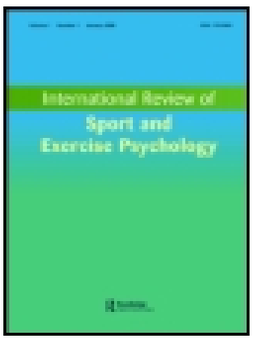

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Mindfulness and acceptance approaches to sporting performance enhancement: a systematic review

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ABSTRACT

Background: Mindfulness and experiential acceptance approaches have been suggested as a method of promoting athletic performance by optimally managing the interplay among attention, cognition, and emotion. Our aim was to systematically review the evidence for these approaches in the sporting domain. *Method:* Studies of any design exploring mindfulness and acceptance in athletic populations were eligible for inclusion. We completed searches of PsycINFO, Scopus, MEDLINE, and SPORTDiscus in May 2016. Two authors independently assessed risk of bias using the Cochrane Risk of Bias tool, and we synthesised the evidence using the GRADE criteria. *Results:* Sixty-six studies ($n = 3908$) met inclusion criteria. None of the included studies were rated as having a low risk of bias. Compared to no treatment in randomised trials, large effect sizes were found for improving mindfulness, flow, and performance, and lower competitive anxiety. Evidence was graded to be low quality, meaning further research is very likely to have an important impact on confidence in these effects. *Conclusions:* A number of studies found positive effects for mindfulness and acceptance interventions; however, with limited internal validity across studies, it is difficult to make strong causal claims about the benefits these strategies offer for athletes.

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Mindfulness; intervention; athlete; performance; flow; review

Optimising performance is considered one of most important goals in the field of sport and exercise psychology (American Psychological Association Division 47, 2016). Strategies to improve performance are typically directed toward either controlling the content of internal experiences or managing attention (Birrer, Röthlin, & Morgan, 2012). Meta-analyses have consistently established that optimal performance is associated with internal experiences like mood (Beedie, Terry, & Lane, 2000), self-confidence (Craft, Magyar, Becker, & Feltz, 2003; Moritz, Feltz, Fahrbach, & Mack, 2000; Woodman & Hardy, 2003), and anxiety (Jokela & Hanin, 1999). Content-focused interventions teach strategies that seek to directly alter the form or frequency of inner experience. For example, athletes may use progressive muscle relaxation (PMR) to reduce what is seen as problematic anxiety (Greenspan & Feltz, 1989), or positive self-talk to improve their confidence (e.g.

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'I can do it', Hatzigeorgiadis, Zourbanos, Galanis, & Theodorakis, 2011). To our knowledge, only one meta-analysis has been conducted on such content-focused interventions for performance, in which Hatzigeorgiadis et al. (2011) found a small–moderate pooled effect size for motivational self-talk, designed to influence arousal, confidence, or mood ($d = 0.37$, 95% confidence interval, CI [0.25, 0.49]). For other content-focused approaches like imagery and relaxation, studies have shown improvements in confidence and emotional control (Birrer & Morgan, 2010; Kudlackova, Eccles, & Dieffenbach, 2013; Mellalieu, Hanton, & Thomas, 2009; Vealey, 1994); few such studies have demonstrated significant effects on performance (e.g. $d = 0.24$, *ns*; Short et al., 2002).

Where these interventions attempt to deliberately change the content of thoughts and feelings, other approaches shift attention to the important components of skill execution. Meta-analyses on these interventions appear to have demonstrated stronger pooled effect sizes on performance. Where Hatzigeorgiadis et al. (2011) found small–moderate effect sizes of motivational self-talk, they found strong effects for instructional self-talk ('cues aiming at focusing or directing attention', p. 349) for fine motor skills (e.g. basketball free-throws, golf putting; $d = 0.83$, 95% CI [0.64, 1.02]). Goal setting, which is argued to 'direct attention and effort toward goal-relevant activities and away from goal irrelevant activities' (Locke & Latham, 2002, p. 706), has shown promise in sport and exercise settings. A meta-analysis of 36 goal-setting interventions found that moderately difficult goals were associated with the largest improvements in performance (effect size, ES = 0.53, 95% CI [0.45, 0.61]; Kyllo & Landers, 1995). Finally, Driskell, Copper, and Moran (1994) completed a meta-analysis on mental practice, which involves the cognitive rehearsal of a skill prior to physical execution. When looking at the skill execution that involved muscular strength, endurance, or coordination, they found a strong, significant effect size ($d = 0.78$). All three interventions appear more focused on shifting attention to useful cues, rather than controlling emotional states; however, the exact mechanism of action for these interventions is still debated (Locke & Latham, 2002; Wakefield, Smith, Moran, & Holmes, 2013). While these meta-analyses paid limited attention to the methodological rigour of the included randomised trials, the large effect sizes provide some support for the use of these interventions in athletic populations.

More recently, another class of interventions has been reported to also help athletes sustain task-focused attention, in this case by training open, non-reactive, present-moment awareness (Birrer et al., 2012). Mindfulness and acceptance interventions aim 'to promote a modified *relationship* with internal experiences (i.e. cognitions, emotions, and physiological sensations), rather than seeking to change their form or frequency' (Gardner & Moore, 2012, p. 309). They often emphasise the acceptance of internal processes as a typical part of the athletic experience, and focus on the present moment regardless of those internal processes (Baltzell, Caraballo, Chipman, & Hayden, 2014; Birrer et al., 2012; Gardner & Moore, 2007, 2012; Mosewich, Crocker, Kowalski, & Delongis, 2013). These interventions have largely drawn from psychotherapeutic approaches like mindfulness meditation (Kabat-Zinn et al., 1992), acceptance and commitment therapy (ACT; Hayes, Strosahl, & Wilson, 1999), and self-compassion interventions (Gilbert, 2009; Neff, 2003). Meta-analyses in the clinical domain have found these approaches to have a positive effect for various psychological conditions (e.g. depression, chronic pain, tinnitus; Brown, Glendenning, Hoon, & John, 2016; Khoury et al., 2013; Ost, 2014). More generally, meditative approaches have been shown to reduce anxiety, stress, and neurobiological markers such as cortisol, epinephrine, and norepinephrine (Chen et al., 2012; Chiesa & Serretti, 2010).

In the sporting domain, authors have argued that focusing on the present moment with acceptance facilitates the automatic execution of performance (Gardner & Moore, 2006, 2007, 2012). Birrer et al. (2012) suggested that athletes perform at their peak when executing skills with automaticity, and with open awareness to the context so they can make goal-directed adjustments. To use the case of a golfer, she performs best when open to environmental stimuli such as the wind, the lie of the ball, and the target, but executing her swing without conscious control. Theoretically, mindfulness and acceptance promote these characteristics because they reduce ironic rebound effects (Wegner, 1994) and reinvestment (Baumeister, 1984).

Ironic rebound effects refer to the process by which the desire to suppress thoughts and feelings leads to an increase in their presence and the attention paid to them (Wegner, 1994). Efforts to suppress cognitions, emotions, pain, and fatigue have been shown to lead to *increases* in the disruption caused by those processes (Wegner, 1994). Coming back to our golfer, a randomised crossover study found that telling her to 'not putt short' sometimes leads to increased gaze in front of the hole, which in turn led to shorter putts (Binsch, Oudejans, Bakker, & Savelsbergh, 2009). Mindfulness and acceptance approaches theoretically overcome ironic processes by fostering acceptance rather than suppression of the thought or feeling, allowing attention to be directed to more useful cues (Birrer et al., 2012).

Reinvestment is another process by which performance decrements can be accounted for by unhelpful shifts in attention (Masters & Maxwell, 2008). Reinvestment theory proposes that athletes perform less well under pressure when they direct conscious attention to the execution of the skill, rather than allowing the skill to be executed automatically (Baumeister, 1984; Beilock, Carr, MacMahon, & Starkes, 2002; Masters & Maxwell, 2008). Again, performance decrements could be induced in our golfer by asking her to dedicate attention to the steps required to make her putt (e.g. using cues 'arms, weight, head') rather than the characteristic of the putt as a whole (e.g. 'smooth'; Gucciardi & Dimmock, 2008). Mindfulness and acceptance approaches are proposed as an antidote to this process by noticing unhelpful shifts in attention to thoughts, feelings, or attentional foci, and instead redirecting attention to more useful, task-relevant cues (Birrer et al., 2012).

One systematic review has explored the effectiveness of mindfulness approaches in the sport and exercise domain (Sappington & Longshore, 2015). The review found preliminary support for the effectiveness of mindfulness interventions, but highlighted the need for interventions with greater internal validity. The review only included studies that explored mindfulness in isolation, and excluded the broader range of acceptance-based approaches (e.g. self-compassion; Mosewich, Kowalski, Sabiston, Sedgwick, & Tracy, 2011) that may facilitate performance via similar mechanisms of action (Birrer et al., 2012). As mentioned earlier, interventions under the mindfulness and acceptance umbrella operate by increasing contact with the present moment while accepting internal thoughts and feelings; however, interventions differ on the degree to which they focus on acceptance versus present-moment awareness, and the processes have been shown to differentially influence outcomes (Levin, Hildebrandt, Lillis, & Hayes, 2012). In addition, some mindfulness and acceptance interventions also focus on commitment to value-driven action (Moore, 2009) where others forgo this process entirely (e.g. Kaufman, Glass, & Arnkoff, 2009). Similarly, there is discord regarding the measurement of mindfulness, such as whether it is unidimensional or multi-dimensional, and if multi-dimensional, which dimensions are

important (Chiesa, 2013). While it is important to avoid grouping these interventions and outcomes as equivalent, reviews with broader eligibility criteria can assess the generalisability of findings for interventions that operate via similar mechanisms, and they provide a more comprehensive summary of the evidence base (O'Connor, Green, & Higgins, 2008).

Extending the work of Sappington and Longshore (2015), our review aimed to synthesise and critique the research on mindfulness and acceptance approaches in athletic populations. In order to evaluate the quality of the evidence, we chose the Cochrane Risk of Bias tool (Higgins & Altman, 2008) and the GRADE method of interpreting results (Schünemann, Oxman, Vist, et al., 2008). We included studies on athletes using any design to allow for a comprehensive review of the available research. Our primary outcome of interest was athletic performance; evidence regarding proposed mediators of performance (e.g. competitive anxiety) was also collected to explore the other benefits that these interventions may afford athletes.

Method

Eligibility criteria

The studies included in this review sampled participants competing in a sport, classified by SportsAccord (2015) as an activity that includes an element of competition, does not rely on luck, does not put animals or competitors at undue risk, and does not rely on proprietary equipment. We used a broad approach when selecting interventions because mindfulness and acceptance variables are conceptualised under a variety of titles. Studies needed to include mindfulness or acceptance as an independent variable, as defined earlier: one that aims 'to promote a modified *relationship* with internal experiences (i.e. cognitions, emotions, and physiological sensations)' (Gardner & Moore, 2012, p. 309). This definition includes concepts like self-compassion (Neff, 2003), the processes described in ACT (e.g. cognitive fusion/defusion, experiential avoidance/acceptance; Hayes et al., 1999), mindfulness, and various forms of meditation (e.g. transcendental meditation).

Rather than restrict the search to randomised controlled trials (RCTs), we included all study designs because other designs, such as non-randomised controlled trials and before–after designs, are recommended in systematic reviews when it would be beneficial to explore unexpected benefits, harms, and qualitative information that RCTs often neglect (Reeves, Deeks, Higgins, & Wells, 2008). We included both published and unpublished studies to reduce the influence of publication bias. For logistical reasons, the search was restricted to studies that were written in English. We included studies if they were published or completed (but unpublished) at any time before the date of the search.

Information sources

A search of titles, abstracts, and key words was conducted on 9 May 2016 for the following four databases: PsycINFO (database coverage: sixteenth century–present), Scopus (1970–present), MEDLINE (1946–present), and SPORTDiscus (1930–present). These databases were chosen due to their comprehensive date coverage and their use in related meta-analyses (Hatzigeorgiadis et al., 2011; Levin et al., 2012; Manzoni, Pagnini, Castelnuovo, &

Molinari, 2008). Reference lists were searched for any additional studies that would be eligible for inclusion. Additionally, authors of each included study were asked for any published or unpublished works on the topic. Finally, posts were placed on three list-serves (APA Div. 47, SPORTPSY, Association for Contextual Behaviour Science) to request any additional published or unpublished research.

Search strategy

The review team formulated search terms using the titles, abstracts, and keywords of existing meta-analyses (Hatzigeorgiadis et al., 2011; Kyllo & Landers, 1995; Levin et al., 2012), reviews (Birrer et al., 2012; Gardner & Moore, 2012; Sappington & Longshore, 2015), and empirical articles (e.g. Aherne, Moran, & Lonsdale, 2011; Mosewich et al., 2013; Ruiz & Luciano, 2012). Additionally, MEDLINE's Medical Subject Headings (MeSH) were used to identify synonyms for the included search terms.

Using the criteria above, two groups of keywords were developed to identify relevant populations and interventions, respectively: (a) Athlet* OR Sport* OR Players OR Exercise OR Performance OR 'Physical activity' OR 'Physical education' AND (b) Mindful* OR Meditation OR 'Present moment' OR 'Acceptance-based' OR 'MAC approach' OR 'Contemplative science' OR 'Acceptance and Commitment Therapy' OR 'Psychological flexibility' OR 'Experiential acceptance' OR 'Experiential avoidance' OR 'Cognitive fusion' OR Defusion.

Study selection

Results of the search were imported into Endnote (X7; Thomson Reuters, 2015) where duplicates were removed. Titles and abstracts were screened by two independent reviewers, and where discrepancies existed, the paper was included for full-text screening. Where full-texts were not available, we requested the paper from the author via email. Two authors independently screened all full-text articles. Discrepancies were resolved through discussion, with a third author consulted in cases where agreement could not be made.

Data collection process

After initial piloting of data-extraction forms, the first author extracted the data from each study and sent the extracted data to the primary author of that study for confirmation. As per the Cochrane Handbook, these authors were also asked open-ended questions about their methodology where the risk of bias was unclear (Higgins & Altman, 2008). Of the 58 authors for whom email addresses could be identified, 26 responded, and three reported minor inaccuracies, which were corrected by the first author. Another author also checked the data extraction.

Data items

We extracted the age, gender, sport, and sporting experience of the athletes in each study. Where an intervention was conducted, we extracted the study design, intervention content, intervention dose, and details about comparison group, as recommended in Higgins and Deeks (2008). We extracted effect sizes with confidence intervals (CIs)

when reported on primary outcomes, because they allow for more useful comparisons across studies (B. Thompson, 2002), and significance test where CIs were not available. To allow for more parsimonious conclusions, we extracted only composite scale results (e.g. dispositional mindfulness) rather than each subscale within measures (e.g. the Five Facet Mindfulness Questionnaire contains five subscales). Where two measures of a construct were reported (e.g. two measures of dispositional mindfulness), we calculated a mean of the two effect sizes for parsimony.

Performance data were extracted separately for measures of competitive performance (e.g. match performance, season-long scores) and measures of skill execution involving a contrived assessment (e.g. standardised free-throw shooting, non-competitive darts accuracy). As per existing meta-analyses in sport psychology (Hatzigeorgiadis et al., 2011), we coded the skills on two dimensions: We rated the skill as either novel or well learned based on the descriptions of the participants and the task; and we rated the skill as either fine (i.e. those requiring precision, accuracy, and dexterity such as shooting or darts) or gross (i.e. those requiring strength, endurance, and power such as cycling or running). For correlational studies, we extracted relationships between mindfulness or acceptance-focused variables and any other full scales. Finally, for qualitative studies, we extracted major themes from the analyses.

Risk of bias in individual studies

We chose the Cochrane Risk of Bias assessment because it has greater validity, sensitivity, and specificity than scales and checklists that measure bias (Higgins & Altman, 2008). While quantitative measures afford the reader a degree of parsimony, the weights placed on different domains are seldom justified, and many such measures confuse issues of validity with other methodological issues (e.g. whether authors report a power analysis, which relates more to precision than to validity; Higgins & Altman, 2008).

The Cochrane Risk of Bias assessment is a domain-based evaluation that guides reviewers to evaluate studies on the factors that meta-meta-analyses have shown to bias results (Higgins & Altman, 2008): concealed sequence generation, allocation concealment, blinding of participants and personnel, incomplete outcome data, and selective outcome reporting. Two authors then independently completed risk of bias judgments for the RCTs, because all non-randomised controlled trials and before–after designs included in this review had inherent biases and potential confounds. Again, disagreements were resolved through discussions between the two authors, and a third author was consulted to resolve disputes. This information was used in the synthesis to weight the findings with lower risk of bias, as per the GRADE method.

Synthesis of results

Few studies included in this review used similar interventions, comparison groups, or outcome measures, so quantitative syntheses of findings via meta-analyses were not likely to be meaningful (Deeks, Higgins, & Altman, 2008). Instead, as recommended in the Cochrane Handbook (Schünemann, Oxman, Higgins, et al., 2008), we created summary tables for each key outcome and compared the body of evidence with the GRADE criteria (Schünemann, Oxman, Vist, et al., 2008).

The GRADE approach allows reviewers to rate a body of evidence on the level of certainty surrounding the conclusions, from high quality (further research is very unlikely to change our confidence in the estimate of effect) to very low (any estimate of effect is very uncertain). These judgments are formed by evaluating the quality of the evidence (e.g. mostly randomised-controlled trials vs. mostly observational studies), then upgrading or downgrading the evidence on the basis of certain criteria (e.g. high risk of bias, imprecise results; Schünemann, Oxman, Vist, et al., 2008). To facilitate this process, standardised mean differences (*d*) were calculated using the conversion formula provided by Wilson (2001) to allow for some comparisons between studies. Calculations were performed by the first author and cross-checked by another author.

If possible, the dose for each study (in hours) was calculated using the information presented in the manuscript, and scatterplots were created to explore possible dose–response gradients. Two authors independently reviewed the tables, scatterplots, and risk of bias judgments, then collaboratively decided on the GRADE criteria for each outcome. Without enough studies of matching participants, interventions, and outcomes, it was not possible to assess some of the GRADE criteria; for example, 'unexplained heterogeneity in results' requires a series of sufficiently similar studies where differences in participants, interventions, comparisons, or outcomes do not explain heterogeneity. Similarly, publication bias is best assessed using a funnel plot (Sterne, Egger, & Moher, 2008), which usually requires more studies than were included for each outcome in our review.

Results

Study selection

After duplicates were removed, 5198 papers were screened by two authors at the title and abstract level (see Figure 1); 129 full-texts were reviewed, and 66 met the criteria to be included in the qualitative synthesis. The inter-rater reliability of full-text screening was high ($\kappa = .84$).

Study characteristics

The studies included 3908 athletes from a variety of sports and demographics ($M_{age} =$ 22.89 years). There was also a range of athletic experience from beginner to elite international athletes, with most studies including athletes competing at university level or higher. Complete study characteristics are provided in Table 1.

Forty-three studies evaluated an intervention. Of those, 17 were RCTs, 14 included a non-randomised control group, and 12 did not have a control. Finally, 21 studies used observational designs, usually correlational designs including mindfulness or acceptance variable along with a relevant outcome variable (e.g. performance). Effect sizes with CIs on primary outcomes were available for two of the 66 studies (Ivarsson et al., 2015; Zhang et al., 2016). Nine others reported CIs but on outcomes that were not included in this review: for example, subscale scores (Shaw, 2014), mediation models (Gustafsson et al., 2015) or pre–post differences in between-group designs (Goodman et al., 2014).

As mentioned earlier, no set of studies was sufficiently homogenous for a meaningful meta-analysis to be conducted. Of the RCTs, five studies tested mindfulness; two evaluated the mindfulness, acceptance and commitment (MAC) protocol; two examined

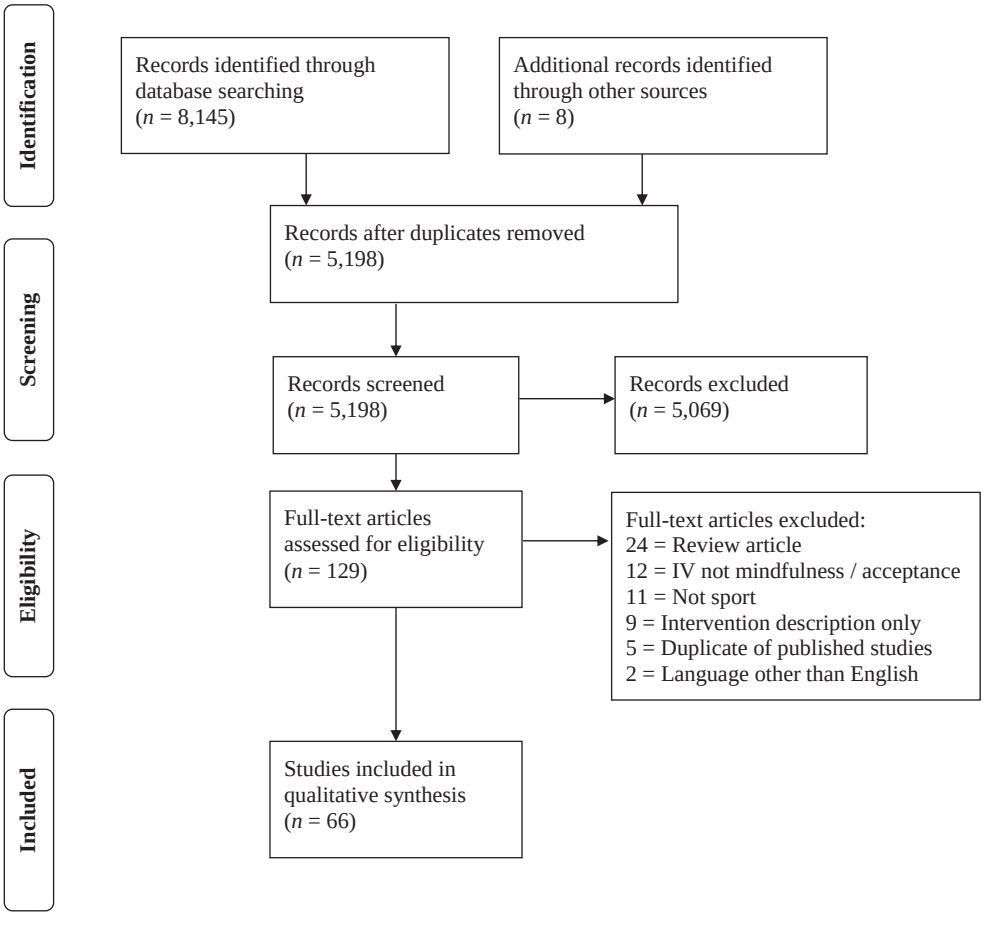

Figure 1. Flow diagram of search results.
Note: IV = independent variable.

transcendental meditation (TM); two investigated Acem meditation; and six explored other types of mindfulness or acceptance interventions. Of the mindfulness studies, three included comparisons with no treatment and three with other interventions. These studies could not be meaningfully aggregated because the reported outcomes varied between studies. This pattern of heterogeneity was consistent across other study designs. Instead of meta-analytic results, key findings are presented in Tables 2 through 5.

Risk of bias within studies

The non-randomised controlled trials we found were all judged to be high risk because the comparison groups varied systematically from the intervention group. For example, comparison groups were selected from: (a) a different training environment (Bernier et al., 2009, 2014; Kettunen & Välimäki, 2014); (b) a different sport (Baltzell & Akhtar, 2014); (c) a different level of competition (Goodman et al., 2014); (d) an online database (Ruiz & Luciano, 2012); or (e) because of their lower self-reported dysfunction (Bortoli et al.,

Table 1. Characteristics of included studies.

Citation	Participant descriptions w/*M* (*SD*)	Intervention	Comparison	Outcomes
Randomised controlled trials				
Aherne et al. (2011)	13 (4 female) athletes from various sports aged 21 (1.69) years from Ireland; national or international level	Mindfulness information sheet and mindfulness CD, postal only minute's contact, 110 min practice/week prescribed	NT	Dispositional mindfulness (CAMS-R); State flow (FSS 2)
Hall and Hardy (1991)	30 (15 female) beginner pistol shooters aged 18–23 years from USA	TM, group with TM expert, 6 × 100 min contact, 280 min practice/week prescribed	NT, VMBR	Skill execution (standardised marksmanship test)
Ivarsson, Johnson, Andersen, Fallby, and Altemyr (2015)	41 (10 female) soccer players aged 16.97 (0.79) years from Sweden; junior elite recruited from one school	MAC, group with first author, 7 × 45 min contact, various different activities prescribed	Sport psych presentation	Exploratory outcomes (injuries recorded by physiotherapists)
Jha (2015)	105 American football athletes aged from USA; Div. I college	Mindfulness, group with a trainer, 4 × 45 min contact, 84 min practice/week prescribed	Relaxation & visualisation	Competitive anxiety (STAI); exploratory outcomes (PSS, Sustained Attention Response Task)
John, Kumar, and Lal (2012)[a]	165 male shooters aged 29.4 (4.3) years from India; 3–5+ years at national level	Mindfulness, group with certified meditation instructor, 24 × 20 min contact	NT, music therapy	Skill execution (standardised shooting test)
Moen and Wells (2016)	78 (26 female) athletes from various sports aged 18.5 years from Norway; junior elite recruited from schools	ATT, *n*, 6 × 120–150 min contact, 60 min practice/week prescribed	NT	Dispositional mindfulness (MAAS); exploratory outcomes (ABQ)
Moen, Abrahamsen, and Furrer (2015)	77 (38 female) athletes from various sports aged 18.5 (16–20) years from Norway; junior elite recruited from schools	Mindfulness, group with experienced mindfulness coach, 4 × 120 min contact, 90–115 min practice/ week prescribed	NT	Dispositional mindfulness (MAAS); exploratory outcomes (ABQ, PSS, Athlete Satisfaction Questionnaire)
Mosewich et al. (2013)	51 female athletes from various sports aged 20.28 (1.75) years from Canada; current varsity athletes	SC, group with first author, 1 × 20 min contact, 50 min practice/week prescribed	Journalling	Exploratory outcomes (SCS, state rumination, state self-criticism, concern over mistakes)
Muangnapoe (1998)	48 (24 female) weightlifters aged 18–30 years from Thailand; elite & sub elite	AM, group, no description of personnel, 30 × 30 min contact, informal practice prescribed	PMR, stretching	Competitive anxiety (SCAT Thai, CSAI 2 Thai); exploratory outcomes (perceived uncertainty and importance of competition)
Ojaghi, Gholizade, and Mirheidari (2013)	40 table tennis athletes from Iran; professional athletes, premier league or first division	Mindfulness, group, no description of personnel, unclear dose	NT	Dispositional mindfulness (MAAS); competitive anxiety (CSAI 2); competitive performance (table tennis match scores)
Papanikolaou (2011)	40 male soccer athletes aged 10.1 (1.1) years from Greece	Various, group with first author, 24 × 30 min contact, various different prescribed	Video review	Exploratory outcomes (Test of Attentional and Interpersonal Style)

(*Continued*)

Table 1. Continued.

Citation	Participant descriptions w/*M* (*SD*)	Intervention	Comparison	Outcomes
Quinones Paredes (2014)	13 female soccer athletes aged 21.5 (19–24) years from USA; 7–20 years experience	Mindfulness, group, no description of personnel, 4 × 45 min contact, 135 min practice/week prescribed	Relaxation	Dispositional mindfulness (MIS, MAAS); dispositional flow (DFS 2); exploratory outcomes (WBSI)
Regan, Aitchison, and Grant (1998)	28 runners aged 24.4 (4.8) years from UK	Meditation, audio file, unclear dose, informal practice prescribed	NT	Competitive anxiety (STAI Y1); exploratory outcomes (body tension, perceived exertion, incredibly short Profile of Mood States, respiratory output)
Scott Hamilton, Schutte, and Brown (2016)	47 (5 female) cyclists aged 39.93 (11.53) years from Australia; competing at club level	MiCBT, group with first author, 8× ~90 min contact, 210 min practice/week prescribed	NT	Dispositional mindfulness (FFMQ); dispositional flow (DFS 2); competitive anxiety (SAS 2); exploratory outcomes (Sport Attributional Style Scale)
Solberg, Berglund, Engen, Ekeberg, and Loeb (1996)	25 (4 female) shooters aged median 25 (18–46) years from Norway; elite based on standardised test (NRAN > 236/250)	Acem, group, no description of personnel, unclear dose, 210 min practice/week prescribed	NT	Skill execution (standardised rifle shooting test); competitive performance (competitive performance over season); exploratory outcomes (tension visual analogue scale)
Solberg et al. (2000)	31 male runners aged 39 (36–42) years from Norway	Acem, group with experienced instructors, 7 × 150 min contact, informal practice prescribed	Autogenic training, problem solving	Competitive anxiety (STAI); exploratory outcomes (maximal and recovery oxygen uptake, stress induced lactate, resting and recovery heart rate)
Zhang et al. (2016)	43 (27 female) dart throwers aged 19.23 (1.27) years from China; amateur with no meditation experience	MAC, group with sport psychology consultants, 7 × 90 min contact, various different activities prescribed	Sport psych lectures	Dispositional mindfulness (FFMQ); dispositional flow (short DFS); skill execution (standardised dart throwing accuracy); exploratory outcomes (AAQ II)
Crossover randomised controlled trials				
Buscombe et al. (2014)	9 (2 female) athletes from various sports aged 31.56 (22–44) years from UK; amateur	TM and Zazen, 1:1 with authors, experienced in all three approaches, 1× U min contact, 140 min practice/week prescribed	Ratio breathing	Exploratory outcomes (electro encephalography respiration rate, electromyography, blood volume pulse, sense of coherence, qualitative, open-ended responses)

Non-randomised controlled trials				
Baltzell and Akhtar (2014)[b]	42 (52 female) soccer and rowing athletes from USA; varsity Div. I	MMTS, group with expert insight meditation teacher, 12 × 30 min contact, 70 min practice/week prescribed	NT	Dispositional mindfulness (MAAS); exploratory outcomes (Psychological Well Being Scale, PANAS, SWLS)
Bernier, Thienot, Codron, and Fournier (2009)	7 (2 female) golfers aged 15.67 (0.74) years from France; junior elite (4–10 years)	ACT & MBCT + PST, group with researcher, 5 years. in PST, 5× U min contact, ∼20 min practice/week prescribed	PST alone	Exploratory outcomes (Ottawa Mental Skills Assessment Tool 3, Qualitative interviews)
Bernier, Thienot, Pelosse, and Fournier (2014)	7 female figure skaters aged 12.57 (0.73, 12–14) years from France; national top 3	ACT & MBCT, 1:1 with researcher, 6 years as sport psychology consultant, ∼16 × 40 min contact, 70 min practice/week prescribed	NT	Competitive performance (average performance at national competitions); exploratory outcomes (customised awareness and acceptance scale)
Bortoli, Bertollo, Hanin, and Robazza (2012)	15 (7 female) rifle & pistol shooters aged 27.9 (8.1, 20–47) years from Italy; top-level international	MAP, 1:1 with author, sport psychology consultant, 12 × 150 min contact	NT	Exploratory outcomes (self-reported behavioural indicators)
Goodman, Kashdan, Mallard, and Schumann (2014)	26 male athletes from various sports aged 20.23 (1.53) years from USA; NCAA Div I.	MAC + Hatha yoga, group with licensed clinical psychologist, 500 hr yoga instructor, 8 × 90 + 8 × 60 (yoga) min contact, various different activities prescribed	NT	Dispositional mindfulness (MAAS); exploratory outcomes (AAQ II, Tolerance of Negative Affect, Adult Hope Scale, PSS, Valued Living Questionnaire, Short Grit Scale, Drexel Defusion Scale, DASS 21)
Hasker (2010)	19 (8 female) athletes from various sports aged 19.4 (18–23) years from USA; NCAA Div II.	MAC, group with two clinical psychology doctoral students, 7 × 60 min contact	Mental training	Dispositional mindfulness (FFMQ); state flow (FSS); Competitive performance (coach and athlete self-report); Exploratory outcomes (AAQ, WBSI, Mini Markers of Big 5 Personality Traits)
Kettunen and Välimäki (2014)	49 female floorball players aged 21.79 (17–38) years from Finland; 9.50 years experience ($SD = 3.1$)	ACT, group with two psychology masters students, 6 × 60 min contact, various different activities prescribed	NT	Dispositional mindfulness (FFMQ); Competitive performance (coach and athlete self-report); Exploratory outcomes (AAQ II, PSS, Mental Health Continuum Short Form, sport self-confidence measure, Group Environment Questionnaire)
Little and Simpson (2000)	7 female softball players aged 20 (18–24) years from USA; >8 years, NCAA Div I.	Acceptance based, 1:1 with sport psychology consultant, unclear dose, informal practice prescribed	NT	Competitive performance (batting, pitching, fielding statistics); exploratory outcomes (WBSI, Fear of Sadness Test, Frequency and Suppression of Thoughts During Competition Questionnaire)

(*Continued*)

Table 1. Continued.

Citation	Participant descriptions w/*M* (*SD*)	Intervention	Comparison	Outcomes
Longshore and Sachs (2015)	20 (12 female) Div I. coaches from various sports aged 34.5 (9.87) years from USA	Mindfulness, group with first author, 1 × 90 min contact, 140 min practice/week prescribed	NT	State and dispositional mindfulness (TMS: MAAS); competitive anxiety (STAI); exploratory outcomes (PANAS, Brunel Mood Scale, qualitative interviews)
Pineau (2014)	55 (29 female) cross-country runners aged 19.35 years from USA; Div I.	MSPE ± SC, group with author or licensed clinical psychologist, 6 × 90 min contact, daily practice encouraged	NT	State and dispositional mindfulness (TMS, PHLMS, FFMQ); state and dispositional flow (FSS 2, DFS 2); competitive anxiety (SAS, CSAI 2R); competitive performance (objective and self-reported race times); exploratory outcomes (Eating Attitudes Test, Multidimensional Body Self Relations Questionnaire, Body Image Coping Strategies Inventory, SCS, CSCI, Thoughts During Running Scale)
Ruiz and Luciano (2012)	5 male chess players aged 23–50 years from Spain; grand master ranking	ACT, 1:1 with author, experienced chess player, 2 × 120 or 3 × 75 min contact	NT	Competitive performance (International Ranking, Elo, 1978); exploratory outcomes (AAQ II, Chess Counterproductive Reactions Questionnaire, believability and interference questions)
Shaw (2014)	51 (14 female) taekwondo athletes aged U (18–70+) years from USA; mostly beginners	ACT, group with licensed psychologist, 1 × 180 min contact	NT	Dispositional mindfulness (FFMQ); exploratory outcomes (PSS, qualitative interviews)
Wolanin and Schwanhausser (2010)	20 female volleyball & field hockey players from USA; NCAA Div I.	MAC, group with 2 clinical psychology doctoral students, 7 × 40 min contact	NT	Competitive anxiety (SAS); competitive performance (coach ratings); exploratory outcomes (Metacognitions Questionnaire, Generalized Anxiety Disorder Scale, Quality of Athletic Life Inventory)
Cohort/case studies				
De Petrillo, Kaufman, Glass, and Arnkoff (2009)[c]	25 (15 female) runners aged 34.73 (18–55) years from USA; 6.68 years experience	MSPE, group with first author, 4 × 150–180 min contact, encouraged to listen to mindfulness CD		State and dispositional mindfulness (TMS, KIMS); competitive anxiety (SAS); competitive performance (self-

			reported best mile time); exploratory outcomes (MPS, TOQS)
Furrer (2014)[d]	29 (14 female) athletes from various sports aged 18.5 (18–20) years from Norway; junior elite recruited from schools	Mindfulness, group session with experienced mindfulness coach, 4 × 120 min contact, 210 min practice/week prescribed	Dispositional mindfulness (MAAS); exploratory outcomes (PSS, Athlete Satisfaction Scale, ABQ)
Gardner and Moore (2004)	2 (1 female) athletes from various sports aged 29.5 (22–39) years from USA; elite	MAC, 1:1 session with author of protocol, 12–16 × 60 min contact, mindfulness prescribed for home	Competitive anxiety (SAS); exploratory outcomes (AAQ, PSWQ)
Haase et al. (2015)	7 BMX riders aged 21.86 (3.67) years from USA; national representatives	mPEAK, unclear mode of administration, 4 × 180 + 6 × 90 min contact, 210 min practice/week prescribed	Dispositional mindfulness (FFMQ); exploratory outcomes [Multidimensional Assessment of Interoceptive Awareness, Toronto Alexithymia Scale, neural response to stress (fMRI inspiratory breathing load)]
Jouper and Gustafsson (2013)	1 female shooter from Sweden; 'top international athlete'	Mindfulness and Qigong, 1:1 with weekly phone or email, unclear dose, 190 min practice/week prescribed	Exploratory outcomes (ABQ, Stress Energy Scale, daily concentration rating)
Kaufman et al. (2009)[c]	32 (9 female) archers & golfers aged 52.19 (18–76) years from USA; recreational	MSPE, manualised treatment with no description of presenter experience, 4 × 150–180 min contact, 165–270 min practice/week prescribed	State and dispositional mindfulness (TMS, KIMS); state and dispositional flow (FSS 2, DFS 2); competitive anxiety (SAS); competitive performance (best score for year, average score for week); exploratory outcomes (MPS, TOQS, CSCI)
Kingma (2014)	5 male golfers aged 53.6 (10.7) years from South Africa; handicaps ≤ 15	MSPE + Schema, delivered by principal researcher, counselling psychologist with >5 years mindfulness experience, 4 × 90 min contact, 50–150 min practice/week prescribed	Dispositional mindfulness (MAAS); exploratory outcomes (Self Consciousness Scale Revised, psychological momentum)
Lutkenhouse (2007)	1 female lacrosse athlete aged 19 years from USA; NCAA Div I.	MAC, 1:1 session with clinical and sport psychology doctoral student, 7 × U min contact, regular practice encouraged	Competitive anxiety (SAS); competitive performance (self-reported lacrosse performance); exploratory outcomes (AAQ R, PSWQ)
Mahoney and Hanrahan (2011)	4 (2 female) athletes from various sports aged 18–49 years from Australia	ACT, 1:1 session with masters student trained in ACT, 4× U min contact	Dispositional mindfulness (MAAS); exploratory outcomes (Sport Injury Anxiety Scale, AAQ II)
Mosewich, Baranoff, and Immink (2016)	1 female athlete from Australia; elite individual sport	SC + Mindfulness, 1:1 session, no description of personnel, 6× U min contact, daily practice encouraged	Qualitative interviews

(*Continued*)

Table 1. Continued.

Citation	Participant descriptions w/*M* (*SD*)	Intervention	Comparison	Outcomes
Perret (2014)	7 (4 female) athletes from various sports aged 18.86 (3.52) years from USA	ACT, 1:1 session with 5 different clinical psychology PhD students, each with 2 years ACT experience, 6 × 90 min contact, various different activities prescribed		Dispositional mindfulness (FFMQ); Exploratory outcomes (AAQ II, Cognitive Fusion Questionnaire, Rehabilitation Adherence Measure for Athletic Training, Psychological Inflexibility in Pain Scale)
Schwanhausser (2009)	1 male diver aged 12 years from USA; 'high level'	MAC, 1:1 session with sport psychology doctoral student, 7 × 45 min contact		Dispositional mindfulness (MAAS, PHMS); state and dispositional flow (FSS 2, DFS 2); competitive anxiety (SAS); competitive performance (scores in diving competition); exploratory outcomes (AAQ II)
Observational designs				*Outcomes*
Baranoff, Hanrahan, and Connor (2015)	44 (17 female) athletes from various sports aged 27 (9.4) years from Australia; athletes postanterior cruciate ligament reconstruction			Exploratory outcomes (AAQ, Pain Catastrophising Scale, Athletic Identity Measurement Scale, DASS 21, Brief Coping Orientations to the Problem Experience)
Blecharz et al. (2014)	10 male soccer players aged 18.14 (1.56) years from Poland; 9.33 years experience (*SD* = 2.64)			Dispositional mindfulness (Freiburg Mindfulness Inventory); skill execution (standardised shooting test); exploratory outcomes (task-related self-efficacy, team, peer, and leadership self-efficacy)
Cathcart, McGregor, and Groundwater (2014)	92 (36 female) athletes from various sports aged 18 (2.6) years from Australia; elite athletes			Dispositional mindfulness (FFMQ); dispositional flow (DFS 2)
Chang, Chi, Lin, and Ye (2015)	76 (32 female) athletes from various sports aged 20 (1.4) years from Taiwan; university athletes			Exploratory outcomes (AAQ II Taiwanese, Center for Epidemiological Studies Depression Scale)
Denny and Steiner (2009)	140 (61 female) athletes from various sports aged 19.4 (1.51, 16–24) years from USA; university athletes			Dispositional mindfulness (MMS); exploratory outcomes (Locus of Control, Weinberger Adjustment Inventory)
Diaz (2009)	79 female equestrian athletes aged U (18–66+) years from USA; 28.5 years experience (range = 1–62)			Dispositional mindfulness (CAMS R); exploratory outcomes (State and Trait Sport Confidence Inventory, Assessment of Schema Polarity Profile, TEOSQ)
Furrer (2014)	382 (116 female) athletes from various sports aged 18.5 (17–20) years from Norway; junior elite			Dispositional mindfulness (MAAS); exploratory outcomes (PSS, Athlete Satisfaction Questionnaire, ABQ)
Gooding and Gardner (2009)	43 male basketball players aged 19–24 years from USA; NCAA Div. I			Dispositional mindfulness (MAAS); competitive anxiety (SCAT); skill execution (non-competitive free throw test); exploratory outcomes (duration of in-game pre-shot routine)
Gustafsson, Davis, Skoog, Kenttä, and Haberl (2015)	233 (107 female) athletes from various sports aged 17.50 (1.08) years from Sweden; high school athletes in national talent programme			Dispositional mindfulness (MAAS); exploratory outcomes (ABQ, PSS, PANAS)
Hanneman (2013)	90 (32 female) runners aged 24.1 (3.49) years from USA; healthy undergraduates			Dispositional mindfulness (FFMQ); exploratory outcomes (Ratings of Perceived Exertion via treadmill test, Body Awareness Questionnaire, Exercise Self Efficacy Scale)
Housley (2009)	146 (42 female) runners & divers aged 32.04 (16–68) years from USA; 1–50 years experience			Skill execution (standardised diving test); exploratory outcomes (AAQ, Eysenck Personality Inventory, self-efficacy measure)
Kee and Wang (2008)	182 (80 female) athletes from various sports aged 22.3 (1.98) years from Singapore; interuniversity athletes			Dispositional mindfulness (MMS); dispositional flow (DFS 2); exploratory outcomes (Test of Performance Strategies)

McCarthy (2011)	52 (36 female) athletes from various sports aged 19.76 (1.3, 18–21) years from USA; NCAA Div. III	Dispositional mindfulness (KIMS); exploratory outcomes (TEOSQ)
Mosewich et al. (2011)	151 female athletes from various sports aged 15.1 (1.2) years from Canada; recreational –international	Exploratory outcomes (SCS, Rosenberg Self Esteem Scale, Test of Self Conscious Affect for Adolescents, Social Physique Anxiety Scale, Obligatory Exercise Questionnaire, Objectified Body Consciousness Scale for Youth, Performance Failure Appraisal Inventory, Fear of Negative Evaluation Scale)
Pineau, Glass, Kaufman, and Bernal (2014)	58 (41 female) rowers aged 28.43 (14–60) years from USA; 3.58 years experience (range = 0–10)	Dispositional mindfulness (FFMQ); dispositional flow (DFS 2); exploratory outcomes (CSCI, individual and team rowing efficacy)
Rafeeque and Sultana (2016)	323 (161 female) track & field athletes aged 18–22 years from India; interuniversity athletes	Dispositional mindfulness (MMS); competitive performance (coach and self-ratings); exploratory outcomes (Mental Toughness Scale)
Röthlin, Horvath, Birrer, and Holtforth (2016)	133 (72 female) athletes from various sports aged 23.68 (6.12) years from Switzerland; national representatives	Dispositional mindfulness (Comprehensive Inventory of Mindfulness Experiences); competitive anxiety (Competition Anxiety Inventory); competitive performance (self-ratings)
Sarnell (2012)	197 female lacrosse athletes aged 14.42 (1.65, 11–18) years from USA; 6.69 years experience (*SD* = 2.16)	Dispositional mindfulness (Children's Acceptance and Mindfulness Measure); competitive performance (coach ratings); exploratory outcomes (Sport Commitment Scale, Sport Motivation Scale)
Steinberg (2011)	114 (42 female) rock climbers aged 29.9 (7.1, 19–61) years from USA; 7.8 years (*SD* = 7.16)	Dispositional mindfulness (MAAS); exploratory outcomes (PANAS, SWLS)
Thienot et al. (2014)	343 (165 female) athletes from various sports aged 23.14 (5.87) years from Australia; elite & sub elite	Dispositional mindfulness (MIS, MAAS); dispositional flow (DFS 2); competitive anxiety (SAS 2); exploratory outcomes (Personal Standards Perfectionism, Evaluative Concern Perfectionism, Rumination from Emotional Control Questionnaire 2)
Wicks (2012)	5 female equestrian athletes aged 13–18 years from USA; 6.6 years experience	Exploratory outcomes (qualitative interviews)

Notes: U = unclear from manuscript; NCAA = National Collegiate Athletic Association; fMRI = functional magnetic resonance imaging. Interventions: NT = no treatment; ACT = acceptance and commitment therapy; AM = anapanasati meditation; ATT = attention training technique; MAC = mindfulness acceptance commitment; MAP = multi action plan; MBCT = mindfulness based cognitive therapy; MBSR = mindfulness based stress reduction; MiCBT = mindfulness integrated cognitive behaviour therapy; MMTS = mindfulness meditation training for sport; mPEAK = mindful performance enhancement, awareness and knowledge; MSPE = mindful sport performance enhancement; PST = psychological skills training; SC = self compassion; TM = transcendental meditation. Measures: AAQ = Acceptance and Action Questionnaire; ABQ = Athlete Burnout Questionnaire; CAMS = Cognitive and Affective Mindfulness Scale; CSAI = Competitive Sport Anxiety Inventory; CSCI = Carolina Sport Confidence Inventory; DASS = Depression Anxiety Stress Scale; DFS 2 = Dispositional Flow Scale; FFMQ = Five Facets of Mindfulness Questionnaire; FSS 2 = Flow State Scale; KIMS = Kentucky Inventory of Mindfulness Skills; MAAS = Mindful Attention Awareness Scale; MIS = Mindfulness Inventory for Sport; MMS = Mindfulness/Mindlessness Scale; MPS = Multidimensional Perfectionism Scale; NRAN = National Rifle Association of Norway; PANAS = Positive and Negative Affect Scale; PHLMS = Philadelphia Mindfulness Scale; PSS = Perceived Stress Scale; PSWQ = Penn State Worry Questionnaire; SAS = Sport Anxiety Scale; SCAT = Sport Competition Anxiety Test; SCS = Self Compassion Scale; STAI = State and Trait Anxiety Inventory; SWLS = Satisfaction with Life Scale; TEOSQ = Task and Ego Orientation in Sport Questionnaire, TMS = Toronto Mindfulness Scale; TOQS = Thought Occurrence Questionnaire for Sport; VMBR = Visuomotor behaviour rehearsal; WBSI = White Bear Suppression Inventory.

[a]Cortisol data from John, Kumar, and Lal (2011).

[b]Qualitative data from Baltzell et al. (2014).

[c]Follow-up data from Thompson, Kaufman, De Petrillo, Glass, and Arnkoff (2011).

[d]Qualitative data from Furrer, Moen, and Firing (2015).

Table 2. Consensus risk of bias for randomised controlled trials.

Citation	Overall risk of bias	Sequence generation	Allocation concealment	Blinding	Incomplete data	Selective reporting	Other bias
Aherne et al. (2011)	?	?[a]	?[a]	?[a]	+	?[e]	+
Hall and Hardy (1991)	?	?[a]	?[a]	?[a]	+	?[e]	+
Ivarsson et al. (2015)	?	?[a]	?[a]	–[c]	?[a]	?[e]	–[g]
Jha (2015)	–	?[a]	?[a]	?[a]	–[d]	–[f]	?[g]
John et al. (2012)	?	?[a]	?[a]	?[a]	–[d]	?[e]	+
Moen and Wells (2016)	–	?[a]	?[a]	?[a]	–[d]	?[e]	–[g]
Moen et al. (2015)	?	?[a]	?[a]	?[a]	–[d]	?[e]	?[g]
Mosewich et al. (2013)	–	+	?[a]	–[c]	+	?[e]	+
Muangnapoe (1998)	–	?[a]	?[a]	–[c]	?[a]	–[f]	+
Ojaghi et al. (2013)	–	?[a]	?[a]	?[a]	?[a]	?[e]	–[h]
Papanikolaou (2011)	–	?[a]	?[a]	–[c]	?[a]	–[f]	+
Quinones Paredes (2014)	?	?[a]	?[a]	?[a]	–[d]	?[e]	?[g]
Regan et al. (1998)	–	?[a]	?[a]	?[a]	?[a]	?[e]	–[h]
Scott Hamilton et al. (2016)	–	+	?[a]	–[c]	–[d]	?[e]	+
Solberg et al. (1996)	–	?[a]	?[a]	–[c]	?[a]	?[e]	–[h]
Solberg et al. (2000)	–	?[a]	?[a]	–[c]	–[d]	?[e]	–[g]
Zhang et al. (2016)	–	+	–[b]	–[c]	+	?[e]	+

Notes: + = low risk of bias; ? = unclear risk; – = high risk of bias; a = unclear description in manuscript or from author's response; b = transparent allocation sequence; c = authors appeared to provide intervention and control; d = significant dropout with inadequate analyses; e = no protocol; f = measures collected but not adequately reported; g = risk of baseline discrepancies; h = inadequate reporting of methods.

2012; Little & Simpson, 2000). Similarly, none of the before–after comparisons included sufficient controls to be considered low risk of bias. As a result, Table 2 contains the risk of bias assessment for the RCTs, with all other studies considered high risk.

Quality of evidence for improving mindfulness

As outlined in Table 3, seven RCTs have explored the influence of mindfulness and acceptance interventions for promoting mindfulness as a presumed facilitator of performance (Aherne et al., 2011; Moen et al., 2015; Moen & Wells, 2016; Ojaghi et al., 2013; Quinones-Paredes, 2014; Scott-Hamilton et al., 2016; Zhang et al., 2016). Risk of bias was judged to be low in none of these studies. Effect sizes ranged from very low (Moen et al., 2015; Quinones-Paredes, 2014) to very high (Aherne et al., 2011; Moen & Wells, 2016; Zhang et al., 2016). Sample sizes were generally small ($n_{mean} = 44$, range = 13–78), and the only reported confidence interval was very wide (95% CI [0.79, 2.14]; Zhang et al., 2016). All effect sizes for non-randomised controlled trials were all positive. All before–after comparisons showed positive effect sizes except one (Kingma, 2014), with no evidence of a dose–response relationship.

Overall, there was a consistent pattern that mindfulness and acceptance interventions increase self-reported mindfulness. The large strength of these effect sizes was tempered by the high risk of bias in the studies and the imprecision of results. Using the GRADE criteria, the quality of the evidence was judged to be low, meaning further research is very likely to have an important impact on our confidence in effect (Schünemann, Oxman, Vist, et al., 2008).

Quality of evidence for increasing flow

In sport, flow is defined as an intense, rewarding, undistracted absorption in the activity, which has been found to be a mediator of success in performance (Swann, Keegan,

Table 3. Effects of mindfulness and acceptance on athlete reports of mindfulness.

Citation	ROB	*N*	Skill level	Type of task	Intervention	Prescribed dose (hours)	Comparison	Mindfulness ES
Randomised controlled trials								
Aherne et al. (2011)	?	13	W	V	Mindfulness	11	NT	**1.02**
Moen and Wells (2016)	–	78	W	V	ATT	26	NT	**1.23**
Moen et al. (2015)	?	77	W	V	Mindfulness	29	NT	**0.17**
Ojaghi et al. (2013)	–	40	W	F	Mindfulness	N	NT	**0.69**
Quinones Paredes (2014)	?	13	W	G	Mindfulness	12	Relaxation	0.1
Scott Hamilton et al. (2016)	–	47	W	G	MiCBT	40	NT	**0.71**
Zhang et al. (2016)	–	43	N	F	MAC	11	Sport psych lectures	**1.47** 95% CI [0.79, 2.14]
Non-randomised controlled trials								
Baltzell and Akhtar (2014)	–	42	W	G	MMTS	13	NT	**0.99**
Goodman et al. (2014)	–	26	W	V	MAC + Hatha yoga	20	NT	**0.68**
Hasker (2010)	–	19	W	V	MAC	7	Mental training	0.24
Kettunen and Välimäki (2014)	–	49	W	G	ACT	6	NT	0.17
Longshore and Sachs (2015)	–	20	W	V	Mindfulness	16	NT	0.37; State: U
Pineau (2014)	–	55	W	G	MSPE ± SC	9	NT	0.07
Shaw(2014)	–	51	N	G	ACT	3	NT	U
Cohort/case studies								
De Petrillo et al. (2009)	–	25	W	G	MSPE	11		0.32; State: 1.15
Furrer (2014)	–	29	W	V	Mindfulness	50		U
Haase et al. (2015)	–	7	W	G	mPEAK	46		0.41
Kaufman et al. (2009)	–	32	V	F	MSPE	8		0.87; State: 0.49
Kingma (2014)	–	5	W	F	MSPE + Schema	13		−0.61
Mahoney and Hanrahan (2011)	–	4	U	V	ACT	~4		U
Perret (2014)	–	7	V	V	ACT	9		U
Schwanhausser (2009)	–	1	W	G	MAC	5		U

Notes: Refers to between-group differences in dispositional mindfulness for randomised controlled trial (RCT) and non-randomised controlled trial (NRCT) designs, or pre–post differences for cohort designs, unless otherwise specified. Significant effects in bold ($p < .05$). ROB = risk of bias; ? = unclear risk; – = high risk of bias; ES = effect size; CI = confidence interval; N = novel skill; W = well-learned skill; F = fine motor tasks; G = gross motor task; V = various; U = unclear from manuscript; NT = no treatment; ACT = acceptance and commitment therapy; AM = anapanasati meditation; ATT = attention training technique; MAC = mindfulness acceptance commitment; MAP = multi action plan; MBSR = mindfulness based stress reduction; MiCBT = mindfulness integrated cognitive behaviour therapy; MMTS = mindfulness meditation training for sport; mPEAK = mindful performance enhancement, awareness and knowledge; MSPE = mindful sport performance enhancement; SC = self compassion. GRADE = Low: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Randomised trials and correlational data support the use of these interventions, and RCT effect sizes are large; however, effect sizes are imprecise, and no studies reported adequate concealment, blinding, or protocols.

Piggott, & Crust, 2012). It can reflect a moment-to-moment experience (state flow) or the tendency of an athlete to experience these states (dispositional flow; Jackson & Eklund, 2002). As outlined in Table 4, four of the seven RCTs that explored mindfulness also examined the influence of the intervention on dispositional flow (Aherne et al., 2011; Quinones-Paredes, 2014; Scott-Hamilton et al., 2016; Zhang et al., 2016). All effect sizes were positive, ranging from small ($d = 0.22$; Quinones-Paredes, 2014) to very large ($d = 1.66$; Aherne et al., 2011). The pattern was less consistent for other designs. Both non-randomised controlled trials reported lower flow as a result of the intervention (Hasker, 2010; Pineau, 2014). Kaufman et al. (2009) found a large effect size for state flow in their before and after study.

Correlational data supported the relationship between mindfulness and flow; effect sizes in all five studies were positive and significant, ranging from 0.15 ($p < .01$; Thienot et al., 2014) to 0.79 ($p < .001$; Kaufman et al., 2009).

Overall, the evidence from interventions and observational designs generally supported the relationship between mindfulness and acceptance interventions and the promotion of flow states, with strong effect sizes. Again, the potential bias in the evidence and imprecise results meant that the overall quality of evidence was judged to be low.

Quality of evidence for reducing anxiety

Six comparisons from four RCTs explored the relationship between mindfulness and acceptance interventions and competitive anxiety (see Table 5; Muangnapoe, 1998; Ojaghi et al., 2013; Scott-Hamilton et al., 2016; Solberg et al., 2000). While all studies were judged to have high risk of bias, each comparison showed greater reductions in anxiety than in the control condition, most with moderate or large effect sizes. Conclusions may not be representative of all mindfulness and acceptance approaches because while all appeared to promote present-moment awareness, only one explicitly included an acceptance component (Scott-Hamilton et al., 2016). Also, all RCTs were conducted on experienced athletes, with none testing novel skill acquisition.

Anxiety reductions were less consistent among the non-randomised controlled trials and before–after designs, with two studies finding reduced anxiety (Kaufman et al., 2009; Longshore & Sachs, 2015) and three finding higher anxiety (De Petrillo et al., 2009; Kingma, 2014; Pineau, 2014). Three correlational studies have explored the relationship between mindfulness and anxiety: Gooding and Gardner (2009) found a positive, non-significant relationship, and both other studies found that mindfulness was associated with significantly lower anxiety (Röthlin et al., 2016; Thienot et al., 2014). Overall, with the high risk of bias among the included studies, and large but imprecise effect sizes, the quality of the evidence reviewed here was judged to be low.

Quality of evidence for performance enhancement

As outlined in Table 6, five RCTs explored the influence of mindfulness and acceptance interventions toward athletic performance enhancement (Hall & Hardy, 1991; John et al., 2012; Ojaghi et al., 2013; Solberg et al., 1996; Zhang et al., 2016). Two studies comparing these approaches to active treatments found effect sizes favouring the other treatment (visuomotor behaviour rehearsal (VMBR) and music therapy, respectively; Hall & Hardy, 1991; John et al., 2012). Of those that compared mindfulness and acceptance

Table 4. Effects of mindfulness and acceptance on athlete reports of flow.

Citation	ROB	*N*	Skill level	Type of task	IV	Prescribed dose (hours)	Comparison	Flow ES
Randomised controlled trials								
Aherne et al. (2011)	?	13	W	V	Mindfulness	11	NT	**1.66**
Quinones Paredes (2014)	?	13	W	G	Mindfulness	12	Relaxation	0.22
Scott Hamilton et al. (2016)	–	47	W	G	MiCBT	40	NT	0.64
Zhang et al. (2016)	–	43	N	F	MAC	11	Sport psych lectures	**1.50 (95% CI [.81, 2.17])**
Non-randomised controlled trials								
Hasker (2010)	–	19	W	V	MAC	7	Mental training	State: **−1.06**
Pineau (2014)	–	55	W	G	MSPE ± SC	9	NT	**−0.79**; State: −0.23
Cohort/case studies								
Kaufman et al. (2009)	–	32	V	F	MSPE	8		0.49; State: **0.93**
Schwanhausser (2009)	–	1	W	G	MAC	5		U; State: U
						Correlation with dispositional flow		
Observational designs								
Cathcart et al. (2014)		92	W	V	Mindfulness	**.33**		
Kaufman et al. (2009)		32	V	F	Mindfulness	**.79**		
Kee and Wang (2008)		182	W	V	Mindfulness	**.28**		
Pineau et al. (2014)		58	V	G	Mindfulness	**.41**		
Thienot et al. (2014)		343	W	V	Mindfulness	**.15**		

Notes: Refers to between-group differences in dispositional flow for randomised controlled trial (RCT) and non-randomised controlled trial (NRCT) designs, or pre–post differences for cohort designs, unless otherwise specified. Significant effects in bold ($p < .05$). ROB = risk of bias; ? = unclear risk; – = high risk of bias; ES = effect size; CI = confidence interval; N = novel skill; W = well-learned skill; F = fine motor tasks; G = gross motor task; V = various; U = unclear from manuscript; NT = no treatment; MAC = mindfulness acceptance commitment; MiCBT = mindfulness integrated cognitive behaviour therapy; MSPE = mindful sport performance enhancement; SC = self compassion. GRADE = Low: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Randomised trials and correlational data support the use of these interventions, and RCT effect sizes are large; however, effect sizes are imprecise, and no studies reported adequate concealment, blinding, or protocols.

Table 5. Effects of mindfulness and acceptance on athlete reports of competitive anxiety.

Citation	ROB	*N*	Skill level	Type of task	Intervention	Prescribed dose (hours)	Comparison	Anxiety ES
Randomised controlled trials								
Muangnapoe (1998)	–	48	W	G	AM	15	PMR	**−0.78**
							Stretching	**−1.38**
Ojaghi et al. (2013)	–	40	W	F	Mindfulness	N	NT	−0.74
Scott Hamilton et al. (2016)	–	47	W	G	MiCBT	40	NT	−0.43
Solberg et al. (2000)	–	31	W	G	Acem	18	Autogenic training	−0.43
							Problem solving	−0.21
Non-randomised controlled trials								
Longshore and Sachs (2015)	–	20	W	V	Mindfulness	16	NT	−0.44
Pineau (2014)	–	55	W	G	MSPE ± SC	9	NT	−0.13
Wolanin and Schwanhausser (2010)	–	20	W	G	MAC	5	NT	U
Cohort/case studies								
De Petrillo et al. (2009)	–	25	W	G	MSPE	11		0.62
Gardner and Moore (2004)	–	2	W	V	MAC	14		U
Kaufman et al. (2009)	–	32	V	F	MSPE	8		0.14
Kingma (2014)	–	5	W	F	MSPE + Schema	13		0.85
Lutkenhouse (2007)	–	1	W	G	MAC	~7		U
Schwanhausser (2009)	–	1	W	G	MAC	5		U
						Correlation with competitive anxiety		
Observational designs								
Gooding and Gardner (2009)		43	W	F	Mindfulness	.26		
Röthlin et al. (2016)		133	W	V	Mindfulness	**−.45** (cognitive); **−.29** (somatic)		
Thienot et al. (2014)		343	W	V	Mindfulness	**−.43**		

Notes: Refers to between-group differences in competitive anxiety for randomised controlled trial (RCT) and non-randomised controlled trial (NRCT) designs, or pre–post differences for cohort designs, unless otherwise specified. Significant effects in bold ($p < .05$). ROB = risk of bias; – = high risk of bias; ES = effect size; CI = confidence interval; W = well-learned skill; F = fine motor tasks; G = gross motor task; V = various; U = unclear from manuscript; NT = no treatment; AM = anapanasati meditation; MAC = mindfulness acceptance commitment; MiCBT = mindfulness integrated cognitive behaviour therapy; MSPE = mindful sport performance enhancement; SC = self compassion. GRADE = Low: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Randomised trials and correlational data support the use of these interventions, and RCT effect sizes are large; however, effect sizes are imprecise, and no studies reported adequate concealment, blinding, or protocols. Findings only generalisable to experienced athletes.

approaches to placebo or wait-list control conditions ($k = 5$), effect sizes were imprecise, with conflicting results from the same participants (Solberg et al., 1996) to large effects with wide confidence intervals (95% CI [1.12, 2.55]; John et al., 2012; Zhang et al., 2016). None of these RCTs reported sufficient detail to be judged as low risk of bias.

Four papers explored the performance benefits of the MAC protocol: one RCT (Zhang et al., 2016), one non-randomised controlled trial (Hasker, 2010), and two before–after comparisons (Gardner & Moore, 2004; Lutkenhouse, 2007). Only Zhang et al. (2016) demonstrated statistically significant increases in performance. Two other interventions were also used in non-randomised controlled trials and before–after designs (ACT; Kettunen & Välimäki, 2014; Ruiz & Luciano, 2012; Mindful Sport Performance Enhancement,

Table 6. Effects of mindfulness and acceptance on athletic performance.

Citation	ROB	*N*	Skill level	Type of task	Intervention	Prescribed dose (hours)	Comparison	Performance ES
Randomised controlled trials								
Hall and Hardy (1991)	?	30	N	F	TM	38	NT	Skill: 0.17
							VMBR	Skill: **−0.54**
John et al. (2012)	?	165	W	F	Mindfulness	8	NT	Skill: 0.87
							Music therapy	Skill: −0.11
Ojaghi et al. (2013)	–	40	W	F	Mindfulness	N	NT	**0.41**
Solberg et al. (1996)	–	25	W	F	Acem	25	NT	**0.26**
								Skill: −0.28
Zhang et al. (2016)	–	43	N	F	MAC	11	Sport psych lectures	Skill: **1.84**
								95% CI [1.12, 2.55]
Non-randomised controlled trials								
Bernier et al. (2014)	–	7	W	G	ACT & MBCT	66	NT	U
Hasker (2010)	–	19	W	V	MAC	7	Mental training	0.16
Kettunen and Välimäki (2014)	–	49	W	G	ACT	6	NT	0.06
Little and Simpson (2000)	–	7	W	F	Acceptance based	N	NT	U
Pineau (2014)	–	55	W	G	MSPE ± SC	9	NT	0.08
Ruiz and Luciano (2012)	–	5	W	F	ACT	4	NT	**1.22**
Wolanin and Schwanhausser (2010)	–	20	W	G	MAC	5	NT	U
Cohort/case studies								
De Petrillo et al. (2009)	–	25	W	G	MSPE	11		U
Kaufman et al. (2009)	–	32	V	F	MSPE	8		U
Kingma (2014)	–	5	W	F	MSPE + Schema	13		0.41
Lutkenhouse (2007)	–	1	W	G	MAC	~7		U
Schwanhausser (2009)	–	1	W	G	MAC	5		U
						Correlation with performance		
Observational designs								
Blecharz et al. (2014)		101	W	G	Mindfulness	**Skill: .17**		
Gooding and Gardner (2009)		43	W	F	Mindfulness	Skill: .14		
Röthlin et al. (2016)		133	W	V	Mindfulness	**.33**		
Sarnell (2012)		197	V	G	Mindfulness	**.19**		

Notes: Refers to between-group differences in competitive performance for randomised controlled trial (RCT) and non-randomised controlled trial (NRCT) designs, or pre–post differences for cohort designs, unless otherwise specified as skill execution in a non-competitive environment. Significant effects in bold ($p < .05$). ROB = risk of bias; ? = unclear risk; – = high risk of bias; ES = effect size; CI = confidence interval; N = novel skill; W = well-learned skill; F = fine motor tasks; G = gross motor task; V = various; U = unclear from manuscript; NT = no treatment; ACT = acceptance and commitment therapy; MAC = mindfulness acceptance commitment; MBCT = mindfulness based cognitive therapy; MSPE = mindful sport performance enhancement; SC = self compassion; TM = transcendental meditation. GRADE = Low: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Randomised trials and correlational data support the use of these interventions, and RCT effect sizes are large; however, effect sizes are imprecise, and no studies reported adequate concealment, blinding, or protocols. Performance effects generalisable to fine motor skills only.

MSPE; Kingma, 2014; Pineau, 2014). Only one of these studies showed a significant improvement in performance (Ruiz & Luciano, 2012). From the observational data, there were small to moderate correlations between mindfulness and performance in three studies (Blecharz et al., 2014; Gooding & Gardner, 2009; Sarnell, 2012).

Overall, there is a dearth of high-quality studies and some inconsistent findings in support of mindfulness and acceptance approaches for performance enhancement. Due to the apparent bias in evidence base, the quality of evidence for these approaches was judged to be low.

Other exploratory outcomes

There are a number of outcomes that were explored by few studies with high internal validity. We present the available evidence on these outcomes here as possible avenues for future research. (See Table 7).

First, two RCTs showed significant reductions in burnout as a result of a mindfulness intervention (Moen et al., 2015; Moen & Wells, 2016). This result may be associated with changes in affect, where mindfulness was found to be correlated with higher positive affect and lower negative affect (Diaz, 2009; Gustafsson et al., 2015; Steinberg, 2011).

Secondly, a number of studies have explored physiological or psychophysiological effects of these interventions (Buscombe et al., 2014; Haase et al., 2015; John et al., 2012; Solberg et al., 2000). Preliminary findings suggest that mindfulness may lead to increased anterior cingulate cortex and insula activation (Haase et al., 2015) and reduced salivary cortisol (John et al., 2012), but no differences have been found for lactate response, heart rate, or oxygen intake (Buscombe et al., 2014; Solberg et al., 2000).

Finally, there is some preliminary evidence for mindfulness and acceptance approaches toward the prevention and management of injuries. Ivarsson et al. (2015) found a reduced injury rate from a seven-week MAC intervention. While Mahoney and Hanrahan (2011) found inconsistent results using ACT with injured athletes over four sessions, Perret (2014) found increased rehabilitation adherence from a six-session ACT intervention.

Qualitative themes

Some qualitative themes from the included studies help extend upon the quantitative data presented thus far. Themes emerged around other benefits of these mindfulness and acceptance interventions. In most studies that reported qualitative data, participants described a direct link between the intervention and the ability to maintain task-focused attention (Baltzell et al., 2014; Bernier et al., 2014; Buscombe et al., 2014; Goodman et al., 2014; Longshore & Sachs, 2015; Quinones-Paredes, 2014; Wicks, 2012). In six studies, participants described how the perceived benefits of mindfulness and acceptance interventions generalised beyond the sporting arena (e.g. via increased concentration or reduced anxiety; Baltzell et al., 2014; Bernier et al., 2014; Buscombe et al., 2014; Goodman et al., 2014; Hickman, Murphy, & Spino, 1977; Wicks, 2012).

Themes also emerged about experience of participating in mindfulness and acceptance interventions. Participants in four studies discussed the difficulty they experienced in learning and practising the skills, particularly with respect to mindfulness (Baltzell et al., 2014; Bernier et al., 2014; Mahoney & Hanrahan, 2011; Quinones-Paredes, 2014). In two

Table 7. Effects of mindfulness and acceptance on other outcomes.

Citation	*N*	Skill level	Type of task	Intervention	Dose (hours)	Comparison	Exploratory and qualitative outcomes
Randomised controlled trials							
Ivarsson et al. (2015)	41	W	G	MAC	5	Sport psych presentation	Lower injuries: $d = -0.59$ (80% CI [−0.37, −0.74])
Jha (2015)	105	W	G	Mindfulness	9	Relaxation & visualisation	Among those who practiced, higher sustained attention for mindfulness
John et al. (2012)	165	W	F	Mindfulness	8	NT, music therapy	Reduced salivary cortisol vs. no treatment; no diff. vs. music
Moen and Wells (2016)	78	W	V	ATT	26	NT	Reduced burnout
Moen et al. (2015)	77	W	V	Mindfulness	29	NT	Reduced burnout
Mosewich et al. (2013)	51	W	V	SC	1	Journalling	Higher self-compassion (0.79), lower rumination (−0.66), self-criticism (−0.89), concern over mistakes (−0.63), all maintained at 1 month
Muangnapoe (1998)	48	W	G	AM	15	PMR, stretching	For confidence, no diff. vs. PMR ($d = -0.03$), sig. increased vs. stretching ($d = \mathbf{0.56}$)
Papanikolaou (2011)	40	U	G	Various	12	Video review	Increased use of different attentional styles
Quinones Paredes (2014)	13	W	G	Mindfulness	12	Relaxation	No diff. for thought suppression, qual. data found increased focus, but mindfulness practice was challenging
Regan et al. (1998)	28	U	G	Meditation	N	NT	No diff. for RPE, mood, anxiety, efficiency
Scott Hamilton et al. (2016)	47	W	G	MiCBT	40	NT	Less pessimism
Solberg et al. (2000)	31	W	G	Acem	18	Autogenic training, problem solving	No diff. vs. either condition for lactate response, oxygen intake, heart rate
Non-randomised controlled trials							
Baltzell and Akhtar (2014)	42	W	G	MMTS	13	NT	Lower negative affect, no diff. for wellbeing, positive affect, life satisfaction; qual. data found increased focus, generalised benefits, challenging to practice, and requested more experiential exercises
Bernier et al. (2009)	7	W	F	ACT & MBCT + PST	11	PST alone	Higher percentage improved national ranking, all improved adherence to routines, higher activation
Bernier et al. (2014)	7	W	G	ACT & MBCT	66	NT	Increased acceptance and awareness in action, qual. reported increased focus, generalised benefits, links between practice and improvement, and challenging to practice
Buscombe et al. (2014)	9	N	V	TM, Zazen	2	Ratio breathing	TM: Higher respiration rate, no diff. on biofeedback, qual. data found increased focus, generalised benefits Zazen: No diff. on biofeedback, qual. data found increased focus, generalised benefits

(*Continued*)

Table 7. Continued.

Citation	*N*	Skill level	Type of task	Intervention	Dose (hours)	Comparison	Exploratory and qualitative outcomes
Goodman et al. (2014)	26	W	V	MAC + Hatha yoga	20	NT	Higher goal-directed energy, qual. data found increased focus, generalised benefits, requested more experiential exercises
Hasker (2010)	19	W	V	MAC	7	Mental training	No diff. on experiential avoidance, suppression
Kettunen and Välimäki (2014)	49	W	G	ACT	6	NT	No diff. on wellbeing, cohesion, confidence ($d = 0.30$)
Little and Simpson (2000)	7	W	F	Acceptance based	N	NT	No sig. diff. on thought suppression or experiential avoidance
Longshore and Sachs (2015)	20	W	V	Mindfulness	16	NT	Lower negative affect
Pineau (2014)	55	W	G	MSPE ± SC	9	NT	No diff. on body image, self-compassion, confidence ($d = -0.04$)
Ruiz and Luciano (2012)	5	W	F	ACT	4	NT	No diff. on experiential avoidance
Shaw (2014)	51	N	G	ACT	3	NT	Lower stress for treatment, not control, some mindfulness facets improved, others worse
Wolanin and Schwanhausser (2010)	20	W	G	MAC	5	NT	No diff. on anxiety, quality of life, performance, metacognition
Cohort/case studies							
De Petrillo et al. (2009)	25	W	G	MSPE	11	No differences for performance (means not reported; improved at follow up), perfectionism, or thought disruption	
Furrer (2014)	29	W	V	Mindfulness	50	Qual. data found increased focus, generalised benefits, higher perceived performance	
Gardner and Moore (2004)	2	W	V	MAC	14	Increased psychological flexibility, perceived performance	
Haase et al. (2015)	7	W	G	mPEAK	46	Increased anterior cingulate cortex and insula activation, lower alexithymia	
Jouper and Gustafsson (2013)	1	W	F	Mindfulness and Qigong	158	Increased concentration, reduced burnout	
Kingma (2014)	5	W	F	MSPE + Schema	13	Qual. data found increased awareness and acceptance	
Lutkenhouse (2007)	1	W	G	MAC	~7	Increased motivation, fitness, performance, team relationships	
Mahoney and Hanrahan (2011)	4	U	V	ACT	~4	Inconsistent effects on psychological flexibility, mindfulness, and anxiety; qual. data found practice was challenging but positive link between practice and improvement, benefits from experiential/metaphorical exercises	
Mosewich et al. (2016)	1	W	U	SC + Mindfulness	~6	Increase emotional regulation, some difficulty with practice	
Perret (2014)	7	V	V	ACT	9	Increased psychological flexibility and rehabilitation adherence	
Schwanhausser (2009)	1	W	G	MAC	5	Increased mindfulness, flow, psychological flexibility, performance, decreased anxiety, qual. data found increased focus	
Observational designs							
Baranoff et al. (2015)	44	U	V	Experiential avoidance	Higher depression ($r = .47$) and alcohol use ($r = .33$) @ 6 months		

Blecharz et al. (2014)	101	W	G	Mindfulness	Higher self-efficacy ($r = .29$) and performance ($r = .17$) at 7-month follow up
Chang et al. (2015)	76	W	V	Experiential avoidance	Higher depression ($r = .70$) and negative affect ($r = .66$); lower autonomy support ($r = -.23$), positive affect (−.37), life satisfaction (−.21)
Diaz (2009)	79	V	F	Mindfulness	Higher confidence ($r = .35$), positive affect ($r = .34$), locus of control ($r = .22$), happiness ($r = .34$), satisfaction with life ($r = .36$) and self ($r = .28$) and denial of distress ($r = .27$); lower negative affect ($r = -.18$)
Furrer (2014)	382	W	V	Mindfulness	Lower stress ($\beta = -.19$), indirect relationships with burnout, performance in sport and school
Hanneman (2013)	90	U	G	Mindfulness	Lower perceived exertion on treadmill test ($r = -.25$)
Housley (2009)	146	V	G	Experiential avoidance	Predicted diving performance over and above physical discomfort tolerance ($\Delta R^2 = .13$)
Kee and Wang (2008)	182	W	V	Mindfulness	'High mindfulness' cluster used more goal setting than all other clusters
McCarthy (2011)	52	W	V	Mindfulness	No significant relationships with gender ($r = .02$), playing time ($r = .10$), task ($r = -.05$), or ego orientation ($r = -.08$)
Mosewich et al. (2011)	151	V	V	Self compassion	Higher self-confidence ($r = .6$); lower physique anxiety ($r = .37$), fear of failure ($r = -.57$), shame ($r = -.39$), and self-consciousness ($r = -.50$)
Rafeeque and Sultana (2016)	323	W	G	Mindfulness	Higher mental toughness (MT; $r = .44$), higher performance controlling for MT ($\beta = .08$)
Röthlin et al. (2016)	133	W	V	Mindfulness	Lower trait cognitive anxiety ($r = -.45$) and trait somatic anxiety ($r = -.29$)
Sarnell (2012)	197	V	G	Mindfulness	Higher self-determined motivation ($r = .18$)
Thienot et al. (2014)	343	W	V	Mindfulness	Lower worry ($r = -.48$), concentration disruption ($r = -.38$), evaluative concern ($r = -.51$), and rumination ($r = -.18$)
Wicks (2012)	5	W	F	Mindfulness	Qual. data found increased focused, generalised benefits of practice

Notes: Refers to between-group differences for randomised controlled trial (RCT) and non-randomised controlled trial (NRCT) designs, or pre–post differences for cohort designs, unless otherwise specified. Significant effects in bold ($p < .05$). CI = confidence interval; N = novel skill; W = well-learned skill; F = fine motor tasks; G = gross motor task; V = various; U = unclear from manuscript; NT = no treatment; ACT = acceptance and commitment therapy; AM = anapanasati meditation; ATT = attention training technique; MAC = mindfulness acceptance commitment; MBCT = mindfulness based cognitive therapy; MiCBT = mindfulness integrated cognitive behaviour therapy; MMTS = mindfulness meditation training sport; mPEAK = mindful performance enhancement, awareness and knowledge; MSPE = mindful sport performance enhancement; PST = psychological skills training; SC = self compassion; TM = transcendental meditation.

of these studies, participants also described a positive association between the amount of practice they completed and the benefits they received (Bernier et al., 2014; Mahoney & Hanrahan, 2011). In three papers, participants reported that the interventions would have been more helpful if they included a greater number of experiential exercises (Baltzell et al., 2014; Goodman et al., 2014; Mahoney & Hanrahan, 2011).

Discussion

While there are a number of studies showing positive effects for mindfulness and acceptance-based interventions for athletes, this systematic review indicates that the evidence is, at present, of low quality. Some studies have found large effect sizes for mindfulness and acceptance interventions for promoting present-moment awareness, flow, and performance, and for reducing competitive anxiety. For all outcomes, the findings were tempered by the risk of bias in included studies and imprecision in the effect sizes. Our review also found research showing preliminary support for the use of these interventions to prevent injuries, reduce burnout, and increase confidence. Observational studies suggest that athletes differ in the degree to which they are mindful, and that a tendency toward mindfulness may be associated with higher mental toughness, self-determined motivation, self-efficacy, lower stress, and lower ratings of perceived exertion.

These findings are largely consistent with previous reviews on mindfulness in sport (Birrer et al., 2012; Gardner & Moore, 2012; Sappington & Longshore, 2015). Our review synthesised the results from a larger number of studies ($k = 66$) than Sappington and Longshore's (2015) systematic review ($k = 19$). Despite the larger pool of evidence, we were not able to make any stronger conclusions about the effectiveness of mindfulness and acceptance approaches for performance enhancement. The need for well-designed RCTs described by previous reviewers (Birrer et al., 2012; Gardner & Moore, 2012; Sappington & Longshore, 2015) appears to still be unmet for this group of interventions.

Other attention management strategies (e.g. mental practice, instructional self-talk, goal setting) also demonstrate large effect sizes for performance enhancement (Driskell et al., 1994; Hatzigeorgiadis et al., 2011; Kyllo & Landers, 1995). These meta-analyses did not systematically explore the risk of bias in the included studies, so conclusions based on those papers should also be tempered by the uncertainty regarding internal validity. Comparing the effect sizes here with those in previous meta-analyses, the incremental benefit of acceptance over and above the attentional management processes may be small. Theoretically, this incremental benefit may still be practically meaningful because effect sizes as small as 0.3 have been hypothesised to increase an athlete's chance of receiving an Olympic medal by 10% (Hopkins, Hawley, & Burke, 1999); however, the evidence found here comparing mindfulness and acceptance to other treatments is weak. No studies found significant benefits in favour of mindfulness (Hasker, 2010; John et al., 2012; Quinones-Paredes, 2014), and one found the alternative treatment to be significantly better (VMBR; Hall & Hardy, 1991). These findings suggest that mindfulness and acceptance approaches may offer some benefit compared to no treatment, but further research is required to rigorously compare these approaches with established interventions that control the content of internal experiences or manage attention.

Strengths and limitations of included studies

Any benefits from mindfulness compared to placebo or wait-list controls ought to be considered in the context of internal validity. As described in previous reviews of mindfulness in sport, research to date has a number of limitations that question our ability to determine causality (Sappington & Longshore, 2015). While Sappington and Longshore (2015) judged two studies to be 'very good quality' (Aherne et al., 2011; John et al., 2011), no studies included in our review were judged to have a low risk of bias using the Cochrane Risk of Bias tool. No study clearly described a system where random allocation was concealed to the experimenter, and we were not able to find any papers that had registered a study protocol. No studies used designs in which all key personnel were blinded, and only six described a priori power analyses to determine sufficient sample sizes.

These internal validity criticisms are neither new nor uncharacteristic of literature exploring other interventions in sport psychology (Greenspan & Feltz, 1989; Martin, Vause, & Schwartzman, 2005; Schweizer & Furley, 2016; Vealey, 1994). In sporting contexts, the desire to establish high levels of external validity can compromise the ability for studies to establish causality due to reduced control and precision (Greenspan & Feltz, 1989; Vealey, 1994). Coaches and athletes can be resistant to experimental designs in which they are given placebos or control conditions (Martin et al., 2005), and smaller pools of potential participants and funding can lead to inadequate sample sizes (Schweizer & Furley, 2016) or less well-controlled studies (Martin et al., 2005).

As a result of these influences, we acknowledge the challenge of meeting the internal validity standards set in other areas such as medicine and clinical psychology. However, meeting those standards would increase the strength of the causal conclusions that researchers could make (Higgins & Altman, 2008). For example, while blinding can be onerous for researchers, a review of meta-analyses found that un-blinded studies were more likely to find significant treatment effects (Pildal et al., 2007), and placebo effects have demonstrated dose–response relationships even in objectively measured cycling performance (Beedie, Stuart, Coleman, & Foad, 2006). In a review of mindfulness-based interventions in clinical domains, a number of studies used double-blind designs, but those studies with higher internal validity demonstrated lower effect sizes, suggesting possible expectancy effects (Khoury et al., 2013).

One internal-validity standard that could be met regardless of sample size, funding, or context is protocol registration. Protocol registration can significantly increase the internal validity of studies because doing so usually requires that researchers declare power calculations, a priori outcomes of interest, blinding, and randomisation processes (Chambers, Feredoes, Muthukumaraswamy, & Etchells, 2014). Most top-quality journals in medicine (De Angelis et al., 2004) and some in psychology (Chambers et al., 2014) are no longer accepting research without a registered protocol, and many others are requiring that authors follow reporting checklists like TIDieR (Hoffmann et al., 2014) and CONSORT (Schulz, Altman, & Moher, 2010) to ensure transparent reporting. Requiring the same standards in the sport psychology literature would encourage a higher level of transparency from authors regarding their methods, giving readers greater confidence in the performance benefits found from interventions.

The performance benefits from the mindfulness and acceptance interventions included in this review varied greatly (Cohen's *d* ranged from −0.54 to 1.84) with no clear dose–

response relationship. It is possible that this heterogeneity may be explained by the different interventions that were grouped under the mindfulness and acceptance umbrella. There were at least 10 different labels for interventions that appear to help athletes via similar mechanisms: All appeared to involve training to bring attention back to the present moment, and most explicitly described an attitude of experiential acceptance. Where Sappington and Longshore (2015) argued for increased manualisation of treatments, others have described a range of scientific advantages from exploring empirically supported principles of change instead of 'branded' interventions (Ciarrochi, Atkins, Hayes, Sahdra, & Parker, 2016; Ciarrochi, Bilich, & Godsell, 2010; Rosen & Davison, 2003). For example, clinical and experimental studies often report the specific ACT process that they are targeting (i.e. defusion, acceptance, present-moment awareness, self-as-context, values, or committed action; Hayes, Luoma, Bond, Masuda, & Lillis, 2006). Doing so has allowed reviewers to conduct moderation analyses that explore the relative impact of targeting the different processes (Levin et al., 2012). In our review, it was not possible to explore these potential moderators because reporting of interventions was inconsistent. For example, it was not possible to discern the degree to which each included study focused on present-moment awareness, acceptance, or both. If future interventions report the specific process being targeted (e.g. via the ACT model) then it would be possible to discern which components are having the biggest influence for athletes. Also, experimental designs could explicitly compare these components (e.g. acceptance vs. present-moment awareness), because each has a theoretical relationship with performance (Birrer et al., 2012). Nevertheless, it is currently unclear whether interventions are best with present-moment awareness, acceptance, or both.

Another approach for looking at processes of change is to explore the mediators through which an intervention has an effect (Ciarrochi et al., 2010). In this review, few studies explored mediators of the intervention effects; however, there were large effect sizes for these interventions to promote mindfulness. The authors often presumed that increasing mindfulness in this way would lead to increases in performance; however, without designing interventions with mediation in mind (e.g. by measuring mindfulness sometime before performance measures) it is difficult to determine the causal nature of these relationships. Designing studies in this way would also allow for more rigorous exploration of the presumed causal chain involved in mindfulness and acceptance-focused performance enhancement.

A number of studies explored changes in anxiety and flow as potential links between mindfulness and acceptance interventions and performance, and this review found low-quality evidence that mindfulness and acceptance approaches help reduce anxiety and increase flow. The hypothesis that targeting these variables will cause performance improvements has yet to be tested. Designing an intervention that targets anxiety reduction may symbolise a theoretical disconnect from the mindfulness and acceptance approaches, since most promote acceptance rather than reduction of anxiety. Some have proposed that both flow (Bortoli et al., 2012) and relaxation (Hayes, Strosahl, & Wilson, 2011) may be 'exhaust from the engine': serendipitous by-products of mindful awareness, without necessarily being mechanisms of action. Again, studies designed with mediation in mind (e.g. explicitly comparing relaxation vs. acceptance) would allow for additional evidence to be collected to explore these proposals.

Strengths and limitations of this review

Including studies reporting any outcome (e.g. performance, mindfulness, flow) was both a strength and a limitation of this review. While it allowed us to discover effects of mindfulness and acceptance approaches on a range of metrics from neurological activation (Haase et al., 2015) to qualitative reports, it was one factor that precluded a meaningful meta-analysis since we could not aggregate across the different outcomes reported by the included studies.

Similarly, by including a diverse range of interventions under the mindfulness and acceptance umbrella, we could not conduct a meta-analysis because a pooled effect size was unlikely to be meaningful (Deeks et al., 2008). Including both mindfulness and acceptance interventions allowed us to synthesise a larger number of conceptually related approaches than did reviews that focused exclusively on mindfulness (Sappington & Longshore, 2015). Nevertheless, despite the broad scope of this review, the small number of studies for each intervention and outcome was another factor that precluded meta-analysis. While the GRADE method used here is methodologically transparent and objective compared with other methods of narrative review (Schünemann, Oxman, Vist, et al., 2008), future reviews in this area would benefit from a quantitative synthesis of findings, perhaps by coding the interventions on the processes of change described earlier.

A related limitation with our methodology is that we could not create funnel plots to assess publication bias. We did search for and include unpublished research, many of which did not find significant effects (Hasker, 2010; Pineau, 2014; Quinones-Paredes, 2014), which may be an indicator of either publication bias or lower methodological rigour. Coronado-Montoya et al. (2016) found data consistent with this bias regarding mindfulness literature in the clinical domain. They discovered a disproportionately high number of published studies with significant findings, and found that 62% of registered protocols were still unpublished 2.5 years after trial completion. These data contribute to the argument for protocols described earlier, because it allows for a systematic exploration of publication bias. Future reviews on this topic would benefit from exploring publication bias more methodically.

One other potential bias in our review comes from the pragmatic decision to only include papers published in English. Nevertheless, our broad inclusion criteria meant we sourced papers from various cultures, including Taiwan, China, India, Iran, Western Europe, North America, and Australasia. We did not examine the effect of culture or gender on the effectiveness of these approaches, so future quantitative syntheses may consider controlling for gender and culture as potential moderators.

Conclusions

Despite these limitations, our systematic review extends the findings of previous research on mindfulness and acceptance in sport by synthesising the results from a large number of studies. The included studies displayed poor internal validity, so future research would benefit from protocol registration, blinding, and reporting via standardised checklists (e.g. CONSORT). The causal processes underlying these interventions could be better explored by examining the empirically supported processes of change and theoretical mediators of performance improvements, rather than branded or trademarked

interventions as a whole. Currently, it appears that these approaches may have benefits for improving performance, but higher quality studies are required to make causal claims about the efficacy of mindfulness and acceptance approaches for athletes.

Disclosure statement

No potential conflict of interest was reported by the authors.

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