The Effects of Psyching-Up on Maximal Force Production: A Systematic Review

ABSTRACT

Background: A comprehensive examination of psyching-up strategies prior to maximal force production is imperative to examine the efficacy of psyching-up, identify beneficial strategies for practitioners, and direct future investigations. The aim of this systematic review was to examine the efficacy of psyching-up strategies on maximal force production. *Methods:* The systematic review followed PRISMA guidelines. A systematic search was carried out in SPORTDiscus, PsychINFO, PsychARTICLES, MEDLINE, Google Scholar, and Web of Science. Studies were included if they used an experimental design, sampled adults, the independent variable included a psyching-up strategy that matched the working definition, and measured maximal force production measure. *Results:* Twenty-seven independent studies met the inclusion criteria for this review. Collectively, 65% of the trials found that psyching-up facilitates maximal force production. Free-choice psyching-up, motivational self-talk, PETTLEP imagery, and prescribed preparatory arousal all consistently enhanced performance. There was also evidence that disparity in the results might be due to the competitive experience of the participants and the type of control condition. *Conclusion:* The findings suggest that free-choice psyching-up, motivational self-talk, PETTLEP imagery and prescribed preparatory arousal may enhance maximal force production. Future research should recruit experienced athletes to identify and test the efficacy of strategies used by applied practitioners.

INTRODUCTION

Developing and utilizing an athlete's maximal force production is required for optimal performance in various sports (33). Alongside physical training, many athletes and coaches believe 'psyching-up' improves force production (40). In practice, these strategies typically aim to alter arousal, focus, efficacy, or confidence to enhance physical and mental activation (6). This is achieved through a wide variety of cognitive interventions, such as free-choice (51), preparatory arousal (14), self-talk (1), emotive imagery (29), stimulus imagery (13), and attention control (30) immediately prior to skill execution. Despite promising evidence for these strategies, it is important to synthesize evidence on the efficacy of psyching-up strategies for force production, understand inconsistent findings, examine the research designs implemented, and identify gaps for future research.

Psyching-up strategies refer to self-directed cognitive techniques that are conducted immediately prior to or during the execution of a skill to enhance performance (50). Although similarities exist between the strategies used while psyching-up and general cognitive interventions (e.g., 9, 11), the distinguishing factor is the acute nature of psyching-up, designed to elicit an immediate effect. At the forefront of current psyching-up research are four primary strategies: preparatory arousal, self-talk, imagery, and attentional focus.

Preparatory arousal is a self-directed method to increase physiological and psychological intensity (64). In accordance with the Yerkes-Dodson law (66), it is proposed that as physiological and psychological arousal increases so does performance, until the arousal level peaks, and further increases in arousal become counterproductive and inhibit performance. Alternative theories such as multi-dimensional anxiety theory (23) and individual zones of optimal functioning theory (38) share this philosophy, proposing the goal of preparatory arousal is to increase physiological arousal to optimal levels to facilitate performance.

Self-talk has been defined as dynamic multidimensional verbalizations to oneself, which possess interpretive elements associated with the task to serve one of two functions: to instruct or to motivate (18). Instructional self-talk involves the athlete using phrases to direct themselves toward the technical elements of the skill, whereas motivational self-talk involves the athlete utilizing phrases to enhance confidence and motivation. The task-matching hypothesis (19) proposes that instructional self-talk is better suited to skill, timing or precision tasks (5), with motivational self-talk being optimal for strength (1) and endurance tasks (10). Support for this hypothesis has been equivocal, demonstrating partial meta-analytical support, with one supporting the hypothesis (20), and a review from the same year reporting limited evidence (53).

Imagery is a specific mental process that creates or recreates an experience (43). This strategy is one of the most commonly practiced interventions in sport psychology, and can improve performance, enhance cognitive skills, and aid injury rehabilitation (43). Research has aided the development of the efficacy of imagery interventions evolving from stimulus only imagery to PETTLEP imagery (22). There are seven factors within PETTLEP imagery: physical, environment, task, timing, learning, emotion, and perspective, which can influence the extent to which the imagery activates the appropriate neural areas associated with the task. Comparisons between PETTLEP imagery and stimulus only have consistently reported PETTLEP imagery to outperform stimulus only imagery (45, 63). Imagery has been utilized in various ways to enhance strength performance through aiming to: improve neural adaptions such as motor unit activation, coordination, and decreasing co-contraction of antagonistic muscles (42); enhance arousal through emotive imagery (29); increase self-confidence and efficacy; and decrease anxiety (49).

Attentional focus strategies require the athlete to allocate mental resources to appropriate cues or stimuli (31). Differences have been proposed in the effectiveness of strategies that direct attention towards an internal compared to an external cue (30). The constrained action hypothesis states that when an individual makes a conscious effort to control their own movements, it constrains the

motor system interfering with automatic motor control processes that normally regulate the movement (27). Based on this theory, strength performance should be enhanced through an external rather than internal focus of attention (65).

Although the aforementioned strategies have been used in research and practice, there is mixed evidence regarding their effectiveness. Despite athletes and coaches believing that performance is enhanced through these strategies (40, 52), empirical evidence has reported positive (50, 52), null (6, 26), and even detrimental effects (13, 29) on maximal force production. Accordingly, synthesizing the literature can summarize empirical evidence regarding the efficacy of psyching-up. Thus, if the present review concludes that only some psyching-up strategies enhance force production, the findings could enable athletes, coaches, and psychologists to better design and implement interventions to improve performance in both training and competition.

The dependent variable in this review is maximal force production. Maximal force production is the maximal voluntary force produced from a muscle group, or group of muscles, varying from maximal strength and explosive power (47). Many explosive-sport based athletes are required to generate maximum voluntary contractions, such as shot-putters (39), sprinters (3), and powerlifters (55). Thus, if psyching-up strategies improve force production, utilizing effective psyching-up strategies could help optimize athletes' performance.

Since the origin of psyching-up research in 1978 (40) there have been limited literature reviews. A 2003 narrative review focused on the effects of psyching-up strategies on muscular strength, endurance, and power, concluding that psyching-up enhances strength performance and that preparatory arousal appeared to be the most effective strategy (51). Following this, a systematic review in 2015 (54) focused on the effect of cognitive strategies on strength performance. The findings suggested that cognitive strategies typically enhanced performance, with 69% of imagery studies, 100% of goal-setting studies, 60% of self-talk studies, 55% of preparatory arousal studies, and 63% of free choice psyching-up reporting significant increases in maximal strength. The previous

reviews provided valuable insight into strategies for force-related performance, but to date no review has systematically collated research specific to psyching-up strategies.

The present review complements and extends the previous literature in three key ways. First, this is the first review to systematically examine psyching-up strategies and their efficacy on maximal force production. Second, it assesses the methodological quality of studies, which could impact the quality and consistency of evidence. Third, the review focuses on the effects of strategies in relation to passive and/or active control conditions, and the experience levels of the participants. Synthesizing the current evidence could provide crucial insight into the efficacy of psyching-up strategies, potential reasons for mixed findings, and directions and methodological considerations for future research. Additionally, the findings should provide practitioners with greater insight into the potential effectiveness of psyching-up, allowing for more informed decisions to facilitate optimal performance.

The overall purpose of the present paper was to review the literature examining the effects of psyching-up on maximal force production, using a transparent systematic approach. The primary aim was to examine the efficacy of psyching-up strategies on maximal force production. The secondary aim was to assess the methodological quality of studies and moderating factors, such as the type of intervention used, the sample, and the control condition that might explain any heterogeneity in the evidence-base.

METHODS

The present review was developed following the guidelines provided by the preferred reporting items for systematic reviews and meta-analyses 2020 (PRIMSA 2020).

INFORMATION SOURCES, SEARCH STRATEGY AND SELECTION PROCESS

The search strategy included: (a) an online search conducted on the 16th of December 2022 using the following databases: SPORTDiscus, PsychINFO, PsychARTICLES, MEDLINE, Google Scholar, and Web

of Science; (b) a manual forward and back search of retrieved articles; and (c) a manual review of reference lists of relevant narrative and systematic reviews and meta-analyses. Titles, abstracts, and key words were searched online, utilizing Boolean operators, using the following string: Psyching OR Arousal AND Strength OR "Weight-lifting task" OR "Force-Production". The initial search terms were developed by the lead author (KC), with the aid of co-authors (PF; JM) and the departmental librarian (GC), and then conducted by KC. The search results were collated using EndNote, with duplicates automatically deleted by the software and manually by the lead author during the screening process. The studies were then exported to an Excel spreadsheet, containing the author names and titles of all the articles gathered, where titles were screened for eligibility by the lead author. The remaining potentially relevant abstracts and full texts were then screened by two researchers (KC and JP). One discrepancy was resolved via discussion, with the study being excluded as it contained participants who were under the age of 18.

ELIGIBILITY CRITERIA

Studies were required to meet the following inclusion criteria:

(a) An experimental design, with counterbalancing or randomization, comparing psyching-up interventions to a control.

(b) The independent variable/s had to be self-directed cognitive techniques that were conducted immediately prior to or during the execution of a skill with the purpose of enhancing performance.

(c) The dependent variable must be a measurable maximal force production output.

(d) The sample must be healthy adults, aged at least 18 years.

(e) The retrieved articles must be available in full-text English, or as a full-text translation, prior to the end of the data collection period (December 2022).

(f) The retrieved articles must also be published in a peer-reviewed journal, scoring at least a moderate risk of bias using the Cochrane risk of bias tool.

ASSESSMENT OF RISK OF BIAS

The lead author followed the instructions in the Cochrane Handbook for Systematic Reviews of Interventions (21) to assess the risk of bias in the included studies using the Risk of Bias 2 Tool (RoB2) (46), which is a valid tool to assess the methodological quality of randomized trials (28). Specifically, the following five domains were considered: randomization process, deviations from the intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. If relevant information was not reported within an article, attempts were made to contact the lead author. Seven authors were contacted, and three provided the requested information. When no response was received, interpretations were made based on the full text, with the options “probably” or “no information” selected.

SYNTHESIS METHODS

The present review extracted data to report into tables. Firstly, for each article we extracted the author/s, study design, participant characteristics (sample size, sex, age, and participant type), type and timing of the intervention, type of control condition, dependent variable, and key findings. Next, to analyze the efficacy of each psyching-up strategy, for each independent variable, the number of significant and nonsignificant results were tallied. As psyching-up could inhibit or facilitate performance, we tallied both positive (+) and negative (-) findings, in addition to null (0) findings. Additionally, tallies were calculated for active and passive control conditions in addition to the type of participant. Based on descriptions and interpretations of the full text, participants were classified into the following categories: undergraduate student, novice, weight-trained, and athlete. Novice refers to any individual whose report specifies the individual had no prior, or limited, training experience. Weight-trained refers to individuals with specified resistance training experience, but no

report of competing within sports. Finally, athletes were classified as participants recruited specifically due to their sporting experience. Lastly, the direct comparisons between the strategies within the articles were extracted and presented using a contingency table showing the number of direct comparisons along the left-hand side of the diagonal line, and the right-hand side showing the percentage in which each trial significantly outperformed the other, in addition to nonsignificant findings.

Due to the variety of strategies meeting the criteria of “psyching-up”, the interventions were categorized into six types. Following the initial categorization, further sub-groups were developed to enable a more nuanced understanding of the efficacy of strategies in facilitating maximal force production. In the occurrence of articles combining multiple strategies, an additional category was created (category 4). The final categories and sub-groups are listed below:

1) Preparatory Arousal
    a) Prescribed Preparatory Arousal
    b) Self-Selected Preparatory Arousal
2) Self-Talk
    a) Motivational Self-Talk
    b) Instructional Self-Talk
3) Imagery
    a) Stimulus Only Imagery
    b) PETTLEP Imagery
    c) Emotive Imagery
4) PETTLEP Imagery & Motivational Self-Talk
5) Attentional Focus
    a) Internal Attentional Focus
    b) External Attentional Focus

6) Relaxation
7) Free-Choice Psyching-Up

RESULTS

Below we report the results of the systematic review. First, we summarize the literature search and sifting process. This is followed by a risk of bias findings for the included studies. We then report the main findings on whether psyching-up strategies influenced maximal force production overall, the efficacy of each strategy, and direct comparisons between strategies. Finally, we report the potential moderating effects of the control conditions and the level of competitive experience.

LITERATURE SEARCH

Figure 1 displays an overview of the search and screening process. The initial search identified 3,381 potential studies. Following the removal of duplicates, and the screening of titles and abstracts, the pool of potential articles was 33. The full text of these 33 articles was screened, which led to a further 12 papers being excluded. A further five papers were identified through the manual search processes, giving 26 included articles, containing 27 studies. Reasons for excluding studies at the full text stage included: the independent variable did not meet the criteria of psyching-up strategies (27% of rejected studies), the dependent variable was not a measure of maximal force production (18%), participants were younger than 18 years (9%), research design (27%), and the article was not published in a peer reviewed journal (18%). All the remaining articles were assessed for risk of bias, with all articles classified as at least a moderate risk of bias. The final articles are summarized in Table 1.

ASSESSMENT OF RISK OF BIAS

Overall, the risk of bias was deemed low or medium in all the items included on the checklist (Fig. 2). Of the 27 studies, 69% were rated as low risk, and 31% as medium risk. The greatest risk was the bias in the selection of the reported result, with 27% of the studies rated as medium within this

domain. Additionally, 15% of studies were rated as a medium risk of bias from the randomization process. Bias due to deviations from intended interventions, missing outcome data, and outcome measurement were all rated low in all the included studies.

DESCRIPTIVE CHARACTERISTICS OF INCLUDED STUDIES

The present review was based on a total population of 1022 (728 males, 256 females, 38 not specified). As presented in Table 2, from the retrieved 27 studies, 55% of samples were male only, with no female only samples. Regarding sample size, 74% of the studies recruited less than 60 participants. Only 26% of the retrieved articles recruited participants with notable competitive experience within sports.

MAIN FINDINGS

EFFECTS OF PSYCHING-UP STRATEGIES ON MAXIMAL FORCE PRODUCTION

Table 3 summarizes the effectiveness of psyching-up strategies on maximal force production. Overall, from the 26 articles, 93 effects were reported that compared an intervention to a control condition. From these comparisons, 60 (65%) reported that psyching-up interventions had positive effects on performance. Twenty-six (28%) of the comparisons indicated that there was no effect of psyching-up, and 11 (8%) comparisons reported a negative effect on performance when compared to a control condition.

PREPARATORY AROUSAL

The effect of preparatory arousal on maximal force production was examined in 11 studies that collectively reported 26 comparisons against a control condition. As presented in Table 3, 69% (*n* = 18) of the effects found that the preparatory arousal condition outperformed the control condition, whereas 4% (*n* = 1) of effects found that the control condition was superior. Further, when the intervention was prescribed, the percentage of comparisons in which the preparatory arousal

condition outperformed the control condition was 74% (*n* = 17). Self-selected preparatory arousal techniques only outperformed the control condition in 33% (*n* = 1) of trials, with the remaining trials reporting no difference between the control and intervention conditions. However, one study that used self-selected preparatory arousal strategies explored the moderating effect of competitive experience; it found that in highly experienced competitive athletes, they only outperformed the control condition with a self-prescribed strategy, whereas the participants with moderate competitive experience experienced greater performance enhancement through prescribed strategies (60).

SELF-TALK

The effect of self-talk on maximal force production was examined in six studies that collectively reported 11 comparisons against a control. As presented in Table 3, 82% (*n* = 9) of the effects found that the self-talk condition outperformed the control condition, with 9% (*n* = 1) reporting that the control condition was superior. Self-talk strategies were then categorized into the sub-groups of motivational and instructional self-talk. A selection of studies used the terminology 'self-efficacy', and after further investigations into the methodologies, these studies were categorized within the motivational self-talk group. Motivational self-talk consistently increased maximal force production, with 89% (*n* = 8) of the nine comparisons reporting that the motivational self-talk condition outperformed the control condition, whereas 11% (*n* = 1) reported negative effects. Conversely, only two studies examined instructional self-talk, and 50% (*n* = 1) found that self-talk outperformed the control condition and 50% (*n* = 1) reported no significant difference.

IMAGERY

The effect of imagery on maximal force production was examined in 10 studies that collectively reported 29 comparisons against a control. As presented in Table 3, imagery presented equivocal results with 52% (*n* = 15) of the effects found that the imagery condition outperformed the control

condition, and 10% (*n* = 3) of the effects found that the control condition was superior. When the imagery methodology was analyzed, the interventions were further subdivided into PETTLEP, stimulus only, and emotive imagery. PETTLEP imagery outperformed the control condition in 68% (*n* = 13) of the effects, with the remaining 32% (*n* = 6) not being statistically significant. Further, from the effects that were not significant, 67% (*n* = 4) originated from an article that tested how changing the duration between psyching-up and the output impacted performance, with the trials that were three and five minutes prior to the output finding no significant effects (16). Stimulus only imagery only outperformed the control condition in 33% (*n* = 2) of the comparisons, with the remaining 67% (*n* = 4) not statistically significant. None of the emotive imagery comparisons found that imagery outperformed the control condition, with the control condition significantly outperforming emotive imagery in 75% (*n* = 3) of the effects.

PETTLEP IMAGERY & MOTIVATIONAL SELF-TALK

A combination of PETTLEP imagery and motivational self-talk strategies was investigated in one article (43), which examined an effect on two outcome measures. As presented in Table 3, both (100%) of the effects found that the combination of strategies outperformed the control condition.

ATTENTIONAL FOCUS

The effect of attentional focus on maximal force production was examined in four studies that collectively reported nine comparisons against a control. As shown in Table 3, 44% (*n* = 4) of the effects found that the attentional focus condition outperformed the control condition, with the remaining 56% (*n* = 5) effects not statistically significant. Further subgroup analysis was performed on internal and external focused strategies. An internal focus outperformed the control condition in only 29% (*n* = 2) of the effects, with the remaining 71% (*n* = 5) effects not statistically significant. Conversely, both effects for externally focused cues found that the intervention outperformed the control condition.

RELAXATION

The effect of relaxation on maximal force production was examined in two studies that collectively reported three comparisons against a control. As presented in Table 3, the relaxation condition did not outperform the control condition in any of the trials, with 67% (*n* = 2) of the effects finding that the control condition was superior, and 33% (*n* = 1) that the conditions were not significantly different.

FREE CHOICE PSYCHING-UP

The effect of free choice psyching-up on maximal force production was examined in six studies that collectively reported 13 comparisons against a control condition. As presented in Table 3, 92% (*n* = 12) of the effects found that free choice psyching-up condition outperformed the control condition, whereas 8% (*n* = 1) were not statistically significant. From the six articles, only one (39) reported the participants' preferred strategy: attentional focus.

DIRECT COMPARISONS

As presented in Table 4, 29 direct comparisons were made between strategies within this review. From these comparisons, only seven significant differences were reported, with preparatory arousal significantly outperforming self-talk (*n* = 1), imagery (*n* = 2), and attentional focus (*n* = 2), and imagery also outperformed preparatory arousal (*n* = 2). The remaining 22 comparisons reported no significant differences between strategies.

MODERATOR VARIABLES

CONTROL CONDITION

The effects of psyching-up strategies were examined in 26 articles, across 27 studies, collectively reporting 93 comparisons against a control condition. Of these comparisons, 36 (39%) psyching-up interventions were compared against a passive control condition, and 57 (61%) were compared

against an active control condition. When interventions were compared against passive control conditions, 58% (*n* = 21) reported positive effects of the intervention. When compared against an active control condition, 68% (*n* = 39) reported positive effects for the intervention.

PARTICIPANT COMPETITIVE EXPERIENCE

The effect of the participants' competitive experience on the efficacy of the strategies was examined across the 27 studies. Of the 93 comparisons, 32 (34%) used undergraduate students, nine (10%) used novice participants, 25 (27%) used weight-trained individuals, and the remaining 27 (29%) used athletes. Just 53% (*n* = 17) of the comparisons that used undergraduates found the psyching-up condition outperformed the control condition, and 16% (*n* = 5) found that the control condition was superior. In novice participants, 56% (*n* = 5) of the effects indicated that psyching-up strategies outperformed the control condition, with 11% (*n* = 1) indicating that the control condition was superior. In weight-trained participants, 84% (*n* = 21) of the effects indicated that the psyching-up condition outperformed the control group, and 0% that the control condition was superior. Finally, in athletes, 63% (*n* = 17) of the effects indicated that the psyching-up condition outperformed the control condition, and 4% (*n* = 1) indicated that the control condition was superior.

SUMMARY

The majority of the trials within this review suggest a positive effect of psyching-up strategies. Prescribed-preparatory arousal strategies, motivational self-talk, PETTLEP imagery, external attentional focus, and free-choice psyching-up enhanced strength performance in over 67% of the trials. Trials that used an active control condition reported more consistent positive effects (68%) of psyching-up strategies, compared to passive control conditions (58%). Finally, trials that used participants with weight training experience provided the most consistent evidence of the efficacy of psyching-up strategies with 84% of trials facilitating performance, whereas only 53% of trials that used undergraduate students reported that strategies facilitated performance.

DISCUSSION

EFFECTS OF PSYCHING-UP STRATEGIES ON MAXIMAL FORCE PRODUCTION

The aims of the present review were to examine the efficacy of psyching-up strategies on maximal force production and assess the methodological quality of the studies and potential moderating factors. This review found 93 comparisons against control conditions, and 29 direct comparisons between interventions, derived from a total of 26 articles that contained 27 experimental studies. The results indicate that psyching-up strategies can facilitate maximal force production, with 65% of the comparisons demonstrating a positive effect. These results are based on research utilizing 12 variations of psyching-up strategies across various forms of maximal force production. The use of prescribed preparatory arousal, motivational self-talk, PETTLEP imagery, external attentional focus, and free choice psyching-up showed consistently positive effects on performance. Conversely, stimulus only imagery, internal attentional focus, and relaxation typically had no impact or adverse effects on performance.

PREPARATORY AROUSAL

The findings suggest that the utilization of preparatory arousal enhances performance across a variety of different maximal force outputs. These findings are consistent with previous attempts to collate the data investigating cognitive strategies on maximal force production (51, 54). Categorizing the strategies into subgroups suggests that most researchers have utilized prescribed cues rather than self-selected cues. Only one article investigated the effectiveness of self-selected cues, and found that only when the participants had high levels of competitive experience was performance was enhanced (60). With the relationship between physiological arousal and performance being dependent upon being in an optimal state (66), participants without sufficient experience of eliciting preparatory arousal cues and/or of the task could surpass or fail to reach this optimal level. This offers a potential explanation for the singular effect where the prescribed-arousal condition was

significantly outperformed by the control condition (13). Specifically, the novice participants were instructed to “get mad” prior to their trial so it might be that the participants exceeded the optimal arousal and therefore inhibited their performance. Overall the findings suggest that preparatory arousal cues can be an effective strategy to enhance performance, however, further investigation is required to determine the efficacy of self-selected cues.

SELF-TALK

Self-talk demonstrated favorable results, suggesting the strategy is effective for enhancing performance in force-production tasks. More specifically, 89% of the comparisons between motivational self-talk and a control condition reported a positive effect. Only two effects of instructional self-talk have been reported, with only one of these effects reporting that instructional self-talk condition outperformed the control condition. The strong support for the benefits of motivational self-talk on maximal force production, and limited and inconsistent evidence for instructional self-talk, align with the matching hypothesis (19). The theory proposes motivational self-talk is better suited to tasks requiring greater physical effort and energy expenditure, such as the tasks and outcomes in this review. Therefore, when engaging in self-talk strategies to maximize force-output, individuals should focus on motivational statements rather than instructional.

IMAGERY

Overall evidence for effects of imagery on maximal force production appear equivocal. However, PETTLEP imagery was generally effective, with stimulus and emotive imagery less so, albeit less researched. Four of the effects that did not support the efficacy of PETTLEP imagery came from a singular study, with the time intervals between the imagery script and the output acting as a moderator (16). The article found this across two outcome measures, with performing the strategy three and five minutes prior to the trial not significantly benefiting performance. In contrast, when the intervention was administered immediately, one or two minutes prior to the trial, the imagery

condition outperformed the control condition. When analyzing the efficacy of stimulus only imagery compared to PETTLEP imagery, our results indicate that PETTLEP is the most effective method to enhance performance. This is consistent with previous research (45, 63). Further, emotive imagery did not significantly enhance performance in any of the studies and was outperformed by the control condition in 75% of comparisons. Despite the limited body of evidence, we theorize a possible explanation for this. Due to the imagery scripts trial attempting to increase arousal through elevating emotions of fear and anger, this may have resulted in physiological arousal levels exceeding an optimal point (66).

FREE-CHOICE PSYCHING-UP

The present results suggest that allowing participants to select their own psyching-up strategy has a positive effect on maximal force production. Specifically, 92% of the trials utilizing free-choice psyching-up enhanced performance, with only one trial not facilitating performance (26). Unfortunately, only one article reported the preferred strategies of the participants (40). In a cohort of competitive weightlifters, attentional focus cues were the favored strategy while performing a hand dynamometer trial, although it was not reported whether the attentional cues were internally or externally focused. Regardless, the preference for attentional cues might reflect the high requirement of coordination and technical focus required within weightlifting (4). Further, 75% of the trials that investigated free-choice psyching-up used participants with a minimum of 12 months of experience weight-training. We speculate that the participants might have selected strategies they had previously used, become accustomed to, and developed a high level of belief in within their own training. Therefore, this could account for the high level of positive effects compared to other strategies. Additionally, in the two trials that directly compared free-choice psyching-up to an alternate strategy, none of the participants reported any competitive experience, potentially explaining the null findings from these comparisons (Table 4).

REMAINING STRATEGIES

Given the limited number of effects within this review for attentional focus, relaxation and strategy combinations, conclusive evidence was not found. The present review found inconsistent effects of attentional focus on maximal force production. However, categorizing the strategy into internal and external focus sub-groups did indicate a potential trend consistent with the constrained action hypothesis (27). The theory proposes that when focus is placed on internal cues, automatic motor processes that regulate movement are obstructed, thus inhibiting motor performance. Based on the current findings, an external attentional focus appears more effective than an internal focus, but more research is required.

When relaxation was utilized as a psyching-up strategy, it was significantly outperformed by the control condition in two of the three trials. Additionally, a relaxing emotive imagery condition was also outperformed by the control condition (29). Eliciting a parasympathetic state through relaxation strategies (8) might be sub-optimal for performance. While in a parasympathetic state, energy is conserved through decreasing the heart rate, enhancing digestion, and increasing enzyme and hormone production control sugar within the bloodstream (25). Conversely, when in a sympathetic state, blood flow towards the working muscles is increased, the uptake of oxygen and the elimination of carbon dioxide is maximized through relaxing the smooth muscles that surround the lungs, and greater availability of metabolic energy is provided through increased concentration of glucose and fatty acids in the blood (25). Thus, being in a sympathetic state is not just optimal for producing maximal force, it is essential. Therefore, future applications and research on psyching-up to enhance maximal-force production should consider alternatives to relaxation strategies.

The use of combined strategies was limited within this review to one article that examined PETTLEP imagery with motivational self-talk (44). The combination of strategies outperformed the control condition in both the half squat and the bench press exercise, whereas PETTLEP imagery with no self-talk did not elicit a significant difference from the control condition. Despite this providing a valuable premise on which to build future research, as the article did not also examine motivational

self-talk in isolation, further exploration is required to provide insight into the efficacy of this strategy combination.

DIRECT COMPARISONS

Direct comparisons between intervention strategies produced limited evidence of an optimal strategy. From the retrieved articles, nine studies containing 29 trials directly compared various interventions including preparatory arousal, self-talk, imagery, attentional focus, relaxation, and free-choice psyching-up. Only seven comparisons identified significant differences and there was no consistent trend amongst these. Most comparisons (76%) reported null findings. Due to limited research comparing strategies and some contradictory findings, there is no compelling evidence within this review for an optimal strategy.

MODERATOR VARIABLES

SAMPLE

The efficacy of psyching-up strategies might vary across different cohorts. Although the efficacy of strategies was higher in athletes compared to undergraduates and novice participants, the most consistent positive effect was found within weight-trained individuals. This might be due to athletes and weight-trained individuals having had previous experience using psyching-up strategies through leisure or sport, but also could reflect familiarity with the tasks and output measures. All six articles that recruited weight-trained individuals reported the participants had vast prior experience with the output, whereas only two (16, 17) of the seven articles that recruited athletes used an output measure that was specific to their respective sport. Although athletes' previous experience may have some transferability, the nature of the output could influence the effectiveness of the psyching-up strategy. Accordingly, future research should employ experienced participants, utilizing variables specific to their chosen population (54).

CONTROL CONDITIONS

A greater number of comparisons used an active control condition rather than passive. From the trials that utilized active control conditions, 68% of the interventions had positive effects, compared to 58% that used a passive condition (Table 3). An active control condition may prevent participants from unintentionally using a cognitive strategy, although it provides a risk of inhibiting performance by directing cognitive attention away from the task (17). Specifically, during active control conditions, participants were asked to complete mental arithmetic (e.g., 6, 13, 14) and reading tasks (e.g., 6, 32, 61), thereby increasing cognitive load on the participants. This increased cognitive load prior to tasks can decrease strength performance (15) and increase the risk of injury (24). As such, in comparisons involving active control conditions, the effect observed could, in part, be because the control condition hindered performance, as well as the psyching-up strategy enhancing performance.

METHODOLOGICAL QUALITY OF INCLUDED STUDIES

Overall, the body of evidence shows a low level of bias (69%). Failing to report pre-planned analysis and a lack of clarity over concealment and randomization processes contributed to some articles being rated as having a moderate risk of bias. Additionally, 19% of articles relied upon a sample size of less than 20 participants, raising potential risks of the statistical power and reproducibility of the results. Further, males accounted for 74% of the participants across the studies, and no studies recruited only female participants. Due to this, it is not clear if the efficacy of psyching-up strategies varies across sexes.

FUTURE RESEARCH DIRECTIONS

Intervention scripts within the articles often lacked specificity and could potentially inhibit performance, particularly when attempting to optimize arousal levels. Directions to the participants included being told to “get emotionally charged up”(14), “get mad, get pumped up, get charged up” (13), and ”get[ting] as mad and as charged up as you can”(61), often on participants with no

reported competitive experience. This highlights the necessity of investigating the methods currently used by practitioners, to enhance the ecological validity of the literature, allowing for more effective interventions to be prescribed within articles. Additionally, due to the definition emphasizing that psyching-up must be self-directed, various strategies currently performed by practitioners and athletes to psych-up may not be considered, such as watching videos (35), listening to music (2), or using ammonia (37). Although such strategies are commonly seen within sports, and considered part of the cognitive preparations of competition day (62), they were not considered within the parameters of this review. Accordingly, future research should focus on identifying the strategies practitioners and athletes currently use and perceive as beneficial to help bridge the gap between research and practice.

Analysis of strategies such as self-selected arousal cues and attentional focus have received limited research. Self-selected arousal cues have shown positive effects in participants with higher levels of competitive experience (60), while attentional focus was the preferred strategy of competitive weightlifters (40). Accordingly, research should place greater emphasis on investigating the efficacy of these strategies. In doing so, authors should evaluate the strategies used in practice, allowing practitioners to make more informed decisions regarding optimal strategies and how they are implemented. Additionally, this review found only one article that investigated the effects of combining strategies. Although the present review has highlighted limitations within the methodology, the premise of strategy combination should be further explored.

Analysis of the samples in the retrieved articles highlighted various potential nuances in the efficacy of the strategies. Despite the appealing nature of recruiting undergraduate students for accessibility, the current findings demonstrate disparity in the efficacy of the strategies compared to athletes, particularly weight-trained individuals. As previously stated, we theorize the higher efficacy in weight-trained individuals might be due to prior experience with the output measure and the interventions. Further, although 56% of the articles sampled only males, there was no article with a

specific focus on females, and no studies compared the efficacy of the intervention between the two sexes. Therefore, future research should focus on recruiting participants, preferably athletes, with equal numbers of males and females, and use an output measure specific to their sport. In doing so, analysis should be conducted to highlight any potential variation across males and females, which could provide insight to allow researchers and practitioners to prescribe the most effective strategy to an individual.

Investigation of the methods and research designs within the articles highlighted more positive effects in studies that used an active control condition (68%) compared to a passive control condition (58%). Future research should utilize passive control conditions, or a combination of active and passive control conditions, to prevent false positive effects being reported due to any potentially adverse influence of active control conditions. Additionally, despite 93 comparisons between intervention strategies and control conditions within this review, there were only 29 comparisons between different strategies. Further research that directly compares strategies is important to progress understanding of psyching-up and identify if there is an optimal strategy.

PRACTICAL IMPLICATIONS

The present findings suggest that psyching-up strategies can positively affect maximal force production. Based on current results, preparatory arousal, motivational self-talk, PETTLEP imagery, or a free-choice psyching-up strategy should be used immediately prior to the task to maximize performance. There was also some support for the use of an external attentional focus. Although the present review did not identify one optimal strategy, it has indicated some interventions that should potentially be avoided: Stimulus only imagery, emotive imagery, internal attentional focus, and relaxation. The number of effects within this review, however, prevents definitive recommendations.

The findings suggest that experienced athletes might benefit from having autonomy over the strategy they utilize for psyching-up. However, conversations with coaches should take place to maximize the effectiveness of the strategy. For example, one should consider content and timing, such as using PETTELP rather than stimulus only imagery, and within 2 minutes of performance (16). Finally, practitioners should ensure that if they are prescribing preparatory arousal strategies to inexperienced athletes, to do so with clear instructions to facilitate athletes achieving an optimal state.

LIMITATIONS

Despite following the PRIMSA 2020 guidelines, some limitations should be acknowledged in the current review. First, the categorization of strategies had potential overlap between the interventions. For example, emotive imagery could overlap with preparatory arousal or relaxation. To address this, when categorizing interventions and collating sample characteristics, we followed the terminology used by the authors of the primary studies for our classifications. Second, the current review excluded non-English studies, which might influence the findings, although a previous review into the effects of plyometric training found less than 0.5% of studies in that context did not use English (36). Third, gray literature was not included in this review, so the results may be subject to publication bias, where articles that fail to report significant or null findings are not published. Therefore, there is a possibility that the present article over-represents the value of psyching-up strategies. However, the publication process often ensures ethical and transparent research methodology, giving greater confidence that the included articles within this research have produced valid results. Finally, due to the heterogeneity of the methodologies used within the retrieved articles, a meta-analysis could not be performed. Though a meta-analysis would provide more precise findings, a review is inherently limited by the primary studies. However, through our data extraction, we have collated and presented the findings appropriately for the existing literature on psyching-up strategies.

CONCLUSIONS

The present review was the first to systematically examine the efficacy of psyching-up strategies on maximal force production, in addition to assessing the methodological quality of the studies and potential moderating factors. The findings suggest that psyching-up can have positive effects on maximal force production. The most consistent and positive evidence exists for preparatory arousal, motivational self-talk, PETTLEP imagery, and a free-choice psyching-up strategy. Future research should explore the strategies used by applied practitioners and athletes, and conduct research on athletes using tasks and outputs specific to their sport. Practitioners should allow experienced athletes autonomy in choosing their preferred strategy, while simultaneously guiding the athletes towards the strategies within this review that consistently enhance performance.

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Fig. 1. PRISMA flowchart illustrating the literature search at each stage. *PRISMA Preferred Reporting Items for Systematic Reviews and Meta Analyses*

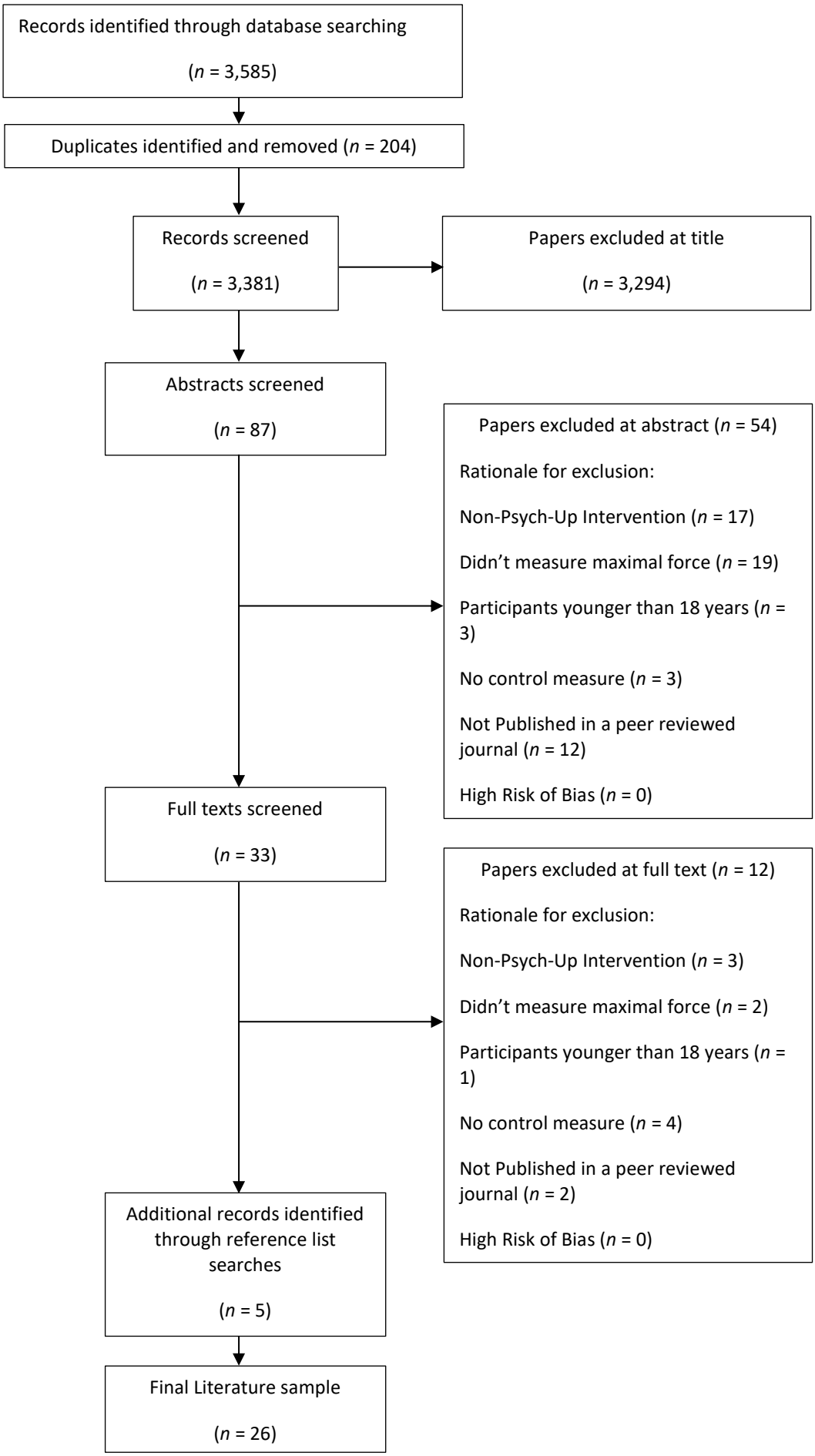

Fig. 2 Risk of Bias assessment for the retrieved articles collated in the present review

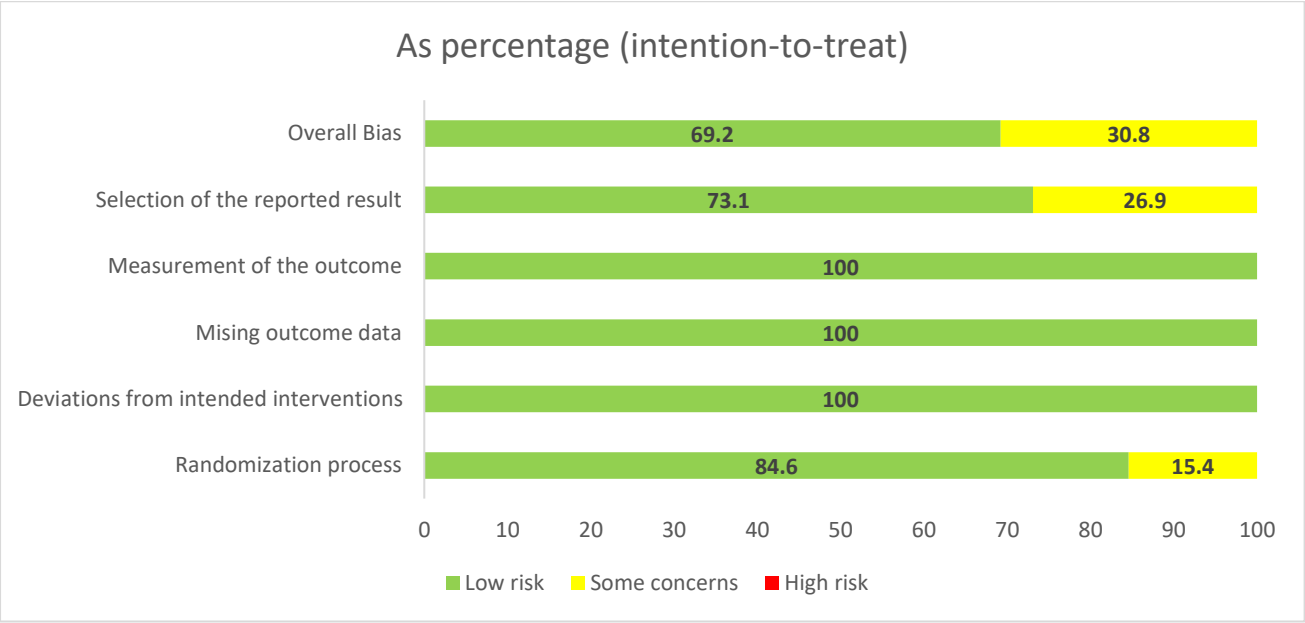

Table 1. Summary of the retrieved articles used within the review

Author	Design	Participants	Interventions		Control	Dependent Variable	Key Findings
			Type	Timing			
Bahari et al. (1)	Crossover	47 untrained M (22.4 years)	(a) Overt motivational ST (b) Covert motivational ST	Immediately prior	Passive	Grip Strength	No sig. diff interventions, both outperformed the control
Brody et al. (6)	Crossover	15 strength trained M (23.6 years)	Arousal cues	20s prior	(a) Reading Task (b) Mental Arithmetic	Isometric Elbow Flexion	No sig. effects on outcome
Charbaghi (7)	Crossover	47 untrained M (22.4 years)	Overt motivational ST	Immediately prior	Passive	Grip Strength	ST sig. outperformed control
Di Rienzo et al. (12)	Crossover	18 M terrestrial sport athletes (19.31 years)	(a) PETTLEP imagery (b) Relaxing imagery	During 60s timed rest	Passive	Elbow Flexion strength	PETTLEP imagery sig. outperformed relaxing and control conditions
Elko and Ostrow (13)	Mixed *2 (age) x 2 (sex) x 3 (interventions)*	(a) 15 M (59.93 years) and 15 F (60.33 years) (b) 15 M (22.14 years) and 15 F (20.96 years)	(a) Arousal cues (b) stimulus imagery	20s prior	Counting backward	Grip Strength	Imagery and control sig. outperformed arousal. No sig. difference between control and imagery conditions.

		No participant had prior experience in strength training.					
Gould, Weinberg and Jackson (14) Study 1	Mixed *2 (sex) x 5 (interventions)*	15 M and 15 F undergraduate students	(a) Internal focus (b) Stimulus imagery (c) Arousal Cues	20s prior	(a) Counting backward (b) passive	Knee Extension Strength	Both imagery and arousal sig. outperformed both controls and focus condition.
Gould, Weinberg and Jackson (14) Study 2	RCT *2 (sex) x 3 (interventions*)	30 M and 30 F undergraduate students	(a) Stimulus imagery (b) Arousal cues	20s prior	Pre-test passive	Knee Extension Strength	Arousal sig outperformed the control condition, with no other sig. differences found.
Hammoudi-Nassib et al. (16)	Crossover	16 M sprinters (20.6 years)	PETTLEP imagery	(a) Immediately prior (b) 1 min. prior (c) 2 min. prior (d) 3 mins. prior (e) 5 mins. prior	Counting backward	Straight Run Sprint (a) Acceleration (0-10m) (b) Overall Sprint (0-30m)	When performed immediately or 1 min or 2 mins prior imagery sig. enhanced performance of both initial acceleration (0-10m) and the overall sprint (0-30m).
Hammoudi-Nassib et al. (17)	Crossover	16 M sprinters (20.6 years)	(a) PETTLEP imagery (b) Arousal cues	30s prior	Focus on and estimate their own heart rate	Straight Run Sprint (a) Acceleration (0-10m) (b) Overall Sprint (0-30m)	Both imagery and arousal sig. outperformed the control condition for acceleration. For overall sprint only imagery made a sig. increase in performance.

McGuigan, Ghiagiarelli and Tod (26)	Mixed *2 (sex) x 2 (interventions)*	10 M (21.6 years) and 10 F (22.4 years) with a minimum of 1 year of weight training experience.	Free choice PU	30s prior	Counting backward	Back Squat 1RM	No sig. differences found
Murphy, Woolfolk and Budney (29)	Crossover	24 M undergraduate students	(a) Relaxing emotive imagery (b) Fearful emotive imagery (c) Anger emotive imagery	Immediately prior to the trial	Pre and post-test passive	Hand Grip Strength	Pre-test produced sig. greater strength performance, with relaxation scoring the sig. lowest strength performance.
Nadzalan et al. (30)	RCT	30 M provided with 6 weeks of resistance training.	(a) Internal focus (b) External focus	During the trial	Passive	(a) Back Squat 1RM (b) Deadlift 1RM	External focus sig. outperformed both control and internal focus on both outcome tasks, with no sig. difference between the latter two.
Perkins, Wilson and Kerr (32)	Crossover	22 M and 6 F elite explosive sport athletes (20.30 years)	1. Respiratory Rate (a) 10 Br.P.M (b) 20 Br. P.M 2. Arousal (a) Para-telic guided imagery (b) Telic guided imagery	Immediately prior	Reading task	(a) Grip Strength	The para-telic condition sig. outperformed both intervention types, with telic sig. outperforming the control task. No sig. effects were found for respiration rate.

Peynirciğlu, Thompson and Tanielian (34)	RCT	60 M and 60 F undergraduate students (20.7 years)	(a) Stimulus imagery (b) Arousal cues	Immediately prior	Arithmetic task	Grip Strength	Arousal sig. improved grip strength
Pierce et al. (35)	Crossover	7 M footballers (18.7 years)	(a) Arousal inducing videos*** (b) Relaxation ****not a PU strategy*	Immediately prior	Passive	(a) Bench Press 3RM (b) Bench Press 1RM	Arousal and control sig. increased 3RM bench press compared to relaxation, with arousal also sig outperforming control. Arousal sig. outperformed relaxation and control for the 1RM.
Shelton and Mahoney (40)	RCT	30 M Olympic weightlifters (23.4 years)	Free choice PU	10s prior	Counting backward	Grip Strength	Free choice PU sig. improved strength performance.
Shukri (41)	Crossover	45 M with at least 6 months of resistance training experience (21.20 years)	(a) motivational ST (b) Instructional ST	Immediately prior, and during the trial	Passive	Bench Press Maximum Repetitions	Motivational ST sig. improved strength performance
Slimani and Chéour (44)	RCT	44 M striking sport athletes (23.2 years)	10 weeks training learning: (a) PETTLEP imagery only (b) PETTLEP imagery and motivational ST	Immediately prior to and during the trial	Passive	(a) Bench Press 1RM (b) Half Squat 1RM	Imagery and motivational ST condition sig. outperformed the control group in both tasks. No more sig. differences were found.
Tenenbaum et al. (48)	RCT	38 untrained undergraduate students	4 weeks training learning:	Immediately prior	Passive	Knee Extension Strength	Control group sig. outperformed both motivational ST and relaxation

			(a) Motivational ST (b) Relaxation				
Theodorakis et al. (50)	RCT	27 M and 36 F undergraduate students (20.98 years)	(a) Motivational ST (b) Instructional ST	Immediately prior	Passive	Knee Extension Strength	Both ST groups sig. outperformed the control group
Tod, et al. (52)	Crossover	12 M (27.4 years) and 8 F with a minimum of 1 year experience with the output measure (20.9 years)	Free choice PU	30s prior to the trial	(a) Focus on and estimate their own heart rate (b) Counting backward	Bench Press	Free choice PU sig. outperformed both control conditions
Tynes and McFatter (56)	Crossover	36 resistance trained M (23.6 years)	(a) Motivational ST (b) Internal focus (c) Arousal Cues	Immediately prior	(a) Counting backward (b) passive	Knee Extension Strength	All PU strategies outperformed control, with arousal sig. outperforming focus and ST.
Weinberg, Gould and Jackson (57)	Mixed *2 (sex) x 2 (interventions).*	10 male and 10 female undergraduate students	Free choice PU	Immediately prior	Counting backward	Knee Extension Strength	PU sig. outperformed the control
Weinberg, Gould and Jackson (58)	RCT	40 M and 40 F undergraduate students	Free choice PU	(a) 15s prior to the trial (b) 30s prior to the trial (c) self-initiated	Passive pre-test	Knee Extension Strength	PU significantly outperformed the control, with no sig. differences found between durations.

			(d) yoked				
Weinberg, Jackson and Seaboune (59)	Crossover	24 M recruited from a local weightlifting class (18-28 years)	(a) PETTLEP imagery (b) Arousal cues (c) Free choice PU	30s prior to the trial	Counting backward	(a) Broad Jump (b) Pull Ups (c) Push Ups (d) Sit Ups	All 3 PU conditions outperformed the control condition across the 4 exercises, with no sig. difference being found between the PU conditions.
Whelan, Epkins and Meyers (60)	Mixed *3 (competition experience) x 4 (interventions)*	44 M and 42 F undergraduate students (30 high, 26 moderate, and 28 low competitive experience) *2 participants removed from data, no mention of gender or competition experience group.*	(a) Self-generated arousal (b) Arousal cues	45s prior	Focus on and estimate their own heart rate	Grip Strength	Low demonstrated no sig. performance increases. Moderate gained greatest performance from arousal cues. High gained greatest improvement from self-generated arousal.
Wilkes and Summers (61)	Mixed *2 (pre-post trials) x 5 (interventions)*	60 M undergraduate students	(a) Arousal Cues (b) Internal Focus (c) Stimulus Imagery (d) Motivational ST	20s prior to the trial	Reading task	Unilateral Knee Extension Strength	Arousal sig. outperformed imagery and control, with ST also outperforming the control.

RCT = Randomized Control Trial; M = Male; F = Female; ST = Self-Talk; PU = Psyching-Up; Br.P.M = Breaths Per Minute

Table 2. Sample characteristics of participants employed, and control conditions utilized in the reviewed articles

Characteristic	No. of Studies
Sex	
Male only	15
Female only	0
Combined	11
Not Stated	1
Sample Size	
<10	1
10-19	4
20-29	6
30-39	5
40-59	4
60+	7
Participant Label	
Undergraduate Student	10
Novice	4
Weight-Trained	6
Athlete	7
Control Conditions	
Passive	12
Active	13
Both	2

Table 3. Effects of each psyching-up strategy on maximal force production

	K	Number of K's supporting the effect			Sum code (%)
		+	-	0	
Psyching-Up Strategies					
Arousal					
Prescribed	23	17	1	5	74
Self-Selected	3	1	0	2	33
Total	26	18	1	7	69
Self-Talk					
Motivational ST	9	8	1	0	89
Instructional ST	2	1	0	1	50
Total	11	9	1	1	82
Imagery					
Stimulus Only	6	2	0	4	33
PETTLEP	19	13	0	6	68
Emotive Imagery	4	0	3	1	0
Total	29	15	3	11	52
PETTLEP Imagery & Motivational ST	2	2	0	0	100
Attentional Focus					
Internal Focus	7	2	0	5	29
External Focus	2	2	0	0	100
Total	9	4	0	5	44
Relaxation	3	0	2	1	0
Free Choice PU	13	12	0	1	92

Control Condition					
Passive	36	21	6	9	58
Active	57	39	1	17	68
Participant Label					
Undergraduate Student	32	17	5	10	53
Novice	9	5	1	3	56
Weight-Trained	25	21	0	4	84
Athlete	27	17	1	9	63
Total	93	60	7	26	65

K = Number of comparisons with a control condition; + = Indicates positive effects; - = Indicates negative effects; 0 = No effect; ST = Self-Talk; PU = Psyching-Up

Table 4. Direct comparisons of each intervention from the retrieved articles

	Arousal	Self-Talk	Imagery	Attentional Focus	Relaxation	Free-Choice
Arousal		A>ST=50% A<ST= 0% A=ST= 50%	A>I= 18% A<I=18% A=I= 64%	A>AF= 67% A<AF= 33% A=AF= 0%	A>R= 0% A<R= 0% A=R= 0%	A>FC=0% A<FC=0% A=FC= 100%
Self-Talk	2		ST>I= 0% ST<I= 0% ST=I= 100%	ST>AF= 0% ST<AF= 0% ST=AF= 100%	ST>R= 0% ST<R= 0% ST=R= 100%	ST>FC= 0% ST<FC= 0% ST=FC= 0%
Imagery	11	1		I>AF= 0% I<AF= 0% I=AF= 100%	I>R= 0% I<R= 0% I=R= 0%	I>FC= 0% I<FC= 0% I=FC= 100%
Attentional Focus	3	2	1		AF>R= 0% AF<R= 0% AF=R= 0%	AF>FC= 0% AF<FC= 0% AF=FC= 0%
Relaxation	0	1	0	0		R>FC= 0%
Free-Choice						

						R<FC= 0% R=FC= 0%
Free-Choice	4	0	4	0	0	

Above the diagonal line shows the percentage of the comparisons where an intervention significantly outperformed another intervention, in addition to how often there was not a significant difference. Below the diagonal line is the number of comparisons between the interventions.

A = Arousal; ST = Self-Talk; I = Imagery; AF = Attentional Focus; R = Relaxation; FC = Free Choice