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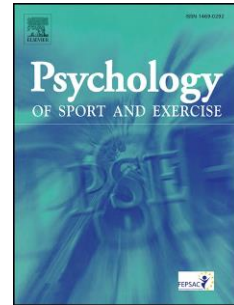
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# Accepted Manuscript

The effects of mindfulness training on beginners' skill acquisition in dart throwing: A randomized controlled trial

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Running head: MINDFULNESS TRAINING AND DART THROWING

The effects of mindfulness training on beginners' skill acquisition in dart throwing: A  
randomized controlled trial

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4 The Effects of Mindfulness Training on Beginners' Skill Acquisition in Dart Throwing: A

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Randomized Controlled Trial

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ACCEPTED MANUSCRIPT

**Abstract**

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**Objectives:** The present study was into whether or not mindfulness training, based on the mindfulness-acceptance-commitment approach (MAC), can improve beginners' skill acquisition of dart throwing.

**Design:** Randomised controlled trial.

**Methods:** A total of 43 first-year college students who had not played darts professionally prior to the study were randomly assigned to either an attention control group ( $n = 21$ ) or a mindfulness training group ( $n = 22$ ) during an eight-week dart training program. Dart throwing and psychological variables were assessed at pre-intervention, post-intervention, and two-week follow-up.

**Results:** Two-way repeated measures ANOVA revealed that the mindfulness group, but not the attention control group had significant improvements in mindfulness, experiential acceptance, and flow at post-intervention and follow-up. Although both groups improved dart throwing performance after the intervention, the improvement of the mindfulness group was statistically higher in comparison to that of the attention control group.

**Conclusions:** It was concluded that the MAC approach could improve the performance and adaptive sport experience of beginners in dart throwing.

**Keywords:** Experiential acceptance; flow; mindfulness intervention; motor skill learning; sport performance.

1 The effects of mindfulness training on beginners' skill acquisition in dart throwing: A  
2 randomized controlled trial

3 The acquisition of motor skills is fundamental in the domain of sport where the  
4 evaluation criteria or the key to success is heavily relied on athletes' ability to reproduce  
5 their sport skills (Williams & Hodges, 2004). Athletes start as beginners to acquire new  
6 skills through self-controlled learning and deliberate practice before becoming  
7 accomplished in their sports. Mindfulness is described as paying attention and  
8 awareness to the present moment with a non-judgmental and non-reactive attitude  
9 (Brown & Ryan, 2003; Kabat-Zinn, 2003), and might be able to facilitate an effective  
10 motor skill learning (Ferrari, 1996). Mindfulness enables individuals to avoid simply  
11 learning through automatic repetition (i.e., processing given information without being  
12 aware of alternative options) by increasing their sensitivity to skill acquisition (Langer,  
13 2000). Recent research supports the effects of mindfulness on basic skill performance  
14 (e.g., finger movement and postural balance; Kee, Chaturvedi, Wang, & Chen, 2013;  
15 Kee, Chatzisarants, Kong, Chow, & Chen, 2012). We, therefore, speculated that  
16 mindfulness training would be useful for enhancing sport beginners' learning experience.  
17 The aim of this study was to test the effects of mindfulness training (i.e., mindfulness-  
18 acceptance-commitment; Gardner & Moore, 2007) on the dart throwing performance  
19 and psychological effects of dart beginners.

20 Mindfulness has been integrated into cognitive behavioural training in the sport  
21 context, with the aim of improving athletes' performance, mental status, and general  
22 well-being (Gardner & Moore, 2012). Compared to traditional cognitive behavioural  
23 training (e.g., psychological skill training), which builds on the rationale of controlling or  
24 changing the contents of performers' undesirable psychological events in order to

1 achieve the optimal psychological states (e.g., the states of peak performance),  
2 mindfulness training is an alternative approach for individuals to experience their  
3 psychological events (i.e., learning experiences). In a state of mindfulness, individuals  
4 apply an accepting and non-judging approach to act and think rather than trying to  
5 change or control those experiences (Gardner & Moore, 2007). Therefore, mindfulness  
6 training encourages individuals to pay attention to the present moment, which helps  
7 disengage distractions from their ruminative states. In other words, mindfulness training  
8 may help individuals avoid ineffective or counterproductive psychological states  
9 (Gardner & Moore, 2007).

10 The benefits of mindfulness training to human learning experience have been  
11 explained by recent studies in cognitive psychology and neuroscience (Chiesa, Calati, &  
12 Serretti, 2011; Peabody, in press). Theoretically, it has been proposed that mindfulness  
13 training (e.g., mindfulness meditation) can enhance attention control, emotion regulation,  
14 and self-awareness (for reviews, see Hölzel Lazar et al., 2011; Tang, Hölzel, & Posner,  
15 2015). With regard to the empirical evidence on the mechanisms of attention control and  
16 self-awareness, it has been demonstrated that both long- and short- term mindfulness  
17 training can cause a structural change of grey matter (Hölzel Carmody et al., 2011) and  
18 white matter (Tang et al., 2007) in the brain. These neurological effects are proposed to  
19 indicate motor learning (Sampaio-Baptista et al., 2013; Wei, Zhang, Jiang, & Luo, 2011). As such,  
20 mindfulness training might well be useful for mastering new sport skills because of its  
21 neurological effects related to motor learning, as well as the psychological effects, such  
22 as attention control.

23 The mindfulness-acceptance-commitment approach (MAC; Gardner & Moore,  
24 2007) is one of the most popular mindfulness training programs in sport. The MAC

1 includes key concepts and practices skills from two widely-recognized mindfulness-  
2 based training programs: the mindfulness-based cognitive therapy (Segal, Williams, &  
3 Teasdale, 2002) and the acceptance and commitment therapy (Hayes, Strosahl, &  
4 Wilson, 1999). In MAC, mindfulness training skills, acceptance, value, and commitment  
5 from these two training programs have been fully integrated and reconstituted with  
6 behaviour-change strategies in sport contexts. The aim of MAC is to help performers  
7 develop skills of non-judging mindful attention and awareness, and experiential  
8 acceptance of internal experiences, while focusing on contextually appropriate  
9 behavioural responses, in order to promote both competitive in-the-moment behaviours  
10 as well as in the pursuit of valued goals (Moore, 2009).

11 Several functions of MAC are suggested to be useful to motor skill learning, such  
12 as task-focused attention, experiential acceptance (i.e., willingness to experience  
13 internal events such as bodily sensation, emotions, thoughts, and memories), and  
14 commitment (Gardner & Moore, 2007; Wulf, Shea, & Lewthwaite, 2010). Task-focused  
15 attention allows learners to focus on the external motor movements rather than their internal self-  
16 referenced thoughts. This is viewed as an effective motor learning principle (Wulf et al.,  
17 2010). In addition, openness to new experience with a nonjudgmental attitude has been  
18 explicitly encouraged in the MAC training (Gardner & Moore, 2007). Individuals, using  
19 this experiential acceptance approach, may easily detect the inconsistencies and  
20 incoherencies in the earlier stages of motor skill learning (i.e., the cognitive and  
21 associative stages in the three-stage model; Fitts, 1964; Fitts & Posner, 1973).  
22 Furthermore, commitment to motor learning goals is important. In MAC, value-driven  
23 behaviours, rather than emotion-driven behaviors, are cultivated in order to promote  
24 individuals consistent commitment to their goals (Gardner & Moore, 2007).



1           Research has shown that mindfulness training can improve athletes' mental  
2 status in sport, such as an increase in experiential acceptance, general well-being, and  
3 flow (i.e., complete absorption in what one does; Csikszentmihalyi, 1990) as well as the  
4 reduction of anxiety, worries, and the risk of burnout (e.g., Aherne, Moran, & Lonsdale,  
5 2011; Gardner & Moore, 2012; Thompson, Kaufman, De Petrillo, Glass, & Arnkoff,  
6 2011). Among all the proposed psychological variables, flow is an immediate and critical  
7 outcome of MAC that can facilitate athletes' adaptive behaviours in competitive sport  
8 (Bernier, Thienot, Codron, & Fournier, 2009; Gardner & Moore, 2007, 2012). Most importantly,  
9 flow experiences also correspond to the description of the autonomous stage of motor skill learning  
10 (Fitts, 1964; Fitts & Posner, 1973), in which athletes perform their skills without the need to  
11 consciously think about what they are doing (Magill, 2004).

12           Although there has been some evidence on the link between mindfulness and  
13 athletes' experience in sport, the application of MAC to sport novices and its prolonged  
14 effects on motor skill acquisition has not been researched. Although MAC training has  
15 been shown to have an acute enhancing effect on athletes' performance in various  
16 sports (e.g., field hockey, volleyball, and diving; Gardner & Moore, 2012;  
17 Schwanhausser, 2009; Wolanin & Schwanhausser, 2010), causal inference could not be  
18 made from previous studies as they were generally conducted using small sample case  
19 studies among elite or collegiate players without randomisation control (Birrner, Röthlin, &  
20 Morgan, 2012). Therefore, generalisability of previous findings was restricted to elite  
21 athletes, but not to athletes at all levels (e.g., sport novices or recreational level players).  
22 Nonetheless, investigating the role of mindfulness training in improving beginner players'  
23 experience, mental status, and sport performance is highly useful for understanding how

1 mindfulness could be applied to learning, improvement, and skill acquisition in sport  
2 training.

3 The aim of the present study was to examine the effectiveness of MAC training  
4 on beginners' mindfulness, experiential acceptance, flow, and dart throwing  
5 performance. It was hypothesised that mindfulness, experiential acceptance, flow, and  
6 dart throwing performance in the mindfulness training group would be significantly  
7 higher than the attention control group immediately-after and two-weeks after the  
8 intervention. In addition, it was hypothesised that the mindfulness training group, instead  
9 of the attention control group, would significantly improve mindfulness, experiential  
10 acceptance, and flow at the post-test and the improvement would be maintained two-  
11 weeks later.

## 12 **Methods**

### 13 **Participants**

14 Ethics clearance was granted by the research ethics committee of the Hong Kong  
15 Sports Institute. A total of 43 first-year college students who were enrolled in a sport  
16 psychology program at a sport university in China participated voluntarily in the study  
17 (response rate = 87.76 %;  $M_{age} = 19.23$ ;  $SD = 1.27$ ). Participants were all right-handed,  
18 had normal or corrected-to-normal vision, did not have any mindfulness training, and  
19 had not played darts professionally prior to the study. Players were self-selecting based  
20 on their being unskilled at playing darts. Written informed consent was provided to  
21 participants before inclusion and the confidentiality and anonymity of their participation  
22 were assured.

### 23 **Intervention Protocols**

1 Mindfulness training in the current study was based on the MAC protocol  
2 (Gardner & Moore, 2007; see the online supplementary material Appendix A), but initial  
3 evidence from two single-case studies in China demonstrated that Chinese athletes had  
4 different interpretations toward the concepts of value and commitment in MAC, because  
5 social-oriented value and commitment were deemed as more appropriate than personal-  
6 oriented value and commitment in the Chinese culture (Bu, 2013; Zhang, 2013). As such,  
7 to facilitate better understanding of these two important concepts, the cultivation of a  
8 new awareness and discovery of social-oriented insights, meanings, and values of life  
9 were integrated into the MAC modules (Si et al., 2014). The adaptation is essential  
10 because the delivery of MAC training is likely to be more effective if the  
11 interpretation of values and commitments in MAC is in line with the indigenous  
12 cultural values and beliefs (Si, Lo, & Zhang, in press). This adapted MAC protocol has  
13 already been demonstrated to be effective in improving mindfulness, experiential  
14 acceptance, and training performance of a sample of six national level elite Chinese  
15 synchronized swimmers (Si et al., in press).

## 16 **Measures**

17 Participants completed a 15-min questionnaire and dart throwing tests at pre-  
18 intervention (Week 1), post-intervention (Week 8), and follow-up (Week 10).

19 Mindfulness was measured using the Chinese version of Five Facet Mindfulness  
20 Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) developed in  
21 a recent study (Deng, Liu, Rodriguez, & Xia, 2011) with supporting evidence regarding  
22 the factorial validity of the measure in a Chinese population. Using a five-point Likert  
23 scale (1 = *never or very rarely true*; 5 = *very often or always true*), participants rated 39  
24 items from five dimensions, including: observe (e.g., "I notice the smells and aromas of

1 things.”), describe (e.g., “I can usually describe how I feel at the moment in considerable  
2 detail.”), act with awareness (e.g., reverse-worded “I rush through activities without  
3 being really attentive to them.”), non-judgment (e.g., reverse-worded “I tell myself that I  
4 shouldn’t be thinking the way I’m thinking.”), and non-react (e.g., “When I have  
5 distressing thoughts or images, I just notice them and let them go.”). There was  
6 acceptable internal consistency reliability of the FFMQ across three assessments ( $\alpha$   
7 = .71 to .94).

8         Experiential acceptance was measured by the Chinese version (Zhang, Chung,  
9 Si, & Liu, 2014) of Acceptance and Action Questionnaire-II (AAQ-II; Bond et al., 2011).  
10 The measure has seven items (e.g., “My painful experiences and memories make it  
11 difficult for me to live a life that I would value.”) and data from previous studies  
12 supported its factorial validity (Bond et al., 2011; Zhang et al., 2014).  
13 Responses were made on 7-point Likert scale (1 = *never true*; 7 = *always true*). This  
14 single-dimension scale produced satisfactory internal consistency during our three  
15 assessments ( $\alpha$  = .82 to .93).

16         Flow was assessed by the Chinese version (Liu, 2010) of Short Dispositional  
17 Flow Scale (SDFS; Jackson, Martin, & Eklund, 2008), in which both versions  
18 demonstrated satisfactory factorial validity. Participants rated the seven items (e.g.,  
19 “When participating in my sport, I know clearly what I want to do.”) of SDFS on a 5-point  
20 Likert scale (1 = *never*; 5 = *always*). The internal consistency reliability of SDFS was  
21 satisfactory across our three assessments ( $\alpha$  = .66 to .82).

22         The dart throwing performance was measured approximately five minutes after  
23 participants completed the self-report measures of mindfulness, experiential acceptance,  
24 and flow at each of the three assessments (pre-intervention, post-intervention, and

1 follow-up). Two dartboards that were made-up of ten concentric circles were used,  
2 rather than the traditional style. The position of the dartboards was set according to  
3 international standards, where the bullseye was 1.73 meters from the floor and the  
4 throwing line was 2.37 meters away from the dartboard. The score for each throw was  
5 given by how close the dart hit the bullseye, ranging on a scale from 10 (bullseye) to 0  
6 (outside the dartboard). Participants were asked to throw three darts in each round, and  
7 their performance of dart throwing was the total score they obtained in five consecutive  
8 rounds.

### 9 **Procedure**

10 All participants took part in an eight-week dart training program instructed by a  
11 professional dart playing coach. In the first two weeks, the basic knowledge and skills of  
12 dart throwing were introduced to the participants. In the subsequent weeks (Week 3 to  
13 Week 8), participants were given two 30 minutes sessions of dart throwing practice  
14 every week. Mindfulness training began in Week 2, in which participants were randomly  
15 divided into a mindfulness group ( $n = 22$ , 10 males and 12 females) or an attention  
16 control group ( $n=21$ , 6 males and 15 females), based on a simple randomisation (i.e.,  
17 use of random number tables). From Week 2 to Week 8, the mindfulness group received  
18 MAC mindfulness training while the attention control group received sport psychology  
19 lectures.

20 In accordance with the guidelines of Gardner and Moore (2007), the mindfulness  
21 group was given homework to practice mindfulness a minimum of three times per week.  
22 Similarly, the attention control group was required to revise the learning materials of the  
23 previous lecture three times per week. The sport psychology lecture intervention for the  
24 attention control group was an introductory course of sport and exercise psychology

1 (see the online supplementary material Appendix B). Topics included history, research,  
2 theories, talent identification, and athletes' lifespan development. MAC training was  
3 delivered to the mindfulness group by one instructor, and the sport psychology lecture of  
4 the attention control group was conducted by another independent instructor. They were  
5 both qualified sport psychology consultants and had more than one year experience in  
6 mindfulness practice. With a single-blinded design, these two instructors understood  
7 about the research purpose, but they did not have any mutual interference during the  
8 intervention period and were not allowed to disclose the study hypotheses, study design,  
9 or methodology to the participants. A session was given in each of the weeks, and the  
10 duration was 80 to 90 minutes for each group, and the amount of time and level of  
11 interaction that the instructors had with the participants was consistent between the two  
12 groups.

### 13 **Data Analysis**

14 Two-way repeated measures analyses of variance (ANOVA) were conducted to  
15 test the effect of time (within-subject independent variable: levels = pre-intervention,  
16 post-intervention, and follow-up) and group (between-subject independent variable:  
17 levels = mindfulness group and attention control group) on mindfulness, experiential  
18 acceptance, flow, and dart throwing performance respectively. Post-hoc paired sample *t*-  
19 tests were further used to investigate whether there was any within-group difference  
20 between three assessments of each group.

### 21 **Results**

22 In preliminary data screening, no missing data were observed and there were no  
23 significant between-group differences on any study variables at pre-intervention ( $p > .05$ ).  
24 See Table 1 for the means, standard deviations, skewness, kurtosis, and internal

1 consistencies (Cronbach's  $\alpha$ ) of the study variables of each group across three  
2 assessments.

3 Two-way repeated measure ANOVA of mindfulness revealed a significant time by  
4 group interaction effect,  $F(2, 40) = 6.59, p = .003, \eta^2 = .25$  and a significant between-  
5 group difference,  $F(1, 41) = 27.79, p < .001, \eta^2 = .40$ . Furthermore, within-group  
6 difference of mindfulness scores across time was significant,  $F(2, 40) = 8.28, p = .001,$   
7  $\eta^2 = .29$ . Post-hoc independent sample  $t$ -tests indicated that the mindfulness scores of  
8 mindfulness group were significantly higher than attention control group at both post-  
9 intervention and follow-up (see Table 2). Post-hoc paired sample  $t$ -tests indicated that,  
10 in mindfulness group, the mindfulness scores were significantly higher in post-  
11 intervention and follow-up, as compared to that of pre-intervention. Unexpectedly,  
12 mindfulness group significantly decreased their mindfulness scores from post-  
13 intervention to follow-up, but the follow-up mindfulness scores were still significantly  
14 better than the pre-intervention mindfulness scores. No significant differences of  
15 mindfulness scores were observed across three assessments in the attention control  
16 group (see Table 3).

17 No significant time by group interaction was found from the ANOVA of  
18 experiential acceptance,  $F(2, 40) = 2.48, p = .097, \eta^2 = .11$ , but between-group  
19 difference was significant,  $F(1, 41) = 10.50, p = .002, \eta^2 = .20$ . In addition, within-group  
20 difference of experiential acceptance across time was not significant,  $F(2, 40) = 2.24, p$   
21  $= .120, \eta^2 = .10$ . Post-hoc independent sample  $t$ -tests indicated that the experiential  
22 acceptance of mindfulness group were significantly higher than attention control group  
23 at both post-intervention and follow-up. Post-hoc paired sample  $t$ -tests indicated that the  
24 experiential acceptance of mindfulness group were significantly higher during post-

1 intervention and follow-up, in comparison to that of pre-intervention. No significant  
2 differences of experiential acceptance were observed across three assessments in the  
3 attention control group.

4 Repeated measure ANOVA of flow revealed a significant time by group  
5 interaction effect,  $F(2, 40) = 6.07, p = .005, \eta^2 = .23$  and a significant between-group  
6 difference,  $F(1, 41) = 20.89, p < .001, \eta^2 = .34$ . Furthermore, within-group difference of  
7 flow across time was significant,  $F(2, 40) = 5.20, p = .010, \eta^2 = .21$ . Post-hoc  
8 independent sample *t*-tests indicated that the flow of mindfulness group were  
9 significantly higher than attention control group at both post-intervention and follow-up.  
10 Post-hoc paired sample *t*-tests indicated that the flow of mindfulness group was  
11 significantly higher in post-intervention and follow-up, as compared to that of pre-  
12 intervention. No significant differences were found across three assessments of flow in  
13 the attention control group.

14 Repeated measure ANOVA of dart throwing performance revealed a significant  
15 time by group interaction effect of the,  $F(2, 40) = 6.83, p = .003, \eta^2 = .26$  and a  
16 significant between-group difference,  $F(1, 41) = 20.43, p < .001, \eta^2 = .33$ . Furthermore,  
17 within-group difference of dart throwing across time was significant,  $F(2, 40) = 35.51, p$   
18  $< .001, \eta^2 = .64$ . Post-hoc independent sample *t*-tests indicated that the dart throwing  
19 performance of mindfulness group were significantly higher than attention control group  
20 at both post-intervention and follow-up. Post-hoc paired sample *t*-tests indicated that  
21 both mindfulness and attention control group significantly increased dart throwing  
22 performance at post-intervention. Interestingly, from post-intervention to follow-up,  
23 mindfulness group had no significant improvement, whereas the attention control group  
24 had significant decrease in dart throwing performance.



## Discussion

1  
2           The current study provides preliminary evidence for the effectiveness of MAC  
3 training on the skill acquisition of dart throwing for beginners, who never played darts  
4 professionally prior to the experiment. Compared with the attention control group,  
5 beginners in dart throwing who completed the mindfulness training significantly  
6 improved their dart throwing performance, mindfulness, experiential acceptance, and  
7 flow at the post-intervention test and follow-up. From post-intervention to two-week  
8 follow-up, mindfulness group reported no significant changes on experiential acceptance,  
9 flow, and dart throwing performance, while the attention control group significantly  
10 decreased their dart throwing performance, indicating the positive effects of mindfulness  
11 training sustained two weeks after the intervention.

12           Individuals with high levels of mindfulness have an advantage in learning new  
13 motor skills (Kee & Liu, 2011). The current study extended the findings of mindfulness in  
14 previous studies about basic motor skill learning (Kee et al., 2012, 2013) to  
15 sport skill acquisition. It also corroborated the findings of a recent report that supported  
16 the effectiveness of mindfulness training on performance of some motor skills (e.g.,  
17 darts, golf putting, and sinusoid tests; Meeûs, Boen, & De Cuyper, 2010). Notably, in our  
18 study, the dart throwing performance of the attention control group, instead of the  
19 mindfulness group, was impaired in the two-week follow-up which might imply that MAC  
20 training could be useful for preserving a new skill obtained by sport novices. Overall, the  
21 mindfulness group performed better than the control group in dart throwing. This may  
22 mean that although sport novices improve along with their practice, MAC training is  
23 likely to make the improvement better and more sustainable, and these patterns are

1 likely to be associated with increases in psychological variables such as experiential  
2 acceptance and flow.

3         The current findings support the existing literature of the effectiveness of  
4 mindfulness training on salutary psychological variables with regard to mindfulness,  
5 experiential acceptance and flow (e.g., Aherne et al., 2011; Gardner & Moore, 2012;  
6 Schwanhausser, 2009; Thompson et al., 2011). Although the mindfulness group had  
7 increased mindfulness scores after the mindfulness training, the score slightly dropped  
8 by follow-up. Although the score was still significantly higher than the baseline, we  
9 believed that poor adherence to home-based mindfulness practice following the  
10 termination of the intervention was the main reason (Rosenzweig et al., 2010). This  
11 finding further emphasized the importance of behavioural persistence, commitment, self-  
12 initiated training following the termination of mindfulness intervention (Morgan, Grahama,  
13 Hayes-Skelton, Orsillo, & Roemer 2014). Nevertheless, it seemed that the slight  
14 decrease of mindfulness alone did not influence the dart throwing performance of  
15 mindfulness group.

16         Mindfulness has been linked to significant and positive relations with experiential  
17 acceptance and flow in previous correlational and intervention studies (e.g., Aherne et  
18 al., 2011; Kee & Wang, 2008; Thompson et al., 2011; Zhang et al., 2014). As shown in  
19 our study, the mindfulness group had consistently reported higher experiential  
20 acceptance, flow, and performed better dart throwing than the attention control group.  
21 As such, these findings provide further support on our theoretical proposition that  
22 mindfulness training can facilitate experiential acceptance and flow experiences which  
23 can in turn help novices acquire new skills in sport (Ferrari, 1996; Gardner & Moore,  
24 2007; Langer, 2000). As an important component in MAC training, exceptional

1 acceptance facilitates learners' earlier stage of skill acquisition enabling them to accept  
2 the inconsistencies and incoherencies encountered (Langer, 2000). Given that flow  
3 experience is consistent with the characteristic of autonomous stage of motor skill  
4 learning (i.e., knowing what to do without conscious attention control; Csikszentmihalyi,  
5 1990; Ferrari, 1996), it may suggest that flow is one of the key indicators of effective  
6 performing motor tasks during later stage of skill acquisition (Singer, Lidor, & Cauraugh,  
7 1993; Swann, Keegan, Piggott, & Crust, 2012).

8         Despite its merits, the present study is not without limitations. Firstly, the two-  
9 week follow-up duration might not be adequate for testing the long-term effects of  
10 mindfulness training across the entire learning progress of sport participants. Also, our  
11 sample size was relatively small and the findings might be tentative. Future research  
12 should include a longer follow-up with a larger sample, and longitudinally assess the  
13 uptake of mindfulness and sport training over a prolonged period (Twisk & Proper, 2004).  
14 Secondly, psychological factors were measured on self-report inventories and  
15 responses could therefore be subjected to social desirability, memory bias, and mere-  
16 measurement effects (Chan & Hagger, 2012; Podsakoff, MacKenzie, & Podsakoff,  
17 2012); future research may consider further including biomarkers in outcome measures  
18 as supplements of an objective indicator of the mental status, for example, heart rate  
19 variability (Mankus, Aldao, Kerns, Mayville, & Mennin, 2013) and saliva secretory  
20 immunoglobulin A (SIgA; Taylor, Turner, Gleeson, & Hough, 2015). Thirdly, the present  
21 study could not examine the independent effects of each key component of mindfulness  
22 and acceptance training provided by MAC because the intervention was delivered as a  
23 whole package. Future studies may adopt a cluster randomised controlled trial to partial  
24 out the effects of separate elements of MAC. Fourthly, the single-blinded design may

1 raise issues about whether the expectations of the instructors might lead participants to  
2 behave or respond to the assessment according to the study hypothesis. Although we  
3 tried to minimise this problem by having trained the experimenters not to disclose the  
4 hypothesis and design of the study, future studies should adopt a double-blinded design.  
5 Fifthly, we did not evaluate how well participants applied the skills of MAC for dart  
6 throwing. It was because the evaluation immediately before dart throwing could possibly  
7 interfere participants' performance. Retrospective assessment of home-based MAC  
8 training was possible, but the responses would be subjected to memory loss and self-  
9 reported bias. Future studies may consider using the experience sampling method  
10 (Csikszentmihalyi & Larson, 1987), diary self-monitoring method (Burke, Wang, & Sevick,  
11 2011), or qualitative interview for a more comprehensive measure of participants'  
12 behavioural adherence to the mindfulness and acceptance training.

### 13 **Conclusion**

14 In summary, the present study provided initial evidence supporting the application  
15 of MAC-based mindfulness and acceptance training in dart learning for beginners.  
16 Mindfulness and acceptance training not only appeared to be adaptive to beginners'  
17 sport experience and performance, but it also seemed to reduce the deterioration of the  
18 acquired skill level of sport after the end of sport training. The importance of preserving  
19 the habit of regular mindfulness practice after the completion of mindfulness intervention  
20 (e.g., MAC) is highlighted.

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Table 1

*Descriptive statistics, distributions, and reliability indices of the study variables across pre-intervention, post-intervention, and follow-up*

Measures	Pre-intervention					Post-intervention					Follow-up					
	<i>M</i>	<i>SD</i>	Skew	Kur	$\alpha$	<i>M</i>	<i>SD</i>	Skew	Kur	$\alpha$	<i>M</i>	<i>SD</i>	Skew	Kur	$\alpha$	
Mindfulness																
Mindfulness group	3.14	.32	.56	.16	.85	3.75	.50	.68	-.30	.94	3.52	.29	-.34	-.51	.85	
Attention control group	3.11	.22	.97	.37	.71	3.11	.28	.99	-.16	.76	3.12	.26	-.39	-.04	.78	
Experiential acceptance																
Mindfulness group	5.16	1.06	-.60	-1.02	.92	6.00	.83	-.75	-.67	.93	5.86	.75	-.35	-.87	.87	
Attention control group	5.17	.85	-.25	-.72	.82	5.18	.86	-.09	-.29	.86	5.08	.83	.25	-.20	.91	
Flow																
Mindfulness group	3.51	.49	.33	.86	.82	4.02	.44	-.03	-1.14	.76	4.00	.28	-.35	-.55	.66	
Attention control group	3.43	.45	-.48	-.65	.80	3.38	.42	.39	-.06	.77	3.46	.34	.60	-.43	.72	
Dart throwing performance																
Mindfulness group	4.83	1.34	-.22	-.80		6.88	.50	-1.13	3.24		6.64	.44	-.06	-1.37		
Attention control group	4.70	1.15	.18	-.89		5.90	.57	.48	-1.36		5.40	.73	.29	-.64		

*Note.* *M* = Mean; *SD* = Standard Deviation;  $\alpha$  = Cronbach's Alpha; Skew = Skewness; Kur = Kurtosis. Average score of each item/dart throwing is presented.

Table 2

*Summaries of between-group independent sample t-test comparisons*

Measures	Pre-intervention		Post-intervention				Follow-up			
	<i>t</i> value	<i>p</i> value	<i>t</i> value	<i>p</i> value	Cohen's <i>d</i>	95% <i>CI</i>	<i>t</i> value	<i>p</i> value	Cohen's <i>d</i>	95% <i>CI</i>
Mindfulness	.30	.766	4.82	<.001	1.47	[.79, 2.14]	4.79	<.001	1.46	[.78, 2.13]
Experiential acceptance	-.048	.962	3.19	.003	.97	[.33, 1.60]	3.23	.002	.99	[.35, 1.62]
Flow	.57	.572	4.90	<.001	1.50	[.81, 2.17]	5.61	<.001	1.71	[1.00, 2.41]
Dart throwing performance	.07	.945	6.04	<.001	1.84	[1.12, 2.55]	7.99	<.001	2.43	[1.63, 3.22]

*Note.* *CI*= confidence interval. The degree of freedom of all *t*-test comparisons equal to 41.

Table 3

Summaries of within-group paired sample *t*-test comparisons among pre-intervention, post-intervention, and follow-up

Measures	Pre- intervention			Pre-intervention			Post-intervention		
	VS			VS			VS		
	Post-intervention			Follow-up			Follow-up		
	<i>M Diff</i>	<i>t</i>	<i>df</i>	<i>M Diff</i>	<i>t</i>	<i>df</i>	<i>M Diff</i>	<i>t</i>	<i>df</i>
Mindfulness Group									
Mindfulness	-23.86	-4.45**	21	-14.77	-4.09**	21	9.09	2.75*	21
Experiential acceptance	-5.91	-2.77*	21	-4.96	-2.39*	21	.96	-.49	21
Flow	-4.55	-5.04**	21	-4.41	-4.52**	21	.14	.15	21
Dart throwing performance	-31.14	-8.00**	21	-28.23	-6.30**	21	2.91	1.12	21
Attention control group									
Mindfulness	-1.62	-.54	20	-.29	-.11	20	1.33	.53	20
Experiential acceptance	-.05	.03	20	.62	-.37	20	.67	-1.75	20
Flow	.48	.43	20	-.29	-.26	20	-.76	-1.93	20
Dart throwing performance	-16.71	-4.11**	20	-8.52	-3.14**	20	8.19	3.00**	20

Note. *M Diff*=Mean Difference; *df* = degree of freedom; \*  $p < .05$ , \*\*  $p < .01$ , at two-tailed significance.

- Mindfulness training can facilitate the skill acquisition of dart throwing beginners.
- Mindfulness training can help prevent the decline of beginners' performance once they stop practicing their skills.
- Continued practice of mindfulness is required to maintain its benefits.

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## Appendix A (Supplementary Online Material)

*Outline of the Intervention Protocol for Mindfulness Group*

Theme of each week	Contents
Week 2: Preparing the participants with psychoeducation	<ol style="list-style-type: none"> <li>1. Introducing the entire structure of the mindfulness training program</li> <li>2. Theoretical rationale and specific aims of the program</li> <li>3. A story on the application of mindfulness of an athlete</li> <li>4. The practice of brief centering exercise and group sharing</li> <li>5. Homework (brief centering exercise)</li> </ol>
Week 3: Introducing mindfulness	<ol style="list-style-type: none"> <li>1. Introducing the definition of mindfulness (<i>as it is and here and now</i>)</li> <li>2. Introducing Eastern mind and heart in mindfulness</li> <li>3. The practice of exercises of mindfulness breathing, mindfulness walking and mindfulness fruit eating and group sharing</li> <li>4. Homework (mindfulness breathing, mindfulness walking and mindfulness fruit eating)</li> </ol>
Week 4: Introducing cognitive defusion	<ol style="list-style-type: none"> <li>1. Introducing the concept of cognitive defusion</li> <li>2. From ruminated self-orientation to task-orientation</li> <li>3. The practice of mindfulness exercises such as forgetting-self behaviour exercise and group sharing</li> <li>4. Homework (forgetting-self behaviour exercise)</li> </ol>
Week 5: Introducing acceptance	<ol style="list-style-type: none"> <li>1. Strengthen participants' understanding of acceptance and avoidance of experiences in dart throwing</li> <li>2. Emphasizing the attitudes of accepting and non-judging towards</li> </ol>

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	experiences in dart throwing
	3. The practice of coexistence exercise I and II and group sharing
	4. Homework (coexistence exercise)
Week 6: Introducing value, value-driven behaviour and insight	1. Introducing the concept of value (personal- and social- oriented values) 2. Introducing the concept of insight (a new understanding of values and value-driven behaviours) 3. The relationship between social-oriented values and insight 4. A storytelling and sharing approach to help participants develop insight 5. Homework (previous mindfulness exercises)
Week 7: Introducing commitment	1. Introducing the concept of commitment 2. The importance of commitment to dart throwing training and beyond 3. Linking commitment with insight, value-driven behaviour and social-oriented value 4. Homework (previous mindfulness exercises)
Week 8: Comprehensive review and skill consolidation	1. Summarizing the aims of all sessions to get an overall understanding of the program: Combing mindfulness, acceptance, and commitment 2. Reviewing and practicing some key mindfulness exercises 3. Maintaining and enhancing the application of the mindfulness-acceptance-commitment approach

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## Appendix B (Supplementary Online Material)

*Outline of Intervention Protocol for Attention Control Group*

Theme of each week	Contents
Week 2: What is sport and exercise psychology	<ol style="list-style-type: none"> <li>1. Sport psychology in sports context</li> <li>2. Exercise psychology in the context physical activity and exercise</li> <li>3. Sport and exercise psychology in the context of physical education</li> <li>4. Homework (review lecture notes)</li> </ol>
Week 3: History of sport and exercise psychology	<ol style="list-style-type: none"> <li>1. The beginning of sport psychology in 19<sup>th</sup> century</li> <li>2. Coleman Griffith as American First Sport Psychologist</li> <li>3. History of International Society of Sport Psychology (ISSP)</li> <li>4. History of Asian South Pacific Association of Sport Psychology (ASPASP)</li> <li>5. History of Chinese sport and exercise psychology</li> <li>6. Homework (review lecture notes)</li> </ol>
Week 4: Research methods and paradigms in sport and exercise psychology	<ol style="list-style-type: none"> <li>1. Four different levels of research (describe, interpretation, predict and intervention)</li> <li>2. Two different orientations of research (theoretical and practical)</li> <li>3. Quantitative and qualitative research</li> <li>4. Introducing five main journals in sport and exercise psychology (JSEP, PSE, IJSEP, JASP, and TSP)</li> <li>5. Homework (review lecture notes)</li> </ol>
Week 5:	<ol style="list-style-type: none"> <li>1. Theories of sport psychology in athletic excellent performance</li> </ol>

Theories and concepts of sport and exercise psychology	<p>(e.g., Individual Zone of Optimal Functioning)</p> <p>2. Motivation theories in the context of sport, exercise and physical education (e.g., SDT)</p> <p>3. The relations and changing mechanisms between physical activity and mental health</p> <p>4. Homework (review lecture notes)</p>
Week 6: Personality theories and concepts linking with sport	<p>1. What is personality?</p> <p>2. Psychodynamic theory</p> <p>3. Trait theory of personality in sport</p> <p>4. Theory of the Big Five personality in sport</p> <p>5. Homework (review lecture notes)</p>
Week 7: Talent identification of athletes	<p>1. Significance of talent identification in sports</p> <p>2. Personality characteristics of athletes and talent identification</p> <p>3. Progress and updates of talent identification</p> <p>4. Homework (review lecture notes)</p>
Week 8: The life-long development of athletes	<p>1. Importance of athletic life-long development</p> <p>2. The relation between sport performance and life-long development</p> <p>3. Interactive and whole-person development</p> <p>4. Emphasizing longitudinal research</p> <p>5. Homework (encouraging continued lecture notes review)</p>