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The effect of mindfulness training on attention and performance in national-level swimmers

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Effect of Mindfulness Training on Attention and Performance

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The Effect of Mindfulness Training on Attention and Performance in National-Level

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Swimmers: An Exploratory Investigation

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Abstract

This quasi-experimental intervention study investigated the impact of mindfulness training on attention and performance in swimmers. Following an 8-week intervention with six national-level university swimmers ($M = 20$ years), single case analysis of pre- and post- measurements for three of six participants showed large improvements in mindfulness and attention efficiency. Two participants showed a small increase in one of mindfulness or attention efficiency, and one showed no changes. Four participants improved performance times compared to season-best, and five participants improved self-rated performance. Athletes and coach positively evaluated mindfulness training. This study, with strong ecological validity, shows improvements in mindfulness, attention, and performance, consistent with theory that proposes attention as a mechanism for mindfulness based performance changes. Mindfulness training can be an effective and practical intervention. Further applied research is required utilising designs to determine causality and further test the proposed mechanisms through which mindfulness may influence performance.

Keywords: mindfulness, intervention, attention mechanisms, social validation, swimming

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35 The ability to direct and control attention is a critical component of success in any area
36 of skilled performance (Moran, 2011). Understanding the processes and limitations of
37 attentional processing has been a dominant focus for cognitive psychology, and theories and
38 concepts that underpin attention control have been widely applied in the sport psychology
39 literature (see Moran, 2011 for a review). In sport, techniques to enhance attention such as
40 goal setting, pre-performance routines, trigger words, and imagery are common features of
41 psychological skills developed to support optimal performance.

42 Recent developments in applying *mindfulness* have particular relevance for self-
43 regulated, present-moment attention required in athletic performance (Gardner & Moore,
44 2004). Mindfulness can be defined as “the awareness that emerges through paying attention on
45 purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment
46 by moment” (Kabat-Zinn, 2003, p.145). The ability to maintain present moment focus has
47 been identified as an effective strategy to achieve peak performance and flow in sport, and
48 mindfulness develops a non-judgemental, accepting dimension to flow experiences (Aherne,
49 Moran, & Lonsdale, 2011). Acceptance-based approaches to sport performance enhancement
50 reflect the ‘third wave’ of cognitive-behavioural therapy in psychology (e.g., acceptance and
51 commitment therapy; Hayes, Strosahl, & Wilson, 1999), emphasising acceptance rather than
52 control. Acceptance is considered advantageous because accepting internal experiences, and
53 persisting despite self-regulatory disruption, can maintain focus on the task rather than the self
54 (Moore, 2009). In contrast, attempts to control thoughts and emotions may be
55 counterproductive and have paradoxical effects on attention (e.g., scanning for discomfort).
56 Self-focused ironic processing can lead to impaired sport performance (e.g., Beilock,
57 Afremow, Rabe, & Carr, 2001). Thus, it is not the presence or absence of negative cognitions

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58 and emotions which is key, but the extent to which the performer can accept these and remain
59 engaged with the task.

60 Mindfulness is proposed to be underpinned by three fundamental components (axioms)
61 - intention, attention, and attitude (openness and non-judgmental) - which lead to a significant
62 and transformational shift in perspective, termed *reperceiving* (Shapiro, Carlson, Astin, &
63 Freedman, 2006). Reperceiving is described by Shapiro et al. (2006) as a meta-mechanism
64 which overarches four additional direct mechanisms: self-regulation; values clarification;
65 cognitive, emotional, and behavioural flexibility; and exposure. The fundamental component
66 of *attention* in achieving mindfulness requires one to observe the operations of moment to
67 moment internal and external experience (through meditation inspired activities) to develop
68 present-moment awareness. This ability to self-regulate attention is developed through
69 practicing attending to one object for long periods (vigilance/sustained attention), shifting
70 attention between objects (task switching), and inhibiting secondary elaborative processing of
71 thoughts and feelings (cognitive inhibition; Shapiro et al., 2006). It has been suggested that
72 mindfulness training could enhance working memory capacity (e.g., Chiesa, Calati, & Serretti,
73 2011) and that meditation training improves brain efficiency, possibly via improved sustained
74 attention and impulse control (Kozasa et al., 2012).

75 Although meditation features in developing mindfulness (due to its origins in Buddhist
76 meditative tradition), the intention of mindfulness meditation is to consciously attend to
77 specific thoughts and feelings that arise in awareness and observe them non-judgmentally (i.e.,
78 zoning-in). This differs from basic meditation that typically involves emptying the mind of
79 thoughts (i.e., zoning out). Similarly, although mindfulness-based training techniques have
80 demonstrated efficacy in reducing stress and worry, highly relevant to athletic performers, the

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81 techniques differ from relaxation or arousal regulation techniques because mindfulness
82 encourages acceptance of internal and external experiences (Moore, 2009). Given a function of
83 pre-performance routines is to optimise attention (e.g., Moran, 2011) the use of mindfulness
84 techniques could augment these, particularly during focusing stages.

85 A small number of studies have demonstrated positive performance effects from
86 mindfulness training interventions. For example, Gardner and Moore (2004) found
87 performance improvement using a Mindfulness Acceptance Commitment (MAC) training
88 protocol in single-case studies with an inter-collegiate male swimmer and a masters-level
89 female weightlifter. A single nine-week case study of an adolescent springboard diver showed
90 that competition scores improved by up to 14% on 3-m dives, following a MAC protocol
91 (Schwanhausser, 2009). Furthermore a season-long study with elite young golfers
92 demonstrated that all seven participants improved their national ranking (Bernier, Thienot,
93 Codron, & Fournier, 2009). Whilst prolonged study across a season has advantages, other
94 factors that could have contributed to the performance changes, such as physical maturation
95 and the quality of golf coaching, were not assessed. Aherne et al. (2011) adopted a reliable
96 protocol, using CD-guided mindfulness training with thirteen athletes, randomly assigned to
97 experimental and control groups. The experimental group (n = 6) undertook six weeks of
98 mindfulness training and reported greater flow than before the program and in comparison to
99 the control group. Whilst Aherne et al. (2011) review literature in which flow is associated
100 with peak performance, no direct assessment of performance changes were made in that study.

101 However, not all studies have found evidence of mindfulness improving performance.
102 A four-week practitioner-led Mindful Sport Performance Enhancement (MSPE) protocol
103 showed no immediate performance benefit for recreational archers, golfers (n = 32; Kaufman,

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104 Glass, & Arnkoff, 2009) and runners (n = 25; De Petrillo, Kaufman, Glass, & Arnkoff, 2009),
105 Although a one-year follow up with the runners indicated significant improvements in best
106 mile-times for runners (n=13; Thompson, Kaufman, De Petrillo, Glass, & Arnkoff, 2011),
107 these results should be treated cautiously. Average mile-times across a small group, with a
108 wide range of times, and the potential, as recreational runners, to make significant
109 improvements easily could lead to false-positive interpretation of results.

110 Empirical studies into mindfulness training in sport are few, and the evidence
111 equivocal, so further research is required to examine the potential impact on performance, and
112 address limitations identified in previous research, by using high level athletes, multiple data
113 sources, and consideration of mediating variables. Given mindfulness training is proposed to
114 enhance self-regulation of attention, and through this benefit sports performance, the current
115 study assessed changes in attention, and in particular measures related to working memory and
116 efficiency. Furthermore, the current study used mixed methods to reduce over-reliance on
117 single source, self-report data and benefit from triangulating data to enhance confidence in
118 conclusions. This counters some of the existing limitations in determining the efficacy of
119 mindfulness training in sport.

120 This study investigated the impact of an eight-week mindfulness training intervention
121 on attention and performance in six national-level swimmers. Given the study was exploratory,
122 and conducted in ecological setting with limited experimental control, analysis of single cases
123 was chosen to determine changes. The research aimed to contribute to the literature by
124 assessing whether increases in mindfulness would correspond with improved attention and
125 performance. It was hypothesised that a mindfulness training program would lead to
126 participants experiencing: (i) increased mindfulness; (ii) improved attention; (iii) increased

127 attention efficiency; (iv) improved performance times; and (v) higher self and coach ratings of
128 performance.

129 **Method**

130 **Design**

131 This study was conducted in an ecologically valid context, and assessed changes from
132 pre- to post-intervention through analysing responses of six single-subject cases. Intervention
133 impact was assessed by comparing pre-existing performance data and baseline measures on
134 mindfulness and attention with post-intervention scores, and in addition social validation
135 interviews (Page & Thelwell, 2013). Using multiple cases increased the confidence in
136 determining impact when changes emerge consistently across cases. Constraints placed on
137 design, by participant availability and competitive scheduling, prevented either more extensive
138 baseline testing or application of staggered baseline. However the authors considered the
139 strong ecological validity achieved by working with high standard athletes and real
140 competitive performance data countered these limitations from an applied practitioner
141 perspective. The study received approval from the relevant Institutional ethics committee.

142 **Participants**

143 Six swimmers (2 males, 4 females; *M* age = 20.00 years, *SD* = 1.40 years, range 18-22
144 years) from a United Kingdom (UK) University ‘High Performance Programme’ all
145 competing at national level volunteered and provided informed consent to participate.

146 **Measures and Training**

147 **Mindfulness.** The Cognitive and Affective Mindfulness Scale – Revised (CAMS-R;
148 Feldman, Hayes, Kumar, Greerson, & Laurenceau, 2007), developed using university students,
149 assesses mindful approach to thoughts and feelings via 12 items rated on a Likert scale from 1

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150 (*rarely/not at all*) to 4 (*almost always*) with high scores indicating greater mindfulness. The
151 CAMS-R has shown acceptable internal consistency ($\alpha = .81$) (Baer, Smith, Hopkins,
152 Krietemeyer, & Toney, 2006) and has been used previously in sports based research
153 investigations (Aherne et al., 2011).

154 **Attention test.** The ‘elevator counting with reversal’ sub-test of the Test of Everyday
155 Attention (TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996) was used to measure
156 auditory-verbal working memory component of attention. Participants listened via headphones
157 to a fixed-speed presentation of three different tones, and were required to mentally follow the
158 progress of an imaginary elevator, based on the different tones, indicating whether the elevator
159 was going up, down, or was at a floor. Each test, lasting approximately 5 minutes, commences
160 with three example trials which had to be completed successfully, or repeated, before a series
161 of ten trials with progressive difficulty and duration. This published, psychometric test has
162 shown, through factor analysis, to load the same component of attention as Paced Auditory
163 Serial Addition Test. To avoid practice effects, it offers three versions that show good
164 reliability ($r = 0.66$). This test of a fundamental component of attention has been used in
165 previous applied cognitive psychology research within a physical performance context (Leach
166 & Ansell, 2008). Additional advantages of the chosen test are that it does not use word stimuli
167 or require mathematical operations meaning it is suitable to use with different nationalities,
168 and may be less influenced by educational attainment or specific ability limitations such as
169 dyslexia or dyscalculia, than other widely used tests.

170 **Mental effort.** The Rating Scale for Mental Effort (RSME; Zijlstra, 1993) assesses
171 self-reported effort. Participants indicate effort level on a vertical scale with verbal anchors
172 ranging from 0 (not at all effortful) to 150 (very effortful). The RSME has demonstrated

173 reliability in work settings ($r = 0.78$), and in the laboratory ($r = 0.88$) and has been shown to
174 correlate with physiological indices of effort (Zijlstra, 1993). The scale has been applied in
175 previous sport psychology research (e.g., Wilson, Smith, & Holmes, 2006).

176 **Performance time.** Competitive performance times were reported as a percentage of
177 the participant's season's best for their primary event, for three competitions during the
178 intervention period and five competitions prior to the intervention period.

179 **Performance criteria rating.** Self- and coach-assessed performance used performance
180 criteria to rate performance (Wilson & Richards, 2011). Prior to the intervention each
181 participant identified in discussion with the coach up to five key performance indicators
182 (KPIs). KPIs were individual specific and related to technical and tactical components of
183 performance, for example, *Dive entry and breakout*, and *First 50m pace*. Performance was
184 assessed by combining ratings for all KPIs made on a Likert scale including verbal anchors
185 (10, *the best ever done*, to 1, *the worst ever done*). Participants and coach rated KPIs
186 independently and within two hours following the competition to minimise the risk of
187 retrospective recall bias.

188 **Social validation.** In accordance with recommendations (Page & Thelwell, 2013),
189 individual, semi-structured social validation interviews were conducted with each participant
190 and the coach, to determine the satisfaction with the mindfulness training and its impact on
191 performance. Interviews, lasting 30-45mins, were audio-recorded and transcribed.

192 Additionally, each participant rated how beneficial the mindfulness training was to their
193 performance on a 1-10 scale with verbal anchors: 0 (no benefit at all); 5 (moderately
194 beneficial); and 10 (extremely beneficial).

195 **Training.** Each participant received a one page written explanation of mindfulness
196 including information about the strong experience and expertise of Jon Kabat-Zinn the author
197 of the CD “Guided Meditation Practices” (Williams, Teasdale, Segal, & Kabat-Zinn, 2007).
198 This commercially available CD, used in recent experimental work (Aherne et al., 2011),
199 enabled the intervention to be delivered in a standardised and reliable format and excluded the
200 influence of practitioner-led intervention, which would restrict opportunities for replication
201 studies. Training comprised four exercises, each lasting 10-30 minutes: “Breath”; “Breath and
202 Body”; “Standing Yoga”; and “Body Scan”. Adherence to training was monitored via a simple
203 weekly log, collected each week. Participants also received a courtesy call (week 1) and
204 subsequent weekly emails to answer questions and promote commitment to training.

205 **Procedure**

206 *Baseline Phase*

207 Participants completed paper and pencil mindfulness tests (15 mins approx.) and then
208 the attention test auditory-verbal working memory test in a quiet room wearing headphones,
209 followed immediately by rating subjective effort (RSME). All tests were conducted with the
210 researcher present to ensure the protocols were followed precisely. After a 15-minute lapse the
211 attention test (alternate version to avoid practice effects) and effort rating were repeated.

212 *Intervention Phase*

213 Following instruction participants commenced mindfulness training, keeping a weekly log to
214 determine adherence and receiving prompts and support from the researcher. They attended
215 further testing sessions through the intervention period, completing the attention test and effort
216 rating on weeks 3, 5, and 7, and mindfulness tests on week 5.

217 *Post-Intervention Phase*

218 Participants completed mindfulness and attention tests, effort rating, and took part in a social
219 validation interview in the week following the intervention being completed. Participants
220 required no amendments to summary transcripts provided for review and comments, to enable
221 ‘member checking’ (Lincoln & Guba, 1985).

222 *Swimming Performance*

223 Performance times for each participant were collected from published results for swim meets
224 before the study began. Participants competed at weeks 4, 5, and 8, and race times together
225 with self and coach ratings of KPIs were collected following each event.

226 **Analysis**

227 All measurements were completed except for one attention test by Participant 4 (third
228 measurement during intervention) who was unavailable. Only the second attention test during
229 baseline was included in analysis as the first test was a familiarization trial. Attention scores
230 were ‘scaled’ for the relevant age group following the published manual (Robertson et al.,
231 1996) and attention efficiency was determined by dividing scaled attention scores by self-rated
232 effort. To improve graphical presentation and facilitate visual inspection attention efficiency
233 scores (ranging between 0.03-0.3) were subject to square root transformation before plotting.
234 Performance times were presented as proportion of pre-intervention season’s best, so an
235 upward trend would represent improvement, aiding consistency of presentation with the other
236 plotted measures in this study. Performance criteria ratings for each participant were compared
237 over time and visually assessed for correspondence with the coach ratings for that performer.

238 Analysis for all data variables was performed through a combination of visual
239 inspection, descriptive statistics, together with content analysis of the social validation

240 transcripts. A similar range of analysis techniques has been utilised in single-case design
241 studies (e.g., Neil, Hanton, & Mellalieu, 2013).

242 Visual inspection of mindfulness, attention, effort, and attention efficiency were
243 undertaken, based on recommendations by Hrycaiko and Martin (1996), to identify if a
244 treatment effect had occurred: (a) baseline performance was stable or in a direction opposite to
245 that predicted for the treatment; (b) effect is replicated within and across participants; (c) there
246 are few overlapping data points between the baseline and intervention periods; (d) the effect
247 occurs soon after the introduction of the intervention; and (e) the effect is large compared to
248 the baseline. Quotations from social validation interviews were used to interpret findings from
249 visual inspection of numerical data and contribute to understanding experiences of
250 mindfulness training experience, whilst individual Likert rankings were reported to determine
251 overall perceived impact of training.

252 Results

253 **Mindfulness and Training.** Five participants reported 100%, and one participant 75%,
254 adherence with the mindfulness training program. Visual inspection showed three participants
255 (Participants 1, 3, and 5) had increased mindfulness following the intervention, with
256 Participant 6 showing very minor improvement as measured by the CAMS-R. Participant 1
257 had the lowest pre-intervention score and most marked improvement across the intervention
258 (see Figure 1). Participants 2 and 4 showed no improvement in their CAMS-R scores.

259 ****Figure 1 near here****

260 **Attention, Effort, & Attention Efficiency.** Visual analysis of the attention scores
261 indicated a ceiling effect, therefore a more meaningful analysis of the impact of the
262 intervention was provided by attention efficiency, derived from attention and effort. Four

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263 participants (1, 2, 3, and 5) showed improved attention efficiency over the study period (see
264 Figure 2) although these were minor for Participant 2. Participant 5 showed the greatest
265 improvement, particularly for the high post-intervention test score. Neither Participants 4 nor
266 6 showed improvements across the study.

267 ****Figure 2 near here****

268 **Performance times.** Four participants (1, 2, 3, and 4) had improved performance times
269 for their primary event during the intervention period. Participants 2 and 3 had significant
270 improvements and swam faster than their pre-intervention season's best for all three
271 competitions in the intervention period (i.e., no overlapping data points) (top panel, Figure 3).
272 The average improvement in performance time for intervention period compared to pre-
273 intervention season's best was 1.5% for Participant 3 and 1.1% for Participant 2, representing
274 substantial progress for races typically lasting 60 to 70 seconds. Participants 1 and 4 (see
275 middle panel, Figure 3) had improved performance times, although both had one overlapping
276 data point (for the final competition). On average during the intervention period Participant 1's
277 performance time was 0.4% better than the pre-intervention season's best, whilst Participant
278 4's equivalent average was in line with the season's best. Participants 5 and 6 (see bottom
279 panel, Figure 3) had several overlapping data points and neither swam faster than their pre-
280 intervention season's best during the study period. On average, Participant 6 swam
281 consistently faster during the intervention period than pre-intervention, whilst Participant 5's
282 average times were slower during the intervention period. This participant reported an illness
283 preceding the final event which had adversely affected performance. Excluding this
284 competition, Participant 5's average times during the intervention were in line those from pre-
285 intervention.

286

****Figure 3 near here****

287

Performance criteria ratings. The performance criteria ratings made by the coach

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were consistent with those of the athletes, lending support to this metric. For simplicity only

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athlete ratings are presented for the three competitions that occurred during the intervention

290

(denoted as Intervention Competitions 1-3) in Figure 4. Five participants had improved rated

291

performance, with the most marked increases being shown for Participants 3, 4, and 5, and a

292

more moderate improvement for Participants 2 and 6. The reduction in rated performance for

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Participant 1 is driven by the poorer average score for Intervention Competition 3. Four

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participants rated their highest average score for Intervention Competition 2 and then reported

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a lower score for Intervention Competition 3.

296

****Figure 4 near here****

297

Social Validation

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The participants and coach reported strongly positive appraisals of the intervention and

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its effects. The benefit of mindfulness training to swimming performance was rated on a 10-

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point scale (0, *not at all beneficial*; 5, *moderately beneficial*; and 10, *extremely beneficial*).

301

Two (Participants 4 and 5) rated training as eight, two rated training as seven (Participants 2

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and 3), and two rated it as six (Participants 1 and 6). The coach reported that performances of

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five participants (all except Participant 6) exceeded his expectations for the three competitions

304

in the intervention phase. Furthermore, the coach subjectively reported that overall

305

performance criteria ratings for four athletes improved compared to what he had observed in

306

the pre-intervention period.

307

During the interview participants reported specific effects of the intervention which

308

analysis grouped under three key themes. Firstly, increased relaxation, particularly around

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332 following the intervention. Importantly results showed improvement in attention, tested using
333 a measure of auditory-verbal working memory, which supports the proposal that attention is a
334 mechanism through which mindfulness enhances performance.

335 Four participants improved attention efficiency (three strongly), five participants
336 improved self-evaluated performance criteria ratings, and four participants improved
337 performance times compared to pre-intervention season-best. Although data from just six
338 single cases has limitations, and possible covariates must be considered especially with regard
339 to performance (see study limitations), results support the proposition that mindfulness may
340 improve attention efficiency. Improvements in efficiency of the working memory component
341 of attention could facilitate participants' ability to self-regulate attention (e.g., sustained
342 attention, switching, and cognitive inhibition) consistent with the *reperceiving* mechanism
343 proposed by Shapiro et al. (2006).

344 Social validation interviews showed all six athletes rated mindfulness training as
345 beneficial to performance. Performance times, across primary and non-primary events, swam
346 by five athletes exceeded the coach's expectations. Analysis of individual cases shows
347 theoretically consistent patterns of change, supporting the efficacy of mindfulness training.
348 Participants 1 and 3 had relatively large improvements in mindfulness, attention efficiency,
349 performance times, and performance criteria ratings, and both exceeded coach expectations.
350 Participant 5 had improved mindfulness, attention efficiency, and performance criteria ratings.
351 Whilst Participant 5 did not improve performance times, other positive impacts were reported
352 through social validation interviews. These three cases provide support that the intervention
353 had a positive effect and demonstrate theoretical consistency between an increase in
354 mindfulness, improvement in attention, and improvement in performance.

355 A different picture is evident for Participants 2 and 4. Although both had improved
356 performance times and performance criteria ratings, neither had a meaningful increase in self-
357 reported mindfulness and only Participant 2 showed minor improvement in attention
358 efficiency. This may suggest that mindfulness was not a major contributory factor to observed
359 changes for these individuals, perhaps in part due to higher baseline mindfulness levels
360 relative to other participants (see study limitations for other possible explanations for change).

361 The findings from this study are consistent with existing literature (Gardner & Moore,
362 2004; Schwanhausser, 2009) showing performance improvement following mindfulness
363 intervention. In addition the current study provides a new contribution to the research by
364 measuring changes in function of attention, a potential mechanism through which mindfulness
365 may impact on performance. Self- and coach-rated performance criteria together with social
366 validation provides confirmatory support to the competitive performance times, providing a
367 more robust suite of outcome measures than in previous research.

368 The intervention used in the current study replicated that used by Aherne et al. (2011),
369 and was identical across all participants. This use of a CD-based intervention recognises the
370 importance of using a standardised protocol that can be easily replicated, and enables viable
371 comparisons with future research to facilitate the development of a coherent body of evidence
372 on mindfulness. Importantly, this method avoids the potential significant variation in
373 practitioner-led mindfulness training programs (e.g., Gardner & Moore, 2004; Schwanhausser,
374 2009; Thompson et al., 2011), which risks confusing the impact (or lack) of an intervention
375 with the therapeutic relationship. Further confidence in findings of the current study was
376 provided by assessing adherence to mindfulness training and social validation data.

377 **Study Limitations and Future Research Directions**

378 The lack of prolonged baseline data for attention efficiency and performance criteria
379 ratings were limitations in this study. It would have been preferable for the intervention phase
380 to have commenced when baseline-dependent variables were stable, or in the opposite
381 direction to that predicted for the treatment. This would provide more confidence in attributing
382 change in the dependent variables to the intervention (Hrycaiko & Martin, 1996). However
383 this was prevented in this study due to participant availability, and furthermore stability in one
384 of the dependent variables, performance times, could not have been expected. The study
385 limitations must also acknowledge that attempts to measure performance changes with KPIs,
386 whilst providing more comprehensive assessment, may have inadvertently provided attentional
387 cues for performers. A further limitation, learning effects on the test of attention, could have
388 been further reduced with more opportunity for baseline measurement.

389 The potential for other contributory factors to have affected performance, as reported
390 by the coach, represent limitations to the strength of conclusions that can be made. Three
391 competitions during the intervention period were in the ‘racing phase’ of the season, with
392 training designed for swimmers to peak and deliver best performances. Secondly, facility
393 constraints meant that training sessions in a competition-size 50m pool could not take place
394 until partway through the pre-intervention period. However the pre-intervention period was a
395 very important part of the season, including Olympic trials, and participants’ motivation to
396 perform was high. Furthermore participants were all national standard therefore performance
397 improvements seen in the intervention period for Participants 1 to 4 were relatively large.

398 With respect to all of these limitations the opportunities to spend longer were
399 constrained by the time available and the need to conduct research aligned to the performers’
400 competition schedules. Despite the limitations inevitably experienced in conducting field-

401 based applied research, the study design offers a strong contribution to the developing research
402 in this area because of strong ecological validity and participation of high performance
403 athletes.

404 Where possible future single-case design research should use multiple baseline to
405 offset the potential effect of confounding variables and afford greater confidence that observed
406 outcome changes were due to the intervention. Furthermore research should assess not just
407 performance changes but the mechanisms through which mindfulness operates, such as
408 attention. The current study provides initial support for attention as a mechanism. Although
409 the TEA (Robertson et al., 1996), was developed for determining cognitive impairment in
410 clinical settings, the psychometric validation work included both clinical and normal
411 populations and the test has been applied to detect functional changes in military personnel
412 during field exercises (Leach and Ansell, 2008). Further investigations using alternative and or
413 additional attention measures would contribute to examining this mechanism for mindfulness.
414 Future research could include attention measures in performance settings, although this may
415 prove difficult in practice, and measurements of state anxiety. This could provide a link to
416 research into choking-susceptible athletes (e.g., Mesagno & Marchant, 2013), and would allow
417 assessment of whether improved mindfulness is beneficial to such performers. Further
418 research is also necessary into how re-perceiving might facilitate a more adaptive and flexible
419 response to the environment in contrast to the more rigid patterns of reflexivity that can lead to
420 cognitive fusion and ironic processing (Shapiro et al., 2006).

421 Whilst the athletes in the current study were short distance swimmers whose
422 performance may have benefited from improved pre-race focus, longer distance events are
423 associated with greater opportunities to experience distractions linked to pain and suffering

424 during performances so may offer different opportunities for mindfulness to have an impact on
425 performance. Therefore research could be extended to longer, endurance sports settings.
426 Finally, alternative research design could investigate the dose effect of mindfulness-based
427 interventions, to determine how much training is enough to elicit a positive effect.

428 **Implications for Practitioners and Conclusions**

429 This study gives promising evidence for practitioners, coaches, and performers. The CD-based
430 intervention can be used flexibly by athletes at times to suit training, can be used at a rate to
431 suit individual skill development, and does not require intensive, time consuming, or costly
432 practitioner input compared to fully practitioner-led programs. The total mindfulness training
433 time was 90 minutes per week over eight weeks. This is relatively short when improved
434 performance times and participant ratings of beneficial impact indicate a good return on
435 invested time. These exploratory findings lend support to using a CD, and brief guided support
436 from a practitioner, to develop mindfulness and potentially benefit components of
437 performance. The acceptance by athletes of this intervention was strong with five of the six
438 participants indicating they would fully recommend mindfulness training to other athletes,
439 whilst the remaining participant would recommend it for some athletes or circumstances.

440 In conclusion, the current study adds to the existing literature by illustrating that
441 mindfulness training can enhance performance times and performance criteria ratings in a real-
442 world sport setting. Crucially, this study also contributes to the literature by demonstrating
443 increases in attention efficiency, adding support to the theoretical proposals that mindfulness
444 enhances performance through self-regulated attention mechanisms related to working
445 memory and efficiency. Further research is needed to test the mechanisms through which
446 mindfulness may benefit sport performance.

447

448

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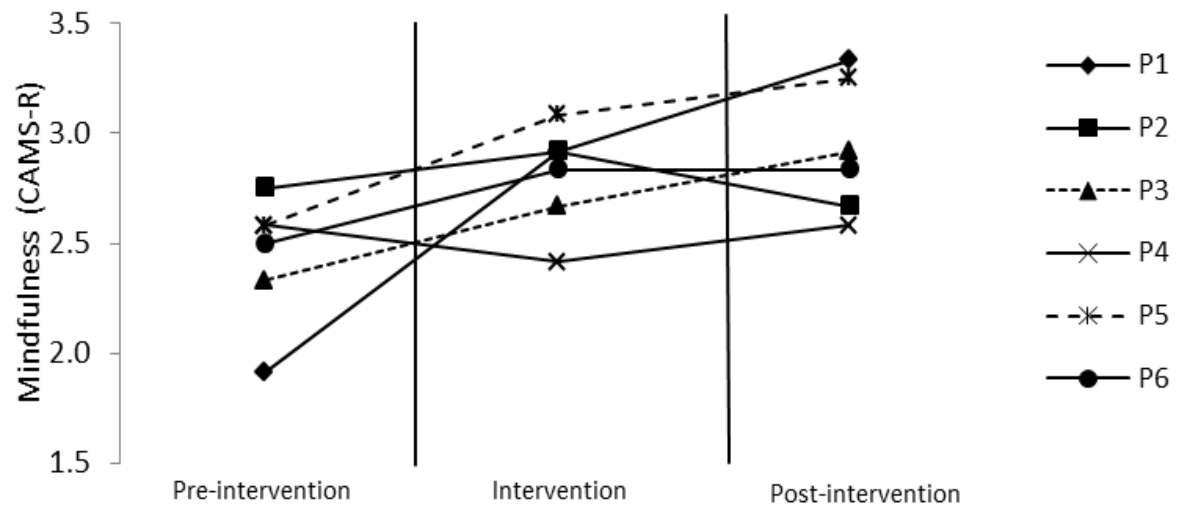
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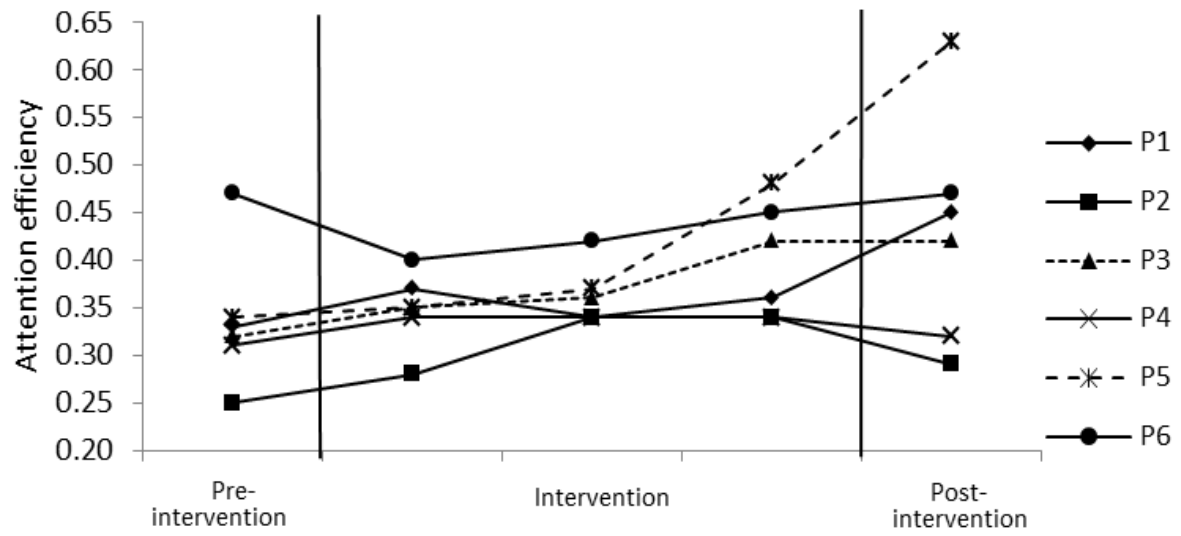
525 **Figure 1** - Changes in mindfulness, as measured by mean scores from The Cognitive and Affective
526 Mindfulness Scale – Revised (CAMS-R) across the phases of the study for the six participants (P1-P6).

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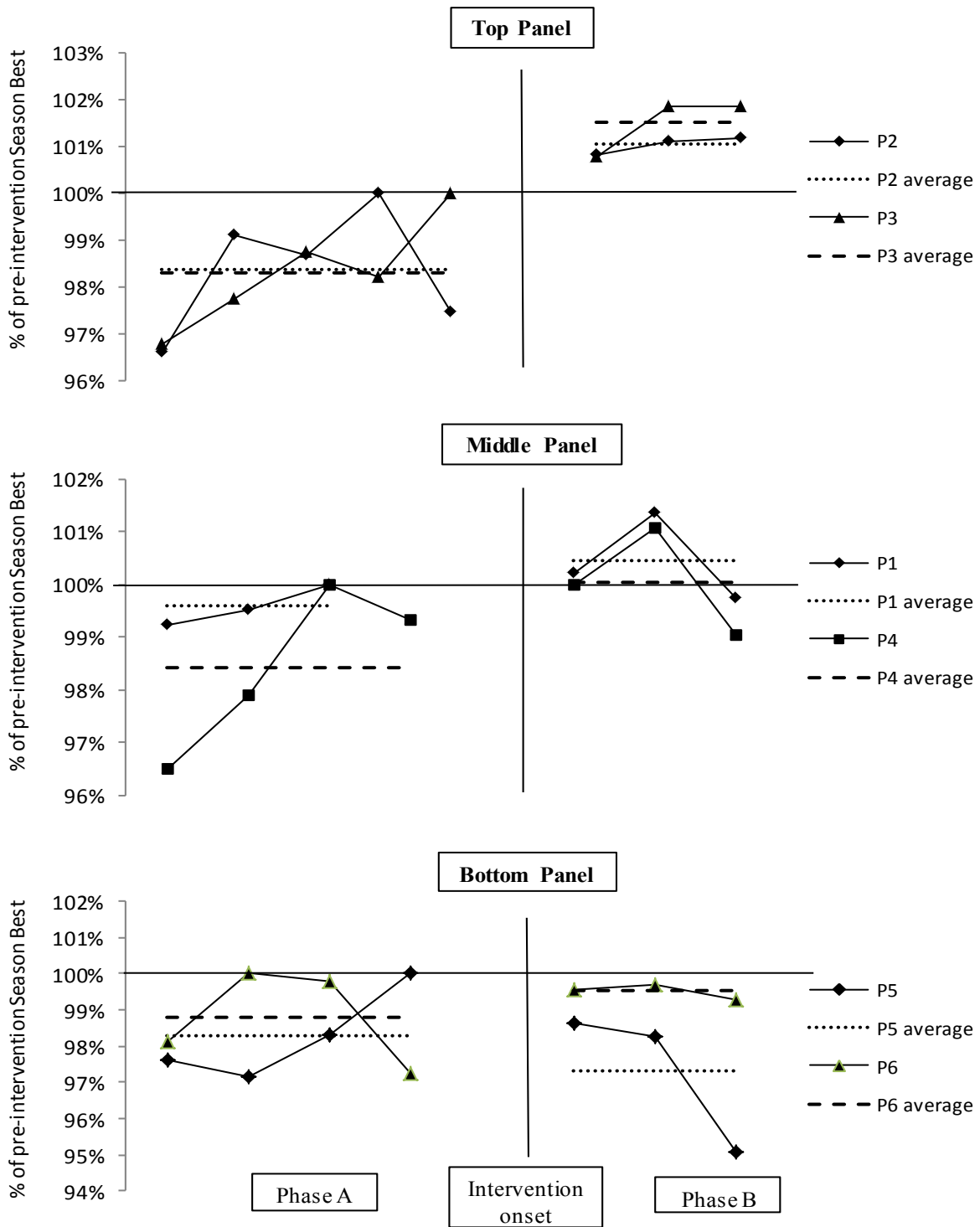
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Figure 2 - Mean attention efficiency scores for the six participants (P1-P6). Efficiency calculated as attention score divided by self-reported mental effort.

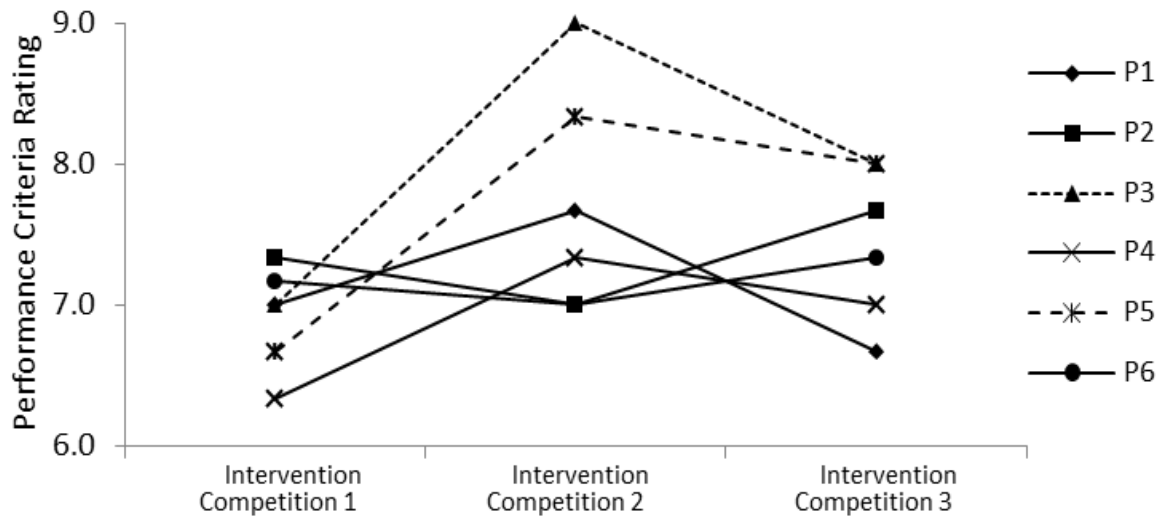
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Figure 3 - Performance times expressed as a proportion of pre-intervention season-best for the six participants (P1-P6). Phase A shows pre-intervention performances and Phase B shows performances during the 8-week intervention period.

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Figure 4 - Mean self-reported performance criteria ratings for the six participants (P1-P6) for the three competitions during the intervention period.