Conscious motor processing and the pressure-performance relationship: a systematic review

Robyn Sullivan[a], Liis Uiga[b], Rich S. W. Masters[c], Greg Anson[a] and Arne Nieuwenhuys[a]

[a]Department of Exercise Sciences, University of Auckland, Auckland, New Zealand;
[b]Department of Sport and Exercise Sciences, Manchester Metropolitan University, Manchester, UK;
[c]Te Huataki Waiora School of Health, University of Waikato, Hamilton, New Zealand

Abstract

This systematic review examined evidence for the role of conscious motor processing in the pressure-performance relationship and, specifically, whether pressure-induced changes in conscious motor processing are associated with pressure-induced changes in performance. Following PRISMA guidelines, 29 studies published up to August 22, 2022 were included. Studies were required to be published in a peer-reviewed journal, include a pressure manipulation, include an outcome measure of conscious motor processing, and examine performance of a perceptual-motor skill. Studies were excluded if conscious motor processing was experimentally manipulated, the research design involved skill acquisition strategies that influenced conscious motor processing, or the study was unpublished or not published in English. Studies were retrieved from PubMed, Scopus, SPORTDiscus, and Web of Science databases. Risk of bias was assessed with the Risk of Bias Assessment Tool for Nonrandomized Studies and strength of evidence was determined with the sum code classification system. Results confirmed that pressure generally increases conscious motor processing but there was insufficient evidence to conclude that conscious motor processing directly contributes to pressure-induced changes in motor skill performance. Future studies are encouraged to directly test for mediation and to contrast effects of conscious motor processing with other cognitive processes evoked by pressure (e.g., distraction).

Keywords: Anxiety, explicit monitoring, skill-focus, skill execution, perceptual-motor performance

Conscious motor processing and the pressure-performance relationship:

A systematic review

In both athletic performance and day to day life, performance pressure, resulting from the presence of incentives to perform well (e.g., reward, punishment, competition, presence of an evaluative audience; Baumeister & Showers, 1986), can disrupt the execution of perceptual-motor skills. Negative effects of pressure on perceptual-motor performance, among other factors, are thought to be due to changes in attention that reduce an individual's ability to effectively coordinate movement (Nieuwenhuys & Oudejans, 2012; 2017). One perspective that has received a lot of attention in the literature views pressure as a factor that causes people to consciously use previously acquired explicit knowledge of how to perform a skill in order to maintain performance. This 'reinvestment' of knowledge (Masters, 1992), imposes additional strain on working memory and can disrupt the proceduralized control of movement (see Masters & Maxwell, 2008, for a review).

Proceduralized control of movement gradually develops during motor learning. According to stage models (e.g., Fitts & Posner, 1967), motor learning begins with a cognitive stage where knowledge is explicit and movement control requires a great deal of effort. This stage is highly attention-demanding and movements are consciously controlled, with the primary focus on how to perform a movement (Magill & Anderson, 2010). In the second stage, the associative stage, less cognitive involvement is required to perform motor skills and efforts are directed at skill refinement and achieving consistency in performance (Magill & Anderson, 2010). The final stage of motor learning is the autonomous phase, where much knowledge is implicit and performance is effortless and automatic (Fitts & Posner, 1967; Magill & Anderson, 2010). Thus, motor learning progresses from a novice stage in which skill execution requires a large degree of conscious control, towards an expert stage, in which information supporting the execution of the skill has become proceduralized and very little conscious control is required (Masters & Maxwell, 2008). Since motor skills are performed largely without conscious control during the later stages of motor learning, circumstances that cause performers to reinvest explicit knowledge about skill execution – a process referred to as ‘conscious motor processing’ (Masters, 1992) – may negatively impact performance.

Whilst conscious motor processing may be induced by a variety of contingencies, (e.g., preparation time, personality characteristics, movement disorders), the focus of the current review is on conscious motor processing that is induced by increases in performance pressure (Masters, 1992; Masters & Maxwell, 2008). According to the integrated model of anxiety and perceptual-motor performance (Nieuwenhuys & Oudejans, 2012; 2017), increased performance pressure may lead to anxiety and diminish attentional control, causing the individual performer to shift attention from task-relevant information to the source of their anxiety and how to respond. This may lead to distraction (e.g., worrying about consequences of failure) and result in insufficient attention for task execution (Nieuwenhuys & Oudejans, 2012; 2017). However, it may also lead to increased awareness of how a particular motor skill is controlled and induce conscious processing of rule-based information, especially when anxiety is associated with skill execution itself (Masters, 1992; Masters & Maxwell, 2008; Masters et al., 1993). For experts, who have proceduralized their execution of motor skills, conscious motor processing interrupts automaticity of the movement and has been shown to degrade performance across a range of motor skills, including sport-related skills such as golf putting and basketball free-throw shooting (e.g., Beilock & Carr, 2001; Gomez et al., 2018; Guccicardi & Dimmock, 2008; Masters, 1992), work-related skills such as laparoscopic surgery (e.g., Malhotra et al., 2012), as well as more phylogenetic skills such as balance and walking (e.g., Ellmers et al., 2020b).

In the literature, the term 'reinvestment' has been utilized in order to merge views about the conscious control of movement and to explain how attention to movement impacts skilled performance under pressure (Masters & Maxwell, 2008). According to the Theory of Reinvestment (Masters, 1992; Masters & Maxwell, 2008; Masters et al., 1993), and mirrored by 'explicit monitoring hypothesis' (Beilock & Carr, 2001), high-pressure performance situations increase movement self-consciousness, which can cause performers to direct more attention to the process of skill execution. The Theory of Reinvestment proposes that performers sometimes consciously manipulate explicit, rule-based information about how they perform the skill, in an attempt to maintain or improve their performance (Masters & Maxwell, 2008). In skilled performers, this attempt at conscious control may cause normally integrated control structures to be broken down into a sequence of smaller, independent units, that need to be separately controlled and executed (similar to how control is organized in earlier stages of motor learning; e.g., Fitts & Posner, 1967), putting a strain on working memory (i.e., occupying and potentially exceeding the individual's capacity to effectively process task-relevant information; Spillers et al., 2012) and introducing additional opportunity for error.

In the literature, conscious motor processing is usually assessed subjectively with the Movement Specific Reinvestment Scale (Masters et al., 2005), a 10-item questionnaire designed to assess trait or state 'movement self-consciousness' and 'conscious motor processing'. Alternatively, studies have inferred conscious motor processing using less subjective measures, such as reaction times during a skill-focused dual task (reflecting attention to movement execution; e.g., Gray, 2004), electroencephalographic (EEG) recordings of neural activation (in particular Fz-T3 coherence; e.g., Zhu et al., 2011), which is taken to reflect verbal engagement in task execution (but see Parr, Gallicchio, & Wood, 2021, for a critical review), or by examining downstream effects on movement kinematics, which – due to conscious motor processing – can indicate a return to movement patterns that are characteristic of earlier stages in motor learning (e.g., Pijpers et al., 2005).

Over the past three decades, many studies have investigated the implications of conscious motor processing for performance in both experts and novices (e.g., see Beilock & Gray, 2007; Masters & Maxwell, 2008; Roberts, 2019 for reviews). Until recently, however, few studies have investigated if and how conscious motor processing is naturally induced in pressure-filled performance situations and whether it directly contributes to performance breakdown under pressure (cf. Nieuwenhuys & Oudejans, 2012; Oudejans et al., 2011). In a seminal study, which directly addressed this issue, Gray (2004; Experiment 3) assessed virtual baseball batting under low and high pressure conditions (control vs. pressure group). Conscious motor processing was assessed using two dual-task conditions (extraneous and skill-focused dual-tasks) compared to a single-task condition (baseball batting only). In the extraneous dual-task condition, one of two tones (250 or 500 Hz) was presented after the ball was released and participants responded by indicating whether the pitch of the tone was 'low' or 'high'. In the skill-focused dual-task condition, participants responded to the tone by indicating whether their baseball bat was moving 'up' or 'down' at the presentation of the tone. Under pressure, performance decreased significantly, indicating that performance was negatively impacted by the pressure manipulation. Additionally, under pressure in the skill-focused dual-task condition, but not the extraneous dual-task condition, participants were significantly better at indicating whether the bat was moving 'up' or 'down' during the tone. This was taken to indicate that under pressure, participants were more aware of their swing, suggesting that an increase in conscious motor processing may have contributed to the observed reduction in batting performance.

Subsequent to Gray (2004), a growing number of studies have investigated effects of pressure on conscious motor processing and performance in both sport and non-sport tasks (e.g., golf putting, darts throwing, walking, balance), employing a wide range of pressure manipulations and measures of conscious motor processing (e.g., Cooke et al., 2011; Ellmers & Young, 2020a; Lo et al., 2019; Stins et al., 2011). This systematic review aims to bring together findings from these studies in order to quantify evidence for the idea that pressure naturally leads to increases in conscious motor processing and, also, whether pressure-induced changes in conscious motor processing are indeed associated with pressure-induced changes in performance. As such, and in addition to previous reviews of the wider literature on performance pressure and conscious motor processing (e.g., Beilock & Gray, 2007; Masters & Maxwell, 2008; Roberts et al., 2019), the current review will seek to answer the following two questions: (1) What is the influence of pressure on conscious motor processing and – importantly – (2) To what extent does available evidence indicate that pressure-induced changes in conscious motor processing are associated with (mediate) the influence of pressure on motor skill performance? Based on the Theory of Reinvestment (Masters, 1992; Masters & Maxwell, 2008), it was hypothesized that pressure would lead to an increase in conscious motor processing and that – especially in expert performers – pressure-induced increases in conscious motor processing would lead to a decrease in motor skill performance under pressure across both sport and non-sport tasks.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA; Page et al., 2021) 2020 guidelines were followed to conduct this review. Prior to conducting the search, the review was registered on PROSPERO (International Prospective Register of Systematic Reviews; registration number CRD42020190090).

Search strategy and study eligibility criteria

An electronic search of PubMed, Scopus, SPORTDiscus, and Web of Science databases was initially conducted on December 7, 2020 and then re-run on August 22, 2022 to gather relevant studies related to conscious motor processing and performance under pressure. In order to capture a broad range of studies, the following combination of search terms was utilised: *Conscious motor processing* (OR conscious processing OR reinvestment OR explicit monitoring OR skill focus OR movement focus OR attentional focus OR internal focus OR self-focus OR attentional control OR executive control OR cognitive control) AND *Pressure* (OR anxiety OR stress OR threat) AND *Performance* (OR task execution OR movement execution OR skill execution). Peer reviewed, and English language were used as filters. Two authors independently completed each step of the screening process and compared records. Titles and abstracts retrieved using the search strategy were screened against predetermined inclusion and exclusion criteria (see below). Full-text articles meeting the criteria were then assessed for eligibility. Microsoft Excel was used to aid in the removal of duplicates within search results from the different electronic databases and to record information about inclusion and exclusion of articles in the screening process.

To be included in the review, studies were required to meet the following criteria: (1) published in a peer-reviewed journal, (2) include a pressure manipulation, (3) include a measure of conscious motor processing, and (4) test performance of a perceptual-motor skill. Studies were excluded based on the following: (1) conscious motor processing was experimentally manipulated, (2) the study involved skill acquisition (i.e., strategies that directly influence engagement in conscious motor processing), (3) the study was not published in the English language, and (4) the study was unpublished material (e.g., theses and dissertations).

To provide further context regarding the inclusion and exclusion criteria, studies were included if they utilized any means of increasing performance pressure (e.g., audience, competition, monetary incentive, etc.) within a group or condition. With regard to the measure of conscious motor processing, a broad definition was deliberately implemented and studies were included if they utilized a measure of conscious motor processing (e.g., questionnaire, skill-focused dual-task, EEG, movement kinematics) that assessed changes in skill-focused attention (e.g., explicit monitoring) and/or changes in conscious control. A motor skill was broadly defined as any perceptual motor task that requires the coordination of movement in relation to perceptual information (e.g., balance, locomotion, aiming or reaching in sport and non-sport settings, but not simple reaction time tasks). This review sought to investigate how pressure naturally leads to increases in conscious motor processing and thus any studies that experimentally manipulated conscious motor processing and used conscious motor processing as an independent or predictor variable, were excluded. Finally, studies involving skill acquisition were excluded only when the employed skill acquisition strategy directly influenced participants' engagement in conscious motor processing (e.g., implicit vs. explicit learning; Masters, 1992).

Data extraction and risk of bias assessment

Once all relevant articles were retrieved, risk of bias was assessed and the data extracted. The following information was extracted from each article: author(s), publication year, sample size, participant characteristics (i.e., age, gender, expertise level), study design, setting (i.e., sport vs. non-sport), motor task, pressure manipulation, performance measure, measure of conscious motor processing, results, and conclusions. Some studies (e.g., Gray & Cañal-Bruland, 2015; Schücker et al., 2013) performed post-hoc analyses comparing participants that were and were not affected by the pressure manipulation (i.e., choking vs. clutch performance). For these studies only results considering all participants were extracted.

Risk of bias of included studies was assessed by two authors using the Risk of Bias Assessment Tool for Nonrandomized Studies (RoBANS; Kim et al., 2013). No disagreements arose. The RoBANS contains 6 items to assess 'selection of participants', 'confounding variables', 'measurement of exposure', 'blinding of outcome assessments', 'incomplete outcome data', and 'selective reporting'. Items are rated as 'low', 'high' or 'unclear' risk of bias. With regard to item 2 (confounding variables), articles were identified as high risk of bias if studies that implemented a between-group manipulation of pressure did not randomly assign participants to groups and did not monitor between-group differences in relevant trait characteristics such as trait anxiety or reinvestment. Articles were identified as high risk of bias for item 3 (measurement of exposure) if no manipulation check of pressure was reported.

Strength of evidence

Due to heterogeneity in study methods and outcome reporting across the included studies, the summary code classification system (Hase et al., 2019; Sallis et al., 2000) was utilised instead of meta-analysis to quantify the strength of cumulative evidence for each research question. Based on a formal mediation model (MacKinnon, Fairchild, & Fritz, 2007), which considers associations between all factors included in the research question, strength of evidence was calculated separately for: (1) the effect of pressure on performance, (2) the effect of pressure on conscious motor processing, (3) the effect of conscious motor processing on performance, and (4) the extent to which pressure-induced changes in conscious motor processing were associated with (mediate) the effect of pressure on motor skill performance. Note that whilst all associations were considered, associations #2 and #4 directly examined the current study's research question and hypotheses. The percentage of studies supporting each association was calculated by dividing the number of effects providing positive, none, or negative support for the association by the total number of effects available for that association (Sallis et al., 2000). Based on the percentages calculated, support for each association was assigned a summary code and classified as reflecting either 'no support' ("0"; 0%-33% of effects support the association), ‘indeterminate/inconsistent support’ (“?”; 34%-59% of effects support the association), or ‘positive support’ (“+”; >60% of effects support the association). Codes were doubled (“00”, “??”, “++”) if four or more effects supported the (lack of) association. Sub-analyses for: (i) task setting (sport vs. non-sport), (ii) expertise, and (iii) measure of conscious motor processing, were conducted to further specify the strength of cumulative evidence.

Results

Search results

The initial database search yielded 2940 results. After removing duplicates and screening titles and abstracts, 377 articles remained for which full-texts were assessed for eligibility. Inclusion/exclusion of articles was confirmed between two authors, with no disagreement regarding inclusion of articles. Full-text assessment yielded 23 articles that met the inclusion criteria and reference lists of these articles as well as citing articles were screened for further eligible studies, resulting in the inclusion of 6 additional articles. Thus, a final list of 29 articles was identified as being appropriate to include in the systematic review (see Figure 1).

[Figure 1 here]

Risk of bias assessment

The risk of bias results are presented in Table 1. There were no disagreements between assessors regarding risk of bias. A *low* risk of bias emerged for ‘selection of participants’ (93%) ‘confounding variables’ (97%), ‘measurement of exposure’ (90%), ‘incomplete outcome data’ (100%), and ‘selective outcome reporting’ (97%). Risk of bias was largely *unclear* for ‘blinding of outcome assessments’ (93%), with most studies not reporting information on this potential source of bias.

[Table 1 here]

Characteristics of included studies

A summary of characteristics and findings of the included studies is presented in Tables 2 and 3.

[Table 2 here]

[Table 3 here]

The sample size of included studies ranged from 11 to 82 participants, with a mean sample size of 30 participants (SD = 19.24) per study and the total number of participants across all included studies being 904. The majority of studies included participants of both genders; however, eight studies included only males, one study included only females, and three did not indicate a gender ratio. The age of participants for the 26 studies that indicated an age statistic ranged from 17.50 to 77.60 years, with a mean age of 30.23 years across all studies (SD = 17.94).

Studies were classified as sport or non-sport based on the type of motor task assessed (15 sport, 14 non-sport). Of the 15 studies classified as a sport, three included both novice and expert athletes, eight included only experts, and four included only novices. A range of motor tasks was assessed across the studies (see Table 2), including golf putting (8), walking (5), balance/postural control (6), baseball batting (2), rhythmic ball bouncing (1), aiming (1), dart throwing (1), simulated driving (1), tennis serving (1), baseball pitching (1), climbing (1), and basketball free throw shooting (1).

Pressure was manipulated through one or a combination of the following manipulations: monetary incentive (15), competition (11), performing at a height (e.g., elevated platform or climb) (7), expert evaluation (4), postural threat (4), threat of shock (3), videotaping (3), audience (2), constrained walking (1), threat of falling (1). Most studies verified the success of their pressure manipulation with one or more manipulation checks.

Self-report measures included fear of falling (0-100%; 6), State Trait Anxiety Inventory (STAI; 5), Immediate Anxiety Measures Scale (IAMS; 3), Mental Readiness Form-3 (MRF-3; 3), Intrinsic Motivation Inventory (2), anxiety thermometer (2), and the Competitive State Anxiety Inventory 2 (CSAI-2; 2). Objective measures included heart rate (4) and electrodermal activity (2). Of the 26 studies that performed a manipulation check, 24 studies successfully manipulated pressure or performed targeted analyses on those participants that were affected by pressure. Two studies reported an unsuccessful manipulation of pressure (Tanaka & Sekiya 2010_a; Tanaka & Sekiya 2010_b). Three studies did not perform a manipulation check (Gray, 2004; Gage et al., 2003; Stins et al., 2011).

Finally, conscious motor processing was assessed using various measures (see Table 2). The majority of studies utilised an attentional focus questionnaire (8), while the remaining studies assessed conscious motor processing using either a state version of the Movement Specific Reinvestment Scale (S-MSRS; Masters et al., 2005) (6), kinematic data (6), a skill-focused dual-task paradigm (5), EEG (2), verbal report (2) or a task-irrelevant dual-task paradigm (1).

Strength of evidence

Influence of pressure on performance

Across the 29 studies that were included in the review, 80 effects examined the association between *pressure and performance* (Table 4).

[Table 4 here]

Sum code calculations determined that 53% of effects supported the hypothesized negative association between pressure and performance (indeterminate/inconsistent support), with 41% and 6% of effects providing no support or support for the opposite association (i.e., improved performance under pressure; see Table 4). Strength of evidence was then calculated based on setting (sport vs. non-sport) and expertise (expert vs. novice). Strength of evidence was highly similar across sport and non-sport settings (53% and 52%, respectively), again reflecting indeterminate/inconsistent support. With regard to expertise, strength of evidence was slightly higher for novices (55%) than for experts (43%), but in both cases was classified as indeterminate/inconsistent support (see Table 4). Note that expertise was only quantified for sport settings.

Influence of pressure on conscious motor processing

Fifty-six effects examined the association between *pressure and conscious motor processing* (see Table 5).

[Table 5 here]

Overall, 64% of effects supported the hypothesized association (positive support), indicating that pressure generally leads to an increase in conscious motor processing. Strength of evidence was then calculated based on setting (sport vs. non-sport), expertise, and the measure of conscious motor processing that was employed. Strength of evidence for sport and non-sport settings was drastically different, with 48% (indeterminate/inconsistent support) for sport settings and 79% (positive support) for non-sport settings. Strength of evidence differed somewhat between experts and novices, with 33% for novices (no support) and 45% for experts (indeterminate/inconsistent support). Note that expertise was only quantified for sport settings. Finally, regarding the different measures of conscious motor processing, strength of evidence varied depending on the measure. Strongest evidence was observed for kinematic data (75%; positive support) and the state-version of the Movement Specific Reinvestment Scale (67%; positive support). Weakest evidence was observed for skill-focused dual task paradigms (38%; indeterminate/inconsistent support). Only a few studies assessed conscious motor processing based on EEG, task-irrelevant dual-tasks, or verbal report. Observed strength of evidence for these measures was 50% (indeterminate/inconsistent support; Table 5).

Sum codes calculations were not performed for the association between *conscious motor processing on performance*, with only one study reporting the effect (Englert & Oudejans, 2014; no effect). However, 12 effects across six studies were available for the association between *pressure-induced changes in conscious motor processing and pressure-induced changes in motor skill performance* (see Table 6). Overall, 42% of effects supported the association (indeterminate/inconsistent support). In considering this number, it should be noted that most studies performed regression analyses to examine the association and that only two studies performed a formal mediation analysis (i.e., Cooke et al., 2011, and Englert & Oudejans, 2014; both no effect).

[Table 6 here]

Strength of evidence was then calculated based on setting (sport vs. non-sport), expertise, and the measure of conscious motor processing that was employed. With regard to setting, strength of evidence was higher for non-sport settings (57%; indeterminate/inconclusive support) than for sport settings (20%; no support), though in both cases far from conclusive. With regard to expertise, strength of evidence was 0% (no support) for experts and 33% (no support) for novices, although it should be noted that very few effects were available for this analysis and that expertise was only quantified for sport settings. Finally, strength of evidence across studies that used attentional focus questionnaires and kinematic measures of conscious motor processing was 50% (indeterminate/inconsistent support). For other measures of conscious motor processing, strength of evidence for the association between pressure-induced changes in conscious motor processing and pressure-induced changes in motor skill performance could not be determined, due to an insufficient number of effects being available (see Table 6).

Discussion

The current systematic review examined available evidence for the role of conscious motor processing in the pressure-performance relationship. Specifically, this review sought to answer the following questions: (1) What is the influence of pressure on conscious motor processing and (2) to what extent does available evidence indicate that pressure-induced changes in conscious motor processing are associated with (mediate) the effect of pressure on motor skill performance? Results indicate that whilst there appears to be general support for the hypothesis that pressure leads to an increase in conscious motor processing (Masters, 1992; Masters & Maxwell, 2008), at present, there is insufficient evidence to conclude that pressure-induced changes in conscious motor processing directly contribute to performance breakdown under pressure.

Included studies

A total of 29 studies were included in the review. All studies included an outcome measure of conscious motor processing, examined performance of a perceptual-motor skill, and performed an experimental manipulation of performance pressure. In most cases, the manipulation of pressure was verified by means of a manipulation check and considered successful. However, three studies did not verify their pressure manipulation (Gray, 2004; Gage et al., 2003; Stins et al., 2011) and two studies reported their pressure manipulation to be unsuccessful (Tanaka & Sekiya 2010$_a$; Tanaka & Sekiya 2010$_b$).[1] Studies examined a range of motor skills across sport and non-sport settings and utilised a variety of measures to assess conscious motor processing. Studies that examined performance in a sport setting, assessed performance of experts as well as novices. Overall, risk of bias assessment showed the included studies to have a relatively low risk of bias, with most studies scoring 'low' on

[1] Sum code calculations were re-run without these studies included. While this modified the percentages trivially, exclusion of the articles did not cause any changes in sum code classifications or in the weight of evidence for each hypothesis.

five out of six items on the RoBANS (Kim et al., 2016; see Table 1). For one item (item 4), risk of bias was generally rated as 'unclear', with almost none of the studies reporting blinded outcome assessments (see Elmers et al., 2020a, and Schucker et al., 2013, for exceptions). This is an issue that has been noted previously in the literature (e.g., Hase et al., 2019) and while blinding of outcome assessments may not be necessarily problematic in case of objective assessments and outcomes (e.g., reaction times), it may be an issue in case of subjective assessments (e.g., scoring of movement quality) and in those cases leaves room for improvement. For instance, researchers involved in the assessment of movement quality should be blind to information relating to pressure condition, wherever possible.

The influence of pressure on performance

Across the included studies, pressure inconsistently resulted in negative effects on performance, as was indicated by 53% of effects supporting the association, 41% showing no effect, and 6% reflecting improved performance under pressure. While these findings are limited by the inclusion criteria of the current study (i.e., included studies only cover a small proportion of the broader pressure-performance literature) they are largely consistent with prevailing insights, which show that whilst pressure often leads to a decrease in perceptual-motor performance (e.g., see Beilock & Gray, 2007, and Payne et al., 2019, for reviews) this is not always the case as not all individuals are equally sensitive to pressure (e.g., see Allen et al., 2013 and Mosley & Laborde, 2015, for reviews) and performance environments may be interpreted either as a challenge or threat depending on perceived task demands and available coping resources (Hase et al., 2019). For example, characteristics such as trait anxiety, fear of negative evaluation, self-consciousness, experience, and dispositional reinvestment can all influence how an individual responds to pressure (Masters & Maxwell, 2008; Mesagno et al., 2012). Apart from Englert and Oudejans (2014), Johnson et al. (2019_b), Pijpers et al. (2005), and Zabak et al. (2015), none of the included studies considered the potential influence of trait-like characteristics, thus introducing potential disparity in observed outcomes. Future studies may consider including trait characteristics as co-variates in order to reduce the potential disparity. Furthermore, ensuring that a proper pressure manipulation check is performed is crucial to confirm that pressure was indeed experienced by participants.

In the current study, effects of pressure on performance were largely similar across sport and non-sport settings; however, for sport settings, the negative effect of pressure on performance was more commonly observed in novices than experts (i.e., with 55% and 43% of effects supporting the association, respectively; see Table 5). This, again, is in line with the literature (Roberts et al., 2019) and may be due in part to experts having more experience in performing the specific motor task under pressure-invoking situations. Moreover, previous research has shown that experts possess a greater repertoire of coping strategies to effectively deal with pressure (e.g., Calmeiro et al., 2014).

The influence of pressure on conscious motor processing

Immediately speaking to the research question and hypotheses, results from the current review show that across the included studies, pressure generally led to an increase in conscious motor processing. This finding is directly in line with the Theory of Reinvestment (Masters, 1992; Masters & Maxwell, 2008) and, with 64% of effects supporting the association, provides evidence for the idea that conscious motor processing naturally and spontaneously increases under pressure (cf. Nieuwenhuys & Oudejans, 2012; Oudejans et al., 2011; for discussion). As with the effect of pressure on performance, one reason why pressure does not always lead to an increase in conscious motor processing may be that not all individuals are equally inclined to engage in conscious motor processing (e.g., Masters et al., 1993). For example, research suggests that individuals with a higher propensity for reinvestment (e.g., higher scores on the trait version of the MSRS) are more likely to engage in conscious motor processing under pressure (Masters & Maxwell, 2008). Moreover, differences in challenge vs. threat appraisals may also influence findings, as individuals who appraise the performance situation as a challenge rather than a threat have been shown to exhibit less conscious motor processing (Moore et al., 2013). Apart from Wilson et al. (2007) and Zabak et al. (2015), none of the studies in the current review considered the potential influence of these characteristics, thus introducing potential disparity in observed outcomes. Also, it should be acknowledged that an increase in conscious motor processing does not mean that distraction or worries do not increase as well and may potentially impact performance (see Nieuwenhuys & Oudejans, 2012, 2017, for review).

To gain further insight, effects of pressure on conscious motor processing were analysed separately for sport vs. non-sport task settings. Interestingly, the observed strength of evidence was much higher for non-sporting tasks (with 79% of effects supporting the association) than for sporting tasks (with 48% of effects supporting the association; see Table 4). A potential explanation for this disparity may be that many of the examined non-sport tasks involved so-called phylogenetic motor skills that are executed on a daily basis and would normally be expected to require little conscious control (e.g., walking and standing; Young et al., 2016, and Zaback et al., 2005; see Table 1). Potentially, low attentional requirements for non-sporting tasks such as walking or standing leave more room for pressure-induced increases in conscious motor processing to occur, as opposed to sporting tasks which, especially for non-experts, are already characterized by higher levels of conscious control (Fitts & Posner, 1967).

In sport settings, pressure-induced increases in conscious motor processing were somewhat more commonly observed in experts (45% of effects supporting the association) than novices (33% of effects supporting the association). Although speculative, one explanation for this may be the existence of a potential ceiling effect for novices. In the early stages of motor learning skill execution is effortful and requires a great deal of conscious control (Fitts & Posner, 1967), so there may be less scope for pressure-induced increases in conscious motor processing to occur. The opposite is true for experts. Since experts have more experience with the task they are likely to have a larger body of explicit knowledge available to reinvest under pressure and, since conscious control of movement is argued to affect at least partially automated movements, this would be most reflected in expert performance (Masters & Maxwell, 2008).

Finally, strength of evidence was shown to vary depending on the measure of conscious motor processing that was used. Subjectively, the association was most strongly supported by studies that used the state version of the Movement Specific Reinvestment Scale (S-MSRS; Masters et al., 2005), showing comparable results for the movement self-consciousness and conscious motor processing subscales. Similarly, studies that used customized attentional focus questionnaires also showed consistent support for the association. Findings from this group of studies, however, may need to be approached with some caution because the questionnaires were often not validated and, in some cases, reflected difference scores rather than asking for attentional focus in each condition separately (Tanaka & Sekiya, 2010_a, 2010_b, 2011). Furthermore, whilst conscious motor processing by definition is a conscious process, a more general critique on subjective measures is that they are retrospective and that the degree to which an individual can accurately recall and report engaging in conscious motor processing may therefore be questionable (Payne et al., 2019).

Objectively, effects of pressure on conscious motor processing were most strongly supported by measures of movement kinematics, with 75% of effects supporting the association. More direct measures of conscious motor processing, such as EEG (Fz-T3 coherence; 50%) and skill-focused dual-task paradigms (38%), only resulted in inconsistent support, with the low support for skill-focused dual-task paradigms potentially reflecting uncertainty about whether the task indeed probed aspects of the movement that are likely to receive more attention under pressure (for a review and critique on EEG measures of conscious motor processing, see Parr et al., 2021). Importantly, objective measures of conscious monitoring often do not distinguish between monitoring and control aspects of conscious motor processing (cf. Masters & Maxwell, 2008) and although the degree of observed support may vary between measures, lower support does not necessarily imply that a particular measure is also less sensitive or valid. Future work, which contrasts and compares various (subjective and objective) measures of conscious motor processing under specific attentional focus conditions (e.g., reflecting various degrees of conscious engagement in movement execution), may help researchers to select the most appropriate measure for their study.

Do pressure-induced increases in conscious motor processing impact performance under pressure?

Although many studies that were included in this review concluded that effects of pressure on performance were related to observed (pressure-induced) increases in conscious motor processing, only six studies directly examined this association (see Table 3). Across the 12 effects that were available, 42% supported the association, leading to the overall conclusion that, at present, there is insufficient evidence to conclude that pressure-induced changes in conscious motor processing directly contribute to performance breakdown under pressure.

As with the effect of pressure on conscious motor processing, support was stronger across non-sport settings than sport settings, with 57% and 20% of effects supporting the association, respectively. Across two experiments, Ehrlenspiel et al. (2010) observed changes in kinematic indicators of conscious motor processing under pressure to be associated with changes in variable error (but not absolute error) in a virtual ball-bouncing task. Johnson et al. (2019a) observed pressure-induced changes in attentional focus to be associated with changes in two out of three indicators of postural control in a balance (standing) task. In sport tasks, support for the association was found by Tanaka and Sekiya (2010b) in a golf putting task (i.e., one out of two attentional focus change-scores associated with pressure-induced changes in putting accuracy), but not by Cooke et al. (2011; golf putting), Englert and Oudejans (2014; tennis serve) or Lo et al. (2019; dart throwing). Most studies performed regression or correlation analyses to examine the association between change scores in conscious motor processing and change scores in performance. Of the two studies that performed mediation analyses, Englert and Oudejans (2014) observed that instead of being mediated by conscious motor processing, effects of pressure on performance were mediated by an increase in distraction, whilst Cooke et al. (2011) observed mediation by increases in heart rate and on-task effort. Importantly, based on the small number of observations, differences between sport and non-sport task settings should be approached with caution and at this stage are more likely to be related to characteristics of individual studies (e.g., observed variability in conscious motor processing and performance, sample size, validity of outcome measures) rather than anything else.

In considering the lack of consistent support for the idea that pressure-induced changes in conscious motor processing directly contribute to performance breakdown under pressure, it is important to acknowledge the robust performance effects that are indicated in the broader literature on conscious motor processing (e.g., see Masters & Maxwell, 2008, and Roberts et al., 2019, for reviews) as well as the fact that strict inclusion criteria applied in the current review caused some studies that confirm mediation but included skill acquisition strategies that directly influence engagement in conscious motor processing to be excluded (e.g., Daou et al., 2019; Malhotra et al., 2015). All in all, in order to move forward in the literature and confirm or falsify prevailing theories and hypotheses (e.g., Beilock & Carr, 2001; Masters, 1992; Masters & Maxwell, 2008), more studies are required that directly examine the extent to which pressure-induced increases in conscious motor processing contribute to performance breakdown under pressure. Doing so, will not only contribute to understanding of the mechanisms that govern skill breakdown under pressure, but will also provide a stronger basis for interventions (e.g., Liao & Masters, 2002; Shücker et al., 2013). By providing evidence that conscious motor processing directly contributes to observed effects of pressure on motor skill performance, we can be confident that interventions that target reinvestment are likely to have a positive effect.

Limitations

Although the current systematic review was conducted methodically, there are some possible limitations. First, while the risk of bias assessment deemed included studies to generally have a low risk of bias, most studies did not report whether outcome assessments were blinded. Future studies could improve on blinding of outcome assessments by ensuring that, where possible, researchers involved in the assessment of outcomes variables do so without information relating to the condition that participants were performing under. Additionally, it is important to note that the studies included in this review showed relatively large disparity in methodology, which makes it difficult to interpret overall strength of evidence for the research questions. To overcome this limitation, sub-analyses were performed for selected study characteristics (task setting, expertise, measure of conscious motor processing). However, it should be acknowledged that distinguishing between study characteristics in some cases led to a low number of available effects, especially for the association between pressure-induced changes in conscious motor processing and performance under pressure (Table 6), which impacts the robustness of reported outcomes. Finally, it should be acknowledged that the current study adopted a broad definition of conscious motor processing and that, based on the measures of conscious motor processing that were employed, many of the included measures are unable to distinguish between internal, skill-focused attention (e.g., explicit monitoring; Beilock & Carr, 2001; cf. Wulf, Shae, & Park, 2001) and deliberate attempts to consciously control movement (Masters, 1992; also see Masters & Maxwell, 2008). Future studies are encouraged to select more direct measures of conscious motor processing, such as the movement-specific reinvestment scale (Masters et al., 2005) or EEG (Zhu et al., 2011), which may allow dissociating between attention and control processes.

Conclusion

To conclude, the current systematic review comprehensively examined available evidence for the role of conscious motor processing in the pressure-performance relationship. In line with the Theory of Reinvestment (Masters, 1992; Masters & Maxwell, 2008) and related models of skill breakdown under pressure (e.g., explicit monitoring; Beilock & Carr, 2001), general support was observed for the hypothesis that increases in performance pressure lead to increases in conscious motor processing. The current review is the first to systematically quantify evidence for this phenomenon and, with 56 effects across 29 studies included in the analysis, the observed support of 64% may be considered relatively robust. Insufficient evidence, however, was available to support the hypothesis that pressure-induced increases in conscious motor processing directly contribute to performance breakdown under pressure (12 effects; 42% support). Future studies should be designed to directly examine this association and, in addition, may examine which environmental and personal factors make pressure-induced increases in conscious motor processing more likely to occur. Furthermore, future studies may concurrently assess pressure-induced increases in conscious motor processing and distraction (e.g., worrisome thoughts) in order to uncover the conditions under which either process occurs and impacts on performance. Doing so will progress understanding about the mechanisms that govern skill breakdown under pressure (e.g., Nieuwenhuys &

Oudejans, 2012, 2017; Roberts et al., 2019) and provide an evidence basis for future interventions.

Declaration of interest statement: The authors have no conflicts of interest to declare that are relevant to the content of this article.

Data availability statement: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

References

References preceded by an asterisk (*) were included in the systematic review.

Allen, M., Greenlees, I., & Jones, M. (2013). Personality in sport: A comprehensive review. *International Review of Sport and Exercise Psychology, 6*(1), 184-208. https://doi.org/10.1008/1750984X.2013.769614

*Allsop, J., Lawrence, G., Gray, R., & Khan, M. (2017). The interaction between practice and performance pressure on the planning and control of fast target directed movement. *Psychological Research, 81,* 1004-1091. https://doi.org/ 10.1007/s00426-016-0791-0

*Arsal, G., Eccles, D., & Ericsson, A. (2016). Cognitive mediation of putting: Use of a think-aloud measure and implications for studies of golf-putting in the laboratory. *Psychology of Sport and Exercise, 27,* 18-27. https://doi.org/10.1016/j.psychsport.2016.07.008

Baumeister, R. (1984). Choking under pressure: Self-consciousness and paradoxical effects of incentives on skilful performance. *Journal of Personality and Social Psychology, 46*(3), 610-620. https://doi.org/10.1037/0022-3514.46.3.610

Baumeister, R., & Showers, C. (1986). A review of paradoxical performance effects: Choking under pressure in sports and mental tests. *European Journal of Social Psychology, 16*(4), 361-383. https://doi.org/10.1002/ejsp.2420160405

Beilock, S., & Carr, T. (2001). On the fragility of skilled performance: What governs chocking under pressure? *Journal of Experimental Psychology: General, 130*(4), 701-725. https://doi.org/10.1037//0096-3445.130.4.701

Beilock, S., Carr, T., MacMahon, C., & Starkes, J. (2002). When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied,* 8(1), 6-16. https://doi.org/10.1037//1076-898X.8.1.6

Beilock, S., & Gray, R. (2007). Why do athletes choke under pressure? In G. Tenenbaum & R. Eklund (Ed.). *Handbook of Sport Psychology, Third Edition* (pp.425-444). John Wiley & Sons, Inc.

Beilock, S., & Gray, R. (2012). From attentional control to attentional spillover: A skill-level investigation of attention, movement, and performance outcomes. *Human Movement Science,* 31(6), 1473-1499. https://doi.org/10.1016.j.humov.2012.02.014

Bellomo, E., Cooke, A., & Hardy, J. (2018). Chunking, conscious processing, and EEG during sequence acquisition and performance pressure: A comprehensive test of reinvestment theory. *Journal of Sport and Exercise Psychology,* 40(3), 135-145. https://doi.org/10.1123/jsep.2017-0308

Calmeiro, L., Tenenbaum, G., & Eccles, D. (2014). Managing pressure: Patterns of appraisals and coping strategies of non-elite and elite athletes during competition. *Journal of Sports Sciences, 32*(19), 1813-1820. https://doi.org/10.1080/02640414.2014.922692

Campbell, M., McKenzie, J., Sowden, A., Katikireddi, S., Brennan, S., Ellis, S., Hartmann-Boyce, J., Ryan, R., Shepperd, S., Thomas, J., Welch, V., & Thomson, H. (2020). Synthesis without meta-analysis (SWiM) in systematic reviews: Reporting guideline. *BMJ* 2020;368:l6890. https://doi.org/10.1136/bmj.l6890

*Cooke, A., Kavussanu, M., McIntyre, D., Boardley, I., & Ring, C. (2011). Effects of competitive pressure on expert performance: Underlying psychological, physiological, and kinematic mechanisms. *Psychophysiology, 48*(8) 1146-1156. https://doi.org/10.1111/j.1469-8986.2011.01175.x

Daou, M., Hutchison, Z., Bacelar, M., Rhoads, J. A., Lohse, K. R., & Miller, M. W. (2019). Learning a skill with the expectation of teaching it impairs the skill's execution under psychological pressure. *Journal of Experimental Psychology: Applied*, *25*(2), 219–229. https://doi.org/10.1037/xap0000191

*Ehrlenspiel, F., Wei, K., Sternad, D. (2010). Open-loop, closed-loop and compensatory control: performance improvement under pressure in a rhythmic task. *Experimental Brain Research, 201,* 729-741. https://doi.org/ 10.1007/s00221-009-2087-8

*Ellmers, T., & Young, W. (2018). Conscious motor control impairs attentional processing efficiency during precision stepping. *Gait & Posture, 63,* 58-62. https://doi.org/10.1016/j.gaitpost.2018.04.033

*Ellmers, T., & Young, W. (2019). The influence of anxiety and attentional focus on visual search during adaptive gait. *Journal of Experimental Psychology: Human Perception and Performance, 45*(6), 697-714. https://doi.org/10.1037/xhp0000615

*Ellmers, T., Cocks, A., Kal, E., & Young, W. (2020$_a$). Conscious movement processing, fall-related anxiety, and the visuomotor control of locomotion in older adults. *Journals of Gerontology: Series B, 75*(9), 1911-1920. https://doi.org/10.1093/geronb/gbaa081

Ellmers, T., Cocks, A., & Young, W. (2020$_b$). Exploring attentional focus of older adult fallers during heightened postural threat. *Psychological Research, 84*(7), 1877-1889. https://doi.org/10.1007/s00426-019-01190-6

*Ellmers, T., Kal, E., & Young, W. (2021). Consciously processing balance leads to distorted perceptions of instability in older adults. *Journal of Neurology, 268*(4), 1374-1384 https://doi.org/ 10.1007/s00415-020-10288-6

*Englert, C., & Oudejans R. (2014). Is choking under pressure a consequence of skill-focus or increased distractibility? Results from a tennis serve task. *Psychology, 5,* 1053-1043. https://doi.org/10.4236/psych.2014.59116

Eysenck, M., Derakshan, N., Santos, R., Calvo, M. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*(2), 336-353. https://doi.org/10.1037/1528- 3542.7.2.336

Fitts, P., & Posner, M. (1967). *Human Performance*. Belmont, CA: Brooke/Cole.

*Gage, W., Sleik, R., Polych, M., McKenzie, N., Brown, L. (2003). The allocation of attention during locomotion is altered by anxiety. *Experimental Brain Research, 150*(3), 385-394. https://doi.org/10.1007/s00221-003-1468-7

*Gallicchio, G., Cooke, A., & Ring, C. (2016). Lower left temporal-frontal connectivity characterizes expert and accurate performance: High-alpha T7-Fz connectivity as a marker of conscious processing during movement. *American Psychological Association,* 5(1), 14-24. https://doi.org/10.1037/spy0000055

Gómez, M., Avugos, S., Oñoro, M., Lorenzo, A., & Bar-Eli, M. (2018). Shaq is not alone: Free-throws in the final moments of a basketball game. *Journal of Human Kinetics, 62,* 135-144. https://doi.org/10.1515/hukin-2017-0165

*Gray, R. (2004). Attending to the execution of a complex sensorimotor skill: Expertise differences, choking, and slumps. *Journal of Experimental Psychology: Applied, 10*(1), 42-54. https://doi.org/10.1037/1076-898X.10.1.42

*Gray, R., & Allsop, J. (2013). Interactions between performance pressure, performance streaks, and attentional focus. *Journal of Sport & Exercise Psychology, 35*(4), 368-386. https://doi.org/10.1123/jsep.35.4.368

*Gray, R., Allsop, J., & Williams, S. (2013). Changes in putting kinematics associated with choking and excelling under pressure. *International Journal of Sport Psychology, 44*(4), 387-407. https://doi.org/10.7352/IJSP2013.44.387

*Gray, R., & Cañal-Bruland. (2015). Attentional focus, perceived target size, and movement kinematics under performance pressure. *Psychonomic Bulletin Review, 22*(6), 1692-1700. https://doi.org/10.3758/s13423-015-0838-z

*Gray, R., Orn, A., & Woodman, T. (2017). Ironic and reinvestment effects in baseball pitching: How information about an opponent can influence performance under pressure. *Journal of Sport & Exercise Psychology, 39*(1), 3-12. https://doi.org/10.1123/jsep.2016-0035

Hase, A., O'Brien, J., Moore, L., Freeman, P. (2019). The relationship between challenge and threat states and performance: A systematic review. *Sport, Exercise, and Performance Psychology, 8*(2), 123-144. https://doi.org/10.1037/spy0000132

*Huffman, J., Horslen, B., Carpenter, M., & Adkin, A. (2009). Does increased postural threat lead to more conscious control of posture? *Gait & Posture, 30*(4), 528-532. https://doi.org/10.1016/j.gaitpost.2009.08.001

Jackson, R., Ashford, K., & Norsworth, G. (2006). Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport & Exercise Psychology, 28*(1), 49-68. https://doi.org/10.1123/jsep.28.1.49

*Johnson, K., Zaback, M., Tokuno, C., Carpenter, M., & Adkin, A. (2019$_a$). Exploring the relationship between threat-related changes in anxiety, attention focus, and postural control. *Psychological Research,* 83(3), 445-458. https://doi.org/10.1007/s00426-017-0940-0

*Johnson, K., Zaback, M., Tokuno, C., Carpenter, M., & Adkin, A. (2019$_b$). Repeated exposure to the threat of perturbation induces emotional, cognitive, and postural adaptations in young and older adults. *Experimental Gerontology, 112,* 109-115. https://doi.org/10.1016/j.exger.2019.04.015

Kim, S., Park, J., Lee, Y., Seo, H., Sheen, S., Hahn, S., Jang, B., & Son, H. (2013). Testing a tool for assessing the risk of bias for nonrandomized studies showed moderate reliability and promising validity. *Journal of Clinical Epidemiology, 66*(4), 408-414. https://doi.org/10.1016/j.jclinepi.2012.09.016

Liao, C., & Masters, R. (2001). Analogy learning: A means to implicit motor learning. *Journal of Sports Sciences, 19*(5), 307-319. https://doi.org/10.1080/02640410152006081

*Lo, L., Hatfields, B., Wu, C., Chang, C., & Hung, T. (2019). Elevated state anxiety alters cerebral cortical dynamics and degrades precision cognitive-motor performance. *Sport, Exercise, and Performance Psychology, 8*(1), 21-37. http://dx.doi.org/10.1037/spy0000155

MacKinnon, D., Fairchild, A., & Fritz, M. (2007). Mediation analysis. *Annual Review of Psychology*, *58*, 593-615. doi: 10.1146/annurev.psych.58.110405.085542

Magill, R., & Anderson, D. (2014*). Motor learning and control: Concepts and applications* (10th ed.). McGraw-Hill.

Malhotra, N., Poolton, J., Wilson, M., Ngo, K., & Masters, R. (2012). Conscious monitoring and control (reinvestment) in surgical performance under pressure. *Surgical Endoscopy,* 26(9), 2423-2429. https://doi.org/10.1007/s00464-012-2193-8

Malhotra, N., Poolton, J., Wilson, M., Omuro, S., & Masters, R. (2015). Dimensions of movement specific reinvestment in practice of a golf putting task. *Psychology of Sport and Exercise, 18*, 1-8. https://doi.org/10.1016/j.psychsport.2014.11.008

Masters, R. (1992). Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology, 83*(3), 343-358. https://doi.org/10.1111/j.2044-8295.1992.tb02446.x

Masters, R., Polman, R., & Hammond, N. (1993). 'Reinvestment': A dimension of personality implicated in skill breakdown under pressure. *Personality and Individual Differences,* 14(5), 655-666. https://doi.org/10.1016/0191-8869(93)90113-H

Masters, R., Eves, F., & Maxwell, J. (2005). Development of a movement specific reinvestment scale. In T. Morris, P. Terry, S. Gordon, S. Hanrahan, L. Ievleva, G. Kolt, & P. Tremayne (Eds.) *Proceedings of the ISSP 11th World Congress of Sport Psychology*, Sydney, Australia.

Masters, R., & Maxwell, J. (2008). The theory of reinvestment. *International Review of Sport and Exercise Psychology, 1*(2), 160-183. https://doi.org/10.1080/17509840802287218

Mesagno, C., Harvey, J., & Janelle, C. (2012). Choking under pressure: The role of fear of negative evaluation. *Psychology of Sport and Exercise, 13*(1), 60-68. https://doi.org/10.1016/j.psychsport.2011.07.007

Moher D., Liberati A., Tetzlaff J., Altman D., & The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Open Medicine, 3,* 123-130.

Nieuwenhuys, A., & Oudejans, R. (2012). Anxiety and perceptual-motor performance: Toward an integrated model of concepts, mechanisms, and processes. *Psychological Research,* 76(6), 747-759. https://doi.org/10.1007/s00426-011-0384-x

Nieuwenhuys, A., & Oudejans, R. (2017). Anxiety and performance: Perceptual-motor behavior in high-pressure contexts. *Current Opinion in Psychology, 16,* 28-33. https://doi.org/10.1016/j.copsyc.2017.03.019

Oudejans, R., Kuijpers, W., Kooijman, C., & Bakker, F. (2011). Thoughts and attention of athletes under pressure: skill-focus or performance worries? *Anxiety, Stress & Coping, 24*(1), 59-73. https://doi.org/ 10.1080/10615806.2010.481331

Page, M., McKenzie, J., Bossuyt, P., Boutron, I., Hoffmann, T., Mulrow, D., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. https://doi.org/10.1136/bmj.n71

Parr, J., Gallicchio, G., & Wood, G. (2021). EEG correlates of verbal and conscious processing of motor control in sport and human movement: a systematic review. *International Review of Sport and Exercise Psychology,*1-32. http://doi.org/ 10.1080/1750984X.2021.1878548

Payne, K., Wilson, M., & Vine, S. (2019). A systematic review of the anxiety-attention relationship in far-aiming skills. *International Review of Sport and Exercise Psychology, 12*(1), 325-355. https://doi.org/10.1080/1750984X.2018.1499796

Pijpers, J., Oudejans, R., Holsheimer, F., & Bakker, F. (2003). Anxiety-performance relationships in climbing: A process-oriented approach. *Psychology of Sport and Exercise, 4*(3), 283-304. https://doi.org/10.1016/S1469-0292(02)00010-9

*Pijpers, J., Oudejans, R., & Bakker, F. (2005). Anxiety-induced changes in movement behaviour during the execution of a complex whole-body task. *The Quarterly Journal of Experimental Psychology, 58*(3), 421-445. https://doi.org/10.1080/02724980343000945

Roberts, L., Jackson, M., & Grundy, I. (2019). Choking under pressure: Illuminating the role of distraction and self-focus. *International Review of Sport and Exercise Psychology, 12*(1), 49-69. https://doi.org/10.1080/1750984X.2017.1374432

Sallis, J., Prochaska, J., Wendell, T. (2000). A review of correlates of physical activity of children and adolescents. *Medicine & Science in Sports & Exercise, 32*(5), 963-975. https://doi.org/10.1097/00005768-200005000-00014

Schücker, L., Ebbing, L., & Hagemann, N. (2010). Learning by analogies: Implications for performance and attentional processes under pressure. *Human Movement, 11*(2), 191-199. https://doi.org/10.2478/v10038-010-0025-z

*Schücker, L., Hagemann, N., & Strauss, B. (2013). Attentional processes and choking under pressure. *Perceptual & Motor Skills: Exercise & Sport, 116*(2) 671-689. https://doi.org/10.2466/30.25.PMS.116.2.671-689

Spillers, G., Brewer, G., & Unsworth, N. (2012). Working memory and information processing. Seel, N (Eds.) Encyclopaedia of the Sciences of Learning, Boston, MA. https://doi.org/10.1007/978-1-4419-1428-6_787

*Stins, J., Roerdink, M., & Beek. (2011). To freeze or not to freeze? Affective and cognitive perturbations have markedly different effects on postural control. *Human Movement Science, 30,* 190-202. https://doi.org/ 10.1016/j.humov.2010.05.013

*Tanaka, Y., & Sekiya, H. (2010_a). The influence of audience and monetary reward on the putting kinematics of expert and novice golfers. *Research Quarterly for Exercise and Sport, 81*(4)*,* 416-424. https://doi.org/10.1080/02701367.2010.10599702

*Tanaka, Y., & Sekiya, H. (2010_b). The relationships between psychological/physiological changes and behavioral/performance changes of a golf putting task under pressure. *International Journal of Sport and Health Science, 8,* 83-94. https://doi.org/10.5432/ijshs.20100006

*Tanaka, Y., & Sekiya, H. (2011). The influence of monetary reward and punishment on psychological, physiological, behavioral and performance aspects of a golf putting task. *Human Movement Science, 30*(6), 1115-1128. https://doi.org/10.1016/j.humov.2011.04.008

Wielenga-Meijer, E., Taris, T., Kompier, M., & Wigboldus, D. (2010). From task characteristics to learning: A systematic review. *Scandinavian Journal of Psychology*, *51*(5), 363-375. https://doi.org/10.1111/j.1467-9450.2009.00768.x

*Wilson, M., Chattington, M., Marple-Horvat, D., Smith, N. (2007). A Comparison of Self Focus Versus Attentional Explanations of Choking. *Journal of Sport & Exercise Psychology, 29,* 439-456. https://doi.org/ 10.1123/jsep.29.4.439

Wulf, G., Shea, C., & Park, J-H. (2001). Attention and motor performance: Preferences for and advantages of an external focus. *Research Quarterly for Exercise and Sport, 72*(4), 335-344. https://doi.org/10.1080/02701367.2001.10608970

*Young, W., Olonilua, M., Masters, R., Dimitriadis, S., & Williams, A. (2016). Examining links between anxiety, reinvestment and walking when talking by older adults during adaptive gait. *Experimental Brain Research, 234*(1), 161-172. https://doi.org/10.1007/s00221-015-4445-z

*Zaback, M., Cleworth, T., Carpenter, M., Adkin, A. (2015). Personality traits and individual differences predict threat-induced changes in postural control. *Human Movement Science, 40,* 393-409. https://doi.org/10.1016/j.humov.2015.01.015

Zhu, F., Poolton, J., Wilson, M., Maxwell, J., & Masters, R. (2011). Neural co-activation as a yardstick of implicit motor learning and the propensity for conscious control of movement. *Biological Psychology, 87*(1), 66-73. https://doi.org/10.1016/j.biopsycho.2011.02.004

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram of search results.

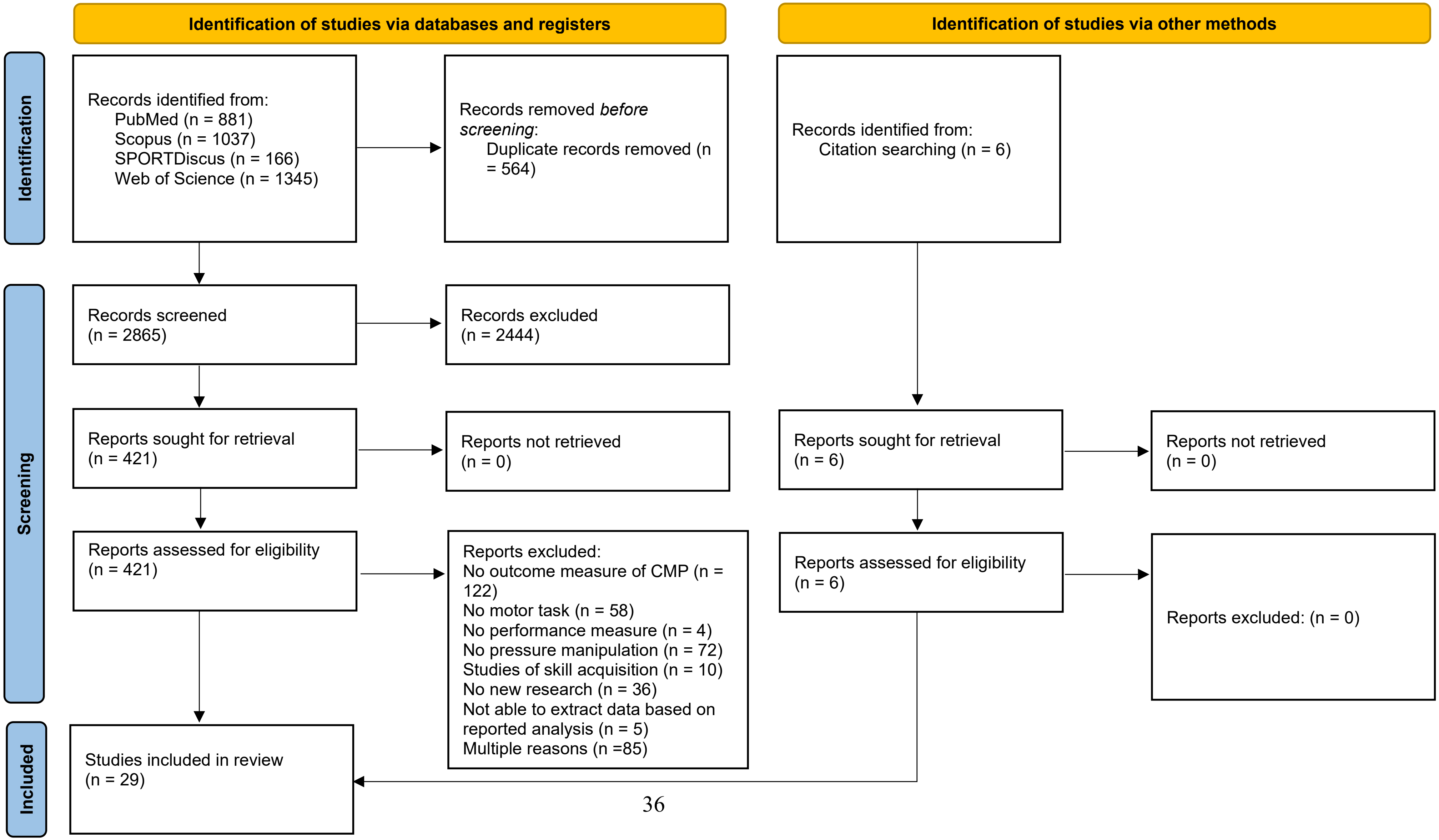

Table 1. Risk of bias assessment

Ref. #	Article	Items					
		1	2	3	4	5	6
1	Arsal et al. (2016)	Low	Low	Low	Unclear	Low	Low
2	Allsop et al. (2017)	Low	Low	Low	Unclear	Low	Low
3	Cooke et al. (2011)	Low	Low	Low	Unclear	Low	Low
4	Ehrlenspiel et al. (2010)	Low	High	Low	Unclear	Low	High
5	Ellmers & Young (2018)	Low	Low	Low	Unclear	Low	Low
6	Ellmers & Young (2019) (Exp. 1)	Low	Low	Low	Unclear	Low	Low
7	Ellmers et al. (2020$_a$)	Low	Low	Low	Low	Low	Low
8	Ellmers et al. (2021)	Low	Low	Low	Unclear	Low	Low
9	Englert & Oudejans (2014)	Low	Low	Low	Unclear	Low	Low
10	Gage et al. (2003)	Low	Low	High	Unclear	Low	Low
11	Gallicchio et al. (2016)	Unclear	Low	Low	Unclear	Low	Low
12	Gray (2004) (Exp. 3)	Low	Low	High	Unclear	Low	Low
13	Gray & Allsop (2013) (Exp. 2)	Low	Low	Low	Unclear	Low	Low
14	Gray & Cañal-Bruland (2015)	Low	Low	Low	Unclear	Low	Low
15	Gray et al. (2013)	Low	Low	Low	Unclear	Low	Low
16	Gray et al. (2017)	Low	Low	Low	Unclear	Low	Low
17	Huffman et al. (2009)	Low	Low	Low	Unclear	Low	Low
18	Johnson et al. (2019$_a$)	Low	Low	Low	Unclear	Low	Low
19	Johnson et al. (2019$_b$)	Low	Low	Low	Unclear	Low	Low
20	Lo et al. (2019)	Low	Low	Low	Unclear	Low	Low
21	Pijpers et al. (2005) (Exp. 2)	Low	Low	Low	Unclear	Low	Low
22	Schücker et al. (2013)	Low	Low	Low	Low	Low	Low
23	Stins et al. (2011)	Low	Low	High	Unclear	Low	Low
24	Tanaka & Sekiya (2010$_a$)	Unclear	Low	Low	Unclear	Low	Low
25	Tanaka & Sekiya (2010$_b$)	Low	Low	Low	Unclear	Low	Low
26	Tanaka & Sekiya (2011)	Low	Low	Low	Unclear	Low	Low
27	Wilson et al. (2007)	Low	Low	Low	Unclear	Low	Low
28	Young et al. (2016)	Low	Low	Low	Unclear	Low	Low
29	Zaback et al. (2015)	Low	Low	Low	Unclear	Low	Low

Note: Item 1 = selection of participants; item 2 = confounding variables; item 3 = measurement of exposure; item 4 = blinding of outcome assessments; item 5 = incomplete outcome data; item 6 = selective outcome reporting (RoBANS; Kim et al., 2013).

Table 2. Summary of included studies.

Ref. #	Article	Sample Size (Male)	Age (M)	Design	Setting	Expertise	Motor Task	Pressure Manipulation	Performance measure	Measure of CMP
1	Arsal et al. (2016)	52 (45)	21.65/21.85	Mixed	Sport	Novice/expert	Golf putt	• Expert evaluation • Monetary incentive	• Putting score • Task duration	• Verbal report
2	Allsop et al. (2017)	24(11)	25.3	Mixed	Non-sport	NA	Aiming task	• Competition • Monetary incentive • Videotaping	• Movement time • Absolute/variable error	• Kinematic Data
3	Cooke et al. (2011)	50 (44)	20.3	WS	Sport	Expert	Golf putt	• Competition • Monetary incentive • Videotaping	• Putting score • Mean radial error	• S-MSRS
4a	Ehrlenspiel et al. (2010) (Exp. 1)	48 (19)	-	Mixed	Non-sport	NA	Rhythmic ball bouncing	• Competition • Monetary incentive	• Absolute error • Variable error	• Kinematic Data
4b	Ehrlenspiel et al. (2010) (Exp. 2)	24 (10)	-	Mixed	Non-sport	NA	Rhythmic ball bouncing	• Competition • Monetary incentive	• Absolute error • Variable error	• Kinematic Data
5	Ellmers & Young (2018)	15 (8)	25.5	WS	Non-sport	NA	Walking	• Elevated platform	• Stepping accuracy • Gait speed	• S-MSRS
6	Ellmers & Young (2019) (Exp. 1)	14 (6)	25.9	WS	Non-sport	NA	Walking	• Elevated platform	• Stepping error • Task duration	• Verbal report
7	Ellmers et al. (2020_a)	18 (7)	71.2	WS	Non-sport	NA	Walking	• Elevated platform	• Stepping error • Task duration • Stance duration	• Attentional focus questionnaire
8	Ellmers et al. (2021)	26 (7)	74.2	WS	Non-sport	NA	Standing	• Elevated platform	• Postural control	• Attentional focus questionnaire
9	Englert & Oudejans (2014)	53 (34)	29.9	BS	Sport	Expert	Tennis serve	• Expert evaluation • Competition	• Serve accuracy	• Attentional focus questionnaire
10	Gage et al. (2003)	31 (11)	22.4/67.5	WS	Non-sport	NA	Walking	• Elevated platform • Constrained walking	• Gait kinematics	• Task-irrelevant dual-task
11	Gallicchio et al. (2016)	20 (20)	-	Mixed	Sport	Novice/expert	Golf putt	• Competition • Monetary incentive	• Putting score	• S-MSRS • EEG

12	Gray (2004) (Exp. 3)	12	-	Mixed	Sport	Expert	Baseball batting	• Competition • Monetary incentive	• Mean temporal swing error	• Skill-focused dual-task
13	Gray & Allsop (2013) Exp. 2)	20	21.7	WS	Sport	Expert	Baseball batting	• Competition • Monetary incentive • Audience	• Mean # of hits	• Skill-focused dual-task
14	Gray & Cañal-Bruland (2015)	25 (17)	20.1	WS	Sport	Expert	Golf putt	• Competition • Monetary incentive	• Mean radial error	• Skill-focused dual-task
15	Gray et al. (2013)	13 (11)	20.7	WS	Sport	Expert	Golf putt	• Competition • Monetary incentive	• Putting accuracy	• Kinematic data
16	Gray et al. (2017)	24 (24)	22.6/23.9	Mixed	Sport	Expert	Baseball pitching	• Expert evaluation • Competition • Monetary incentive	• # targets hit • Mean pitch velocity	• Kinematic data
17	Huffman et al. (2009)	48 (24)	24.8	WS	Non-sport	NA	Standing	• Postural threat	• Postural control	• S-MSRS
18	Johnson et al. (2019a)	80 (30)	21.7	WS	Non-sport	NA	Standing	• Postural threat	• Postural control	• Attentional focus questionnaire
19	Johnson et al. (2019b)	54 (25)	70/22.2	Mixed	Non-sport	NA	Standing	• Postural threat	• Postural control	• Attentional focus questionnaire
20	Lo et al. (2019)	21 (21)	21.8	WS	Sport	Novice	Dart throwing	• Videotaping • Monetary incentive • Threat of shock	• Throwing score	• EEG
21	Pijpers et al. (2005) (Exp. 2)	15 (13)	20.7	WS	Sport	Novice	Climbing	• Elevated climb	• Climbing time • Movement time • Total contact time • Hand/foot holds contact time	• Kinematic data
22	Schücker et al. (2013)	22 (22)	17.5	WS	Sport	Expert	Basketball free throw	• Expert evaluation	• Free throw score	• Skill-focused dual-task
23	Stins et al. (2011)	18 (6)	26.0	WS	Non-sport	NA	Standing	• Elevated platform	• Postural control	• Kinematic data

24	Tanaka & Sekiya (2010a)	11 (11)	21.2/24.7	Mixed	Sport	Novice/expert	Golf putt	• Audience • Monetary incentive	• Putting score	• Attentional focus questionnaire
25	Tanaka & Sekiya (2010b)	16 (16)	19.6	WS	Sport	Novice	Golf putt	• Threat of shock • Monetary incentive	• Putting score	• Attentional focus questionnaire
26	Tanaka & Sekiya (2011)	20 (20)	19.7	WS	Sport	Novice	Golf putt	• Threat of shock • Monetary incentive	• Putting score	• Attentional focus questionnaire
27	Wilson et al. (2007).	24(0)	19.0	WS	Non-sport	NA	Driving Task	• Competition • Monetary incentive	• Completion time	• Skill-focused dual-task
28	Young et al. (2016)	24	77.6	WS	Non-sport	NA	Walking	• Threat of falling	• Task duration	• S-MSRS
29	Zaback et al. (2015)	82 (44)	24.0	WS	Non-sport	NA	Standing	• Postural threat	• Postural control	• S-MSRS

Note: WS = within subject; BS = between subject; CMP = conscious motor processing; S-MSRS = State version of the Movement Specific Reinvestment Scale

Table 3. Summary of findings

Ref. #	1. Pressure → Performance	2. Pressure → CMP	3. CMP → Performance	4. Mediation	Conclusions
1	Pressure decreased performance (increased task duration; η_p^2= .29), no effect on putting score	No effect of pressure on CMP (mechanics thoughts)	-	-	Task duration increased under pressure while CMP and putting score were unaffected
2	No effect of pressure on movement time (η_p^2 = 0.15) or absolute error/variable error	Pressure increased CMP (increase in variability of kinematic landmarks)	-	-	Performance changes under pressure may be related to CMP
3	Pressure increased performance (decreased MRE; η_p^2 = .13), no effect on number of putts holed	Pressure decreased CMP (S-MSRS score higher under low-pressure condition; η_p^2 = .25)	-	Influence of pressure on performance not mediated by CMP	Performance accuracy increased under pressure, CMP decreased under pressure, while number of putts holed was unaffected
4a	Pressure increased performance (absolute error and variable error decreased)	No effect of pressure on CMP (closed-loop control unaffected)	-	Changes in closed-loop control associated with changes in variable error but not absolute error.	Performance increased, while CMP was unaffected by pressure. ΔCMP associated with ΔPerformance
4b	Pressure increased performance (absolute error and variable error decreased)	Pressure increased CMP (closed-loop control increased)	-	Changes in closed-loop control associated with changes in variable error but not absolute error	Performance and CMP increased under pressure. ΔCMP associated with ΔPerformance
5	No effect of pressure on accuracy or gait speed	Pressure increased CMP (CMP subscale of S-MSRS higher during high-pressure condition (η_p^2 = .31), no difference in MSC subscale	-	-	CMP increased under pressure, while performance was unaffected
6	Pressure decreased performance (increased task duration; d = .85), no effect on stepping error	Pressure increased CMP (more attention directed towards movement processes)	-	-	Performance changes under pressure may be related to CMP
7	Pressure decreased performance (increased task duration (η_p^2 = .47), and stance duration (η_p^2 = .50)), no effect on stepping error (η_p^2 = .17)	Pressure increased CMP (more attention directed towards movement processes)	-	-	Performance changes under pressure may be related to CMP

8	Pressure decreased performance (2 of 3 postural variables significantly affected by pressure)	Pressure increased CMP (more attention directed towards movement processes	-	-	Performance changes under pressure may be related to CMP
9	Pressure decreased tennis serve accuracy (*B* = -.24)	No effect of pressure on CMP (skill-focus not affected; *B* = .09)	No effect of CMP on tennis serve accuracy (*B* = .02)	Influence of pressure on performance not mediated by CMP (*B* = -.02)	Performance was negatively impacted by pressure, while CMP was unaffected. ΔCMP not associated with ΔPerformance
10	Pressure decreased performance for both the constrained and unconstrained walking conditions (increased stance duration, decreased gait speed), no effect on stride length	Pressure increased CMP (increased RT) in the constrained condition, no effect of pressure in the unconstrained condition	-	-	Performance changes under pressure may be related to CMP
11	No effect of pressure on number of putts holed (η_p^2 = .16)	No effect of pressure on CMP. S-MSRS scores not affected (η_p^2 = .00). T7-Fz ISPC not affected (η_p^2 = .056).	-	-	Pressure did not result in any significant alterations in performance or CMP
12	Pressure decreased performance (mean temporal swing error increased; Cohen's *f* = 1.23)	Pressure increased CMP (increased accuracy on the skill-focused task; Cohen's *f* = .62). No effect on extraneous dual task.	-	-	Performance changes under pressure may be related to CMP
13	Pressure decreased performance (mean number of hits decreased)	No effect of pressure on CMP (skill-focused and extraneous dual task performance unaffected).	-	-	Performance was negatively impacted by pressure while CMP was unaffected.
14	Pressure decreased performance (increased MRE; η_p^2 = .49)	Pressure increased CMP (lower accuracy on the hole (external; η_p^2 = .42) secondary task and higher accuracy on the club (internal; η_p^2 = .50) secondary task)	-	-	Performance changes under pressure may be related to CMP
15	No effect of pressure on performance (putting accuracy unaffected)	Pressure increased CMP (4 of 5 kinematic variables significantly affected by pressure)	-	-	CMP increased under pressure, while performance was unaffected
16	Pressure decreased performance (less target hits; η_p^2 = .66), mean pitch velocity was unaffected	Pressure increased CMP (3 of 4 kinematic variables significantly affected by pressure	-	-	Performance changes under pressure may be related to CMP

17	Pressure decreased performance (2 of 3 postural variables significantly affected by pressure	Pressure increased CMP (scores increased in both CMP and MSC subscales)	-	-	Performance changes under pressure may be related to CMP
18	Pressure decreased performance (3 of 6 postural variables significantly affected by pressure) in both the threat no-experience and threat experience condition	Pressure increased CMP (more attention towards movement processes) in both the threat no-experience and threat experience condition	-	Pressure-induced changes in CMP associated with pressure-induced increase in 2 of 3 postural variables (*B* = .31-.32; more CMP = decreased postural control)	Performance decreased while CMP increased under pressure. ΔCMP associated with ΔPerformance
19	Pressure decreased performance (4 of 6 postural variables significantly affected in both the threat early and threat late trials compared to baseline)	Pressure increased CMP from baseline in both the threat early and threat late trials (more attention towards movement processes)	-	-	Performance changes under pressure may be related to CMP
20	Pressure decreased performance (lower dart throw total score; η_p^2 = .24	Pressure increased CMP (elevated T3-Fz coherence)	-	No significant linear relationship between changes in T3-Fz EEG high-alpha coherence and performance accuracy under pressure	Performance decreased while CMP increased under pressure. ΔCMP not associated with ΔPerformance
21	Pressure decreased performance (increased total climbing time (*ES* = 1.17), average movement time between holds (*ES* = 1.11), total contact time (ES = 1.23), and contact time with hand and foot holds (*ES*= 1.13-1.33))	Pressure increased CMP (increased exploratory movements; *ES* = .66). No difference in performatory movements.	-	-	Performance changes under pressure may be related to CMP
22	No effect of pressure on performance (performance scores unaffected; η_p^2 = .08)	No effect of pressure on CMP (dual-task performance unaffected; η_p^2 = .07)	-	-	Pressure did not result in any significant alterations in performance or CMP
23	Pressure decreased performance (increase mean AP COP position). No effect on variability of AP COP.	Pressure increased CMP (increased MPF and sample entropy). No effect on F95.	-	-	Performance changes under pressure may be related to CMP
24	No effect of pressure on performance (putting score unaffected)	No effect of pressure on CMP (calculated CMP score unaffected)	-	-	Pressure did not result in any significant alterations in performance or CMP

25	No effect of pressure on performance (putting score unaffected)	Pressure increased CMP (score on CMP items significantly different from ‘0’)	-	-	CMP increased under pressure, while performance was unaffected
26	No effect of pressure on performance (putting score unaffected)	No effect of pressure on CMP items (score on CMP items not significantly different from ‘0’)	-	1 of 2 CMP items (Q1) significant predictor of LP-HP differences in putting scores (β = .52; more CMP = more affected by pressure)	Performance and CMP unaffected by pressure. CMP (change) score associated with ΔPerformance
27	No effect of pressure on performance (completion time unaffected)	Pressure decreased CMP (decreased accuracy on the skill-focused task)	-	-	Pressure did not result in any significant alterations in performance or increases in CMP
28	No effect of pressure on performance (task duration unaffected)	Pressure increased CMP (higher S-CMP and S-MSC scores)	-	-	CMP increased under pressure, while performance was unaffected
29	Pressure decreased postural control, for the quiet standing all 3 postural variables significantly affected (η_p^2 = .64). For the rise to toes task the 2 postural variables significantly affected (η_p^2 = .55).	Pressure increased CMP (higher S-CMP scores) in both the quiet standing (η_p^2 = .14) and rise to toes task (η_p^2 = .11). Higher S-MSC scores in rise to toes task (η_p^2 = .055), no effect in quiet standing.	-	-	Performance changes under pressure may be related to CMP

Note: CMP = Conscious motor processing; MSC = Movement self-consciousness; LP = low pressure; HP= high pressure; MRE = mean radial error; AP COP = anterior-posterior centre-of-pressure; MPF = mean power frequency; F95 = 95% power frequency. Effect sizes reported where available (*η_p^2 = partial eta-squared [ANOVAs]; ES = effect size [t-test]; B = unstandardized regression coefficient [regression analyses]; β = standardized regression coefficient [regression analyses]*)

Table 4. Effect of pressure on performance

	Article number	Number of effects	Percentage of effects supporting association			
			Positive	Negative	No effect	Sum Code
Overall effect	1-29	80	6	53	41	??
Setting						
Sport	1,3,9,11,12,13,14,15,16,20,21,22,24,25,26	21	5	52	43	??
Non-Sport	2,4,5,6,7,8,10,17,18,19,23,27,28,29	59	7	53	41	??
Expertise						
Expert	1,3,9,11,12,13,14,15,16,22,24	14	7	43	50	??
Novice	1, 11, 20, 21, 24, 25, 26	11	0	55	45	??

Note: “0” indicates that 0% to 33% of the studies supported the association, “?” indicates that 34% to 59% of the studies supported the association, and “+” indicates that 60% or more of the studies supported the association (Sallis et al., 2000). Codes are doubled (“??”, 00, or ++ if 4 or more studies supported the association.

Table 5. Effect of pressure on conscious motor processing

	Article number	Number of effects	Percentage of effects supporting association			
			Positive	**Negative**	**No effect**	**Sum Code**
Overall effect	1-29	56	64	4	32	++
Setting						
Sport	1,3,9,11,12,13,14,15,16,20,21,22,24,25,26	27	48	4	48	??
Non-Sport	2,4,5,6,7,8,10,17,18,19,23,27,28,29	29	79	7	17	++
Expertise						
Expert	1,3,9,11,12,13,14,15,16,22,24	22	45	5	50	??
Novice	1,11,20,21,24,25,26	9	33	0	67	00
Measure of CMP						
Attentional focus questionnaire	7,8,9,18,19,24,25,26	10	70	0	30	++
EEG	11, 20	2	50	0	50	?
Kinematic data	2,4,15,16,21,23	20	75	0	25	++
Skill-focused dual-task	12,13,14,22,27	8	38	13	50	??
S-MSRS	3,5,11,17,28,29	12	67	8	25	++
Task-irrelevant dual-task	10	2	50	0	50	?
Verbal report	1,6	2	50	0	50	?

Note: CMP = conscious motor processing; "0" indicates that 0% to 33% of the studies supported the association, "?" indicates that 34% to 59% of the studies supported the association, and "+" indicates that 60% or more of the studies supported the association (Sallis et al., 2000). Codes are doubled "??", 00, or ++ if 4 or more studies supported the association.

Table 6. Changes in CMP associated with changes in performance

	Article number	Number of effects	Percentage of effects supporting association			
			Positive	Negative	No effect	Sum Code
Overall effect (ΔCMP → ΔPerformance)	3, 4, 9, 18, 20, 26	12	42	0	58	??
Setting						
Sport	3, 9, 20, 26	5	20	0	80	00
Non-Sport	4, 18	7	57	0	43	??
Expertise						
Expert	3, 9	2	0	0	100	0
Novice	20,26	3	33	0	67	0
Measure of CMP						
Attentional focus questionnaire	9, 18, 26	6	50	0	50	??
EEG	20	1	-	-	-	-
Kinematic data	4	4	50	0	50	??
Skill-focused dual-task	-	-	-	-	-	-
S-MSRS	3	1	-	-	-	-
Task-irrelevant dual-task	-	-	-	-	-	-
Verbal report	-	-	-	-	-	-

Note: CMP = conscious motor processing; "0" indicates that 0% to 33% of the studies supported the association, "?" indicates that 34% to 59% of the studies supported the association, and "+" indicates that 60% or more of the studies supported the association (Sallis et al., 2000). Codes are doubled "??", 00, or ++ if 4 or more studies supported the association.