a stress-related response within the athletes (Fletcher & Arnold, 2021; Fletcher &
126 Sarkar, 2016; Kegelaers, Wylleman, & Oudejans, 2020). To illustrate, Oudejans and Pijpers
127 (2009, 2010) considered the presence of at least some mild anxiety, which can be considered
128 an emotional stress response (Vine et al., 2016), as a key property of effective PT. Second,
129 PT typically also includes a physical practice component (Low et al., 2021). Some authors
130 have described it as a way to "familiarise" (Kegelaers, Wylleman, & Oudejans, 2020) or
131 "acclimatise" (Beseler et al., 2016) athletes to increased pressure. However, Oudejans and
132 Pijpers (2009) demonstrated that exposure to a stress-inducing stimulus in and of itself was
133 insufficient to reduce negative performance effects of pressure. Only if participants had to
134 execute a certain task under pressure conditions did performance on that specific task
135 increase (Oudejans & Pijpers, 2009). In this regard, Low et al. (2021) argued that "PT does

not just train the ability to cope with anxiety; instead, it trains the ability to cope while simultaneously executing skills or making decisions" (p.150).

Looking at the literature in a little more detail, it would seem two broad approaches can be distinguished regarding the tasks around which PT is organised. A first approach has considered PT specifically as a means to reduce choking on a well-defined sport-specific task (Gröpel & Mesagno, 2019). In general, these studies tend to focus on simulating the specific conditions and performance stressors associated with task performance as closely as possible (Pinder et al., 2011). This may explain the observation that most research has focused on PT in relation to closed skill tasks (Low et al., 2021), including basketball free-throw shooting (Oudejans & Pijpers, 2009; Experiment 1), goal kicking in Australian football (Beseler et al., 2016), or badminton serves (Alder et al., 2016), as the structured and predictable nature of such tasks is easier to simulate within practice. At the same time, some studies seemed to consider PT as a broader stress management intervention, aimed at helping athletes cope with a wider range of different and sometimes unexpected stressors (Henriksen, 2018; Kegelaers, Wylleman, & Oudejans, 2020). For example, Kegelaers, Wylleman, and Oudejans (2020) described how coaches used pressure manipulations outside of the usual practice environment, including long travels, poorly organised training camps, or even non-sport-related activities (e.g., military training camp). From this perspective, PT may help athletes and teams familiarise and cope with a broader range of stressors, including organisational stressors. Eccles et al. (2022), for example, suggested that such PT could train athletes to cope with physical and mental fatigue. For the purpose of the present paper, both approaches will be considered within the narrative review, although future work should more carefully examine the similarities and distinctions between both broad types of PT.

Functions of Pressure Training

As stated, several review papers have highlighted the effectiveness of PT on performance outcomes, without necessarily expanding on the underlying processes that could lead to such positive performance (Gröpel & Mesagno, 2019; Kent et al., 2018; Low et al., 2021). Nevertheless, research has hinted a multiple different psychological or psychosocial functions that may be achieved using PT (e.g., Kegelaers, Wylleman, & Oudejans, 2020; Kent et al., 2021; Low, Freeman, et al., 2022; van Rens et al., 2021). These can be considered potential mechanisms underpinning positive performance outcomes (Low, Freeman, et al., 2022) or desired outcomes in and of itself (Kegelaers, Wylleman, & Oudejans, 2020). Developing a better understanding of these potential functions is important as it may hold key implications for the effective implementation of PT in practice (Low, Freeman, et al., 2022). In this section, we will discuss the functions that have been presented within the current literature. To be clear, this should not necessarily be considered an exhaustive list. As PT forms a relatively new research area, it may well be that other potential functions exist which, to date, have received no explicit attention within the literature. Additionally, these should not necessarily be considered mutually exclusive, as PT interventions may serve several functions simultaneously and conjointly.

Strengthening Psychological Characteristics

Several authors have suggested that PT can strengthen psychological characteristics associated with positive adaptation to pressure and stress, including mental toughness (Bell et al., 2013; Crust & Clough, 2011; Weinberg et al., 2016) and psychological resilience (Fletcher & Sarkar, 2016; Kegelaers & Wylleman, 2019; Sarkar & Hilton, 2020). To illustrate, Weinberg et al. (2016) examined sport psychologists' perspectives on mental toughness development, highlighting the need to "create situations of challenge and failure" (p.237) to develop athletes' skills and competency to cope with similar non-simulated stressors. Similarly, Bell et al. (2013) found that a 2-year long PT intervention lead to

improved coach-perceived mental toughness and associated behavioural correlates (i.e., multistage fitness test) in elite cricketers. In parallel with the mental toughness literature, qualitative research has shown that coaches may foster psychological resilience by creating a challenging yet supportive practice environment for their athletes (Kegelaers & Wylleman, 2019; Sarkar & Hilton, 2020). Athletes' appraisals of a stressor as a challenge and opportunity for growth, rather than a threat, forms a core fundament of this resilience process (Fletcher & Sarkar, 2016; Sarkar & Fletcher, 2014). Providing tentative support for the importance of such a 'challenge mindset', van Rens et al. (2021) found medium sized positive effects of a PT intervention on female cricket players' challenge appraisals, although these differences nevertheless failed to reach significance, likely due to the small sample size.

Mastering Coping Skills

Another important proposed function of PT involves the training, refinement, and mastery of coping skills (Kegelaers, Wylleman, & Oudejans, 2020; Low, Freeman, et al., 2022), typically formally developed outside of the PT context itself (Bell et al., 2013; Kent et al., 2021; van Rens et al., 2021). Several authors have argued that the inclusion of ample opportunities to develop coping skills outside of PT forms a crucial condition for its success (e.g., Bell et al., 2013; Driskell et al., 2014; Fletcher & Arnold, 2021). To illustrate, interventions have complemented PT with principles such as goal-setting, imagery, arousal regulation, self-talk, refocusing, cognitive restructuring, mindfulness-acceptance, and biofeedback training (Beauchamp et al., 2012; Bell et al., 2013; Kent et al., 2021; Larsson et al., 1988; van Rens et al., 2021). Although the use of such coping or stress management interventions is not new in sport psychology (Kent et al., 2018; Murdoch et al., 2021; Rumbold et al., 2012), PT can then provide an opportunity for athletes to test, tweak, and eventually master these coping resources in an "ecologically valid setting" (Low et al., 2021, p.159). At its core, this approach is grounded within stress inoculation training (SIT;

Meichenbaum, 1985). Such SIT traditionally adheres to a pre-defined three-phase structure, including a *conceptualisation phase* (i.e., psychoeducation on the nature, causes and consequences of stress), a *skill acquisition and rehearsal phase* (i.e., teaching coping skills), and an *application and follow-through phase* (i.e., gradually exposing individuals to realistic stressors) (Meichenbaum, 1985). Early case studies on SIT within sports already date back to the 1980s (Mace & Carroll, 1986, 1989). Since then the original clinically-focused SIT has been adapted to be more applicable for performance settings such as sports (Driskell et al., 2014; Gustafsson et al., 2017). Among others, researchers have proposed a more iterative or oscillated process of challenge and support (Fletcher & Sarkar, 2016; van Rens et al., 2021). Nevertheless, consistent with SIT, the central tenet of these skills-based approaches remains that PT should be accompanied with adequate support and learning opportunities – often in the form of accompanying workshops – to help athletes develop a suitable coping repertoire (Collins et al., 2016a).

Building Confidence

Several authors have suggested that PT should not only aim to develop athletes' coping skills, but also – and crucially – help build their confidence to withstand non-simulated pressure or stressful situations (Collins et al., 2016a). Beaumont et al. (2015) found that sport psychologists considered creating pressure situations within practice as an important approach to develop robust sport confidence. More specifically, it is suggested that using PT may help build athletes' confidence in their ability to tolerate somatic symptoms of stress (Gustafsson et al., 2017) and in the possession and application of their own coping skills (Collins et al., 2016a; Driskell et al., 2014). Providing support for these assertions, both van Rens et al. (2021) and Kent et al. (2021) found that athletes reported increased confidence in their ability to perform under pressure following a PT intervention. Of importance, experiencing mastery within the practice environment and feeling prepared for

competition provide important sources of sport confidence (Vealey et al., 1998). Hence, gaining success experiences in managing the demands of PT, rather than pressure in and of itself, may be important to strengthen athletes' confidence to cope with comparable non-simulated stressors (Beaumont et al., 2015).

Reducing Choking

Although PT can be effective to help athletes train, master, and gain confidence in their coping skills, Low et al. (2021) pointed out in their meta-analysis that formal skills development is not a necessity to accrue positive benefit on performance outcomes. Processing efficiency theories such as the Attentional Control Theory (Eysenck et al., 2007) or the Integrated Model of Anxiety and Perceptual-Motor Performance (Nieuwenhuys & Oudejans, 2012) have been proposed to explain how PT can have positive performance effects. These theories suggest that choking (i.e., acute decrease in skill execution under pressure) occurs due to a shift away from task-relevant goal-directed processes towards more stimulus-driven processes, including increased attention for external or internal stimuli, thereby disrupting automatic movement patterns, and ultimately leading to compromised performance. Athletes can compensate for this negative impact of anxiety on performance by exerting increased effort to inhibit stimulus-driven processes and enforce or maintain goal-directed processes (Eysenck et al., 2007; Nieuwenhuys & Oudejans, 2012). Such notions are consistent with Low, Freeman, et al. (2022), who found that PT can lead to increased investment of effort during practice. Effective compensatory efforts can be difficult without experience, but become more achievable as performers are familiarised with particular high-pressure conditions (Nieuwenhuys & Oudejans, 2017). For example, Oudejans and Pijpers (2010) found that novice dart players who participated in pressure training were able to maintain dart performance under post-test high anxiety conditions compared to low anxiety conditions, whereas dart players in the control group demonstrated significant decreases in

performance in high anxiety conditions (i.e., choking) compared to low anxiety conditions (for similar results, see Alder et al., 2016; Lawrence et al., 2014; Oudejans & Pijpers, 2009; for a notable exception, see Beseler et al., 2016). Moreover, both groups exerted increased mental effort during high anxiety conditions compared to low anxiety conditions, which did not change following pressure training (Oudejans & Pijpers, 2010). Alder et al. (2016) found that PT could also lead to improved visual search behaviours under high pressure conditions, indicative of compensatory effort (see also Nieuwenhuys & Oudejans, 2011). Conjointly, these findings suggest that, with experience, athletes can learn to prevent choking by investing extra mental effort to maintain goal-directed processes. As such they learn to perform the tasks in question under the right circumstances, even in the absence of formal coping skills development (Nieuwenhuys & Oudejans, 2012).

Increasing Awareness

Another purported function of PT is increasing athletes' self-awareness concerning their typical responses to pressure or stress situations (Kegelaers et al., 2021; Kegelaers, Wylleman, & Oudejans, 2020; Low, Butt, et al., 2022; Low, Freeman, et al., 2022; van Rens et al., 2021). Reflective (i.e., meta-cognitive) behaviours can play an important role in understanding, accepting, and adapting to stressful or challenging experiences (Sarkar & Fletcher, 2014). As such, PT can provide a realistic but safe condition to let athletes reflect on and gain awareness of their cognitions, emotions, and behaviour under pressure, recognise personal stress triggers, assess their adopted coping strategies, and evaluate how these adopted strategies affect performance (Crane et al., 2019; Fletcher & Arnold, 2021; Low, Freeman, et al., 2022). For example, Kent et al. (2021) found that following a PT intervention, participants reported increased understanding of their thoughts and emotions under pressure, as well as insights into the use of more appropriate coping strategies. Similarly, van Rens et al. (2021) found that athletes became more aware of the appraisals and

emotion management strategies they utilised following PT. The lack of inclusion of reflective practices has been recognised as a key limitation of earlier PT research in sport (Driskell et al., 2014). However, recent studies have started to account for this limitation by advocating for the complementation of PT with systematic reflective practices (Fletcher & Arnold, 2021; Low, Butt, et al., 2022). This may, for example, be achieved in the form of guided reflection (Kegelaers et al., 2021) or reflective diaries (Kent et al., 2021). Importantly, PT may not only increase awareness in athletes but also in coaches. Kegelaers et al. (2021) found that coaches used PT to gain insight into how their athletes typically responded under increased pressure. It seems realistic that such increased awareness of individual players' responses could inform coaches' decision-making during high pressure game situations. However, more importantly, this shared awareness can provide an important starting point for coaches or practitioners and athletes to discuss functioning under pressure, target the development of specific coping skills, and inform the design or modification of subsequent practice interventions to train these skills (Fletcher & Arnold, 2021).

Promoting Team Functioning

Finally, although most research has focused on the level of the individual athlete, some evidence suggests that PT could also develop shared resources and promote team performance. Teams equally can experience shared deleterious cognitive (e.g., insecurity), affective (e.g., negative emotional contagion), or behavioural (e.g., blaming) consequences following increased pressure, even when previously performing well (Wergin et al., 2018). Consequently, teams need to draw upon shared resources and processes to protect against the negative effects of collectively encountered stressors, a process referred to as team resilience (Morgan et al., 2013, 2015). Qualitative research already demonstrated the use of PT within team sport settings as a way to strengthen such collective resources and promote team resilience (Kegelaers, Wylleman, Blijlevens, et al., 2020; Morgan et al., 2019). Chapman and

Gucciardi (2021) proposed three overarching benefits relating to team-level PT. First, PT could develop a collective understanding of a team's affective and behavioural responses to increased pressure and strengthen shared mental models. Second, PT could develop coordinated team strategies and skills (e.g., communication, leadership) under pressure. Third, having experience with overcoming challenging experiences in practice can develop a team's collective efficacy to manage real-life pressure situations (Chapman & Gucciardi, 2021). In line with these proposed team-level benefits, Kegelaers et al. (2021) found that a PT intervention within a female basketball academy was effective at reducing team-level vulnerabilities (e.g., communication breakdown, conflict) under pressure. Qualitative follow-up evaluations suggested that this reduction in team-level vulnerabilities, in part, resulted from improved awareness of team-level functioning under pressure, emerging shared leadership, improved communication channels, and the development of shared tactical plans under pressure (Kegelaers et al., 2021).

Designing Pressure Training in Practice

Pressure may be increased within practice environments by increasing the demands of a stressor and by increasing the significance of the appraisals (Fletcher & Arnold, 2021; Fletcher & Sarkar, 2016). The current literature describes a wide variety of practice stressors. For example, several studies used social judgement, in the form of some type of external observation or evaluation, to increase pressure on athletes (e.g., Alder et al., 2016; Oudejans & Pijpers, 2009), whereas others have relied on punishment conditioned stimuli (e.g., Bell et al., 2013; van Rens et al., 2021). Nevertheless, most of these pressure-inducing strategies have been proposed based on theoretical considerations or applied experience. Some studies have even adopted experimental designs (e.g., anxiety induced by a climbing wall), which likely hold limited ecological validity for real-world PT (Oudejans & Pijpers, 2010). Remarkably limited empirical attention has been directed towards the different ways pressure

335 can be induced within applied settings. To the best of our knowledge, only two studies have
336 examined how coaches or other practitioners systematically apply PT within their practice
337 (Kegelaers, Wylleman, & Oudejans, 2020; Stoker et al., 2016).
338 Stoker et al. (2016) interviewed 11 professional UK coaches to explore how they
339 designed PT. The authors identified two major approaches to increase pressure, including
340 manipulating the demands of training and manipulating the consequences of training. In line
341 with Newell's (1986; see also Davids et al., 2008) model of constraints, the authors found
342 that manipulating the training demands can be achieved by including task stressors (e.g.,
343 equipment), performer stressors (e.g., fatigue), and environment stressors (e.g., sounds).
344 Manipulating training consequences on the other hand can be done by including forfeits (e.g.,
345 missing practice time), rewards (e.g., place in the team), and social judgement (e.g.,
346 spectators) stressors (Stoker et al., 2016). Building on this work, Kegelaers, Wylleman, and
347 Oudejans (2020) further explored different types of practice manipulations to increase
348 pressure, which they labelled *planned disruptions*. Using interviews with Dutch and Flemish
349 elite-level coaches, the authors identified nine types of planned disruptions, including:
350 fatigue, competition simulation, forfeits and rewards, unfairness, stronger competition, task
351 restrictions, distractions, location, and outside-the-box strategies. Each of these planned
352 disruptions are briefly described in Table 1.
353 -- INSERT TABLE 1 AROUND HERE --
354 Recently, Fletcher and Arnold (2021) proposed the first comprehensive applied PT
355 framework for coaches and practitioners. The authors suggested a multi-phased approach,
356 consisting of three main phases: preparation and design, delivery and implementation, and
357 debrief and review. The preparation and design phase should involve close collaboration
358 between coaches and sport psychologists to establish the necessary conditions to effectively
359 implement PT (e.g., culture, stress education), determine the specific aims and desired

outcomes, and strategically plan the incorporation of PT within existing training programs. The delivery and implementation phase should include the provision of sufficient learning opportunities for athletes to develop the necessary coping skills (e.g., mental skills straining), gradual increase of pressure-inducing activities, and ongoing monitoring and modification. Finally, the debrief and review phase should include evaluations of both the outcome and process of PT and the facilitation of reflective activities to maximise learning (Fletcher & Arnold, 2021). Although this evidence-informed framework could provide an important step towards guiding coaches and practitioners to design effective PT, clearly more empirical research testing the framework remains necessary.

Key Considerations for Pressure Training Implementation

It is evident from the planned disruptions framework (Kegelaers, Wylleman, & Oudejans, 2020) that coaches and practitioners can use a wide variety of practice manipulations – either in isolation or combined – to increase pressure during training. However, in order to avoid potentially abusive practice behaviours, the implementation of PT should always be designed carefully, deliberately, strategically, and, where possible, in an individualised manner, based on the specific needs of the athletes (Collins et al., 2016a; Fletcher & Arnold, 2021; Stoker et al., 2016). Several important applied considerations for effective PT implementation have therefore been proposed within the extant literature. First, coaches and practitioners need to carefully consider how closely the PT context reflects the actual performance context (Collins et al., 2016a; Fletcher & Arnold, 2021). It has been argued that PT "must be designed to address the specific stress and task components that are likely to be encountered" (Driskell et al., 2001, p. 100). In this regard, the notion of a *representative learning design* may be particularly relevant (Pinder et al., 2011). In order to transfer skill development, the information sources and performance conditions of the training environment should closely match those of the actual performance context (i.e.,

action fidelity) to which it is intended to generalise (Pinder et al., 2011). As noted, most research has studies PT in relation to well-defined and predictable closed skill tasks (Low et al., 2021). However, evidence suggests that PT may equally be effective for more dynamic open skill tasks (Bell et al., 2013; Kent et al., 2021; Nieuwenhuys & Oudejans, 2011) and that positive effects of PT can be generalised over novel stressors and novel tasks (Driskell et al., 2001). Although such findings somewhat nuance the absolute need for a representative learning design, coaches and practitioners are nevertheless advised to design their practice manipulations based on a careful analysis of the actual task environment (Fletcher & Arnold, 2021; Johnston & Cannon-Bowers, 1996).

When designing PT, it is also important to consider that not every practice manipulation is likely to increase pressure to the same extent. Stoker et al. (2017, 2019) found that manipulating consequences (e.g., forfeits & rewards, social judgement) tends to increase both self-reported as well as physiological indicators of anxiety more than strategies aimed at increasing task demands (e.g., task restrictions, noise). Moreover, practice manipulations may further increase pressure when they affect multiple individuals beyond the individual athlete (e.g., consequences for teammates) or extend beyond a single practice session (e.g., recording scores over the course of a season) (Low, Freeman, et al., 2022). Careful selection and design of the appropriate practice manipulations is crucial to ensure pressure is high enough to accrue the benefits of PT, but not too high that the athlete cannot overcome the pressure and training becomes strenuous and detrimental. At the same time, it seems evident that the emotional experiences of certain competition situations can never be fully simulated within practice (Low, Freeman, et al., 2022; Stoker et al., 2016). For example, it would be impossible to replicate the pressure experienced when taking the game-winning penalty kick during a Champions League final. This in itself might not necessarily be a problem as there is evidence to suggest that practicing under mild anxiety already has a

positive impact on performance under high anxiety conditions (Oudejans & Pijpers, 2010). In this regard, Low, Freeman, et al. (2022) argued that one-to-one replication of competition pressure is less critical than "having athletes practice the thinking and behaviours that would help them cope with that pressure" (p.12).

Practitioners should also consider to which extent they involve their athletes in the design of practice manipulations (Fletcher & Arnold, 2021). Letting athletes self-define stressors (e.g., determine own forfeits) can lead to the design of more meaningful pressure manipulations (Low, Butt, et al., 2022) and improve autonomy and athlete buy-in (e.g., Bell et al., 2013; van Rens et al., 2021). At the same time, the surprise nature of some planned disruptions might be an essential feature to increase pressure (Kegelaers, Wylleman, & Oudejans, 2020). To illustrate, informing athletes prior to a practice competition that the referee will make a deliberate erroneous call may defeat the purpose of the exercise. Hence, coaches and practitioners should consider how involving athletes in the design of these disruptions could actually decrease the perceived pressure. When involving athletes in the design of PT, the use of language should also be carefully considered (Low, Butt, et al., 2022). van Rens et al. (2021), for example, argued that negative connotations could be associated with certain labels, such as punishment, and, therefore, advocated the use of alternatives terms (e.g., forfeits, consequences) in discussions with athletes.

When implementing PT, it is also important to remain cognizant of potential deleterious effects (Fletcher & Arnold, 2021; Howells & Wadey, 2021; Owusu-Sekyere & Gervis, 2016). Fletcher and Sarkar (2016) argued that excessively imposed pressure, without adequate support structures, could lead to an unrelenting environment, characterised by, among others, unhealthy competition, a blame culture, and lack of care for athlete well-being. Moreover, Kegelaers, Wylleman, and Oudejans (2020) found that PT could also be a source of strain on the relationship between athletes and coaches. Mitigating such challenges

requires adequate leadership skills (Bell et al., 2013) and emotional intelligence (Kegelaers, 2019) on behalf of the one implementing the PT. Moreover, prior to implementing PT, it is crucial to provide a clear rationale for the intervention (Gustafsson et al., 2017), gain athlete consent (Fletcher & Arnold, 2021), and emphasise the developmental aspect to increase athlete buy-in and avoid frustration or conflict (Kegelaers, Wylleman, & Oudejans, 2020; Kent et al., 2021). The intervention itself should be introduced progressively and adapted to the developmental level of the athletes (Fletcher & Arnold, 2021; Kent et al., 2021). Crucially, during the intervention athletes need to experience a sense of control over their situation, or at least their own responses, to avoid developing learned helplessness and avoidance behaviours (Collins & MacNamara, 2012; Gustafsson et al., 2017). Finally, some authors have suggested that PT interventions should only by conducted by (Gustafsson et al., 2017) or in close collaboration with (van Rens et al., 2021) experienced and properly trained sport psychology practitioners. Evidence outside sport suggests that PT principles can be equally effective when implemented by less experienced trainers (Saunders et al., 1996). Nevertheless, even when conducting PT without the aid of an experienced sport psychologist, coaches should carefully and continuously monitor the physical and mental well-being of athletes and adapt the intensity of, or even cease, PT when athletes start to respond adversely (Fletcher & Arnold, 2021).

Future Directions

Studies on PT in sports form a relatively small but growing research base. A particular strength of this research base is the inclusion of both experimental (e.g., Oudejans & Pijpers, 2009) and field-based (e.g., Bell et al., 2013) studies, as well as the recent inclusion of mixed-methods designs (Kegelaers et al., 2021; Kent et al., 2021; van Rens et al., 2021). Nevertheless, more research on the application of PT within sports remains necessary. As stated, strong empirical support is available for the effectiveness of PT on general

performance outcomes (Gröpel & Mesagno, 2019; Kent et al., 2018; Low et al., 2021). However, more high-quality research is needed to evaluate the process of PT, including direct assessments of the proposed functions outlined in this article. In particular, randomised control trials with sufficiently large sample sizes are necessary to convincingly demonstrate causal effects on these functions. Moreover, future research could equally consider PT for other key populations which are prone to experiencing high levels of stress within the sporting environment, including coaches and support staff (Olusoga & Thelwell, 2016). In addition to this overall need for more high-quality PT research across different populations, we suggest three specific avenues wherein future research could expand the current knowledge of PT.

Potential Downside of Pressure Training

A first important topic for future research should be to further consider the downsides and ethical challenges associated with PT (Fletcher & Arnold, 2021; Fletcher & Sarkar, 2016; Howells & Wadey, 2021). Following a number of recent highly publicised scandals, there has been growing attention for the presence of destructive and abusive cultures within high-performance sports (e.g., Feddersen et al., 2020; Grey-Thompson, 2017). It seems evident that the notion of PT has the potential to be misused to establish or maintain destructive sporting cultures or to assert power and dominance within such a culture (Owusu-Sekyere & Gervis, 2016). To illustrate, one could imagine excessively harsh practice regimes being set up under the guise of PT. It should be clear that such nefarious use of PT is inexcusable and does not align with the rationale outlined in this and other articles. Nevertheless, as stated earlier, it should be recognised that, even when setting up well-intentioned PT, more subtle deleterious effects can still occur (Fletcher & Sarkar, 2016; Kegelaers, Wylleman, & Oudejans, 2020; Owusu-Sekyere & Gervis, 2016). Research has already demonstrated that at least some mild frustration is likely to be present during PT (Kegelaers et al., 2021; van Rens

et al., 2021). However, future work should continue to examine how PT can also negatively impact athletes' functioning and well-being and develop a better understanding of contraindications (e.g., acute mental health crisis) for the use of PT. To this end, we suggest including longitudinal well-being measurements and assessment of potential moderators within future interventions (see van Rens et al., 2021). Additionally, qualitative follow-up evaluations, with specific focus on affective responses and well-being, could provide insights into athletes' idiosyncratic experiences before, during, and after PT. Alternatively, future work may also consider adopting a negative case analysis approach (Gledhill & Harwood, 2015), examining existing applied PT initiatives which have been shown to be ineffective or even detrimental for athletes' well-being and performance. Such research could provide more insight into the individual and situational complexities differentiating effective PT from more detrimental or deleterious approaches.

Duration and Timing of Pressure Training

Future research should equally consider the most optimal duration and timing for effective PT. Within their meta-analysis, Low et al. (2021) found that most PT interventions within the literature were relatively brief, concluding that interventions consisting of five or more sessions actually presented the smallest effect sizes. These results confirm research outside the field of sport suggesting that benefit can be derived even from single PT sessions (Saunders et al., 1996). van Rens et al. (2020) provide a potential explanation for the effectiveness of such shorter interventions as they suggested that the impact of certain pressure manipulations could 'wear off' when used for a prolonged period of time, eventually diminishing the effectiveness of PT. However, it remains unclear to which extent effects are sustained over time. Some research in the field of policing found positive retention effects up to four months after PT (Nieuwenhuys & Oudejans, 2011), although similar longitudinal retention tests remain absent within sports. Low et al. (2021), therefore, suggested that the

"advantage of long interventions could be in sustaining performance under pressure throughout a competitive season or career" (p.159). Future research should also consider the most effective approaches towards periodising PT (Collins et al., 2016a; Kegelaers, Wylleman, & Oudejans, 2020). For example, Collins et al. (2016a) advocated for relatively brief PT interventions, followed by sufficient intermittent opportunities to apply the skills and knowledge gained from such PT within non-pressurised settings. In this regard, some authors have proposed sporadic "refresher" (Driskell et al., 2014) or "booster sessions" (Gustafsson et al., 2017) following longer PT interventions. Effective periodisation may also be particularly important, as Lawrence et al. (2014) found that PT alone could help improve performance under non-simulated pressure, but actually decreased performance under low pressure conditions. Hence, a mix of both PT and low-pressure practice conditions is suggested to lead to the most robust performance. Echoing Low et al. (2021), it is clear more research is still needed to examine these different PT durations and approaches towards periodisation, including longitudinal retention evaluations.

Integration of Novel Technologies

Finally, future work should explore how novel computer-based technologies can be integrated and applied for PT purposes. Virtual reality (VR) environments in particular could provide a fascinating new avenue (Fletcher & Arnold, 2021). VR refers to an interactive computer-simulated environment that evokes a sense of being physically and mentally present in another place. This technology might be particularly suited for use in sport as it allows for easy manipulation of environmental constraints, is controllable and reproducible, allows for the practice and assessment of domain-specific skills, and is commercially available (Neumann et al., 2018). Cotterill (2018) suggested that VR can serve a number of benefits for sports, including the development of perceptual-motor skills, tactical and decision-making training, and, most interestingly from a PT perspective, enhancing

psychological resilience. Stinson and Bowman (2014) reported a preliminary study, demonstrating that VR training was effective at increasing both subjective and physiological anxiety measures during a penalty-defending task, which was partially moderated by the inclusion of anxiety triggers (e.g., lack of control, unpredictability), a narrow field of regard, and simulation fidelity (e.g., inclusion of crowd, game noises). These results seem to suggest that VR at least holds potential for PT within sport (see also Sanz et al., 2015). PT interventions using VR have already been found effective in several other performance domains, including the military (Pallavicini et al., 2016), music education (Aufegger et al., 2017), and public speaking (van Ginkel et al., 2019). Nevertheless, more research is needed to examine how PT through the use of VR in sport can influence long-term outcomes in actual performance conditions, and explore potential moderating influences of the VR environment (e.g., CAVE vs HMD display systems) or performer characteristics (e.g., subjective immersion) (Neumann et al., 2018).

Concluding Remarks

Given the complexity and demanding nature of sports, there is an everlasting need for high-performance athletes to learn to perform under pressure and develop effective stress management strategies. The aim of this narrative review was to discuss the current understanding on the application of PT within sports. As we hope to have shown, PT may serve multiple functions in relation to the psychological or psychosocial development of athletes. At the same time, successful implementation of PT is likely highly complex and nuanced. Not in the least because ineffective implementation could lead to potentially unethical and abusive practice situations. Undoubtedly, some scholars and practitioners would propose this warrants reason to abandon the use of PT altogether. However, we would suggest this is throwing out the proverbial baby with the bathwater. First, it neglects the evident positive effect PT can have on sport performance, as highlighted within previous

meta-analytical work (Low et al., 2021). Moreover, it negates the fact that many coaches and practitioners are already using PT within applied settings (Kegelaers, Wylleman, & Oudejans, 2020; Stoker et al., 2016). As such, rather than abandoning the notion of PT, we would advocate for increased research endeavours to help elucidate effective – and ineffective – ways to design and implement different PT approaches. Such a better understanding is needed to design novel education programs that can support coaches and practitioners in creating safe but effective PT. It is our hope that with this narrative review we have helped build the agenda for such future research within high-performance sports.

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854 Table 1.

855 *Planned disruptions framework of Kegelaers et al. (2020)*

Fatigue	Fatigue refers to letting athletes train under increased physical or mental fatigue. Straining exercises can be used as a stressor in and of itself. Alternatively, fatigue can also increase the challenge level of separate technical or tactical task and simulate somatic anxiety symptoms (e.g., increased heart rate, shallow breath). A basketball coach could, for example, let athletes complete a free-throw exercise directly following a high-intensity physical exercise.
Competition simulation	Competition simulation refers to recreating competition elements and game-like conditions during practice. Coaches can let athletes compete head-to-head during exercises, introduce scoring systems, and use rankings (e.g., score board) within a single exercise or across multiple exercises or training sessions. Additionally, coaches or practitioners can further simulate competition by creating realistic competition demands, such as simulating pre-performance conditions or introducing referees.
Forfeits and rewards	Forfeits and rewards refer to including positive and negative consequences to practice tasks or competitions. In sports, consequences often take the form of small physical forfeits, such as running laps or doing push-ups. However, coaches and practitioners can also be more creative in the design of specific forfeits and rewards which are not physical in nature, such as monetary prizes, cleaning up the gym, giving a speech, preparing a dinner for the winning team, or even playing time.
Unfairness	The use of unfairness refers to creating a temporary sense of perceived injustice or grievance in athletes. This could, for instance, be achieved by instructing referees to deliberately make a bad call during practice competitions. Alternatively, coaches or practitioners could also load practice competitions by introducing handicaps for certain players (e.g., time penalties), thereby reducing the chance of success compared to their peers.
Stronger competition	Using stronger competition refers to letting athletes compete against other athletes or teams who can reasonably be expected to be considerably stronger or better than them. One example might be to let young athletes regularly compete above their age grade.
Task restrictions	Task restrictions refer to increasing the challenge level of a particular task by manipulating the parameters under which the task must be performed. This could, for example, be done by introducing time limitations for executing a task or by altering the conditions or rules of specific practice games.
Distractions	The use of distractions refers to the inclusion of external visual or auditory interferences to increase the challenge level of specific tasks or practice competitions. A simple example of such distractions could be to include additional noise during practice, such as playing loud music or audience sounds.
Location	Location refers to practicing in specific places that increase challenge or pressure. This can be done by practicing in a location which is pressure inducing in and of itself. For example, a coach may organize a training camp under sub-optimal conditions (e.g., poor accommodation, practice facilities). Alternatively, practice can also be set up within the actual real-life pressure setting (or a close

	approximation). Young high-level football players could, for instance, be allowed to regularly practice within the first-team stadium, rather than on a separate practice pitch.
Outside-the-box	Outside-the-box strategies refer to participating in challenging activities which (seemingly) do not directly relate to athletes' specific sport. Such 'outside-the-box' strategies could include letting athletes participate in completely different (high-intensity) sports or even non-sport related activities. Examples include letting athletes complete a survival camp or partake in military special forces training.

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