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

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ABSTRACT

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.

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

Mindfulness has been integrated into cognitive behavioural training in the sport context, with the aim of improving athletes' performance, mental status, and general well-being (Gardner & Moore, 2012). Compared to traditional cognitive behavioural training (e.g., psychological skill training), which builds on the rationale of controlling or changing the contents of performers' undesirable psychological events in order to achieve the optimal psychological states (e.g., the states of peak performance), mindfulness training is an alternative approach for individuals to

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experience their psychological events (e.g., learning experiences). In a state of mindfulness, individuals apply an accepting and non-judging approach to act and think rather than trying to change or control those experiences (Gardner & Moore, 2007). Therefore, mindfulness training encourages individuals to pay attention to the present moment, which helps disengage distractions from their ruminative states. In other words, mindfulness training may help individuals avoid ineffective or counterproductive psychological states (Gardner & Moore, 2007).

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

The mindfulness-acceptance-commitment approach (MAC; Gardner & Moore, 2007) is one of the most popular mindfulness training programs in sport. The MAC includes key concepts and practices skills from two widely-recognized mindfulness-based training programs: the mindfulness-based cognitive therapy (Segal, Williams, & Teasdale, 2002) and the acceptance and commitment therapy (Hayes, Strosahl, & Wilson, 1999). In MAC, mindfulness training skills, acceptance, value, and commitment from these two training programs have been fully integrated and reconstituted with behaviour-change strategies in sport contexts. The aim of MAC is to help performers develop skills of non-judging mindful attention and awareness, and experiential acceptance of internal experiences, while focusing on contextually appropriate behavioural responses, in order to promote both competitive in-the-moment behaviours as well as in the pursuit of valued goals (Moore, 2009).

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

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

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

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

1. Methods

1.1. Participants

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

1.2. Intervention protocols

Mindfulness training in the current study was based on the MAC protocol (Gardner & Moore, 2007; see the online supplementary material Appendix A), but initial evidence from two single-case studies in China demonstrated that Chinese athletes had different interpretations toward the concepts of value and commitment in MAC, because social-oriented value and commitment were deemed as more appropriate than personal-oriented value and commitment

in the Chinese culture (Bu, 2013; Zhang, 2013). As such, to facilitate better understanding of these two important concepts, the cultivation of a new awareness and discovery of social-oriented insights, meanings, and values of life were integrated into the MAC modules (Si et al., 2014). The adaptation is essential because the delivery of MAC training is likely to be more effective if the interpretation of values and commitments in MAC is in line with the indigenous cultural values and beliefs (Si, Lo, & Zhang, in press). This adapted MAC protocol has already been demonstrated to be effective in improving mindfulness, experiential acceptance, and training performance of a sample of six national level elite Chinese synchronized swimmers (Si et al., in press).

1.3. Measures

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

Mindfulness was measured using the Chinese version of Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) developed in a recent study (Deng, Liu, Rodriguez, & Xia, 2011) with supporting evidence regarding the factorial validity of the measure in a Chinese population. Using a five-point Likert scale (1 = *never or very rarely true*; 5 = *very often or always true*), participants rated 39 items from five dimensions, including: observe (e.g., "I notice the smells and aromas of things."), describe (e.g., "I can usually describe how I feel at the moment in considerable detail."), act with awareness (e.g., reverse-worded "I rush through activities without being really attentive to them."), non-judgment (e.g., reverse-worded "I tell myself that I shouldn't be thinking the way I'm thinking."), and non-react (e.g., "When I have distressing thoughts or images, I just notice them and let them go."). There was acceptable internal consistency reliability of the FFMQ across three assessments ($\alpha = .71–.94$).

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

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

The dart throwing performance was measured approximately five minutes after participants completed the self-report measures of mindfulness, experiential acceptance, and flow at each of the three assessments (pre-intervention, post-intervention, and follow-up). Two dartboards that were made-up of ten concentric circles were used, rather than the traditional style. The position of the dartboards was set according to international standards, where the bullseye was 1.73 m from the floor and the throwing line was 2.37 m away from the dartboard. The score for each throw was given by how close the dart hit the bullseye, ranging on a scale from 10 (bullseye) to 0 (outside the dartboard). Participants were asked to throw three darts in each round, and their performance of dart throwing was the total score they obtained in five consecutive rounds.

1.4. Procedure

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

In accordance with the guidelines of Gardner and Moore (2007), the mindfulness group was given homework to practice mindfulness a minimum of three times per week. Similarly, the attention control group was required to revise the learning materials of the previous lecture three times per week. The sport psychology lecture intervention for the attention control group was an introductory course of sport and exercise psychology (see the online supplementary material Appendix B). Topics included history, research, theories, talent identification, and athletes' lifespan development. MAC training was delivered to the mindfulness group by one instructor, and the sport psychology lecture of the attention control group was conducted by another independent instructor. They were both qualified sport psychology consultants and had more than one year experience in mindfulness practice. With a single-blinded design, these two instructors understood about the research purpose, but they did not have any mutual interference during the intervention period and were not allowed to disclose the study hypotheses, study design, or methodology to the participants. A session was given in each of the weeks, and the duration was 80–90 min for each group, and the amount of time and level of interaction that the instructors had with the participants was consistent between the two groups.

1.5. Data analysis

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

2. Results

In preliminary data screening, no missing data were observed and there were no significant between-group differences on any study variables at pre-intervention ($p > .05$). See Table 1 for the means, standard deviations, skewness, kurtosis, and internal consistencies (Cronbach's α) of the study variables of each group across three assessments.

Two-way repeated measure ANOVA of mindfulness revealed a significant time by group interaction effect, $F\ (2, 40) = 6.59$, $p = .003$, $\eta^2 = .25$ and a significant between-group difference, $F\ (1, 41) = 27.79$, $p < .001$, $\eta^2 = .40$. Furthermore, within-group difference of mindfulness scores across time was significant, $F\ (2, 40) = 8.28$, $p = .001$, $\eta^2 = .29$. Post-hoc independent sample *t*-tests indicated that the mindfulness scores of mindfulness group were

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				
	M	*SD*	Skew	Kur	α	*M*	*SD*	Skew	Kur	α	*M*	*SD*	Skew	Kur	α
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*; α = Cronbach's Alpha; Skew = Skewness; Kur = Kurtosis. Average score of each item/dart throwing is presented.

significantly higher than attention control group at both post-intervention and follow-up (see Table 2). Post-hoc paired sample *t*-tests indicated that, in mindfulness group, the mindfulness scores were significantly higher in post-intervention and follow-up, as compared to that of pre-intervention. Unexpectedly, mindfulness group significantly decreased their mindfulness scores from post-intervention to follow-up, but the follow-up mindfulness scores were still significantly better than the pre-intervention mindfulness scores. No significant differences of mindfulness scores were observed across three assessments in the attention control group (see Table 3).

No significant time by group interaction was found from the ANOVA of experiential acceptance, F (2, 40) = 2.48, p = .097, η^2 = .11, but between-group difference was significant, F (1, 41) = 10.50, p = .002, η^2 = .20. In addition, within-group difference of experiential acceptance across time was not significant, F (2, 40) = 2.24, p = .120, η^2 = .10. Post-hoc independent sample *t*-tests indicated that the experiential acceptance of mindfulness group were significantly higher than attention control group at both post-intervention and follow-up. Post-hoc paired sample *t*-tests indicated that the experiential acceptance of mindfulness group were significantly higher during post-intervention and follow-up, in comparison to that of pre-intervention. No significant differences of experiential acceptance were observed across three assessments in the attention control group.

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

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

3. Discussion

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

Individuals with high levels of mindfulness have an advantage in learning new motor skills (Kee & Liu, 2011). The current study extended the findings of mindfulness in previous studies about basic motor skill learning (Kee et al., 2012, 2013) to sport skill

Table 2
Summaries of between-group independent sample t-test comparisons.

Measures	Pre-intervention		Post-intervention				Follow-up			
	t value	*p* value	*t* value	*p* value	Cohen's *d*	95%*CI*	*t* value	*p* value	Cohen's *d*	95%*CI*
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 VS post-intervention			Pre-intervention VS follow-up			Post-intervention VS follow-up		
	M Diff	*t*	*df*	*M Diff*	*t*	*df*	*M Diff*	*t*	*df*
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.

acquisition. It also corroborated the findings of a recent report that supported the effectiveness of mindfulness training on performance of some motor skills (e.g., darts, golf putting, and sinusoid tests; Meeûs, Boen, & De Cuyper, 2010). Notably, in our study, the dart throwing performance of the attention control group, instead of the mindfulness group, was impaired in the two-week follow-up which might imply that MAC training could be useful for preserving a new skill obtained by sport novices. Overall, the mindfulness group performed better than the control group in dart throwing. This may mean that although sport novices improve along with their practice, MAC training is likely to make the improvement better and more sustainable, and these patterns are likely to be associated with increases in psychological variables such as experiential acceptance and flow.

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

Mindfulness has been linked to significant and positive relations with experiential acceptance and flow in previous correlational and intervention studies (e.g., Aherne et al., 2011; Kee & Wang, 2008; Thompson et al., 2011; Zhang et al., 2014). As shown in our study, the mindfulness group had consistently reported higher experiential acceptance, flow, and performed better dart throwing than the attention control group. As such, these findings provide further support on our theoretical proposition that mindfulness training can facilitate experiential acceptance and flow experiences which can in turn help novices acquire new skills in sport (Ferrari, 1996; Gardner & Moore, 2007; Langer, 2000). As an important component in MAC training, experiential acceptance facilitates learners' earlier stage of skill acquisition enabling them to accept the inconsistencies and incoherencies encountered (Langer, 2000). Given that flow experience is consistent with the characteristic of autonomous stage of motor skill learning (i.e., knowing what to do without conscious attention control; Csikszentmihalyi, 1990; Ferrari, 1996), it may suggest that flow is one of the key indicators of effective performing motor tasks during later stage of skill acquisition (Singer, Lidor, & Cauraugh, 1993; Swann, Keegan, Piggott, & Crust, 2012).

Despite its merits, the present study is not without limitations. Firstly, the two-week follow-up duration might not be adequate for testing the long-term effects of mindfulness training across the entire learning progress of sport participants. Also, our sample size was relatively small and the findings might be tentative. Future research should include a longer follow-up with a larger sample, and longitudinally assess the uptake of mindfulness and sport training over a prolonged period (Twisk & Proper, 2004). Secondly, psychological factors were measured on self-report inventories and responses could therefore be subjected to social desirability, memory bias, and mere-measurement effects (Chan & Hagger, 2012; Podsakoff, MacKenzie, & Podsakoff, 2012); future research may consider further including biomarkers in outcome measures as supplements of an objective indicator of the mental status, for example, heart rate variability (Mankus, Aldao, Kerns, Mayville, & Mennin, 2013) and saliva secretory immunoglobulin A (SIgA; Taylor, Turner, Gleeson, & Hough, 2015). Thirdly, the present study could not examine the independent effects of each key component of mindfulness and acceptance training provided by MAC because the intervention was delivered as a whole package. Future studies may adopt a cluster randomised controlled trial to partial out the effects of separate elements of MAC. Fourthly, the single-blinded design may raise issues about whether the expectations of the instructors might lead participants to behave or respond to the assessment according to the study hypothesis. Although we tried to minimise this problem by having trained the experimenters not to disclose the hypothesis and design of the study, future studies should adopt a double-blinded design. Fifthly, we did not evaluate how well participants applied the skills of MAC for dart throwing. It was because the evaluation immediately before dart throwing could possibly interfere participants' performance. Retrospective assessment of home-based MAC training was possible, but the responses would be subjected to memory loss and self-reported bias. Future studies may consider using the experience sampling method (Csikszentmihalyi & Larson, 1987), diary self-monitoring method (Burke, Wang, & Sevick, 2011), or qualitative interview for a more comprehensive measure of participants' behavioural adherence to the mindfulness and acceptance training.

4. Conclusion

In summary, the present study provided initial evidence supporting the application of MAC-based mindfulness and acceptance training in dart learning for beginners. Mindfulness and acceptance

training not only appeared to be adaptive to beginners' sport experience and performance, but it also seemed to reduce the deterioration of the acquired skill level of sport after the end of sport training. The importance of preserving the habit of regular mindfulness practice after the completion of mindfulness intervention (e.g., MAC) is highlighted.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.psychsport.2015.09.005.

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