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Mindfulness, Movement Control, and Attentional Focus Strategies: Effects of Mindfulness on a Postural Balance Task

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We examined whether the momentary induction of state mindfulness benefited subsequent balance performance, taking into consideration the effects of dispositional mindfulness. We also tested whether our mindfulness induction, grounded in sustaining moment-to-moment attention, influenced the attentional focus strategies that were adopted by the participants during the balancing task. Balance performance was ascertained based on approximate entropy (ApEn) of the center of pressure (COP) data. The study involved 32 males (age: M = 22.8, SD = 1.94) who were randomly assigned to the mindfulness or control group. Using difference in pretest to posttest performance based on the medio-lateral movements as the dependent variable, the test for interaction showed that the mindfulness induction was more effective for participants with higher dispositional mindfulness. Participants who underwent mindfulness induction also reported greater use of external focus strategies than those in the control group. Results suggest that momentary mindful attention could benefit balance performance and affect the use of attentional focus strategies during movement control.

Keywords: nonlinear approach, motor control, attentional focus, mental skills, present-moment focus, approximate entropy

The study of mindfulness has received increasing attention in various subdisciplines of psychology (Andersen & Mannion, 2011). Of late, interests in mindfulness in the context of human movement have also grown. Topics that have been examined range from mindfulness and flow (e.g., Kee & Wang, 2008; Aherne, Moran, & Lonsdale, 2011), mindfulness and game performance (e.g., Gooding &

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Gardner, 2009), mindfulness and exercise intentions (Chatzisarantis & Hagger, 2007), mindfulness and postural balance (Mills & Allen, 2000), mindfulness and skill learning (Kee & Liu, 2011), and mindfulness and walking speed (Djikic, Langer, & Stapleton, 2008), to name a few. Taken together, these studies generally show that mindfulness enhances human movement performance and experience to some degree.

Despite increased research interests on this topic over the recent years, very few studies have examined the effects of mindfulness on actual motor control—the foundation of all human movements. More research on the immediate effects of mindfulness on motor control is needed to improve our understanding of the implications of mindfulness during sports performances. In this study, we examined (a) the effects of mindfulness induction and mindfulness disposition on postural control (as a proxy for physical performance), and (b) investigated whether attentional focus strategies differed after the brief mindfulness induction. This study fills the current gap in the literature, since previous studies on the issues of mindfulness and human movements have mainly dealt with the effects of disposition mindfulness (e.g., Chatzisarantis & Hagger, 2007) and training (e.g., Mills & Allen, 2000) over a longer time scale, and not on the immediate effects of mindfulness.

Before investigating how mindfulness might affect motor control, it is important to revisit the current definitions of mindfulness. A commonly accepted description of mindfulness is that of nonjudgmental present moment awareness (Brown & Ryan, 2003). Alternatively, mindfulness has been viewed as the antonym of mindlessness, in that it involves the active engagement of alternative perspectives in counteracting mindless behavior (Langer, 1989). The former description is focused on mindfulness as bare attention and awareness of an ongoing situation, while the second is associated with the notion of cognitive flexibility, openness, and acceptance at the attitudinal level. These two conceptualizations are encapsulated in the two-component model of mindfulness proposed by Bishop et al. (2004)—self-regulation of attention, and orientation to experience. Specifically, Bishop et al. (2004) combined these two components of mindfulness by describing "mindfulness as a process of regulating attention in order to bring a quality of nonelaborative awareness to current experience and a quality of relating to one's experience within an orientation of curiosity, experiential openness, and acceptance" (p. 234).

Brown and Ryan (2004), however, argue that the second component of mindfulness proposed by Bishop at al. (2004), which is grounded in acceptance, appears to be fundamentally redundant for conceptualizing mindfulness, because acceptance is subsumed within (their definition of) mindfulness. Brown and Ryan (2004) noted that during the initial development of the Mindful Attention Awareness Scale (MAAS), the inclusion of the acceptance factor along with the presence factor (present-centered attention and awareness) did not provide an explanatory advantage over the use of the presence factor alone. They argued that sustaining mindfulness, defined as frequent attention and awareness of what is occurring, necessarily involves openness and nonjudgmental observation (Brown & Ryan, 2004). In short, by definition, when mindfulness is applied, one is approaching the present moment with acceptance. As such, they proposed that mindfulness be conceptualized as bare awareness and attention to the present moment.

Becoming mindful based on the notion of bare awareness and attention to the present moment, however, does not necessarily facilitate efficient movement control. Paying attention to bodily movements involved in action, for example, has been linked with lower force production when compared with paying attention externally to intended movement outcomes (Marchant, Greig, & Scott, 2009). The former approach is known as internal focus strategy and involves present moment awareness of the body. In contrast, thinking about intended movement outcomes as a form of external focus strategy involves projecting to the future, which means that present moment focus is not sustained. Similarly, research on attentional focus in motor control also suggests that attention directed to the movement itself (internal focus) tends to interfere with the body's natural control processes (Wulf & Prinz, 2001), and is less effective than external focus. Despite the extant literature suggesting that mindfulness (or present moment awareness) may be beneficial for human movements in general, mindfully attending to ongoing movements—which characterizes internal focus—seems to have detrimental effects on actual motor control.

To further examine the relationships between mindfulness and movement control, we began by investigating the immediate effects of mindfulness induction on a postural control task whereby performance is quantifiable. As personality factor may predispose some individuals to adopt certain mental skills more effectively (e.g., O'Halloran & Gavin, 1994), we also tested for interactive effects of dispositional mindfulness and mindfulness induction on performance to examine whether a brief mindfulness induction benefits only individuals with certain levels of mindfulness disposition. Secondly, we also examined whether a brief application of mindfulness based on bare attention and awareness led to sustained internal focus during the subsequent postural control task, or whether the generally more efficacious external focus could be elicited as a result of the mindfulness induction. If the latter is observed, the facilitation of external focus through momentarily inducing mindfulness could be a discovery that may interest practitioners who are seeking ways to promote learners' use of external focus during skill acquisitions and performance (see Chow & Tan, 2009; Peh, Chow, & Davids, 2011 for a discussion on focus of attention).

In terms of advancements on methodology, we included two novel provisions in this study. The first is on the induction of mindfulness, and the second is on the measurement of performance. To the best of our knowledge, the only published study that examined the immediate effects of mindfulness induction on motor performance was the work reported by Djikic et al. (2008). Djikic et al., however, induced mindfulness differently by heightening participants' sense of novelty with a picture-sorting task which involved self-generation of categories before asking them to sort pictures that included elderly people. This approach is based on Langer's notion of mindfulness as active engagement of alternative perspectives was elicited. Since we were interested in whether mindfulness as bare awareness and attention would influence subsequent attentional strategies, inducing mindfulness by heightening the active engagement of an alternative perspective using this approach would not be appropriate.

To momentarily induce mindfulness as a state of bare awareness and attention according to Brown and Ryan's (2004) definition, we prescribed a mindfulness induction task that affords opportunities for sensory awareness and self-regulation, similar in principle to the "raisin tasting" approach adopted by Kabat-Zinn (1990) and Heppner et al. (2008) (whereby participants were asked to savor the taste and texture of raisins), but dissimilar in that we asked participants to move their hands in water and heighten their sensory awareness of water. We also provided periodic reminders that supported mindful attention. The effects of this mindfulness induction approach were investigated for the first time, and the findings may be relevant for researchers and applied sport psychologists looking for new ways of inducing mindfulness.

The other novel contribution made in terms of methodology was the use of a performance task which allows for a more elaborate quantification. In the study conducted by Djikic et al. (2008) with adults in their midtwenties, they assessed the effects of mindfulness based on the time taken to walk to a destination within the experiment site without the participants knowing they were being observed. The results showed that those in the mindfulness condition took a shorter time to walk the same distance compared with those in the control condition. This suggests that momentarily eliciting mindfulness through the sorting task reduced the effects of ageism stereotype associated with being exposed to the pictures of elderly people, and this made them walked faster than those who were in the control condition. The performance measure of total duration of the walk, however, provided little information about behavior during the walk. For example, whether mindfulness would result in a distinctively different gait pattern was not ascertained. In short, there is a lack of evidence to show that motor control is enhanced by mindfulness.

Thus, as an improvement to the work of Djikic et al. (2008) in terms of assessing performance, we adopted a motor control task where the full duration of the task performance could be meaningfully analyzed. Specifically, the task selected was the one-leg postural control task, performed by balancing oneself over a brief period. As the ground reaction force from the standing foot varies while balancing, changes in the center of pressure (COP) applied to a force plate (in the anterior-posterior and medio-lateral directions) provided an indicator of balance performance. However, simply quantifying the *amount* of variability based on measures, such as standard deviation of the COP and maximum displacement, is limited because these measures do not account for the degree of *structure* in the time series data (Cavanaugh, Guskiewicz, & Stergiou, 2005). As different sets of time series data may differ in terms of their temporal structure with some being less periodic (more unpredictable) than others, performance can be ascertained based on the degree of structure found in the data. In fact, a more complete analysis of the performance can be achieved by studying the variability in the structure of time series data, because assessing postural control based on the amount of variability, say, by averaging the readings over time to derive a standard deviation measure or by calculating the maximum sway amplitude, causes much useful information on what happened during the process to be lost.

Instead of using traditional measures that quantify amounts of variability, the alternative for quantifying postural steadiness is to quantify the degree of complexity in the structure of the time series data (e.g., Cavanaugh et al., 2005). Although a smaller amount of variability (inferred by, for example, smaller standard deviation) is generally positively associated with precision regulation of body position in space (Cavanaugh et al.), adaptive postural control has been associated with a higher variability in the data structure for time series data (Newell & James, 2008). Variability in the structure of time series data, usually inferred by nonlinear measures, is positively linked to better postural control, because a more complex structure in the time series data suggests that the numerous connections among the components involved in balance are capable of adapting to various task demands and external conditions (Cavanaugh et al.). Contrarily, research shows that the variability in the structure of COP profiles is usually smaller (less complex) for participants displaying less capability in adapting, such as those with tardive dyskinesia (Newell, van Emmerik, Lee, & Sprague, 1993). Because we were interested in whether mindfulness would be facilitative in the inhibition of the tendency to fall when faced with ongoing demands, we based our assessment of balance performance primarily on the degree of structure in the data instead of the amount of variability in the data.

In this study, the specific nonlinear measure of approximate entropy (ApEn: Pincus, 1991) was used to quantify the extent of irregularity in the structure of the COP time series data. It was adopted because it allows researchers to appreciate postural balance performance based on the attention-constraint interpretation (Borg & Laxabåck, 2010). The attention-constraint interpretation, based on the analysis of entropy in the context of postural control, assumes that automatic responses/control increases entropy, while volitional control decreases it (F. Borg, personal communication, December 2, 2011). Here, we expect mindfulness to be associated with greater efficiency during postural control, such that the control becomes automatic-like and results in higher entropy. Past studies (e.g., Schmit, Regis, & Riley, 2005; Stins, Michielsen, Roerdink, & Beek, 2009) associate an increase in entropy with greater efficiency in postural control, because higher entropy corresponds to greater irregularity in the temporal structure of postural sway. The irregularity in the structure of the COP data is the result of a larger number of interacting components being involved while balancing (Cavanaugh, et al., 2005), which meant that the motor system is less constrained and is likely associated with automaticity and efficiency. Conversely, as an individual devotes more attention to balancing (more volitional), a regularization of structure in the COP data (lower entropy) ensues, because fewer components of the balancing system are integrated and movements become more constrained.

We purposely adopted the entropy measure because we were interested in examining ongoing balance performance after inducing mindfulness. If we expect that momentarily induced mindfulness will continue to bring about effects associated with moment-to-moment awareness in a later task, the performance of the task should be investigated in a fashion whereby moment-to-moment behavioral change can be tracked. The nonlinear measure of entropy, which takes into account changes in the time series data by quantifying the degree of variability in its structure, is therefore a more appropriate measure than traditional measures.

In summary, we investigated the effects of our brief mindfulness induction on the performance of the one-leg postural control task, and controlled for effects from dispositional mindfulness, with the aim of clarifying links between mindfulness and subsequent movement control. As an additional analysis, we also investigated the differences in attentional strategies adoption during the control of movement between groups to see if mindfulness as bare awareness and attention leads to greater use of certain attentional strategies (internal focus and external focus) that could provide further glimpses to understanding the behavioral effects of mindfulness.

Method

Participants

Thirty-five male participants studying in a university in Singapore were recruited for the study. Thirty-two of them (M_{age} = 22.8, SD = 1.94) were successful in maintaining balance during the 30-s trials for both the pretest and posttest, and only their data were included in the present report. Their countries of origins were Singapore, India, Malaysia, Indonesia, and Vietnam. They declared that they had no history of serious lower limb injuries. It is not known if they had previous mindfulness training experience, but it is unlikely that the majority of them would, since they are deemed to be representative of the typical student population. They were told that they were participating in a study examining ways of improving balance. The research ethics committee of the faculty of the university, where the research was conducted, approved the study. Each participant was paid a token fee of approximately US$3. All participants provided informed consent. They were debriefed at the end about the real purpose of the study.

Instruments

Kistler Force Plate. COP changes resulting from postural balance were measured with the portable Kistler force plate (model 9287BA; Kistler Instrument Corp., Amherst, NY). Two sets of time series data were derived from the raw COP data to represent variations in medio-lateral and antero-posterior movements. The sampling rate of 50 Hz was used during the data acquisition phase.

Manipulations Check Items. To ascertain the perceived usefulness of the manipulation task, the seven-item usefulness subscale from the Intrinsic Motivation Inventory (IMI; Deci & Ryan, n.d.) was used. A sample item reads, "I believe this activity could be of some value to me." The alpha coefficient of this subscale for the current sample was .85. It has been suggested that subscales of the IMI can be used independently to address specfic issues in research (Deci & Ryan, n.d.). The concentration subscale of the Flow State Scale-2 (FSS-2; Jackson & Eklund, 2004) was also included to assess the extent of concentration that participants experienced during the induction task. An example of the item is, "I had total concentration." Since these state-oriented items are typically used for assessing the experience following a recently performed movement activity, we deemed the items suitable as a postactivity manipulation check in our study. The alpha coefficient of this subscale for our sample was .73. The 7-point Likert scale, ranging from 1—*not at all true* to 7—*very true*, was used for both subscales, and these items were randomly ordered to form the manipulation check items. The original FSS-2 adopts a 4-point Likert scale, ranging from 1—*strongly disagree* to 4—*strongly agree*, but since the majority of the manipulation check items were from the usefulness subscale, the anchors adopted followed that of the latter.

Postbalance Items. Two sets of task-specific items were developed by the authors to assess participants' adoption of internal and external focus strategies during the second one-leg balancing task (posttest). Internal focus strategies were assessed via the following: (a) I notice myself swaying and I did something to minimize the sway, and (b) I make adjustments to my body to maintain balance. The alpha coefficient for the internal focus subscale for our sample was .78. To external focus strategies, the two items used were: (a) I try to look at some spots in front of me while I balance, and (b) I try to look at a fixed spot in front of me while I balance. The alpha coefficient for the external focus strategies subscale was .71. The 7-point Likert scale, ranging from 1—*not at all true* to 7—*very true*, was used for these two subscales.

Mindful Attention Awareness Scale (MAAS). The MAAS (Brown & Ryan, 2003) consists of 15 items for assessing mindfulness disposition. The items are comprised of statements about everyday experiences for gauging frequency of receptive awareness of and attention to present-moment events and experiences. A sample item reads, "I rush through activities without being really attentive to them." The 6-point scale, ranging from 1 (*almost always*) to 6 (*almost never*), was used. Higher mean scores derived from all 15 items correspond to a stronger mindfulness disposition. Previous work suggests that the single factor scale has acceptable validity and reliability (alpha coefficients of above .80) for assessing mindfulness disposition (Brown & Ryan, 2003). The alpha coefficient of the scale for the current sample was .90.

Tasks

One-Leg Balancing Task. The one-leg balancing task used in this study involved standing barefooted on one's nonpreferred leg with eyes open. The other foot was positioned on the posterior side of the knee of the standing leg. The arms were placed crossed over the chest. The participants were asked to maintain this position for 30 s during each trial. Participants who failed to maintain the required 30 s in any of the trials were omitted from the study. Since this was a novel and reasonably challenging balance task requiring initial adjustments, only data points from the last 20 s of the maintenance of balance in each trial were used for analysis. The preliminary assessment of data also showed that the largest amplitudes of body movement generally occurred within the first 10 s, suggesting that active adjustment happened during this period. Thus, the last 20 s was a more suitable period for assessing sustained efforts in postural control.

Mindfulness Induction and Control Condition. The manipulation task involved moving the fully submerged left hand back and forth to the two opposite ends of a rectangular basin (38 × 32 × 15 cm) filled with tap water for 6 min. The task was performed while standing, since the basin was placed on a table. Instructions used for induction were provided via recorded audio scripts through a headset. In the mindfulness induction condition, participants were first told to focus on the sensation of the water on their hands as they moved them slowly across the opposite ends of the basin continuously. A short prompt of "How does your hand feel?" was asked at the end of the initial instruction. The question "How does your hand feel right now?" was asked repetitively at the beginning of each minute to remind them to be mindful. Participants were not expected to answer the question. It was expected that asking the question primarily directed the participants' attention to the present moment and served as a reminder of the initial instruction. Our protocol can be considered to be facilitative for mindfulness, because the reminders directed them to refocus on the sensation of water flowing over their hands. In the control condition, participants were told they can move their hands between the ends of the basin continuously at their own pace. A beep was sounded at the turn of each minute. For both conditions, a computer screen depicting a running stopwatch was placed within the view of the participants. This was to increase the likelihood of the participants in the control condition becoming naturally distracted during the manipulation task. None of the participants were told of the exact duration of the manipulation task beforehand.

Procedures

After providing informed consent, participants were randomly assigned to either the experimental (mindfulness induction) or control condition. The experimenter was unaware of each participant's assigned condition. The experimenter first demonstrated the one-leg balance task before the participants performed the single-trial pretest. Next, the participants listened to the assigned audio script and performed the manipulation task accordingly. Upon completion, the manipulation check items were answered. The single-trial posttest was performed next. Finally, the postbalance items and the measures of mindfulness disposition were completed by the participant.[1]

Data Reduction and Analysis

Approximate Entropy. Consider a time series with multiple data points in which values are highly repeatable in a periodic fashion (e.g., a sinusoidal function with minimal noise). When a segment comprised of a few consecutive data points with a length of m is compared with all other segments of the same length, the probability of finding similar segments is high. This high probability is associated with the high repeatability and predictability in the time series (see Cavanaugh, Mercer, & Stergiou, 2007; Pincus, 1991). The notion of similarity is important here, and can be inferred by whether sets of values compared are within the tolerance of a similarity criterion (r). If r is high (and less stringent), for the sake of argument 100% of the standard deviation of the values in the individual time series, the probability of judging the two segments as being more similar is higher than when r is lower (and more stringent), at 20% of the standard deviation, for example. By keeping m and r constant, the likelihood of repeatability within a longer time series data can be used as an outcome variable for assessing balance performance.

Approximate entropy, introduced by Pincus (1991), quantifies the degree of repeatability of a short sequence of data points within a time series, as described above. Typically, the ApEn algorithm can be used for small data sets of between 50 and 5,000 data points (Pincus, 1995, 2000, as cited in Stergiou, Buzzi, Kurz, & Heidel, 2004). The unitless measure ranges between 0 and 2. A time series data having more repetitive patterns will have a lower ApEn, while less predictable time series data correspond to higher values. A completely random time series will produce an ApEn of 2. Based on previous works (Cavanaugh et al., 2006, 2007; Vaillancourt & Newell, 2000), an m of 2 (length of 2 data points in each sequence) and an r of 0.2 (20% of the standard deviation of an individual time series) were selected for our analysis. To reduce the influence of extraneous noise in the data, the effective sampling frequency was reduced to 10 Hz from the initial 50 Hz in the main analysis (Cavanaugh et al., 2006, 2007). The calculation of ApEn was performed using MATLAB software (Mathworks, Natick, MA). For each trial performed, two values of ApEn were derived from the antero-posterior and medio-lateral data, respectively.

It was important for the collected data to be suitable for analysis using the nonlinear approach. Before the main analysis, a surrogation procedure was applied to the original data to verify that it was deterministic in nature (Cavanaugh et al., 2007). Surrogation involves shuffling the order of data points in such a way that it becomes a time series with a stochastic process having the same mean, standard deviation, and autocorrelation as the experimental data. We performed the procedure using the MATLAB codes provided by Schiff, Sauer, and Chang (1994), which was based on the algorithm developed by Theiler, Eubank, Longtin, Galdrikian, and Farmer (1992). When the ApEn values of the surrogate data were compared with the ApEn generated from the corresponding original data sets, results from independent *t* tests showed that the surrogate data set had significantly higher ApEn values than its original counterparts (all ps $< .05$). Since a high ApEn characterizes randomness, which is expected of the surrogate data because of its inherent stochasticity, the significantly lower ApEn values found in the experimental data suggest that the processes inherent in the experimental data were not random. The experimental dataset was thus deemed suitable for nonlinear analysis.

Results

Descriptive Statistics

Table 1 shows the means, standard deviations, and the correlations between the variables. Dispositional mindfulness of the sample is not skewed. There is also a high correlation between perceived usefulness of the manipulation task and concentration experienced during the manipulation phase.

Manipulation Check

Results from the independent *t* tests show that those in the experimental condition ($M = 4.44$, $SD = 1.10$) reported that the mindfulness induction task was significantly more useful compared with those in the control condition who performed the control task ($M = 3.35$, $SD = 0.97$), $t(30) = -2.97$, $p = .01$, $r = .48$. Those in the experimental condition ($M = 4.86$, $SD = 1.41$) reported slightly higher concentration than those in the control condition ($M = 4.27$, $SD = 1.30$), $t(30) = -1.25$, $p = .22$, $r = .22$, but the results are not statistically significant.

Hierarchical Multiple Regression Analyses

Hierarchical regression analyses were used to determine the effects of mindfulness on balance performance based on ApEn.[2] Separate analyses were conducted for data representing the medio-lateral and anterior-posterior movements.

Table 1 Descriptive Statistics

	Measure	*M*	*SD*	1	2	3	4	5	6	7	8	9
1	Mindfulness – MAAS	3.74	.96	—								
2	Postinduction – Usefulness	3.89	1.16	.08	—							
3	Postinduction – Concentration	4.57	1.37	.10	.63*	—						
4	Postbalance – External Focus	3.90	1.74	–.10	.24	.07	—					
5	Postbalance – Internal Focus	5.28	1.44	–.35*	–.11	–.18	.16	—				
6	ApEn – Pretest ML	.75	.06	.00	–.38*	–.27	–.30	.19	—			
7	ApEn – Pretest AP	.75	.07	–.13	–.16	–.18	.30	.42*	.08	—		
8	ApEn – Posttest ML	.76	.07	–.08	.28	.29	.12	.15	.01	.26	—	
9	ApEn – Posttest AP	.74	.08	–.35	–.12	–.25	–.09	.24	.13	–.06	–.26	—

The dependent variables used are the differences between the posttest and pretest ApEn scores. To examine the moderating effect, the mindfulness disposition scores were standardized before the construction of the product term, with the experimental condition coded as 1 and the control condition as –1. Standardizing the variables can prevent the problem of high multicollinearity resulting from high correlations between first-order terms and the interaction terms (Jaccard & Turrisi, 2003). For the analysis of the anterior-posterior movement data, no significant result was found.[3] For the medio-lateral movements, the first step of hierarchical multiple regression indicated that conditions were approaching statistical significance ($b = .04$, $p = .06$), while mindfulness disposition did not ($b = –.01$, $p = .83$). Both conditions and mindfulness disposition accounted for 12% of explained variance of ApEn. More importantly, a significant interaction effect was found ($b = .04$, $p = .03$) in the second step and accounted for an additional 14% of explained variance after controlling for the main effects.

The interaction portrayed in Figure 1 is based on Aiken and West's (1996) suggestion. Our results indicate that mindfulness disposition or condition did not have independent effects on the pre- to posttest difference of ApEn medio-lateral; only the combination of both disposition and condition showed significant effect. As depicted in Figure 1, participants with stronger mindfulness dispositions benefited from the mindfulness induction by performing better (increase in ApEn), while participants with similarly strong mindfulness dispositions performed worse (decrease in ApEn) when they were in the control condition. In fact, those with the latter combination generally performed worse than participants who were low in mindfulness disposition, regardless of conditions assigned.

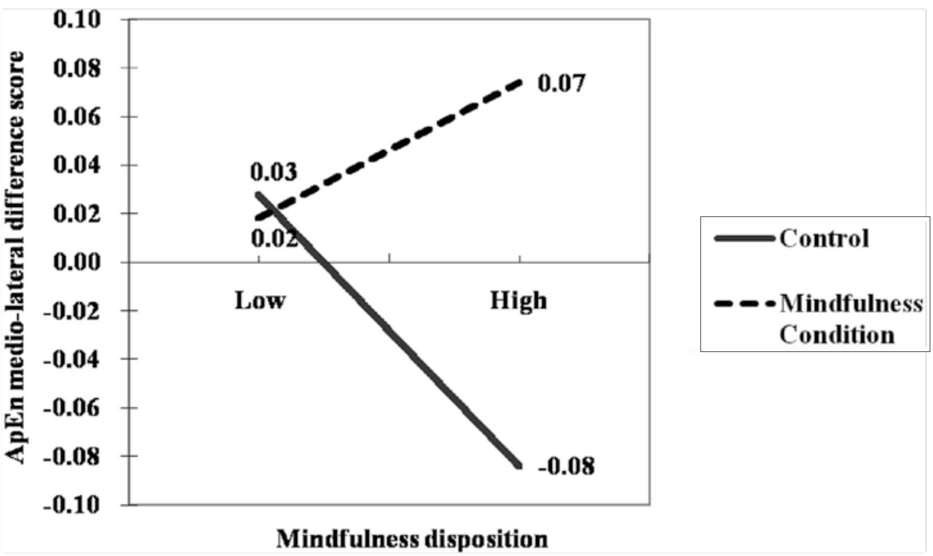

Figure 1 — Significant interaction effects for manipulation by mindfulness disposition for pre- to posttest difference in ApEn of the medio-lateral movement.

Differences in Attentional Focus Adopted

Table 2 shows the between-conditions comparisons of postbalance items scores. Results from the independent *t* tests show that those in the experimental condition ($M = 4.56$, $SD = 1.72$) reported significantly greater use of external focus strategies during the balancing task than those in the control condition ($M = 3.22$, $SD = 1.53$), $t(30) = –2.37$, $p = .03$, $r = .40$. At the level of individual items for external focus, those in the experimental condition scored significantly higher than the control condition only in the item "I try to look at some spots in front of me while I balance." The two groups did not differ significantly in their use of internal focus strategies (experimental condition: $M = 5.13$, $SD = 1.37$ versus control condition: $M = 5.44$, $SD = 1.54$), $t(30) =.61$, $p = .55$, $r = .11$.

Discussion

We first examined the effects of brief mindfulness induction on subsequent physical behavior (specifically, postural balance), taking into the account effect of the participants' mindfulness disposition and the interaction term. In addition, we examined group differences in the attentional focus strategies adopted. We failed to find main effects of mindfulness induction on balance behavior. However, the test for interaction effects revealed that the mindfulness induction was more effective for participants with higher dispositional mindfulness than for those with lower dispositional mindfulness when it came to predicting the pre- to posttest changes in ApEn of the medio-lateral movements. It is important to mention that this interaction accounts for an additional 13% of explained variance after controlling for the main effects. This should be noted as a key contribution of the current study. In addition, we found that those who underwent the mindfulness induction reported greater use of external focus strategies, but no group difference in the use of internal focus strategies was reported. To summarize, the combined effect of mindfulness induction and dispositional mindfulness has a facilitative effect on postural control, and the mindfulness induction itself seems to lead to external focus and not internal focus.

The beneficial effect of mindfulness on postural control is evident in this study. When there is concordance arising from higher mindfulness disposition and mindfulness induction, the pre- to posttest difference in the ApEn, specifically of the medio-lateral direction,[3] is significantly higher. In this study, when ApEn increases after the mindfulness induction, we interpret that there is greater variability in the structure of the COP profile as a result of mindfulness. This increased variability in the structure of the time series data are considered to be adaptive, because it is a sign that larger numbers of interacting components are involved while balancing (Cavanaugh et al., 2005). As a measure of the variability of the output signal, ApEn increases if there is a greater contribution from a larger number of system components (Cavanaugh et al., 2005). In effect, higher ApEn suggests that the postural balance system has become more complex and integrated, such that by involving large numbers of interacting components, each interaction contributes to the composite system in a relatively small way while balance is maintained. Seemingly, participants who were not benefiting from mindfulness were unable to integrate a large numbers of interacting components when performing the balancing task, and thus they had to apply greater constraints to maintain balance.

Table 2 Comparisons of Scores for Postbalance Items

Measures	Experimental		Control			
	M	*SD*	*M*	*SD*	*p*	*r*
Internal Focus						
I notice myself swaying and I did something to minimize the sway.	5.00	1.51	5.13	1.86	.44	.04
I make adjustments to my body to maintain balance.	5.25	1.57	5.75	1.48	.36	.17
Internal focus subscale	5.13	1.37	5.44	1.54	.55	.11
External Focus						
I try to look at some spots in front of me while I balance.	4.88	1.71	3.25	1.92	.02	.42
I try to look at a fixed spot in front of me while I balance	4.27	2.12	3.19	1.83	.14	.27
External focus subscale	4.56	1.72	3.21	1.53	.03	.40

As a result, the structure of the COP profile is less varied (lower ApEn), likely because of the fewer numbers of system components involved. Since mindfulness corresponds to higher entropy measures, and the body's increased capability of adapting to various task demands and external conditions with less attention is related to higher entropy (e.g., Schmit, Regis, & Riley, 2005; Stins, Michielsen, Roerdink, & Beek, 2009), mindfulness might have elicited a kind of "relaxed attention" that benefited postural control performance.

It is important to note that those with higher mindfulness disposition who were given the mindfulness induction performed better than those with similar mindfulness disposition placed in the control condition. In fact, the latter performed even worse than those with lower mindfulness disposition, regardless of assigned conditions. This is a case of actual behavior resulting from interactions between the individual and the encountered situation, as outlined in the interactional model of personality (Endler & Parker, 1992). For the dispositionally more mindful, the opportunity to be mindful during the 6-min mindfulness induction task may have elicited the salutary effects of mindfulness, such as better self-control and behavioral self-regulation (Brown, Ryan, & Cresswell, 2007) facilitative for efficient postural control. Another explanation could be that the match between mindfulness disposition and mindfulness induction results in a sustained mindfulness-like regulatory orientation, similar to the "feeling right" discussed in the regulatory fit literature (Aaker & Lee, 2006). When the more mindful individuals underwent the control condition, they experienced a nonfit, and thus their balance performance worsened. Researchers and practitioners should note that the implications arising from this observation are that the more mindful individuals tend to benefit more from mindfulness induction than the less mindful.

When we examined whether our state mindfulness induction affected attentional focus strategies adopted during performance, results showed that the experimental group reported greater use of external focus than the control group, while no group difference in the use of internal focus strategies was found. In other words, inducing state mindfulness as bare awareness and attention did not lead to the internal focus of bodily movement, which we might expect if there had been a similar effort to apply moment-to-moment awareness following their recent mindful experience with the water task. Instead, the mindfulness induction had a significant effect on the two-item external focus subscale and specifically on the item "I try to look at some spots in front of me while I balance." However, there was no effect found for the other external focus item "I try to look at a fixed spot in front of me while I balance." Taken together, this suggests that momentarily inducing mindfulness facilitated the use of external focus strategies, specifically the tendency of changing the object of attention but not fixating on a single point of attention. We might interpret this to mean that the mindfulness induction allowed participants to be more attuned with the ongoing needs to shift focus during postural control to aid balance, rather than to stay rigidly focused on a fixed point.

This finding is interesting in that we demonstrated that, despite a recent mindful induction based on bare awareness and attention, focus of attention in a subsequent task tended to be externally oriented rather than internally oriented. Moreover, this switch toward external focus is considered to be facilitative for postural control (e.g., Chiviacowsky, Wulf, & Wally, 2010), and concurs with research which shows that mindfulness generally facilitates performance. Furthermore, the tendency to focus on different points while maintaining balance perhaps indicated that the participants were self-generating distractions to suppress with the tendency to fall. This may be viewed as an act of solution exploration and concurs with Langer's notion of mindfulness, particularly flexibility and novelty production (Langer, 1989). It is noteworthy that our mindfulness induction was grounded in moment-to-moment awareness, and yet the results suggest that inducing mindfulness without eliciting flexibility and novelty production during the induction stage may still induce these qualities of exploration. To our knowledge, this is the first study which found evidence to suggest that the adoption of external focus strategies can be facilitated without explicit instructions to do so during the induction stage. Since state mindfulness as bare awareness and attention seems to affect the choice of attentional strategies, our findings may have relevance for future research in the area of attentional focus in sports. As attentional focus during actions continues to be of interest (see Peh et al., 2011), further research on the role of state mindfulness on internal and external foci adoption in sports and skills learning is warranted.

In terms of advancing research methodology in the study of the effects of mindfulness on movement control, the novel one-leg balancing task as a proxy for behavior, coupled with using the ApEn measure as the performance indicator, appears to be an appropriate approach, particularly because balancing affords opportunities for sustained activity and habitual inhibition. Previous attempts in the study of state mindfulness and movement behavior (e.g., Djikic et al., 2008) did not provide measures to ascertain moment-to-moment changes during sustained activity; but ApEn provides such a possibility, since it measures the irregularity of time series. With the advent of nonlinear methods in research (e.g., Harbourne & Stergiou, 2009), future research in state mindfulness and human movement may certainly benefit from the possibility of such detailed investigations of moment-to-moment changes using the nonlinear approach.

There are two recommendations of practical value that arise from the current observations. First, though the balancing task adopted is a novel one, the potential for a brief mindfulness intervention in promoting postural control should be noted. Researchers and practitioners in sports should further explore the beneficial role of state mindfulness in specific events in which balance is crucial (e.g., diving and gymnastics). Practitioners in rehabilitation healthcare could also benefit from the exploration of the benefits of state mindfulness, particularly since this study in part corroborated findings by Mills and Allen (2000), which suggest that patients with multiple sclerosis may benefit from a few sessions of mindfulness training. Secondly, since we have demonstrated that those with stronger mindfulness disposition who underwent our brief mindfulness induction improved their postural control, there is a possibility that athletes with stronger mindfulness disposition who are seeking peak performance in sports may benefit from spending a few minutes on mindful attention practice before their performances. It is possible that the application of mental discipline grounded in mere mindful attention toward ongoing occurrence may promote athletes' adoption of alternative perspectives that are productive during competition, such as the more effective use of external focus strategies. For example, momentarily paying attention to the ongoing present moment during a basketball game may subsequently enhance external focus, which in turn allowed the player to move into the right position.

There are some limitations of the current study that must be noted. First, the use of a difference score as the dependent variable has its associated weaknesses, particularly in terms of issues related to reliability and levels of initial values (Thomas, Nelson, & Silverman, 2011, p. 343). Secondly, we did not measure state mindfulness after the second balance task to ascertain the extent of mindfulness experienced during the task. A measure of state mindfulness at that stage would enable us to make a more definitive statement about the level of on-task state mindfulness. Future research should consider the inclusion of the MAAS state form to assess the current expression of mindfulness (Brown & Ryan, 2003). Thirdly, since the dispositional mindfulness scale was not measured in a separate occasion, participant responses might be influenced by participant experiences of the experimental tasks. Finally, the assessment of focus of attention is based on a retrospective approach using questionnaire items that have not been extensively validated. The findings should be treated with care.

In conclusion, we found that brief mindfulness in the form of bare awareness and attention leads to better movement control for those with stronger mindfulness dispositions. We also found that momentarily applying mindfulness through bare awareness and attention serves to elicit external strategies. Overall, we have demonstrated that mindfulness is facilitative of the performance of the type of motor control we examined, specifically the task of balancing on one leg. While postural balance is only one of many forms of motor behavior humans are capable of, the beneficial influence of momentary mindfulness on behavioral control is noteworthy, because we have demonstrated that momentary mindfulness impacts performance and use of attentional strategy. The current study will serve as an impetus for further examination of mindfulness in motor control, such that the fields of sport and exercise psychology could understand the link between mindfulness and performance better.

Notes

1. Though the MAAS was administered at the end of the session, as these items were aimed at assessing dispositional mindfulness, we found no significant difference in the mean scores between groups post manipulation ($p > .05$).

2. Identical regression analyses performed based on standard deviation and maximum sway on both directions as measures of amount of variability yielded nonsignificant results.

3. One possible reason why a similar finding is not observed in the posterior-anterior direction is the greater ease in balancing in this direction. When standing on one foot, the change in center of gravity causes balancing in the medio-lateral direction to be more difficult than balancing in the antero-posterior direction. There is more room for improvement in balancing medio-laterally; thus, the effects of mindfulness on this orientation are more pronounced.

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