A TIME-VARYING PERSPECTIVE ON MINDFULNESS AND PHYSICAL ACTIVITY

A Dissertation in

Kinesiology

by

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

August 2017
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Abstract

Physical activity and mindfulness training can each be health enhancing but limited efforts have been made to integrate them in research or clinical practice. Combining physical activity with mindfulness as a single intervention have potential to escalate the health effects. Practicing mindfulness during physical activity interventions may also help people to maintain their increased physical activity level, leading to a more sustainable intervention. The disproportional attention on trait mindfulness but limited focus on state mindfulness in previous studies signifies a main barrier that restricted the application for implementing mindfulness in physical activity interventions. To overcome this main obstacle, three studies in this dissertation were designed to address the barrier and advance understanding of the relation between physical activity and mindfulness.

The first study involved a systematic review of peer-reviewed research articles in major academic database and Google Scholar to synthesize and identify gaps in the mindfulness-physical activity literature. Available evidence showed that physical activity and trait mindfulness were positively related, but little has been known regarding the association between physical activity and state mindfulness. Based on the lack of state mindfulness studies in the current literature, a three-level mindfulness framework (global, contextual, and situational level) was proposed to organize current research studies and available mindfulness self-report measures within each mindfulness level. This hierarchical framework that differentiated the contextual and temporal specificity of mindfulness is needed to bridge the gap in the literature.

The second study applied experience sampling methods to investigate the relations between momentary time allocation in different daily activities/postures and well-being among college students (N=158). Results from multilevel analysis suggested that college students’
negative affect was associated with their daily activities/postures and mindfulness in the within-person level. When students moved more or stood more compared to sitting in their daily life, they reported lower levels of negative affect. Further, students’ situational mindfulness seemed to moderate this within-person association between momentary activities/postures and negative affect. When students were more mindful while moving, they experienced greater degrees of reduction in negative affect momentarily.

The final study designed and evaluated an outdoor mindful walking program to determine its feasibility, acceptability, sustainability and preliminary efficacy in reducing negative affect among older adults. Community-dwelling older adults (N=27) attended a one-month, eight session mindful walking program and completed multiple self-report measures before, during, and after the program. Overall, participants perceived this outdoor mindful walking program to be acceptable, engaging and appealing. After the program, most of them were still willing to maintain and actually continued practicing mindful walking in their leisure time. Preliminary efficacy of the program was also identified. After the mindful walking sessions, reductions in negative affect were associated with increases in situational mindfulness among older adults. Based on the promising results, future randomized controlled trials are warranted to test the efficacy of mindful walking program among older adults.

Collectively, these studies highlight the value of studying mindfulness as a time-varying construct in physical activity studies. Differentiating global mindfulness from context- or situation-specific mindfulness not only broadens our scope in understanding the relation between physical activity and mindfulness, but also provides a new avenue for future research. Each study in the current dissertation made unique contributions to the physical activity and mindfulness literature. First, this dissertation synthesized research evidence on the physical activity-
mindfulness association, identified the literature gap, and provided a useful framework for further studies to close the gap. Second, this dissertation was the first experience sampling study that identified the time-varying association between momentary physical activity, mindfulness, and negative affect in daily life. Lastly, this dissertation designed an innovative and feasible mindful walking program which may inform future dissemination for reducing negative affect in older adults. In general, the within-person associations between physical activity and mindfulness established in this dissertation provided valuable implications in facilitating and developing effective behavioral intervention strategies to promote health and well-being in different populations.
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Acknowledgements

In my journey of pursuing the doctoral degree in Kinesiology, I have received tremendous support from multiple individuals. My success is the product of their support and encouragement.

First and foremost, I would like to express my sincere gratitude to my advisor David E. Conroy for providing me his excellent guidance and support throughout my graduate training over the past four years. His mentorship is always thoughtful and patient. I am very fortunate to be his student and work with him. His expertise and constructive feedback have inspired my work and prepared me to become a better researcher. My deepest appreciation also goes out to Dr. Steriani Elavsky, Dr. Blair Evans, and Dr. Lesley Ross for their kindness and precious time in serving on my dissertation committee. With their valuable insights and feedback, the quality of my dissertation has elevated in all aspects.

I am forever grateful to my family, including my parents and my sisters Peggy and Carol, for their consistent, unconditional support and love; and to my dear friends and colleagues both in Taiwan and Penn State for their support and positive thoughts. I am also grateful to Jessie Fu for believing in me and willing to walk with me in reaching the finish line of this marathon. Her warm consideration and understanding has undoubtedly strengthened my ability to complete this challenging process.

Special thanks to my bachelor and master mentor Dr. Zhong, Sheng-Xiao, Dr. Sheue-Mei Lu, and Principle Ching-Yuan Huang at Ta-Yeh Elementary School for their encouragement, ongoing support, and valuable experiences they have shared with me. Thanks to all the great people in Happy Valley, to those who were so gracious with their time and resources in helping with my study recruitment, and to those who expressed their genuine attitude in participating my study. Without their commitment, there would not be my dissertation.

Finally, I would also like to acknowledge the funding agents - the Studying Abroad Scholarship from the Ministry of Education in Taiwan for supporting my graduate training, and the Dissertation Research Endowment Funds from College of Health and Human Development at Penn State for supporting my dissertation work. Without the financial resources, my work would not be possible.
Chapter 1: Introduction
The mind-body practice of mindful movement has become increasingly popular as a non-pharmacological therapy to promoting health and well-being. This approach can be simply described as combining features from both mindfulness meditation and bodily-based activities into a particular form of practice (La Forge, 2016; Tang, Jiang, & Tang, 2017). Accumulating research evidence has revealed the salutary impacts of mindful movement approach on a variety of physical and mental health outcomes in both the clinical and general populations (Appling, Scarvalone, MacDonald, McBeth, & Helzlsouer, 2012; Lee, Mancuso, & Charlson, 2004; Paul et al., 2013; Schure, Christopher, & Christopher, 2008; Tang et al., 2017; Wells, Phillips, & McCarthy, 2011). Despite the promising outcomes of mindful movement interventions, the association between mindfulness and physical activity has not been fully studied.

Mindfulness is the ability to regulate one’s attention and awareness towards the present moment experiences, and adopting an accepting, open-minded, and curious orientation towards these experiences (Kabat-Zinn, 2011; Langer, 1992). Previous research has made a distinction between trait and state modes of mindfulness to characterize their between-person and within-person individual difference, respectively (Brown & Ryan, 2003; Thompson & Waltz, 2015). Trait and state mindfulness are closely associated, but they are considered different constructs theoretically and operationally (Bishop et al., 2004). The literature points to a profound effect of mindfulness-based interventions on physical and mental health. These interventions are generally designed to target people’s trait mindfulness, so the beneficial effects can be observed as participants’ trait mindfulness increased (Greeson, 2009). Mindfulness-based interventions can positively impact health behaviors including eating, sleeping, substance use, and cardiovascular health (Gilbert & Waltz, 2010; Loucks et al., 2015). They have also consistently exerted substantial efficacy in reducing negative affective states including stress, anxiety, and depression.
(Davis & Hayes, 2011; Gotink et al., 2015; Grossman, Niemann, Schmidt, & Walach, 2004; Keng, Smoski, & Robins, 2011; Sharma & Rush, 2014). These results have mostly focused on health behavior and well-being differences between more and less mindful people. Only a few studies thus far explored the time-varying association between mindfulness and negative affect (Snippe et al., 2016; Snippe, Nyklíček, Schroeven, & Bos, 2015).

Physical activity refers to any bodily movement that increases energy expenditure from the contraction of skeletal muscle (Caspersen, Powell, & Christenson, 1985). Engaging in moderate-to-vigorous physical activity can lower the risk for early death, heart disease, stroke, type-2 diabetes, depression, and some cancers (Physical Activity Guidelines Advisory Committee, 2008). Regular physical activity participation is also associated with better mental health and less psychological illness in different populations (Biddle & Asare, 2011; Mammen & Faulkner, 2013; Rebar et al., 2015; Rosenbaum, Tiedemann, Sherrington, Curtis, & Ward, 2014). For improving well-being, recent reviews and meta-analyses have reported that physical activity engagement, especially under moderate and vigorous intensities, may reduce different aspects of negative affect including stress, anxiety, and depression. (Cooney, Dwan, & Mead, 2014; Ensari, Greenlee, Motl, & Petruzzello, 2015; Schuch, Rocha, & Cadore, 2015; Stults-Kolehmainen & Sinha, 2013). As with mindfulness research, the majority of these findings are based on between-person differences, with fewer studies focusing on within-person associations between physical activity and negative affective states (Dunton et al., 2014; Hyde, Conroy, Pincus, & Ram, 2011; Liao, Shonkoff, & Dunton, 2015). Based on the well-established positive findings in both physical activity and mindfulness interventions in improving health and well-being, it would be interesting to investigate how mindfulness is related to physical activity, and whether there
would be potential synergistic effects from integrating these two factors in promoting health and well-being.

In mindfulness-based interventions, the training on attention-regulation and the adoption of an open, accepting orientation to mental and bodily experience are considered central elements across different schools of thought (Hart, Ivtzan, & Hart, 2013). Considering the critical role of self-regulation in sustaining people’s physical activity, training the regulation of attention and awareness via mindfulness interventions may also play beneficial roles in maintaining individual’s physical activity (Bandura, 2005; Buckley, Cohen, Kramer, McAuley, & Mullen, 2014; de Bruin et al., 2012). In fact, one cross-sectional study has already identified that people’s trait mindfulness level may amplify relations between intentions and physical activity (Chatzisarantis & Hagger, 2007). Thus, prescribing mindfulness practice in physical activity programs may provide additional intervention effect in increasing and sustaining people’s physical activity level.

On the other hand, regular physical activity participation can also impact people’s cognitive ability including attention and executive function (Best, Nagamatsu, & Liu-Ambrose, 2014; Kamijo & Takeda, 2010; Sofi et al., 2011). The improved attention and self-control from physical activity are common outcomes from mindfulness practices, suggesting that physical activity engagement may also facilitate people to be more mindful (Dickenson, Berkman, Arch, & Lieberman, 2012; Jha, Krompinger, & Baime, 2007; Tang et al., 2007). Preliminary research evidence supported this notion by showing that people who exercise more regularly and who can meet their exercise goals tend to report higher levels of mindfulness (Ulmer, Stetson, & Salmon, 2010).
Although there are some studies focusing on how physical activity and mindfulness could facilitate each other, these studies focus on linking trait mindfulness with physical activity, and few studies have examined associations between state mindfulness and physical activity. Thus, little is known about whether state mindfulness, or the mindfulness people experience at a given moment in time, may also relate to physical activity or interact with physical activity momentarily in predicting health outcomes. Based on the conceptualization that mindfulness is more of a state than a trait mental construct, researchers should study mindfulness as a time-varying state to unpack its relation with physical activity, health, and well-being (Bishop et al., 2004).

To overcome this limitation in current literature, this dissertation comprises three studies that advance understanding of how mindfulness and physical activity combine at the momentary level to enhance health and well-being. Negative affect regulation was used as an indicator of well-being for this work because negative affective experiences are prevalent in people’s daily life across different populations (American Psychological Association, 2015). Excessive daily negative affective experiences (i.e., feelings of stress, anxiety, depression) have been documented as precursors to more severe, clinical-level mental disorders (Cohen, Janicki-Deverts, & Miller, 2007; Watson, Clark, & Carey, 1988). Tackling these negative affective states may prevent the onset of mental illness, and in turn, improve people’s health and well-being.

The conceptual model in Figure 1.1 illustrates the overall association of the main study constructs. The solid arrows represent the established between-person association among the constructs based on the literature. These associations are served as the background information and are not the focus of the current dissertation. For example, intention could predict physical activity and physical activity could further impact negative affect. However, negative affect
could in turn moderate intention-behavior relations. The dashed arrows represent the gaps in the literature that have not been explored fully, especially from the within-person perspective. For example, the within-person association between physical activity and mindfulness, or their potential interaction in predicting negative affect, has not been addressed in depth thus far. Using this model as a guide, three studies were conducted to address key gaps in the literature.

Chapter 2 reports a systematic literature review of evidence regarding the association between trait or state mindfulness and physical activity. This review (a) synthesized current strength of research evidence between both forms of mindfulness and physical activity, (b) identified key gaps in the literature, and (c) proposed a hierarchical framework to organize mindfulness at different levels of analysis to improve conceptual clarity and precision.

Chapter 3 reports results from a 14-day experience sampling study conducted to evaluate among daily activities/postures, mindfulness and negative affect among college students. This study (a) separated the time-varying and time-invariant components of daily activities/postures and mindfulness that regulate negative affect in college students, and (b) established the potential interaction effect of daily activities/postures and momentary mindfulness in moderating negative affect. These findings provide a foundation for the development of mindful movement interventions to improve well-being.

Chapter 4 presents the results from a study investigating the feasibility of an outdoor mindfulness-based walking program implemented with healthy, community-dwelling older adults. This study (a) evaluated whether an outdoor mindful walking program was feasible, acceptable, and sustainable to older adults in the community, and (b) examined whether this intervention showed promise for reducing negative affect among older adults.
These three studies fill important gaps in the literature on mindfulness and physical activity. They address the need to disambiguate forms of state mindfulness in physical activity research. They provide an example of how mindful movement can improve one indicator of well-being. These results provide critical insights and generate new hypotheses to inform efforts to integrate mindfulness and physical activity in ways that improve health and well-being.
References


Figure Caption

Figure 1.1. Conceptual framework of the proposed studies designed in the dissertation.
Chapter 2: Mindfulness and Physical Activity: A Systematic Review and Hierarchical Model of Mindfulness
Abstract

Mindfulness has attracted recent interest for its potential to promote and sustain health behaviors such as physical activity. It is conceptualized as an individual characteristic or mental skill reflecting differences between people (trait) as well as differences within people across contexts and time (state). Emerging empirical studies have investigated the association between mindfulness and physical activity, but most have narrowly focused on trait mindfulness and not examined state mindfulness as a time-varying construct. This paper reports a systematic review of research on the association between mindfulness and physical activity. The available evidence supported a positive association between trait mindfulness and physical activity and confirmed a large gap in research on state mindfulness and physical activity. A three-level, hierarchical framework – including global, contextual, and situational mindfulness – was proposed to stimulate research on state mindfulness and physical activity by distinguishing between momentary and context-specific levels of mindfulness. Available mindfulness measures corresponding to each level of analysis were identified and reviewed to recommend measurement options at each level. Finally, future research priorities were proposed based on the three-level framework of mindfulness. These priorities include developing level-specific mindfulness measurements based on a unifying conceptual model, conducting more longitudinal and experimental studies that evaluate the dynamics of mindfulness, and translating emerging evidence into interventions to promote physical activity and public health.
Mindfulness and Physical Activity: A Systematic Review and Hierarchical Model of Mindfulness

Physical inactivity is the fourth leading risk factor for global mortality in both men and women (Bull & Bauman, 2011; Lee et al., 2011). The annual worldwide health care burden of physical-inactivity has been conservatively estimated to exceed $500 billion (Ding et al., 2016). Despite the well-known benefits of physical activity, a substantial proportion of the population fails to meet physical activity guidelines (Centers for Disease Control and Prevention, 2017). Many who are motivated also fail to enact their intentions for physical activity (Rhodes & de Bruijn, 2013). This inactivity problem involves environmental, policy, social, and intrapersonal factors (Seefeldt, Malina, & Clark, 2012; Trost, Owen, Bauman, Sallis, & Brown, 2002).

Mindfulness, a form of heightened awareness and acceptance, is a modifiable intrapersonal factor that has demonstrated a salutary influence on a variety of health behaviors including eating, sleeping, and substance use (Greeson, 2009; Jordan, Wang, Donatoni, & Meier, 2014). Mindfulness meditation has also been shown to improve immune function and lower inflammatory disease risk (Creswell et al., 2016.; Davidson et al., 2003). Emerging evidence suggests a positive association between mindfulness and overall cardiovascular health (Kennedy & Resnick, 2015; Loucks, Britton, Howe, Eaton, & Buka, 2014). This systematic review summarizes the available evidence on associations between mindfulness and physical activity, identifies critical gaps in the literature, and proposes a framework to guide future research.

Mindfulness is conceived as modifiable because it can be trained and cultivated by paying attention in a sustained and particular way (Kabat-Zinn, 2011). The two leading contemporary schools of thought about mindfulness were advanced by Langer and Kabat-Zinn (Hart, Ivtzan, & Hart, 2013). Langer considered mindfulness as both a state of conscious
awareness and a state of openness to novelty (Langer, 1992). Kabat-Zinn, on the other hand, described mindfulness as a process of bringing a certain quality of attention to one's moment-by-moment experience. This process requires paying attention in a very particular way: on purpose, in the present moment, and nonjudgmentally (Kabat-Zinn, 1990, 1994). Bishop et al. (2004) later integrated these definitions and conceived mindfulness as both a state and a mental skill, as well as a constellation of personality traits that contribute to mindful states. The trait and state versions of mindfulness have historically been conceptualized as separate constructs theoretically (Davidson, 2010; Thompson & Waltz, 2015).

Individuals are assumed to have a dispositional capacity (i.e., trait) for mindfulness across contexts. Momentary levels (i.e., state) of mindfulness vary over time during specific activities and situations, regardless of one's level of trait mindfulness (Brown & Ryan, 2003). The established trait and state mindfulness model corresponds to the contrast involving between- and within-person variation (Curran & Bauer, 2011), respectively. It is important to consider both sources of variation to understand fully how mindfulness is associated with physical activity.

The present paper reports a systematic review of literature on mindfulness and physical activity. First, the available evidence linking physical activity with both trait and state mindfulness is summarized. Second, key gaps in that literature are identified. Third, a hierarchical model is proposed to improve conceptual clarity and precision when defining and measuring mindfulness in physical activity studies. Measures at each level of analysis are reviewed to develop recommendations for harmonizing assessments. Finally, priorities for further research are proposed to improve our understanding for how mindfulness can be implemented as a strategy to promote physical activity.
Methods

Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher, Liberati, Tetzlaff, Altman, & Group, 2009) as a guide, we searched the PubMed, PsycINFO, and Web of Science (Science Citation Index and Social Science Citation Index) databases and Google Scholar (limited to the first 1000 articles) to identify relevant research on mindfulness and physical activity. Inclusion criteria for the targeted studies included: (1) peer-reviewed publication, (2) full-text of article is available, (3) published in English, (4) original research, (5) human subject research, and (6) quantitative data for both mindfulness and physical activity. Title and abstract field search was conducted in April 2017 using the following search terms: (exercise OR sport OR sports OR “leisure activity” OR “physical activities” OR “leisure activities” OR “physical activity” OR “health behavior” OR “health behaviour” OR “health behaviors” OR “health behaviours”) AND (mindful* OR mindfulness-based OR meditation OR mind-body OR "acceptance-based" OR self-compassion OR yoga). Key words such as leisure activity, health behavior, acceptance-based, self-compassion, or yoga were included in the search term because of their relevance to physical activity or mindfulness. Articles were excluded out if they did not explicitly assess both mindfulness and physical activity levels. No limitations were specified for the starting date in the search, so the earliest articles were identified automatically by each database or search engine.

Results

As seen in Figure 1.1, a total of 1515 articles were first generated from four sources based on our search term and inclusion criteria. After removing duplicates and screening for eligibility, 13 articles were included in the current review (Butryn, Forman, Hoffman, Shaw, &
Juarascio, 2011; Chatzisarantis & Hagger, 2007; Gilbert & Waltz, 2010; Kangasniemi, Lappalainen, Kankaanpää, & Tammelin, 2014; Loucks et al., 2014; Mothes, Klaperski, Seelig, Schmidt, & Fuchs, 2014; Murphy, Mermelstein, Edwards, & Gidycz, 2012; Roberts & Danoff-Burg, 2010; Ruffault, Bernier, Juge, & Fournier, 2015; Salmoirago-Blotcher, Hunsinger, Morgan, Fischer, & Carmody, 2013; Sheeran, 2002; Tsafou, De Ridder, van Ee, & Lacroix, 2015; Tsafou, Lacroix, Ee, Vinkers, & Ridder, 2016; Ulmer, Stetson, & Salmon, 2010). Table 2.1 summarizes key characteristics of these articles.

**Samples.** Across the 13 articles, a total of 3891 participants were included, with one article including two studies with separate samples (Chatzisarantis & Hagger, 2007). The majority of the studies included both female and male participants, except two studies that recruited only female students (Butryn et al., 2011; Murphy et al., 2012) and one study that included only young male adults (Mothes et al., 2014). All studies included participants who were age 18 or older, but most of studies involved only undergraduates or middle-aged adults. Only three studies included participants with a relatively wider age range (over 18 or between 18 to 65), but the majority of the participants in these studies were middle-aged adults (Tsafou et al., 2015, 2016; Ulmer et al., 2010).

**Study design.** Nine of the 13 studies utilized cross-sectional study designs. One longitudinal study observed undergraduate students’ levels of mindfulness and physical activity at the beginning and the end of a 10-week semester (Murphy et al., 2012). Two randomized controlled trials were conducted to identify whether exercise training could enhance mindfulness in middle-age male adults (Mothes et al., 2014), and whether an Acceptance and Commitment Therapy (ACT) with mindfulness components could increase physical activity in young female adults (Butryn et al., 2011). Finally, one intervention study with a single group pre-post design was
conducted to test if an 8-week mindfulness-based stress reduction program (MBSR) increased physical activity (Salmoirago-Blotcher, Hunsinger, Morgan, Fischer, & Carmody, 2013).

**Mindfulness measures.** Self-report measures were used to assess mindfulness in all studies. Six different mindfulness scales were identified: the *Five-Factor Mindfulness Questionnaire* (FFMQ; Baer et al., 2008), *Mindful Attention Awareness Scale* (MAAS; Brown & Ryan, 2003), *Philadelphia Mindfulness Scale* (PHLMS; Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008), *Kentucky Inventory of Mindfulness Skills* (KIMS; Baer, Smith, & Allen, 2004), *Friebberg Mindfulness Inventory* (FMI; Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006), and *Mindfulness in Physical Activity Questionnaire* (MFPA; Tsafou et al., 2015). The MAAS (used in eight studies including two with Dutch versions) and FFMQ (used in four studies) were the most frequently used instruments to assess trait mindfulness. Three studies used more than one mindfulness scale to assess both state and trait mindfulness. In one study, the MAAS and FMI were used to assess the trait and the state mindfulness, respectively (Ulmer et al., 2010). In the other two studies, MAAS and FFMQ were used to assess trait mindfulness, and the MFPA was designed to measure mindfulness in the context of physical activities (Tsafou et al., 2015, 2016).

**Physical activity measures.** Measures for physical activity were more heterogeneous but 12 of them used self-report measures. The *International Physical Activity Questionnaire* (IPAQ; Craig et al., 2003) was the most common measure being applied in six studies. Other self-report measures included the *Godin Leisure-Time Exercise Questionnaire* (GLTEQ; Godin & Shephard, 1985) and the *Physical Activity, Exercise, and Sport Questionnaire* (Fuchs, Klaperski, Gerber, & Seelig, 2015). Researchers used selected items from *Rapid Assessment of Physical Activity questionnaire* (RAPA; Topolski et al., 2006), *Youth Risk Behavior Surveillance System,*
and the *Weight and Lifestyle Inventory* (WALI; Wadden & Foster, 2006) to assess weekly, daily physical activity, and daily lifestyle activity. One study used the number of athletic center visits as proxy for PA frequency (Butryn et al., 2011). Only one study utilized accelerometers to measure physical activity (Kangasniemi et al., 2014). In addition to assessing physical activity level, several studies also assessed PA habit strength, exercise maintenance, and satisfaction with physical activity via self-report questionnaires (Chatzisarantis & Hagger, 2007; Tsafou et al., 2015, 2016; Ulmer et al., 2010).

**Trait mindfulness and physical activity**

Cross-sectional studies largely indicated a positive association between trait mindfulness and physical activity. Trait mindfulness was positively associated with higher frequency and total volume of physical activity among college students (Gilbert & Waltz, 2010; Roberts & Danoff-Burg, 2010; Tsafou et al., 2015, 2016). Trait mindfulness was also positively associated with physical activity maintenance, achievement of exercise goals, physical activity enjoyment, and satisfaction with physical activity (Loucks et al., 2014; Roberts & Danoff-Burg, 2010; Tsafou et al., 2015; Ulmer et al., 2010). A positive association between mindfulness and device-measured physical activity was observed in one study, suggesting that active people are more mindful than less active people (Kangasniemi et al., 2014). One longitudinal study did not find a significant association between trait mindfulness and frequency of leisure-time exercise at either the beginning or end of a 10-week study period (Murphy et al., 2012).

A single-group intervention study revealed that the proportion of inactive participants decreased after an eight-week MBSR program, and participants increased their overall strength or flexibility (Salmoirago-Blotcher et al., 2013). The correlation between changes in trait mindfulness scores was not significantly related to changes in physical activity in that study. The
The strongest evidence for a positive association between trait mindfulness and physical activity came from two randomized controlled trials. In the first trial, sedentary male employees were randomly assigned to either 12-week aerobic exercise group, relaxation training group, or a waitlist control group (Mothes et al., 2014). The aerobic exercise group increased trait mindfulness, but the relaxation training and control groups did not increase in trait mindfulness. In the second study, female students who completed Acceptance-Commitment Therapy sessions in groups visited the athletic center more frequently over a five-week period than their peers in a physical activity education group (Butryn et al., 2011). Associations were not reported between changes in trait mindfulness and the frequency of athletic center visits from baseline through the end of intervention and the one-month follow-up.

Trait mindfulness may also moderate relations between motivation and action. In one cross-sectional study, intentions positively predicted physical activity for students who were more, but not less, trait mindful. Additionally, those who acted more mindfully and less habitually were more likely to sustain their physical activity intentions than those who acted less mindfully and more habitually (Chatzisarantis & Hagger, 2007). Tsafou et al. (2015) later replicated this finding by showing that trait mindfulness was only associated with physical activity among people with weak physical activity habits. Another cross-sectional study indicated that trait mindfulness moderated relations between intrinsic motivation and physical activity. Compared to medium or lower levels of trait mindfulness, people with higher levels of trait mindfulness had a stronger association between their intrinsic motivation and physical activity (Ruffault et al., 2015).

**State mindfulness and physical activity association**
Two cross-sectional studies examined physical activity-specific state mindfulness and its association with physical activity. In both, increased state mindfulness in physical activity settings was associated with greater physical activity and this association was mediated by satisfaction towards physical activity (Tsafou et al., 2015, 2016). The Tsafou (2016) study further showed that both state mindfulness and satisfaction with physical activity mediated the positive association between trait mindfulness and physical activity. Another cross-sectional study revealed that YMCA exercisers who reported higher levels of state mindfulness had stronger beliefs that they could successfully meet their exercise goals (Ulmer et al., 2010). On the other hand, exercisers who reported missing one week of exercise sessions in the past year had lower state mindfulness; however, the association between state mindfulness (as measured by Frieberg Mindfulness Inventory) and physical activity was not clear. This result may be partially explained by the fact that items from the Frieberg Mindfulness Inventory ask about more advanced mindfulness experiences, and are considered inappropriate for people who are not familiar with or have no experience with mindfulness practices (Bergomi, Tschacher, & Kupper, 2012b). No study assessed momentary mindfulness level and its relation to physical activity based on the current review.

**Discussion**

This review examined research on mindfulness and physical activity. Findings revealed that samples have largely been limited to young and middle-aged adults. No studies to date sampled younger (younger than 18 years) or older adult (older than 65 years) populations. Study designs were typically cross-sectional with self-report measures of both mindfulness and physical activity. Researchers used a variety of measures to assess mindfulness and physical
activity, with the MAAS and the IPAQ being the most popular option for mindfulness and physical activity, respectively.

Previous research has examined both the direct association between mindfulness and physical activity, and the role of mindfulness in moderating relations between motivational processes and physical activity. All 13 studies included in this review assessed trait or dispositional mindfulness, and 10 of them found significant positive associations between trait mindfulness and physical activity. In contrast, only three studies assessed state mindfulness in specific exercise or physical activity contexts, and two of them found that higher state mindfulness could predict physical activity level (Tsafou et al., 2015, 2016). Collectively, the evidence suggests that both trait and state mindfulness are associated with greater physical activity. Also, trait mindfulness may help to bridge the intention-behavior gap for physical activity, so interventions that cultivate mindfulness may be important component of programs to address this persistent barrier to behavior change (Rhodes & Dickau, 2012; Sheeran, 2002).

In terms of the strength of the evidence, 11 out of the 13 studies used observational or cross-sectional designs, so it is not possible to make strong statements about the existence or direction of causal relations between mindfulness and physical activity in most of the reviewed studies. Two studies applied experimental methods to test whether mindfulness impacted physical activity or vice versa, but neither study included mixed gender samples which limited their generalizability. It should also be noted that one of the randomized controlled trials operationalized physical activity as the frequency of athletic center visits (Butryn et al., 2011). This measure may not be sensitive to variability in the duration or intensity of physical activity in that context, or to the frequency, duration or intensity of physical activity in other contexts. Overall, based on the prevalence of cross-sectional designs and the limitations of the few
randomized controlled trials identified, it is not possible to draw strong causal inferences about the direction of relations between mindfulness and physical activity.

**Gap in state mindfulness and physical activity research**

With respect to state mindfulness, no research was identified on relations between momentary mindfulness levels and physical activity. There is a clear gap in our understanding of how state mindfulness influences thoughts, feelings and actions associated with physical activity. Generalizing findings about research on trait mindfulness to predict how mindfulness in a particular context or at a particular moment will impact people’s behavior is risky. People typically do not act, think or feel the same way in all contexts or even on all occasions within a context (Fleeson, 2001). Likewise, mindfulness in a particular context may differ from mindfulness in other contexts or even across occasions within that original context (Brown & Ryan, 2003). State mindfulness experienced during physical activity may be similar to or different from state mindfulness during activities that do not involve physical activity (or even from one physical activity episode to another). In addition to context-specific mindfulness, people can also experience different levels of state mindfulness from moment to moment in their everyday life (Thompson & Waltz, 2015). Without disentangling contextual and temporal variability in state mindfulness, it is not possible to draw clear conclusions about context- and occasion-specific mindfulness experiences. This confound could present a barrier to understanding relations between mindfulness and physical activity. As research on state mindfulness and physical activity develops, it will be important to differentiate between context-specific states and momentary states with a more refined framework.

**The three-level hierarchical mindfulness framework**
A hierarchical, three-level model can be applied to differentiate between forms of state mindfulness based on the contextual- and temporal-specificity of the phenomenon. A similar approach was applied profitably to advance research on intrinsic and extrinsic motivation in sport and exercise (Vallerand, 1997, 2007a, 2007b). This hierarchical framework differentiates three levels of mindfulness: global, contextual, and situational.

*Global mindfulness* represents a general disposition towards mindfulness across the varied contexts and moments of daily life. In that sense, it represents a person’s default level of mindfulness (all else being equal). It is similar to trait mindfulness in the two-component (trait-state) model because it is relatively stable across time and circumstances. *Contextual mindfulness* represents a person’s typical level of mindfulness within a specific life context (e.g., while exercising). It represents a person’s default level of mindfulness at any point of time in a particular context but may vary from one context to another. *Situational mindfulness* represents the level of mindfulness that an individual experiences during a specific activity at a specific moment. That is, situational mindfulness varies as a function of both context and time. These three levels of mindfulness should be differentiated to capture the whole spectrum of mindfulness as it relates to physical activity.

The major difference between the existing two-component model and the proposed hierarchical framework of mindfulness is that the latter decomposes state mindfulness into contextual and momentary components. This distinction reduces conceptual fuzziness and should lead to improved assessments, less ambiguous evidence, and accelerated theory development. A context-specific mindfulness construct is needed because some life contexts or activities may elicit more mindfulness than others. For instance, people who feel more involved in the natural environment have reported higher levels of trait mindfulness and well-being (Howell, Dopko,
Likewise, activities that direct people to the internal incorporation of regulated breathing and focused attention, such as yoga, are believed to evoke more mindfulness than other physical activities (La Forge, 1997). These observations become specific, testable questions if contextual mindfulness is differentiated and assessed.

The hierarchical framework also postulates bidirectional relations across the three levels (Vallerand, 1997, 2007a, 2007b). *Top-down effects* describe how mindfulness at more abstract levels in the hierarchy can influence mindfulness at more specific levels (e.g., global mindfulness influencing contextual mindfulness, or contextual mindfulness influencing situational mindfulness). *Bottom-up effects* describe how mindfulness at more specific levels can accumulate to influence more abstract levels over time (e.g., increases in situational mindfulness within a context accumulating to increase corresponding contextual mindfulness). The *Top-down* principle is consistent with Brown and Ryan’s (2003) study showing that people who had higher global mindfulness were more likely to express higher situational mindfulness, when assessed by both the trait and state versions of Mindful Attention and Awareness Scale. The *Bottom-up* principle has also been partially supported in a longitudinal study showing that over time, increases in global mindfulness level were positively predicted by their rates of change in contextual mindfulness during meditation practice (Kiken, Garland, Bluth, Palsson, & Gaylord, 2015).

**Organizing mindfulness measures within the three-level hierarchical framework**

To realize the potential of this hierarchical framework, researchers need instruments to measure mindfulness validly at each level. The majority of existing scales have been used to assess individual differences in global mindfulness (Bergomi et al., 2012b; Sauer et al., 2012). Only a few scales are available for measuring either contextual or situational mindfulness. Table
2.2 summaries the major measures used in contemporary research on mindfulness (including research on mindfulness and physical activity) according to the three levels in the proposed hierarchical framework of mindfulness.

The eight available global mindfulness measures in Table 2.2 generally demonstrate acceptable validity and reliability (Baer, 2011). They differ in the presumed latent structure of mindfulness, the target populations for which the measures were developed, and the scope of meditation experience required to respond to the items (Sauer et al., 2012). These differences present a challenge when comparing and replicating research findings (Bergomi, Tschacher, & Kupper, 2012a; Bergomi et al., 2012b). The Mindful Attention Awareness Scale has been used most frequently in research on physical activity, followed by the Five Facet Mindfulness Questionnaire. The main difference between the two measures is that the former assesses a unidimensional mindfulness structure, whereas the latter measures a multidimensional mindfulness structure and thus requires more items and time to complete.

Measures of contextual mindfulness are more limited with only three options specific for sport or physical activity contexts. Scores from the Mindfulness Inventory for Sport have psychometric support from factor analysis and evidence of convergent validity with related constructs (Thienot et al., 2014). The State Mindfulness Scale for physical activity is an adaptation of the State Mindfulness Scale (Cox, Ullrich-French, & French, 2016; Tanay & Bernstein, 2013). Scores from State Mindfulness Scale measure have demonstrated convergent validity with scores from the Toronto Mindfulness Scale and showed mean score differences between groups with and without yoga experience. To the best of our knowledge, the six-item Mindfulness in Physical Activity scale (Tsafou, De Ridder, van Ee, & Lacroix, 2015) is the only contextual mindfulness scale that has been used in more than one empirical study to measure
mindfulness in the physical activity context. Neither the validity nor the reliability evidence of scores from this questionnaire were reported in those studies (Tsafou et al., 2015, 2016).

Assessment options for situational mindfulness are also limited. None of the measures in Table 2.2 have been used to assess situational mindfulness during physical activity or even while contemplating physical activity. The Toronto Mindfulness Scale was designed to assess mindfulness as a state that can vary across short periods of time; however, in practice, it has been used exclusively to measure an individual's level of mindfulness during a formal meditation session which requires participants to first sit quietly and pay attention to their breath for a short period of time before responding. This scale has not been widely applied to assess situational mindfulness in different settings (Feldman et al., 2006). The State-Mindful Attention and Awareness Scale is a five-item scale derived from Mindful Attention and Awareness Scale which assesses an individual’s mindfulness over a short period of time (Brown & Ryan, 2003). The main limitation of this short scale is that it mainly samples individuals’ conscious awareness or attention of mindfulness and lacks items for assessing physical and mental experiences that are also central components of mindfulness. For example, it does not involve items measuring the awareness of one’s emotional states, physical sensations, and passing thoughts (Tanay & Bernstein, 2013). As a result, construct validity remains a concern when using the State-Mindful Attention and Awareness Scale to assess situational mindfulness. Lastly, the State Mindfulness Scale measures mindfulness during a specific time period (e.g., the preceding 15 minutes) and in a particular context (e.g., meditation or other types of activities). Strong evidence exists for the construct and incremental predictive validity of scores from this scale. It has been rigorously tested in its developmental phase and corresponds well with the concept of situational mindfulness (Tanay & Bernstein, 2013). Despite the superiority of this tool relative to other
options, it has not yet been used widely in research on mindfulness generally or in research on mindfulness and physical activity specifically.

In sum, the majority of mindfulness measures were designed to assess global mindfulness, and approximately half of these measures have been applied in research on physical activity. Fewer scales with known psychometric properties are available for assessing situational or contextual mindfulness, and these measures have rarely been used in physical activity research. Based on the brief summary of the mindfulness measures, the best available choices for measuring global, contextual and situational mindfulness in physical activity research (at the present time) are likely to be the *Mindful Attention and Awareness Scale*, *State Mindfulness Scale-PA*, and *State Mindfulness Scale*, respectively. The *Mindful Attention and Awareness Scale* is by far the most frequently used measure in physical activity research as well as the most accepted and broadly-applied global mindfulness measure (Sauer et al., 2012). Further, *State Mindfulness Scale-PA* is derived from the *State Mindfulness Scale* and shares a common underlying conceptual model. The shared conceptual model underlying these measures will facilitate meaningful inferences about mindfulness and physical activity relations between the contextual and situational levels. Scores from these three instruments are all well-validated and compatible with unidimensional definitions of mindfulness.

Harmonizing future measures based on conceptual and structural consistency would facilitate comparisons across levels of analysis in research on physical activity. No single measure is capable of capturing all three levels of mindfulness. The three-level framework described above can be applied to develop precise hypotheses, select measures, and refine theories about the role of mindfulness in physical activity promotion.

**Future directions**
This review suggested several priorities for future research on mindfulness and physical activity. First, the bulk of this evidence derives from research on global mindfulness and uses cross-sectional research designs. Future work should emphasize the contextual and situational levels of mindfulness to fill an identified gap and determine whether conclusions about a positive association between global (trait) mindfulness and physical activity generalize to the contextual and situational levels. Future work should also investigate whether contextual and situational mindfulness can bridge the intention-behavior gap that has also been revealed as a within-person phenomenon (Conroy, Elavsky, Doerksen, & Maher, 2013; Conroy, Elavsky, Hyde, & Doerksen, 2011; Maher, Dzubur, Huh, Intille, & Dunton, 2016). To conduct this work, it would be valuable to develop parallel measures for assessing mindfulness at each level of analysis. This work will also benefit from study designs and measures that are capable of capturing both the time-varying nature of situational mindfulness and the context-dependent nature of contextual mindfulness. Ecological momentary assessment is an optimal approach that has been suggested to obtain mindfulness or physical activity in daily settings (Davidson & Kasznia, 2015; Robbins, Kubiak, & Mostofsky, 2014), and should be applied more in future research to test the real-time association between mindfulness and physical activity. Sampling mindfulness during a variety of activities or settings will also be useful for addressing the confounding of mindfulness practices with a specific type of activity (i.e., yoga, walking).

Experimental evidence is needed to draw causal inferences about mindfulness and physical activity. The associations between mindfulness and physical activity reported here were based on college student and mid-age adult populations, and predominately use self-report measurements. Future experimental studies should target understudied populations (e.g., adolescents, older adults), and include objective measures of mindfulness (i.e., cognitive and
attentional tasks) and device-based measures of physical activity (i.e., accelerometers). As this literature develops, researchers will need to investigate questions about dose-response association, the best modes of mindfulness practice, and the potential mechanism and moderators in mindfulness and physical activity.

The population-level inactivity problem also involves prolonged sedentary behavior (i.e., excessive sitting time). Relations between mindfulness and sedentary behavior have not been investigated to date. Sedentary behavior has a habitual component but it also varies within people over time and is negatively associated with fluctuations in intentions to limit sedentary time (Conroy, Maher, Elavsky, Hyde, & Doerksen, 2013). The ability to be more aware of thoughts, emotions and physical sensations in a given moment, which is a key characteristic of mindfulness, may be a potential strategy for helping people to disengage from habitual behavior patterns in different contexts and situations.

**Conclusion**

This review synthesized current evidence addressing the positive association between mindfulness and physical activity, and proposed a hierarchical model to disambiguate mindful states in future research. A similar hierarchical framework has been applied profitably to organize research on intrinsic and extrinsic motivation (Vallerand, 2007a). Existing measures corresponding to each level of mindfulness were summarized, and best-in-class measures of mindfulness at each level were identified. Harmonizing measures in future research would facilitate comparisons of research findings and accelerate understanding of relations between mindfulness and physical activity.

The organizing hierarchical framework outlined in this review will also generate new hypotheses that can inform intervention development. Of particular interest is the potential for
contextual and situational mindfulness to serve as self-regulatory tools for shielding motivation and reducing interference from factors that often derail physical activity. If this potential is borne out, mindfulness training may be a powerful tool for promoting physical activity and improving public health.
References


https://doi.org/10.1016/j.paid.2014.12.044

https://doi.org/10.1097/00005082-199704000-00006


Table 2.1. Description of the reviewed studies on mindfulness and physical activity

<table>
<thead>
<tr>
<th>Article</th>
<th>Participants and design</th>
<th>Measure of mindfulness</th>
<th>Measure of physical activity or exercise</th>
<th>Main findings in mindfulness and physical activity</th>
</tr>
</thead>
</table>
| Roberts, K. C., & Danoff-Burg, S. (2010).    | 553 undergraduate students; Cross-sectional | The Five-Factor Mindfulness Questionnaire (FFMQ) | Selected items from Youth Risk Behavior Surveillance System and Weight and Lifestyle Inventory | Mindfulness was positively associated with:  
1. Perceived daily physical activity level  
2. Enjoyment of physical activity  
3. Number of days reported to be physically active in the past week |
| Gilbert, D., & Waltz, J. (2010).              | 269 undergraduate students; Cross-sectional | FFMQ                  | International Physical Activity Questionnaire (IPAQ) | 1. The Observe subscale of FFMQ predicted MPA and VPA in male.  
2. The Describe subscale predicted MPA, and the Act with Awareness subscale predicted VPA in female. |
| Loucks, E. B., Britton, W. B., Howe, C. J., Eaton, C. B., & Buka, S. L. (2014). | 382 adults with mean age 47; Cross-sectional | Mindful Attention and Awareness Scale (MAAS) | IPAQ short form | High levels of mindfulness related to high levels of physical activity level. |
2. Time1 Frequency of exercise was not significantly related to mindfulness in Time 1 and Time 2. |
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Measures</th>
<th>Findings</th>
</tr>
</thead>
</table>
2. Intentions predicted physical activity for more mindful participants only.  
3. More mindful and not habitual participants are more likely to act on their intentions compared to habitual and not mindful participants. |
<p>| Ruffault, A., Bernier, M., Juge, N., &amp; Fournier, J. F. (2016).        | 280 adults age between 18 and 37; Cross-sectional                             | MAAS, IPAQ, Physical Activity, Exercise, and Sport Questionnaire          | Higher mindfulness level was related to improved intrinsic motivation and physical activity level.                                                                                                           |
| Mothes, H., Klaperski, S., Seelig, H., Schmidt, S., &amp; Fuchs, R. (2014). | 143 sedentary male adults; Cross-sectional                                  | MAAS, Physical Activity, Exercise, and Sport Questionnaire               | Mindfulness increases in the aerobic exercise group but not in the relaxation or the control group.                                                                                                     |</p>
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Sample Size</th>
<th>Measures</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kangasniemi, A., Lappalainen, R., Kankaanpää, A., &amp; Tammelin, T. (2014).</td>
<td>108 Finnish adults. (58 physically less active and 50 physically active); Cross-sectional</td>
<td>Kentucky Inventory of Mindfulness Skills (KIMS), ActiGraph-GT1M accelerometer</td>
<td>1. Mindfulness was positively associated with MVPA time. 2. Compared to less active participants, active individuals had higher mindfulness level and less psychological symptoms.</td>
</tr>
<tr>
<td>Ulmer, C. S., Stetson, B. A., &amp; Salmon, P. G. (2010).</td>
<td>266 YMCA exercisers with age 18 or older; Cross-sectional</td>
<td>Frieberg Mindfulness Inventory (FMI): used to measure state mindfulness in this study, MAAS</td>
<td>Trait mindfulness: 1. Higher levels of mindfulness and acceptance, and lower levels of suppression were found in participants who were more successful at maintaining exercise, who exercising more regularly, and who were more successful in meeting their exercise goals. 2. Lower levels of acceptance and mindfulness were found in participants who missed two consecutive weeks of exercise over the previous year. State mindfulness: 1. Higher levels of acceptance and mindfulness were found in</td>
</tr>
</tbody>
</table>
participants who were more successful in meeting their exercise goals.

2. Higher levels of acceptance and lower levels of mindfulness were found in participants who missed 1 week of exercise over the previous year.

<table>
<thead>
<tr>
<th>Tsafou, K. E., De Ridder, D. T., van Ee, R., &amp; Lacroix, J. P. (2015).</th>
<th>398 Dutch speaking adults age between 18 to 65; Cross-sectional</th>
<th>The Dutch version MAAS</th>
<th>IPAQ short form</th>
<th>Mindfulness in Physical Activity (MFPA)</th>
<th>SRHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Both satisfaction with physical activity and mindfulness predicted physical activity level.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Satisfaction with physical activity significant mediate the relationship between mindfulness and physical activity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3. Mindfulness affects physical activity only when habitual physical activity is weak.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Mindfulness and habit, and their interaction were significant in predicting satisfaction with physical activity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Satisfaction with physical activity mediated the positive association between mindfulness in physical activity and physical activity level. |
2. Trait mindfulness level was positively associated with physical activity level through physical activity mindfulness and satisfaction with physical activity.
Table 2. Current mindfulness questionnaires organized by their level in the proposed hierarchical framework

<table>
<thead>
<tr>
<th>Measurements in each level</th>
<th>Scores and structure</th>
<th>Total items</th>
<th>Used in PA research³</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global Mindfulness Measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freiburg Mindfulness Inventory (FMI; Walach, Buchheld, Buttenmüller, Kleinknecht, &amp; Schmidt, 2006)</td>
<td>Unidimensional</td>
<td>30/14⁴</td>
<td>Yes</td>
</tr>
<tr>
<td>Mindful Attention Awareness Scale (MAAS; Brown &amp; Ryan, 2003)</td>
<td>Unidimensional</td>
<td>15</td>
<td>Yes</td>
</tr>
<tr>
<td>Cognitive and Affective Mindfulness Scale-Revised (CAMS-R; Feldman et al., 2006)</td>
<td>Unidimensional</td>
<td>12</td>
<td>No</td>
</tr>
<tr>
<td>Southampton Mindfulness Questionnaire (SMQ; Chadwick et al., 2008)</td>
<td>Unidimensional</td>
<td>16</td>
<td>No</td>
</tr>
<tr>
<td>Kentucky Inventory of Mindfulness Scale (KIMS; Baer, Smith, &amp; Allen, 2004)</td>
<td>Four factors: (1) Observing (2) Describing (3) Acting with awareness (4) Accepting without judgment</td>
<td>39</td>
<td>Yes</td>
</tr>
<tr>
<td>Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2008)</td>
<td>Five factors: (1) Nonreact (2) Observe (3) Act aware (4) Describe (5) Nonjudge</td>
<td>39</td>
<td>Yes</td>
</tr>
<tr>
<td>Philadelphia Mindfulness Scale (PHLMS; Cardaciotto, Herbert, Forman, Moitra, &amp; Farrow, 2008)</td>
<td>Two factors: (1) Present-moment (2) Awareness and acceptance</td>
<td>20</td>
<td>Yes</td>
</tr>
<tr>
<td>Measure</td>
<td>Description</td>
<td>Factors</td>
<td>Items</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Trait Toronto Mindfulness Scale (Trait-TMS; Davis, Lau, &amp; Cairns, 2009)</td>
<td>Two factors: (1) Decentering (2) Curiosity</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td><strong>Contextual Mindfulness Measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness in Physical Activity Questionnaire (MFPA; Tsafou et al., 2015)</td>
<td>Unidimensional</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Mindfulness Inventory for Sport (MIS; Thienot et al., 2014)</td>
<td>Three factors: (1) Awareness (2) Nonjudgmental attitude (3) Refocusing</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>State Mindfulness Scale for Physical Activity (SMS-PA; Cox et al., 2016)</td>
<td>Unidimensional mindfulness with two main dimensions: (1) state mind (2) state body</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td><strong>Situational Mindfulness Measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Mindful Attention Awareness Scale (State-MAAS; Brown &amp; Ryan, 2003)</td>
<td>Unidimensional</td>
<td></td>
<td>5b</td>
</tr>
<tr>
<td>Toronto Mindfulness Scale (TMS; Lau et al., 2006)</td>
<td>Two factors: (1) Decentering (2) Curiosity</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>State Mindfulness Scale (SMS; Tanay &amp; Bernstein, 2013)</td>
<td>Unidimensional mindfulness with two main dimensions: (1) mindfulness of mind (2) mindfulness of body</td>
<td></td>
<td>21</td>
</tr>
</tbody>
</table>

Note: a Long and short forms of this measure exist. b Adapted from the MAAS. c Not including studies aim at validating the measure.
Figure Caption

Figure 2.1. The PRISMA flow chart for literature research on mindfulness and physical activity.
Data Base Searching in PubMed, PsycINFO and Web of Science  
(n = 1310)

Manual Searching in Google Scholar search engine  
(n = 205)

All records after duplicates removed  
(n = 632)

Excluded articles  
(n = 678)

Excluded articles that did not explicitly include both physical activity and mindfulness component  
(n = 407)

Excluded articles that did not provide quantitative data for both physical activity and mindfulness  
(n = 209)

Excluded articles that did not test association between physical activity and mindfulness  
(n = 3)

Title and abstract screening  
(n = 225)

Final articles included in qualitative synthesis (n = 13)

Full-text screening  
(n = 16)
Chapter 3: Momentary Negative Affect is Lower During Mindful Movement than While Sitting: An Experience Sampling Study
Abstract

Physical activity and mindfulness can decrease many aspects of negative affect (e.g., stress, anxiety, depression). It is unclear whether mindfulness during various activity behaviors or postures (e.g., standing, moving, sitting) influences the associations between those behaviors/postures and negative affect. This study tested whether contextual or situational mindfulness moderated associations between (1) usual behavioral/postural patterns and negative affect, or (2) momentary behaviors/postures and negative affect. A 14-day experience sampling study was conducted to assess college students’ momentary behaviors/postures and subjective experiences using a smartphone application. When students moved (versus sitting), their momentary negative affect was lower if they were more mindful than usual (controlling for the perceived autonomy of their behavior and other temporal variables at that moment). These results extend prior work showing that negative affective states can be reduced by mindfulness and physical activity to the momentary level. Integrating mindfulness practices with physical activity may lead to greater mental health benefits and this hypothesis should be tested in experimental research.
Momentary Negative Affect is Lower During Mindful Movement than While Sitting:
An Experience Sampling Study

Regular physical activity participation has been associated with better mental health and less intense psychological symptoms in both clinical and non-clinical populations (Biddle & Asare, 2011; Mammen & Faulkner, 2013; Rebar et al., 2015; Rosenbaum, Tiedemann, Sherrington, Curtis, & Ward, 2014). Similarly, mindfulness-based interventions that enhance people’s awareness and acceptance of their bodily and emotional responses have consistently reduced negative affect (Davis & Hayes, 2011; Gotink et al., 2015; Grossman, Niemann, Schmidt, & Walach, 2004; Keng, Smoski, & Robins, 2011; Sharma & Rush, 2014). Little is known about whether people’s mindfulness during everyday activity behaviors or postures influences the intensity of negative affective experiences. This study investigated whether usual or momentary mindfulness levels moderated associations between activity behaviors/postures and negative affect.

Negative affect refers to individuals’ subjective experiences of displeasure (Ekkekakis & Petruzzello, 2002). Examples of negative affective states include feeling sad, anxious, stressed, and depressed (Harmon-Jones, Harmon-Jones, Amodio, & Gable, 2011; Posner, Russell, & Peterson, 2005). Young adults, especially the college student population, consistently experience negative affect in their daily life. For instance, young adults’ stress level was well above the average stress level among all generations of US adults (APA, 2015). The American College Health Association (ACHA) similarly revealed that more than half of the college student population experienced negative affective states including overwhelming anxiety (57.7%), sadness (63.5%), or mental exhaustion (81.6%) at least once a year. College students further reported that stress and anxiety were the top two factors impacting their academic performance.
(ACHA, 2015), and these negative states have impaired academic performance, self-esteem and overall health status (Fogle & Pettijohn, 2013; Hudd et al., 2000; Zajacova, Lynch, & Espenshade, 2005). Negative affect is consistently associated with lower levels of physical activity and mindfulness; however, most of this work has focused on characterizing differences between people (Conn, 2010; Davis & Hayes, 2011; Ensari, Greenlee, Motl, & Petruzzello, 2015; Keng et al., 2011; Rebar et al., 2015; Sharma & Rush, 2014; Stathopoulou, Powers, Berry, Smits, & Otto, 2006). Less is known about the role of daily activity behaviors and postures or how mindfulness interacts with those behaviors/postures in regulating momentary affective states.

Physical activity refers to any bodily movement that increases energy expenditure above a basal level due to the contraction of skeletal muscle (Caspersen, Powell, & Christenson, 1985). Physical activity, especially under moderate and vigorous intensities, can reduce negative affective states, including stress, anxiety, and depression. This negative association has been found in research with different designs such as cross-sectional studies, prospective studies, and randomized controlled trials (Cooney, Dwan, & Mead, 2014; Ensari et al., 2015; Schuch, Rocha, & Cadore, 2015; Stults-Kolehmainen & Sinha, 2013). Less is known about how bodily postures that do not involve locomotion (i.e., sitting, standing) or light intensity physical activities can impact negative affect and the available results have been quite heterogeneous. One review focusing on the proximal association of daily physical activity with subsequent affective responses produced mixed and inconclusive findings. Some studies found negative or non-significant associations between daily physical activity and subsequent negative affective responses (Liao, Shonkoff, & Dunton, 2015). Some of this heterogeneity may be due to variation in people’s mental states during their daily activities, such as their mindfulness levels.
Mindfulness is a form of heightened attention and awareness (Kabat-Zinn, 1994). It has been identified as either a trait that varies between people or a state that changes within people over time and contexts (Davidson, 2010; Thompson & Waltz, 2015). Based on different temporal specificities, trait mindfulness can be conceptualized as the global level of mindfulness that is relatively stable across time, whereas state mindfulness can be conceptualized as either the contextual or the situational mindfulness that varies within different contexts and situations (Bishop et al., 2004). This three level framework can enhance conceptual clarity and precision in studying mindfulness, and is similar to what has been used to organize research on intrinsic and extrinsic motivation (Vallerand, 2007; see Chapter 2).

In the past few decades, mindfulness practice has become a popular strategy widely implemented in stress management interventions (Kabat-Zinn & Hanh, 2009; Praissman, 2008). College students who participated in mindfulness-based stress reduction programs have consistently decreased negative affect as indicated by lower levels of stress, anxiety, and depression (Beddoe & Murphy, 2004; Jain et al., 2007; Moscaritolo, 2009; Schure, Christopher, & Christopher, 2008; Shapiro, Oman, Thoresen, Plante, & Flinders, 2008). Aside from the majority of the intervention studies that aim to enhance global mindfulness, simply elevating an individual’s situational mindfulness at a particular time may improve affective valence. Bishop et al. (2004) describe the state (situational) form of mindfulness as an active self-regulation of one’s awareness and attention to the experience in the present moment, which indicates that people could be relatively more mindful in any given moment without extra training in mindfulness or meditation. Previous experience sampling research showed college students’ situational mindfulness level was negatively associated with momentary negative affect in terms of both intensity and frequency over a few weeks (Brown & Ryan, 2003). The present study was
designed to investigate whether situational mindfulness can moderate associations between a person’s activity or posture and their negative affective state.

The interaction hypothesis between mindfulness and physical activity in reducing negative affect has not been explored in depth, and the available findings particularly came from studies comparing between-person differences. In one systematic review including only randomized controlled trials, researchers seek to compare the relative efficacy of reducing depression between mindfulness-based exercise including yoga, tai chi, and qigong training and other exercise interventions. They concluded that both interventions were effective in reducing depression symptoms or levels in the short term (Tsang, Chan, & Cheung, 2008). Findings about differences between mindful and non-mindful exercises were inconclusive due to methodological limitations and insufficient sample sizes in most of the reviewed studies. Older breast cancer survivors who participated in mindful dancing increased their quality of life through reduction of recurrence fear and improvement of global mindfulness attitude compared to cancer survivors in the control group (Crane-Okada et al., 2012). In another study, psychologically-distressed patients who engaged in a mindful walking programs significantly decreased their stress symptoms and increased quality of life compared to the waitlist control group (Teut et al., 2013).

To the best of our knowledge, only one study used experience sampling methods to study the differences in momentary negative affect between more and less mindful activity. In this study, mindful walking was carried out by adults with mindfulness training experiences (most of whom had history of depression). Mindful walking significantly reduced negative affect compared to the same duration of daily normal activities (Gotink et al., 2016).

These studies provide preliminary evidence for integrating mindfulness and physical activity to reduce negative affect, but none explicitly examined the interaction between
momentary mindfulness and activity behaviors or postures. These studies also targeted patients in clinical settings exclusively and no studies focused on college students population that experience high levels of negative affect.

The Present Study

The present study was designed to evaluate whether momentary mindfulness levels moderated associations between physical activity and negative affect. A second goal of this study was to deepen understanding of the specific activity behaviors or postures that are most associated with negative affect so we assessed a variety of activity intensities and postures that are common across contexts of daily life (i.e., sitting, standing, moving). Based on the premise that affect, daily activity behaviors/posture, mindfulness, and negative affect are all time-varying phenomena, experience sampling methods were used to distinguish variance that differentiated between people from variance that differentiated between moments nested within people (Dunton, 2017). The primary within-person hypotheses in the current study were that (1) momentary activity-negative affect relations would be stronger when participants were more mindful than usual, and (2) negative affect would be lower when participants were moving (relative to sitting). The primary between-person hypothesis in the current study was that once the within-person associations were controlled, there would be no significant associations between students’ usual daily activity, usual (global) mindfulness and negative affect.

Given the observational nature of these data, statistical controls were included for age, gender, response time, day of the week, time in study, perceived autonomy, and lagged negative affective state. These covariates were selected because they can each impact negative affect. For example, stress perception or reactivity differ by age, gender, and the temporal contexts within a day or week (APA, 2011; Jorm et al., 2005; Ragsdale, Beehr, Grebner, & Han, 2011; Rudolph &
Hammen, 1999). As the time in study increases, or as the prompts accumulated throughout the day, participants may feel irritated and become more anxious as they receive frequent unpredictable prompts (Beute, de Kort, & IJsselsteijn, 2016). Additionally, many college students’ activities or postures are obligatory (e.g., due to norms for sitting in classrooms), so perceived autonomy was assessed to control its influence on stress, anxiety or mental health (Deci & Ryan, 2008; Ng et al., 2012). A single-lagged negative affect term also included to adjust for any carry-over influence (Towbes & Cohen, 1996).

**Methods**

**Participants and Procedures**

University students enrolled in an undergraduate course ($N = 161$) participated in this study as part of the course requirements. Three participants were excluded from analysis because their data was too sparse ($M = 13$ responses out of 112 prompts). The remaining 158 participants were predominantly female (58%), not Hispanic (91%) and White (82%) with a mean age of 20.0 years ($SD = 1.26$).

The institutional review board approved the study protocol and participants provided informed consent at an initial lab session. Small groups of up to five participants met with the researcher to download and install the Personal Analytics Companion Application (Paco; https://www.pacoapp.com/) onto their smartphones (16% iOS, 84% Android). Following installation, the researcher helped each participant complete a practice experience sampling survey on Paco, and set a personalized 12-hour window for experience sampling prompts. The default time block for receiving the notifications was within 8AM to 8PM, but participants could adjust this time window based on their schedule.
Participants then completed an online questionnaire about their demographic characteristics (e.g., age, gender). For the next 14 days, participants completed up to eight randomly-delivered questionnaires from Paco each day during their waking time. There were a minimum one-hour interval between prompts and a five-minute time window for responding. Following each prompt, students reported their activity behavior/posture and rated their negative affect and mindfulness at the moment they were prompted. Participants on average spent less than one minute to response to each prompt. The researcher deactivated all participants’ accounts from receiving the daily prompts from Paco after the two-week study period, and participants were free to uninstall the app from their smartphones. All data were collected between late October and mid-November 2015.

Measures

Demographics. Age, gender and ethnicity were self-reported.

Daily activity / postures. Momentary activity behaviors/postures were assessed using a single item, “What were you doing when the signal went off?” Response options included sitting, standing, moving, or sleeping. Sleep was rarely reported (5%) so these entries were excluded from the data analysis. Dummy variables were created for standing and moving (0 = not selected, 1 = selected) with sitting serving as the reference category.

Negative affect. Three items were used to measure perceived stress (“During this activity, I felt stressed”), anxiety (“During this activity, I felt anxious”), and affective valence (“Please rate how you felt in general during this activity”). Participants responded to the stress and anxiety items on a scale ranging from 0 (not at all) to 4 (extremely) and to the negative valence item on a reverse-coded scale ranging from 0 (very bad) to 4 (very good). These items were slightly modified from the “Emotional Distress - Anxiety”, “Distress - Depression”, and
“Positive Affect” short form measures in the Patient Reported Outcomes Measurement Information System (PROMIS; Pilkonis et al., 2011; Schalet et al., 2016) to accommodate the frequent momentary assessments required in an experience sampling design. Responses between the stress, anxiety and the valence items were moderately to highly correlated ($r$ ranged from 0.35 to 0.74 across observations and people and from 0.25 to 0.50 across participants), and the three items were internally consistent as a whole (coefficient $\alpha$ was 0.64 across observations and 0.76 across participants). Initial analyses were run on responses to each item individually and results were consistent, so the three items were aggregated into a composite index of negative affect for the analyses reported in the current study.

**Mindfulness.** Momentary mindfulness was assessed using two items from the State Mindfulness Scale (SMS; Tanay & Bernstein, 2013). This measure was developed to assess situational mindfulness (i.e., mindfulness during a specific time period and particular context, such as during academic or other activities). Items were selected based on their factor loadings to include the items whose responses were most closely associated with latent scores for mindfulness of mind (“During this activity, I noticed pleasant and unpleasant emotions”) and body (“During this activity, I noticed physical sensations come and go”). Participants indicated their perceived situational mindfulness level on a scale ranging from 1 (*not at all*) to 5 (*very well*). Based on the strong correlation (Spearman-Brown $\rho$=0.55 across observations and people; $\rho$ = 0.76 across people), the two items were combined to represent situational mindfulness.

**Autonomy.** One item modified from the Situational Motivation Scale (SIMS; Guay, Vallerand, & Blanchard, 2000), was used to assess participant’s momentary perceptions of autonomy: “I was engaging in this activity because I want to, not because I have to.” Participants rated their momentary perceived autonomy on a scale ranging from 0 (*do not agree at all*) to 4
(strongly agree). Higher scores indicated that the person experienced greater relative autonomy for the activity.

**Temporal context.** The temporal context of responses was recorded automatically by the Paco app in the form of time and date stamps for each experience sample. To accommodate college students’ schedules which can run past midnight, the time of day was expressed as minutes since 4am (as opposed to using midnight; see Rives, 2007). Dummy variables were created to represent the day of week and Saturday served as the reference category because it coincided with the lowest mean negative affect scores.

**Data Preparation and Analysis**

Momentary variables were transformed to separate variance at the between- and within-person levels (Bolger, Davis, & Rafaeli, 2003; Schwartz & Stone, 1998). First, each person’s usual level of a variable was calculated as their intraindividual mean (i\text{mean}) score. This data preparation approach was equivalent to cluster-mean centering method described by Enders and Tofighi (2007) for multilevel model analysis. Next, each momentary response was person mean centered by subtracting each individual score from the corresponding person-level mean score. The resulting difference score represented the deviation of a person’s activities or experiences around their mean levels at a given time. For instance, participant \(i\)’s usual level of mindfulness (Usual Mindfulness\(_i\)) was calculated as the i\text{mean} of his/her momentary responses to mindfulness items across the 2 weeks, and each participant’s momentary levels of mindfulness (Momentary Mindfulness\(_i\)) were calculated by subtracting the scores at each occasion \(t\) from his or her i\text{mean}. Usual Mindfulness\(_i\) scores across the 2 weeks differentiate the more or less mindful people in general (between-person differences), whereas Momentary Mindfulness\(_it\) scores represent momentary deviations from usual mindfulness levels (within-person differences).
Negative affect scores were not over dispersed (kurtosis = 0.21) but negatively skewed (skewness = 0.93), so scores were transformed using the Box-Cox method (optimal $\lambda = 0.39$; transformed skew = -0.57; Box & Cox, 1964; Osborne, 2010). This transformed score was used in all analyses. The distributions of momentary mindfulness (skewness = 0.08; kurtosis = -0.75) and perceived autonomy (skewness = -0.61; kurtosis = -0.78) ratings were not over skewed or dispersed so the original score metric was retained.

Due to the nested structure of the data (moments nested within people), multilevel models (MLM) were used to examine the between- and within-person associations between their momentary activities and negative affect. Models were estimated using R 3.2.2 (R Core Team, 2013) with the nlme package (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2016). Missing values (6%) were excluded from the analysis. Predictors in the multilevel models were categorized into three different sources: the between-person factors, the within-person factors, and the interactions between within-person factors. The within-person interactions were selected by all the combinations between mindfulness and the activities (standing and moving).

Consistent with standard multilevel modeling practice, the intraclass correlation coefficients (ICC) and the pseudo-$R^2$ were calculated. The former index estimates the proportion of total variance (between- and within-person) that can be attributed to between-person differences (Kreft, Kreft, & Leeuw, 1998). The latter index represents the proportion of total variability explained by a set of predictors. The pseudo-$R^2$ is also considered as an effect size estimation of the model (Nakagawa & Schielzeth, 2013).

**Model specification.** The final multilevel model in predicting negative affect is presented below:
Level-1: \[ \text{Negative affect}_{it} = \beta_0i + \beta_{1i} (\text{Response time}_{it}) + \beta_{2i} (\text{Day in study}_{it}) + \beta_{3i} \]
\[ (\text{Monday}_{it}) + \beta_{4i} (\text{Tuesday}_{it}) + \beta_{5i} (\text{Wednesday}_{it}) + \beta_{6i} (\text{Thursday}_{it}) + \beta_{7i} \]
\[ (\text{Friday}_{it}) + \beta_{8i} (\text{Sunday}_{it}) + \beta_{9i} (\text{Deviations from usual standing}_{it}) + \beta_{10i} \]
\[ (\text{Deviations from usual moving}_{it}) + \beta_{11i} (\text{Momentary autonomy}_{it}) + \beta_{12i} \]
\[ (\text{Momentary mindfulness}_{it}) + \beta_{13i} (\text{Prior negative affect}_{it}) + \beta_{14i} (\text{Deviations from usual standing}_{it} \times \text{Momentary mindfulness}_{it}) + \beta_{15i} (\text{Deviations from usual moving}_{it} \times \text{Momentary mindfulness}_{it}) + e_{it} \]

Level-2: \[ \beta_0i = \gamma_{00} + \gamma_{01} (\text{Age}_{i}) + \gamma_{02} (\text{Gender}_{i}) + \gamma_{03} (\text{Usual standing}_{i}) + \gamma_{04} (\text{Usual moving}_{i}) + \gamma_{05} (\text{Usual autonomy}_{i}) + \gamma_{06} (\text{Usual mindfulness}_{i}) + u_{0i} \]
\[ \beta_{(1-14)i} = \gamma_{(1-14)0} \]

where \( \gamma_{00} \) represented the intercept for momentary negative affect, \( \gamma_{01} \) to \( \gamma_{06} \) represented the between-person associations between negative affect and age (\( \gamma_{01} \)), gender (\( \gamma_{02} \)), usual standing (\( \gamma_{03} \)), usual moving (\( \gamma_{04} \)), usual mindfulness level (\( \gamma_{05} \)), and usual autonomy level (\( \gamma_{06} \)); \( \gamma_{10} \) to \( \gamma_{70} \) represented the association between negative affect and response time (\( \gamma_{10} \)) and day of the week (i.e., \( \gamma_{20} \) for Monday, \( \gamma_{30} \) for Tuesday, etc.). Saturday had the lowest negative affect so was used as the reference day. The parameters \( \gamma_{80} \) to \( \gamma_{110} \) represented associations between negative affect and individual’s usual level of standing and moving (\( \gamma_{80} \) and \( \gamma_{90} \), both relative to sitting), usual mindfulness level (\( \gamma_{100} \)), and usual autonomy level (\( \gamma_{110} \), respectively; \( \gamma_{120} \) was the association with lagged negative affect; \( \gamma_{130} \) and \( \gamma_{140} \) represented the association between negative affect and interactions between momentary activity and momentary level of mindfulness. All predictors were treated as fixed effects to reduce model complexity and accommodate the available sample.
size. The coefficient $u_{0i}$ is the person-specific residual deviations that is uncorrelated with the momentary-level residual $e_{it}$.

**Results**

Participants provided a total of 14,591 responses (80.9% response rate) and an average of 92 responses per person ($SD = 24.76$) during the two-week study period. The frequency plot in Figure 3.1 shows that almost all the responses (99%) were provided between 8AM and 12PM (midnight), indicating a good coverage of typical waking hours.

As seen in Table 3.1, on average, participants reported low negative affect ($M = 3.15$ on a 0-12 scale), moderate mindfulness ($M = 3.49$ on a 0-8 scale) and moderate perceived autonomy ($M = 2.62$ on a 0-4 scale). Sitting, moving, and standing were reported during 62%, 22%, and 16% of the valid experience samples, respectively. Table 3.1 also reports between- and within-person correlation coefficients above and below the diagonal, respectively. Similar patterns were observed in the between- and within-person correlations. For example, negative affect had a moderate negative association with autonomy (between-person $r = -0.48$; within-person $r = -0.28$), and weak negative associations with standing (between-person $r = -0.07$; within-person $r = -0.08$), and moving (between-person $r = -0.08$; within-person $r = -0.10$). The ICC for negative affect indicated that approximately 37% of the variance in scores was due to differences between people with the remaining variance due to within-person fluctuations or measurement error. This estimate justified testing both between- and within-person hypotheses in a multilevel modeling framework.

Table 3.2 summarizes coefficients from the multilevel model that regressed negative affect on a variety of predictors after controlling for other variables. The outcome variable in this
model is a composite negative affect score but, as a reminder, conclusions were identical when individual models were tested for stress, anxiety and affective valence.

The first primary hypothesis was supported: People reported less negative affect while moving ($\gamma_{90} = -0.70, p < .01$) or standing ($\gamma_{100} = -0.51, p < .01$) than sitting. At moments when people were more active than their usual, they experienced lower levels of negative affect.

The second primary hypothesis was also supported: At moments when individuals were more mindful than usual, the within-person associations between negative affect and moving ($\gamma_{150} = -0.10, p < .01$) differed from when participants were sitting. A significant interaction effect was not observed in the within-person interaction between standing and momentary mindfulness ($p > .05$). People’s momentary negative affect and standing did not vary as a function of their momentary mindfulness. Figure 3.2 presents this interaction in which associations between momentary negative affect and moving varied as a function of their momentary mindfulness. People reported significant less negative affect while moving mindfully compared to sitting.

The hypothesis regarding the primary between-person association was supported: After accounting for the within-person variations in people’s daily activity and mindfulness, the differences between people’s usual activity level as well as their usual mindfulness level did not predict negative affect ($p > .05$). People’s negative affect did not differ for people who more frequently reported moving or standing relative to sitting, nor for people who reported being mindful more frequently.

Both usual and momentary autonomy were negatively associated with negative affect. Individuals with greater autonomy were less likely to experience higher negative affect ($\gamma_{06} = -0.93, p < .01$). In moments when people were more autonomous than usual, they tended to
experience less negative affect ($\gamma_{120} = -0.57, p < .01$). The model also indicated that college student’s negative affect levels differed by the day of the week. Compared to Saturdays, students reported higher negative affect on all other days except Fridays. The model also showed that students’ previous negative affective state carried over with time and positively predicted their subsequent levels of negative affect ($\gamma_{130} = 0.35, p < .01$). The pseudo $R^2$ for this model indicated that the fixed effects of all the predictors in the model accounted for approximately 38% of the variance in momentary negative affect.

**Discussion**

The current study applied experience sampling methods to investigate associations between daily activity behaviors/postures, mindfulness and negative affect in college students’ daily lives. The key finding was that college students who reported being more mindful while moving in everyday life reported lower levels of negative affect than they did when they were less mindful or sitting. This finding was consistent with previous studies showing that engaging in mindful physical activity is associated with lower perceived negative affect (Gotink et al., 2016; Robert-McComb et al., 2015; Teut et al., 2013; Tsang et al., 2008). These results provide the first evidence of mindful movement being associated with negative affect in a variety of life contexts, without participating in a structured mindful moving program.

Both engaging in physical activity and mindfulness practice have been shown to reduce negative affect in the college student population (Regehr, Glancy, & Pitts, 2013; Stults-Kolehmainen & Sinha, 2013). The present study extended previous research by explicitly testing the interaction between these two strategies. A potential synergetic effect emerged between physical activity behavior/posture and mindfulness that dampened negative affect even more
than behavior/posture or mindfulness by itself. Higher levels of momentary mindfulness strengthened the inverse association between physical activity and negative affect. This finding implies that implementing mindfulness practices into everyday activity behaviors/postures may lower students’ negative affective experiences to a greater degree. With the inclusion of usual and momentary mindfulness levels, we also found that only students’ momentary activity behavior/posture, but not their usual level of activity behavior/posture, was associated with negative affect.

The finding that deviations from college students’ usual activity level, but not their usual activity level, was significantly associated with negative affect was consistent with one prior study (Haas, Schmid, Stadler, Reuter, & Gawrilow, 2017), but contradicted with another (Hyde, Conroy, Pincus, & Ram, 2011). Study from Haas et al. (2017) found that when young adults (mostly college students) engaged in more daily moderate to vigorous physical activity than their usual level, they reported lower levels of negative affect in the same evening. The between-person differences in daily physical activity level in this study did not yield the same association with negative affect. On the other hand, study from Hyde et al. (2011) revealed that both college students’ overall and daily free-time physical activity were not associated with daily unpleasant-activated (nervous, embarrassed, upset, stress, and tense) or unpleasant-deactivated (sluggish, sad, bored, depressed, and disappointed) affective responses. These mixed results indicate a need for future studies to investigate whether people’s mindfulness level or the activation (arousal) level of affect are determinants of the between- and within-person association between daily physical activity and negative affect (Dunton et al., 2014; Kanning & Schlicht, 2010; Reed & Ones, 2006).
Further, rather than focusing on moderate-to-vigorous physical activity level in daily life, the present study showed that daily activity behaviors and postures (standing and moving relative to sitting) also yield an inverse association with negative affect. When people moved or stood (relative to sitting), they experienced lower levels of negative affect. This finding may also inform future studies to investigate the role of everyday light activities or postures in improving people’s mental health, which will provide tremendous public health implications.

The present study relied on self-reports and did not incorporate devices (e.g., accelerometers) to capture daily movements and postures. Those devices are often considered gold standards for investigating daily variations in physical activity and affective states (Kanning, Ebner-Priemer, & Schlicht, 2013). The self-reported daily activity patterns reported here corresponded with population-based estimates of time spent in different activity behaviors and postures from devices (Hansen, Kolle, Dyrstad, Holme, & Anderssen, 2012). For example, the proportion of sedentary time reported in both studies was identical (both 62%). This concordance is likely a product of intensive within-person assessments that averaged 909 responses per hour across a broad swatch of waking hours. Future studies should investigate whether ecological momentary assessment approaches with frequent responses of physical activity could be a valid proxy for the total amount of physical activity measured by devices.

The intensive longitudinal assessments in the current study extended prior mindfulness work by demonstrating affective differences as a function of situational mindfulness levels in college student’s everyday life. To reduce negative affect in college students, prior mindfulness-based programs usually focused on affective differences between more and less mindful students, and changes in global mindfulness level before and after the program (Chiesa & Serretti, 2009; Eberth & Sendlmeier, 2012; Shapiro et al., 2008). Those studies usually included
limited samplings of mindfulness and negative affect, and thus could not disaggregate the between-person and within-person variation in these time varying constructs (Beddoe & Murphy, 2004; Jain et al., 2007; Moscaritolo, 2009; Schure et al., 2008; Shapiro et al., 2008). The present finding of a within-person association between mindfulness and negative affect has implications for future intervention designs to examine the associations between people’s global, situational mindfulness and negative affect. An experimental study with ecological momentary assessment of mindfulness and negative affect is needed to establish causality between people’s increases in global and/or momentary mindfulness and reductions in negative affect.

Perceived autonomy is the only predictor in our study that was significant in predicting negative affect at both the between- and the within-person levels. People with higher levels of perceived autonomy or who perceived greater autonomy at a given moment often experience more enjoyment and pleasure while engaging in physical activity (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). It was not surprising to see that higher levels of usual and momentary autonomy were related to lower levels of negative affect in the present study. This finding reinforces the importance of cultivating a sense of autonomy, a key factor depicted in self-determination theory, to support intrinsic motivation for physical activity and promote health and well-being (Deci & Ryan, 2008).

To account for the potential threat of affective reactivity due to intensive measures, time in study and response time variables were included in our analysis to control covariation with negative affect. The model did not indicate any signs of elevated negative affect increased with time, but suggested a significant decrease in negative affect as the numbers of days in the study increased. Thus, concerns about experience sampling-induced reactivity should be minimal. Moreover, with ecological momentary assessment over a course of two weeks, we were able to
test the differences between weekday and weekend differences in negative affect in college students. After controlling for other variables, we identified that college students experienced higher negative affect in most weekdays compared to Saturday. Such cyclicity of weekly negative affective level has also been identified in previous study (Ragsdale et al., 2011). The prevalence of experiencing greater negative affect in school days highlights the need for effective interventions to promote well-being in college students’ daily schedule.

Several limitations in the current study should be noted. The age range of the sample was narrow so conclusions may be age-specific and may not generalize to other populations in different age groups. For instance, younger children usually do their daily activity with less conscious awareness due to the lack of autonomy and agency, since their daily schedule has mostly been instructed and planned out (Fodor & Hooker, 2008). On the other hand, with the perception of limited future life time, older adults tend to pay more attention to their emotional well-being and physical conditions in the present moment of everyday life (Scheibe & Carstensen, 2010). Thus, it is possible that the same study in children or older could lead to different results.

For physical activity measurement, the self-reported momentary activity in our study was not sensitive to differences in the intensity, duration or mode of physical activity. Future work with devices (i.e., accelerometers) that are capable of activity classification would help to extend understanding of the processes of daily activities in predicting negative affect. Also, a number of contextual factors that could influence negative affect were not assessed in the present study. For example, the social context, the built environment, and the weather condition have been shown to impact people’s daily affective responses (Galea, Ahern, Rudenstine, Wallace, & Vlahov,
These factors should be considered as covariates in future research.

To minimize participant burden from responding to the frequent experience sampling prompts, only a few items were selected to measure subjective experiences including negative affect (assessed by three items), mindfulness (two items), and autonomy (one item). Using fewer items to measure psychological constructs is common to reduce burden and fatigue in experience sampling studies, but this approach may be more vulnerable to random measurement errors or unidentified biases in interpretation of the question (Hoeppner, Kelly, Urbanoski, & Slaymaker, 2011). We sought to minimize measurement errors and sustain face validity by selecting and modifying our experience sampling questions from available scales, but results may have differed if other types of measures or more items were used to capture each construct in our study. Finally, the research design was non-experimental, so causal inferences are not possible.

In sum, this study was the first to apply experience sampling methods to investigate the interaction between momentary mindfulness, physical activity, and negative affect. Results revealed a within-person association between daily activity and situational mindfulness in predicting negative affect. Simply moving more or standing more rather than sitting in everyday life may reduce negative affect but this conclusion requires replication using experimental methods. Situational mindfulness may moderate the association between daily activity behaviors/postures and negative affect. These findings suggest new possibilities for using ecological momentary interventions to promote situational mindfulness during upright postures and while moving in everyday life to amplify the effects of physical activity. Instructions on how to carry out mindful movement or incorporate mindfulness techniques with movement-based
activities in college setting may be promising strategies for improving mental health among college students.
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Figure Captions

Figure 3.1. Frequency of experience sampling responses at each time during the study period.

Figure 3.2. Associations of momentary mindfulness and moving on negative affect.
Table 3.1. Descriptive statistics, correlations, and intraclass correlation coefficients of subjective experiences, physical activity, and other variables of interest

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<td>1. Negative Affect</td>
<td>3.15</td>
<td>2.78</td>
<td>.05**</td>
<td>-.48**</td>
<td>-.07**</td>
<td>-.08**</td>
<td>-.14**</td>
<td>-.08**</td>
<td>.09**</td>
<td></td>
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<td>2. Mindfulness</td>
<td>3.49</td>
<td>2.26</td>
<td>.09**</td>
<td>(.59)</td>
<td>.02*</td>
<td>-.06**</td>
<td>.22**</td>
<td>-.07**</td>
<td>.02**</td>
<td>.10**</td>
</tr>
<tr>
<td>3. Autonomy</td>
<td>2.62</td>
<td>1.33</td>
<td>-.28**</td>
<td>.08**</td>
<td>(.17)</td>
<td>.06**</td>
<td>.09**</td>
<td>.19**</td>
<td>.23**</td>
<td>-.06**</td>
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<td>4. Standing (%)</td>
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<td>0.07</td>
<td>-.08**</td>
<td>-.01</td>
<td>.07**</td>
<td>1.00</td>
<td>-.22**</td>
<td>-.08**</td>
<td>.06**</td>
<td>.15**</td>
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<tr>
<td>5. Moving (%)</td>
<td>0.22</td>
<td>0.09</td>
<td>-.10**</td>
<td>.13**</td>
<td>.09**</td>
<td>-.23**</td>
<td>1.00</td>
<td>-.01</td>
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<td>.10**</td>
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<td>6. Response Time (hour)</td>
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<td>.10**</td>
<td>.03**</td>
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<td>-.01</td>
<td>-.03**</td>
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<td>.01</td>
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<td>.09**</td>
<td>.03**</td>
<td>.03**</td>
<td>.01</td>
<td>-.01</td>
<td>-.03**</td>
<td>-.36**</td>
<td>1.00</td>
</tr>
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</table>

*N=158, *p<.05, **p<.01. Intraclass correlations (ICC) were calculated in the diagonal parentheses of the matrix.*
Table 3.2. Multilevel model coefficients for model predicting negative affect

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>2.88</td>
<td>1.51</td>
</tr>
<tr>
<td>Age, $\gamma_{01}$</td>
<td>.08</td>
<td>.08</td>
</tr>
<tr>
<td>Gender, $\gamma_{02}$</td>
<td>.35</td>
<td>.19</td>
</tr>
<tr>
<td>Response Time, $\gamma_{10}$</td>
<td>.01</td>
<td>.01</td>
</tr>
<tr>
<td>Day in the Study, $\gamma_{20}$</td>
<td>-.01**</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Monday, $\gamma_{30}$</td>
<td>.30**</td>
<td>.07</td>
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<tr>
<td>Tuesday, $\gamma_{40}$</td>
<td>.33**</td>
<td>.07</td>
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<tr>
<td>Wednesday, $\gamma_{50}$</td>
<td>.38**</td>
<td>.07</td>
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<tr>
<td>Thursday, $\gamma_{60}$</td>
<td>.15**</td>
<td>.07</td>
</tr>
<tr>
<td>Friday, $\gamma_{70}$</td>
<td>&lt;.01</td>
<td>.07</td>
</tr>
<tr>
<td>Sunday, $\gamma_{80}$</td>
<td>.34**</td>
<td>.07</td>
</tr>
<tr>
<td>Usual standing, $\gamma_{03}$</td>
<td>-1.86</td>
<td>1.20</td>
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<tr>
<td>Usual moving, $\gamma_{04}$</td>
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<td>1.03</td>
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<tr>
<td>Usual mindfulness, $\gamma_{05}$</td>
<td>.08</td>
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<td>Usual autonomy, $\gamma_{06}$</td>
<td>-.93**</td>
<td>.16</td>
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<td>Deviations from usual standing, $\gamma_{90}$</td>
<td>-.51**</td>
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<td>Deviations from usual moving, $\gamma_{100}$</td>
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<td>Momentary mindfulness, $\gamma_{110}$</td>
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<td>Momentary autonomy, $\gamma_{120}$</td>
<td>-.57**</td>
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<td>Previous negative affective state, $\gamma_{130}$</td>
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<td>.01</td>
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<tr>
<td>Deviations from usual standing x Momentary mindfulness, $\gamma_{140}$</td>
<td>-.02</td>
<td>.03</td>
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<tr>
<td>Deviations from usual moving x Momentary mindfulness, $\gamma_{150}$</td>
<td>-.10**</td>
<td>.03</td>
</tr>
</tbody>
</table>

Random Effect

| Variance Intercept, $\sigma^2_{u0}$ | 1.03        |
| Residual Variance, $\sigma^2_\epsilon$ | 3.34       |

*p<.05, **p<.01, N of group=150.
Chapter 4: Feasibility of an Outdoor Mindful Walking Program for Reducing Negative Affect in Older Adults
Abstract

Mindful walking has emerged as a potential intervention strategy to improve mental health and promote well-being in adult and clinical populations. This strategy has not been implemented with older adults to date. This study evaluated the feasibility, acceptability, sustainability, and preliminary efficacy of a mindful walking program for reducing negative affect in older adults. Community-dwelling older adults (n = 29) completed a one-month, outdoor mindful walking program distributed across eight 30-minute sessions. Overall, 93% of the recruited participants (n = 27) completed all walking sessions and assessments. Responses from the post-program and the follow-up questionnaires revealed that mindful walking was well-accepted, highly-valued, and maintained after the program ended. Open-ended feedback reinforced these findings. Analysis from the pre-walk and post-walk surveys also suggested the preliminary efficacy of mindful walking program for reducing negative affect. In general, the mindful walking program in the current study can be implemented as intended (i.e., feasible) and should be considered acceptable and sustainable by older adults. Positive results identified in the current feasibility study indicate readiness for randomized controlled trials to further examine the efficacy and effectiveness of a mindful walking intervention for promoting health and well-being in older populations.
Feasibility of an Outdoor Mindful Walking Program for Reducing Negative Affect in Older Adults

The older adult population is growing rapidly. By 2050, over 20% of the population – approximately two billion of the population globally – will be 60 years of age or older (WHO, 2017). To help this rapidly growing older adult population live longer, healthier and happier, the promotion of healthy aging has become a priority to the society (McLaughlin, Connell, Heeringa, Li, & Roberts, 2010). Approximately 10% of older adults report 14 or more days of poor mental health including stress, depression, or other negative emotional symptoms within a month (CDC, 2008; Gerteis et al., 2014). Around 15% to 52% of community older adults also reported anxiety symptoms based on a literature review (Bryant, Jackson, & Ames, 2008). The prevalence of poor mental health among the elderly foreshadow significant health care challenges. People are now living longer but have lower psychological well-being that may lead to poor health. National data recently revealed that only 1% of the health cost for older Americans have been spent in health prevention work (National Council on Aging, 2015). Therefore, the design and evaluation of cost-effective, innovative, and scalable intervention strategies to improve well-being in older adults is a pressing manner from a public health standpoint.

Engaging in regular physical activity and mindfulness practice have both been introduced as promising strategies to promote successful aging (Harmell, Jeste, & Depp, 2014), but strategies that integrate mindfulness practice and a single form of physical activity have not been explored in depth, especially in older adults. It remains unclear whether a mindful walking program would be feasible and acceptable for older adults or if it could potentially improve their well-being by reducing negative affect. Given this, the present study was conducted to evaluate
the feasibility, acceptability, sustainability, and preliminary efficacy of an outdoor mindful walking intervention for community-dwelling older adults.

Although the rates of psychological symptoms tend to decline with age, older adults experience several aging-related stressors such as decreased physical and mental abilities, physical pain and discomfort, insufficient time spend with family and friends, and concern about their own death during everyday life (Stokes & Gordon, 2003). These stressors exact a toll on older adults’ overall health and well-being, and could impair their quality of life. Poor well-being is closely associated with worse cognitive functioning and physical health in older adults (Federal Interagency Forum on Aging-Related Statistics, 2016). Better well-being is positively associated with longevity and serves a protective role in maintaining physical health while people get older, regardless of baseline mental/physical health and demographic backgrounds (Steptoe, Deaton, & Stone, 2015). On the other hand, health risk behaviors, such as smoking, inactivity, and poor diet, were more common among distressed older adults (CDC, 2008).

Epidemiologic data from older adults indicates that faster cognitive decline is associated with increasing levels of perceived stress after adjusting for various biophysiological factors and demographics (Aggarwal et al., 2014). Collectively, these findings point to the need for prevention work for older adults to alleviate negative affect, improve well-being, and in turn, sustain better mental and physical health.

Exercise, or moderate-to-vigorous physical activity, is widely recognized for its effects on well-being by reducing negative affective states (Rebar et al., 2015; Rosenbaum, Tiedemann, Sherrington, Curtis, & Ward, 2014; Stathopoulou, Powers, Berry, Smits, & Otto, 2006; Stults-Kolehmainen & Sinha, 2013). Older adults engage in very limited amounts of exercise and recent work has examined whether light physical activity, such as walking, can elicit similar
benefits for them. An observational study conducted in two major metropolitan regions in the United States revealed a positive association between light intensity physical activity and well-being (i.e., lower stress and depressed feelings, higher life satisfaction) among older adults (Buman et al., 2010). Another large observational study indicated that older adults who participated in self-selected light intensity for at least five times per week, or leisure walking for at least an hour per week had higher levels of subjective well-being compared to their peers (Black et al., 2015). Meta-analysis has reported that for improving older adults’ psychological well-being, the effect size was modest for moderate exercise ($d = 0.34$) and was small for light-intensity exercise ($d = 0.14$), respectively (Netz, Wu, Becker, & Tenenbaum, 2005).

Integrating other interventions that promote well-being may increase the effects of light physical activity on well-being. Mindfulness is both a trait and a state form of mental experience that is characterized by heightened attention, awareness, and acceptance of emotional and physical sensations (Brown & Ryan, 2003). Trait and state mindfulness can also be conceptualized via the three-level hierarchical framework (see Chapter 2). In this model, trait mindfulness is synonymous with global mindfulness and is relatively time-invariant. State mindfulness can be either contextually- or temporally-specific. Contextual mindfulness refers to a person’s typical level of mindfulness in a particular activity or context, whereas situational mindfulness refers to their momentary experience of mindfulness. Research on the mindfulness-based stress reduction program (MBSR; Kabat-Zinn & Borysenko, 1996; Kabat-Zinn & Hanh, 2009) and the mindfulness-based cognitive therapy (MBCT; Morgan, 2003) indicated a negative association between global mindfulness and negative affect (Fjorback, Arendt, Ørnbøl, Fink, & Walach, 2011; Gotink et al., 2015; Gu, Strauss, Bond, & Cavanagh, 2015). Older adults who completed an eight-week MBSR or MBCT significantly decreased their reported depression and
anxiety symptoms, and improved their emotional well-being (Foulk, Ingersoll-Dayton, Kavanagh, Robinson, & Kales, 2014; Young & Baime, 2010; Splevins, Smith, & Simpson, 2009). One review concluded that the average MBSR effect sizes on negative affect in distressed older adults were moderate ($d = 0.50$), despite the large heterogeneity and publication bias in the mindfulness literature (Young & Baime, 2010). Another meta-analysis focused on the effect of MCBT in older adults, and suggested similar effect sizes for decreasing depressive ($g = 0.55$) and anxious ($g = 0.58$) symptoms (Kishita, Takei, & Stewart, 2016).

Interventions have attempted to integrate physical activity and mindfulness to improve people’s mental health (Russell, 2011; Tsang, Chan, & Cheung, 2008). Mindful movement can be simply described as mindful components being implemented concurrently with physical activity, although light physical activity is considered to be optimal for cultivating mindfulness (La Forge, 2016). For older adults, practicing mindfulness with a slow walking pace may be desirable because light physical activity is both safe and health-enhancing (Loprinzi, Lee, & Cardinal, 2015; Nelson et al., 2007). Only a handful of studies have emphasized mindful walking as primary intervention strategy to enhance people’s well-being or reduce negative affect. Two randomized controlled trials have shown that mindful walking or walking meditation can be effective for decreasing negative affect in adults with moderate to high levels of distress or depressive symptoms (Prakhinkit, Suppapitiporn, Tanaka, & Suksom, 2013; Teut et al., 2013). This literature has important limitations. For example, none of the available trials recruited relatively healthy older adults from the community or engaged participants in walking individually (versus in groups). Only one study provided follow-up information regarding the maintenance rate after the end of the supervised program so it is not clear whether mindful walking is potentially sustainable after an initial supervised period (Teut et al., 2013). Finally,
the mechanism for mindful walking benefits on negative affect likely involves momentary
changes mindfulness while walking but no studies have assessed those momentary changes.

The primary objective of the current study was to evaluate the feasibility of an outdoor
mindful walking program for community-dwelling older adults prior to designing a randomized
controlled trial. Eight 30-minute mindful walking sessions were delivered at an public arboretum
that has flat and wide walking trails. Participants were taught (in stages) to use basic and
common practices in traditional mindfulness training by focusing on their breath, steps,
emotional and bodily sensations while walking at a slow, fixed pace (Kabat-Zinn, 1994; Kabat-
Zinn & Hanh, 2009). Participants completed measures at the beginning and end of the program
as well as before and after each session to evaluate the feasibility of monitoring changes in
mindfulness and negative affect during the program. It was hypothesized that older adults in this
study would perceive this program to be acceptable, feasible and sustainable. Acceptability and
feasibility would be indicated by receiving an average score of six or above (out of a seven-point
Likert scale) on each of the questions regarding program feasibility and acceptability; acceptable
program sustainability would be indicated by obtaining an over 60% maintenance rate of mindful
walking at one month follow-up. Exploratory analyses were conducted to evaluate the benefit of
increasing mindfulness while walking. It was hypothesized that negative affect would decrease
most for older adults who increased their mindfulness most during the slow walks.

Methods

Participants

Recruitment was conducted over 6 weeks using fliers posted in a retirement village, a
senior learning institute and a variety of community locations (e.g., churches, restaurants). The
fliers invited older adults to participate in an outdoor slow walking program at a local arboretum. Fliers did not mention the word “mindfulness” to minimize expectations and biases that could influence the psychological outcomes (Davidson & Kaszniak, 2015). Instead, the project was advertised as a “slow walking” study. Figure 4.1 presents the CONSORT diagram for enrollment and follow-up. Participants were eligible if they were age 65 years or older, could walk without assistance, spoke and read English fluently, and were not allergic to plants and flowers. Older adults were excluded if they had any mobility limitations or contraindications for regular light physical activity.

Over six weeks of advertising, volunteers (n = 29) were enrolled using advertisements in the retirement village (n = 2), community locations (n = 13), and a senior learning institute (n = 14). The mean age of participants was 73.2 years (range = 66 to 89, SD = 6.47). Most participants were female (83%), Caucasian (79%), and highly educated (62% of them earned at least a bachelor’s degree). Three participants (10%) had up to several hours of mindfulness/meditation experiences before but this experience was more than 18 months prior (range = 1.5 to 20.0 years).

**Procedure**

In an initial lab visit, each participant completed a baseline assessment of demographic characteristics. The researcher then scheduled the participant’s eight walking sessions. Prior to the first walking session, the researcher sent each participant a reminder email. Walking sessions involved 30 minutes of individual, slow walking along a flat, designated route in an arboretum. Prior to each walking session, the researcher greeted each participant at the arboretum to provide instructions and a small reminder sheet detailing the mindfulness tasks for that day’s walk. Participants completed a brief survey at the beginning and end of each walking session to report
their negative affect and situational mindfulness. After the final walking session, participants completed a second lab visit. In this visit, they rated the acceptability of the slow walking program. One month after the second lab visit, a web-based follow-up questionnaire was emailed to participants to inquire whether they continued to participate in the slow walking activity following the end of the supervised program. Participants who completed the eight walking sessions and two lab visits were enrolled in a raffle to win one of the nine $25 gift cards. The study protocol and all materials were approved by the institutional review board.

**Mindful Walking Intervention**

The mindful walking program was designed to incorporate basic elements of mindfulness practice or walking meditation in a way that would be accessible for the general older population without extensive experience in meditation or mindfulness training. These elements involved being attentive to the rhythm of their breathing and the movement of each step, and scanning the body to identify sensations that arise (Kabat-Zinn, 1994; Kabat-Zinn & Borysenko, 1996; Kabat-Zinn & Hanh, 2009). Table 4.1 summarizes the timing and content of slow walking and mindfulness training in each of the eight sessions. The first session familiarized participants with the walking route at the arboretum and provided an opportunity to practice walking at a slower pace than normal. Older adults can lose their balance more easily when walking at a much slower speed so participants were asked to select their most relaxing and comfortable way of walking slowly (Morone & Greco, 2014). Paying attention to one’s breath is considered the most fundamental mindful practice so it is incorporated beginning in session 2 (Kabat-Zinn, 1994). Two other mindfulness tasks – namely, focusing on the movement and scanning the body – were introduced in sessions four and six. The duration of mindfulness training during each session increased from five minutes to a maximum of 30 minutes.
Measures

First lab visit. A demographic survey was administered to assess participants’ age, gender, race, highest level of educational attainment, prior experiences in mindfulness (meditation) training or practice, and divided attention. The 4-item Divided Attention subscale from the Everyday Cognition Scale for older adults was applied to characterize participants’ baseline attentional ability (Farias et al., 2008).

Pre-walk survey. Prior to each walking session, participants rated their negative affect, situational mindfulness, and the quality of their previous night’s sleep. Negative affect was assessed using four items that sampled perceived stress (“I feel stressed now”), anxiety (“I feel anxious now”), depression (“I feel depressed now”), and displeasure (“I feel unpleasant now”). Participants responded to each item on a scale ranging from 1 (strongly disagree) to 7 (strongly agree) before and after each walking session. Items were modified from items in the anxiety, stress, and affect pools of the Patient Reported Outcomes Measurement Information System (PROMIS; Ader, 2007; Pilkonis et al., 2011). The four negative affect items were moderately to highly correlated before the walking sessions ($r$ ranged from 0.30 to 0.85) across participants, so the responses were summed to create a single score representing negative affect. The internal consistency ($\alpha$) of the four pre-walk items across all occasions was 0.81.

Situational mindfulness was assessed using two items that measured perceived awareness of mental states (“I notice pleasant or unpleasant emotions now”) and physical states (“I notice bodily sensations come and go now”). These items were selected from the State Mindfulness Scale (SMS) because they sampled the two key components (mindful or physical sensation and mental events) of state mindfulness (Tanay & Bernstein, 2013). Participants rated their perceived mindfulness level on a scale ranging from 1 (strongly disagree) to 7 (strongly agree). The
internal consistency (Spearman-Brown $\rho$) of the two items in pre-walk surveys was 0.45 (Eisinga, Grotenhuis, & Pelzer, 2013). Additional analyses showed that the results did not differ when the mindful-emotion or the mindful-body scores were separated in different models. Thus, two situational mindfulness items were combine to represent a unidimensional construct of mindfulness state (Tanay & Bernstein, 2013).

Participants reported their perceived past-night sleep quality on a 7-point bipolar scale ranging from 1 (very bad) to 7 (very good). The researcher recorded the date, day of the week, number of the session, and the time of both the pre- and post-surveys. Additionally, the daily average temperature and weather conditions during each walking session was collected via the https://weather.com website.

**Post walk.** Immediately after completing each walk, participants rated their negative affect and situational mindfulness with the same items used prior to the walk. Correlations between the negative affect items ranged from 0.40 to 0.76 and the internal consistency ($\alpha$) of the four post-walk items across all occasions was 0.80. The responses from the four items were again summed to create a single score representing negative affect. Likewise, the two post-walk situational mindfulness items were aggregated to represent a unified mindfulness state (Spearman-Brown $\rho = .38$), consistent with the pre-walk measure.

**Second lab visit.** The feasibility and acceptability of the program were assessed using items that sampled perceptions of satisfaction (“I feel satisfied with this program”), usefulness (“I think this program is useful to me”), interest (“I am interested in participating in a similar program in the future”), and overall quality (“I would recommend others to join this program”). Participants rated the four items on the same scale ranging from 1 (strongly disagree) to 7 (strongly agree) after they completed the program, and the responses of the four items were
moderately to highly correlated ($r$ ranged from 0.42 to 0.84). An open-ended question was used to elicit any additional feedback, comments or concerns participants had after completing the program.

**One-month follow-up questionnaire.** Maintenance was assessed with one binary item (“After you finished the program, have you ever done the slow walking in the past month?”). If a participant responded “yes,” additional questions were asked about the frequency and duration of their slow walking. The frequency item was, “After you finished the program, how often did you engage in slow walking for the past month?” and response options included “1 to 3 times”, “4 to 6 times”, “7 to 9 times”, and “more than 9 times.” The duration item was, “After you finished the program, how long did you usually engage in slow walking each time for the past month?” and response options included “less than 30 minutes”, “30 minutes to less than 1 hour”, “1 hour to less than 2 hours”, and “more than 2 hours.” Finally, participants were asked to indicate their continued use of the specific mindfulness training techniques while slow walking on a scale ranging from 1 (almost never) to 4 (almost always).

**Data Analysis**

Descriptive statistics were calculated to characterize the feasibility, acceptability, sustainability, and preliminary efficacy of the program. Single-group repeated measure t-tests were used to determine the within-group differences before and after mindful walking sessions. Standardized mean differences were calculated to represent paired-sample effect sizes. Finally, to account for the inter-dependency of the nested data structure in the current study (the walking session data nested within each participant), a multilevel model was utilized to analyze the association between changes in mindfulness scores and negative affect after mindful walking sessions (Steenbergen & Jones, 2002).
Results

Twenty-seven participants (93%) completed all eight slow walking sessions and the pre-post program measurements, and 26 participants (90%) completed the one-month follow-up questionnaire, indicating high adherence rates. One participant dropped out after her first slow walking session because of difficulties navigating the path in arboretum; another participant dropped out after finishing his fifth slow walking session due to an unexpected painful groin pull during his leisure activity (unrelated to the study). With respect to the measurement completion rate (95%), participants provided data on 525 out of the 551 possible measurement occasions (19 possible occasions/participant: two lab visits, eight pre-walk assessments, eight post-walk assessments, one follow-up).

Table 4.2 summarizes the temporal and environmental context of the slow walking sessions. The majority of the slow walking sessions were held between 10am and 3pm (90%) on weekdays (86% from Monday to Friday) in November (71%). The average daily temperature of all slow walking sessions was 40.6°F (range: 9°F to 72°F), and 18% of the sessions had an average daily temperature at or below 32°F (the freezing point). Adverse weather conditions (e.g., rain, hail, snow) occurred during approximately 10% of the slow walking sessions. Among the 222 scheduled sessions, 17 advance cancellation notices (8% of all scheduled sessions) were received from participants due to adverse weather conditions (i.e., snow shower, n = 6) or holiday traveling (i.e., Thanksgiving break, n = 11). None of the participants missed their walking session without informing the researcher beforehand. Overall, participants completed 92% of their scheduled sessions.

At the end of the slow walking program, 96% of participants indicated that they would recommend this program to others. Participants also reported high levels of satisfaction (M =
6.18, $SD = 0.78$), usefulness ($M = 6.15, SD = 0.87$), and interest ($M = 6.19, SD = 1.08$). In the follow-up questionnaire, 92% of participants indicated that they were still interested in slow walking, and 65% reported that they continued to practice slow walking after program completion. For those who maintained their slow walking practice, more than half (59%) practiced more than 4 times within the past month, and the majority (65%) practiced mindful strategies frequently during their slow walking. All participants who maintained their slow walking practice reported that they practiced slow walking for more than 30 minutes each time.

Table 4.3 summarizes descriptive statistics and correlations for key study variables. There was no temporal trend indicating systematic changes in negative affect or mindfulness as a function of experience with the slow walking (number of attended walking sessions, $p > .05$). Consequently, scores from each participant were averaged for comparisons of pre-post walk on negative affect and mindfulness. Single-group repeated-measure t-tests revealed significant differences between participants’ average pre- and post-walk negative affect ($t[27] = -6.81, p < .01$) and situational mindfulness scores ($t[27] = 4.50, p < .01$). Participants reported significantly less negative affect (average $d = -0.61$, range = -0.60 to -0.77) and greater situational mindfulness (average $d = 0.55$, range = 0.37 to 0.79) following the walking sessions. Of note, 92% of the participants reported lower or similar levels of negative affect ($M_{diff} = -2.45$, $SD = 3.52$), and 87% reported higher or similar levels of mindfulness in the post-walking survey across all mindful walking sessions ($M_{diff} = 1.06$, $SD = 2.03$).

Post-walk negative affect was then regressed on pre-walk negative affect and changes in situational mindfulness, $F (9,178) = 15.57, p < .01$. As seen in Table 4.4, after controlling for the pre-walk negative affect scores and other temporal and contextual factors, residualized changes in negative affect were associated with increases in situational mindfulness scores after the
walking sessions ($\beta = -0.25, p < .01$). That is, older adults who increased their situational mindfulness more than their usual level during the walks also decreased their negative affect most. Overall, based on the conditional pseudo $R^2$, the fixed factors in this model explained approximately 50% of the variance in post-walk negative affect (Nakagawa & Schielzeth, 2013).

Open-ended feedback was very positive and there were no adverse events reported by older adults related to participation. Participants mentioned that the program was interesting (“Great experience! It was interesting overall”), beneficial (“There were days when I was upset and could feel that my blood pressure was elevated, but I no longer felt that way after my walk”), enjoyable (“I enjoyed it so much, even [though] sometimes very cold”), sustainable (“I liked the environment and plan to return to the garden to walk after the program ends”), and fulfilled their needs to reduce stress (“The program was very calming and very beneficial for me to relieve stress”). Although mindfulness training was not explicitly addressed during the whole program, several participants described feelings similar to what they had experienced during prior meditation or yoga practice (“I found that slowing down my steps allowed relaxation, it’s almost a meditation feeling”; “Helped me be more aware of myself and my surroundings, invigorating somewhat like yoga”). Interestingly, some participants also mentioned that walking at the arboretum helped them sustain physical activity or increase their intention for walking (“This program increased my interest in walking in the arboretum periodically”). Some participants raised concerns about the unpleasant weather while partaking this outdoor program in winter. One participant reported not being able to concentrate on the mindfulness task and another questioned whether the response scale on the survey could capture their mental experience.
Discussion

This study evaluated the feasibility, acceptability, and sustainability of an outdoor mindful walking program for reducing negative affect among older adults from the community. Prior work suggested that the combination of walking and mindfulness could be a promising mind-body intervention for reducing negative affect in a few clinical and adult populations, but this combination had not previously been implemented with non-clinical samples of older adults. This population could benefit from the intervention because negative affective responses such as depressive symptoms are critical predictors of overall health and well-being among the elderly. Experiencing higher levels of depressive symptoms are related to higher rates of dementia, physical illness, functional disability, and greater expenditure of health cost and resources in the aging population (Federal Interagency Forum on Aging-Related Statistics, 2016). Consistent with hypotheses, results indicated that (1) it was feasible to implement an outdoor mindful walking program with older adults, (2) the target population found the program to be acceptable, and (3) even a brief supervised program could lead to sustained behavior change one-month after the end of the program.

The mindful walking program implemented in this study differed from previous mindful walking interventions in important ways. First, previous studies have implemented mindful walking in group settings where participants had opportunities to converse or interact with each other while walking (Gotink et al., 2016; Prakhinkit et al., 2013; Shin et al., 2013; Teut et al., 2013). This group approach provides social distractions and may interfere with mindfulness practices that require heightened attention. In contrast, the slow walking program implemented here minimized social interaction and emphasized individual walking to facilitate focus during
the mindfulness practices. Second, participants in previous outdoor mindful walking studies typically walked in unfamiliar environments (e.g., forest, riverside), whereas the present study used a consistent spatial context (Gotink et al., 2016; Shin et al., 2013). This consistency may have facilitated situational mindfulness by reducing the attentional resources required while walking. Third, previous interventions sometimes contained extra mindfulness or physical activity components such as sitting meditation or gymnastic exercises (Gotink et al., 2016; Teut et al., 2013). In contrast, the mindful walking program implemented here only included the essential mindfulness practices to simplify the intervention design.

The high enrollment rate (85%) indicated that a slow walking program was appealing to older adults and it is feasible to enroll older adults from the community. This rate may have been impacted by the timing of recruitment to coincide with the approach of winter. Even better recruitment rates might have been obtained if the program was advertised during a warmer season. Despite the relatively cold weather, participants completed a large proportion of the possible measures (95%), and 93% of the participants completed all study measures, lab visits, and eight walking sessions as scheduled. The enrollment rate in our study was higher than two previous mindful walking studies also reported the screening process. Studies from Teut et al. (2013) and Gotink et al. (2016) had a 44% and 65% enrollment rate, respectively. Both studies had similar sample sizes in mindful walking group (36 and 32 participants) as the current study. The program completion rate in the current study was similar to previous mindful walking studies which ranged from 85% to 92%. This consistent finding suggested that most participants in mindful walking programs are able to comply and finish all study protocols, despite the different designs and target populations. The high measurement completion and attendance rates in this study further indicated that older adults in the community were committed and dedicated
to the program. The current mindful walking program can be delivered as intended to older population.

Based on the post-program questionnaire, participants evaluated the program positively. The majority of them rated this program as highly satisfactory, useful, and interesting. Most participants also indicated that they would recommend the program to others. The written feedback from the participants were also largely positive. Some participants reflected that this program met their needs for relieving stress, and others mentioned that the slow walking practices in the current study were easy to perform and were similar to yoga or meditation training. These comments were noteworthy because mindfulness was not mentioned when advertising the current study. A few participants commented that the program motivated them to sustain their physical activity level and walking habits. Future studies should investigate whether a mindful walking program can support intentions to be active or help older adults to develop walking habits. Feedback also indicated that the arboretum was an optimal and safe place to administer the walking program. Several participants raised concerns about doing mindful walking in adverse weather conditions, but ultimately no study-related adverse events were reported in the current study. Two prior studies had participants doing mindful walking on indoor oval tracks, however, there were no feedback reported from both studies, so we are not aware of whether participants have similar perceptions while walking indoors versus outdoors (Prakhinkit et al., 2013; Shin et al., 2013).

Participants reported a moderate-to-high level of maintenance one-month after completing their last supervised mindful walking session. This rate greatly exceeded the prior two-month estimate of 14% from Teut et al. (2013). This difference may reflect differences in either the follow-up intervals, the populations sampled, or the program components. For
example, Teut et al. (2013) recruited participants age between 18 to 65 who usually had not yet retired, whereas participants in this study were all retired older adults. Time constraints related to daily work schedules may be a barrier to maintaining mindful walking. Moreover, study from Teut et al. (2013) also required participants to complete gymnastic exercises before and after the mindful walking, whereas our program only required participants to walk slower while practicing mindfulness. The extra component and burden required in that mindful walking program may be another determinant of maintenance.

The study was not designed (or powered) to evaluate efficacy but preliminary analyses indicated that participants who increased their situational mindfulness during walks also decreased their negative affect. This result was consistent with previous mindfulness-based walking programs showing significant reductions of negative affect after the walking sessions among more distressed participants (Gotink et al., 2016; McCaffrey & Liehr, 2015; Prakhinkit et al., 2013; Shin et al., 2013; Teut et al., 2013). It was also consistent with a previous mindfulness study targeting older adults (Splevins et al., 2009). The present study concluded that an outdoor mindful walking program was feasible, acceptable and sustainable. Due to the lack of a comparison group in the present study, it was not possible to rule out factors from the program or the environment that could account for the favorable changes (Duvall, 2011; Sternberg, 2010; TKF Foundation, 2012). Future research should incorporate carefully-selected control groups and assign participants to different conditions randomly to strengthen causal inferences about intervention effects.

In contrast to prior studies, participants in this sample were not selected for high levels of distress or negative affect. Participants in this study were mostly white, female, well-educated, healthy, high-functioning, and had middle-to-high social economic status from a restricted
geographic area. It is not clear whether participants from other sub-populations would accept, complete, or sustain the mindful walking program implemented in this study as well. Future studies should recruit more diverse samples in broader geographical regions. On a related note, arthritis symptoms are common among older adults (Hootman, Helmick, Barbour, Theis, & Boring, 2016). These symptoms are closely related to changes in barometric pressure and ambient temperature (McAlindon, Formica, Schmid, & Fletcher, 2007). Walking outdoors during winter may intensify painful feelings from arthritis, and impact participants’ affective responses after walking. If future studies are conducted in similar conditions, it would be useful to collect information on arthritis symptoms, subjective pain, and real-feel temperature during each session.

The intervention dose in this study was informed by previous mindful walking programs (Prakhinkit et al., 2013; Teut et al., 2013). There are no consensus guidelines in terms of the frequency, duration, or other essential elements of an outdoor mindful walking program. Findings may differ with different doses of mindful walking. We included only three basic mindfulness techniques (focusing on breaths, steps and body scan) that were easy to learn if participants were naïve in mindfulness practices. More advanced strategies could be implemented in a mindful walking program and the results may differ. For instance, some mindful walking practices encourage participants to direct their attention to the environment (e.g., the smell, sounds, breeze, sun light), use a phrase with the appropriate number of syllables to pace their breathing or stepping, modify inspiratory and expiratory rhythm as a function of step length, or pay attention on multiple objects simultaneously (Hanh, 1985, 2011; Insight Meditation Center, 2003). The program implemented in this study involved focusing narrowly on one object at a time and did not challenge participants to broaden their attention field. The
majority of the participants were female older adults and previous work has shown stronger associations between light physical activity and well-being for women than men (Conroy, Wolin, Blair, & Demark-Wahnefried, in press). It will be important to test potential sex differences in intervention responses in future research. Finally, it was clear whether participants engaged in extra mindful walking practice in their leisure time. Any differential changes could be due to any additional practice they completed. Future studies should monitor activities outside of the supervised sessions.

**Conclusion**

In sum, this study indicated that participants accepted and complied with the outdoor mindful walking program. Many also sustained their engagement in mindful walking one-month after the supervised sessions ended. This program was implemented as planned with older adults and shows promise for helping them to regulate negative affect. The design of this study precludes causal inferences about intervention effects but, based on the evidence for feasibility, it would be appropriate to design and deliver a randomized controlled trial to evaluate efficacy.
References

Ader, D. N. (2007). Developing the patient-reported outcomes measurement information system (PROMIS): deression, anxiety, and anger. Medical Care, 45(Suppl 1), S1–S2. https://doi.org/10.1097/01.mlr.0000260537.45076.74


https://doi.org/10.1111/j.1600-0447.2011.01704.x


https://doi.org/10.1080/01634372.2013.869787


https://doi.org/10.1371/journal.pone.0124344


https://doi.org/10.1007/s12671-016-0550-8


Figure Caption

Figure 4.1. CONSORT flow diagram of mindful walking program.
Enrollment

Assessed for eligibility (n= 34)

Excluded (n= 5)
- Not meeting inclusion criteria (n=1)
- Declined to participate (n=3)
- Other reason – Injured before the initial lab visit (n=1)

Intervention

Attending initial lab visit (n= 29)
Completed baseline assessment (n= 29)
Started walking program (n=29)

Dropped out (n= 2)
- Injured from leisure activity participation (n=1)
- Incapability of self-navigating (n=1)

End of Program

Completed program and post assessment (n= 27)

Analysis

Date Analysed (n= 27)

Lost to follow-up (n=1)
- Lost contact

Follow-Up

Completed one-month follow-up (n= 26)

Analysis

Follow-up Date Analysed (n= 26)
<table>
<thead>
<tr>
<th>Session</th>
<th>Mindful walking</th>
<th>Slow walking</th>
<th>Mindfulness task and duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 minutes</td>
<td>30 minutes</td>
<td>No mindfulness task. Participants familiarized themselves with the arboretum trail and practice slow walking individually.</td>
</tr>
<tr>
<td>2</td>
<td>5 minutes</td>
<td>25 minutes</td>
<td>Walking slowly while sustaining their attention on the rhythm of their every breath.</td>
</tr>
<tr>
<td>3</td>
<td>10 minutes</td>
<td>20 minutes</td>
<td>Walking slowly while sustaining their attention on the rhythm of their every breath.</td>
</tr>
<tr>
<td>4</td>
<td>10 minutes</td>
<td>20 minutes</td>
<td>Same as session 3</td>
</tr>
<tr>
<td>5</td>
<td>20 minutes</td>
<td>10 minutes</td>
<td>First 10 minutes: walking slowly while sustaining their attention on the rhythm of their every breath. Second 10 minutes: awareness of the gentle heel-to-toe rhythm for each step they make.</td>
</tr>
<tr>
<td>6</td>
<td>20 minutes</td>
<td>10 minutes</td>
<td>Same as session 5</td>
</tr>
<tr>
<td>7</td>
<td>30 minutes</td>
<td>0 minutes</td>
<td>First 10 minutes: walking slowly while sustaining their attention on the rhythm of their every breath. Second 10 minutes: awareness of the gentle heel-to-toe rhythm for each step they make. Last 10 minutes: full body scan to expand their attention to any bodily sensation or emotional feelings that may arise.</td>
</tr>
<tr>
<td>8</td>
<td>30 minutes</td>
<td>0 minutes</td>
<td>Same as session 7</td>
</tr>
</tbody>
</table>
Table 4.2. Contexts of the mindful walking sessions

<table>
<thead>
<tr>
<th></th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Month</strong></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>4 (2%)</td>
</tr>
<tr>
<td>November</td>
<td>158 (71%)</td>
</tr>
<tr>
<td>December</td>
<td>60 (27%)</td>
</tr>
<tr>
<td><strong>Day of the week</strong></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>40 (18%)</td>
</tr>
<tr>
<td>Tuesday</td>
<td>51 (23%)</td>
</tr>
<tr>
<td>Wednesday</td>
<td>40 (18%)</td>
</tr>
<tr>
<td>Thursday</td>
<td>21 (10%)</td>
</tr>
<tr>
<td>Friday</td>
<td>39 (17%)</td>
</tr>
<tr>
<td>Saturday</td>
<td>18 (8%)</td>
</tr>
<tr>
<td>Sunday</td>
<td>13 (6%)</td>
</tr>
<tr>
<td><strong>Time of the day</strong></td>
<td></td>
</tr>
<tr>
<td>9am-11am</td>
<td>67 (30%)</td>
</tr>
<tr>
<td>11am-1pm</td>
<td>106 (48%)</td>
</tr>
<tr>
<td>1pm-3pm</td>
<td>31 (14%)</td>
</tr>
<tr>
<td>3pm-5pm</td>
<td>18 (8%)</td>
</tr>
<tr>
<td><strong>Daily average temperature</strong></td>
<td></td>
</tr>
<tr>
<td>15-32°F</td>
<td>41 (18%)</td>
</tr>
<tr>
<td>32-45°F</td>
<td>97 (44%)</td>
</tr>
<tr>
<td>46-60°F</td>
<td>84 (38%)</td>
</tr>
<tr>
<td><strong>Prevailing Weather Condition</strong></td>
<td></td>
</tr>
<tr>
<td>Sunny</td>
<td>56 (25%)</td>
</tr>
<tr>
<td>Fair, partly or mostly cloudy</td>
<td>82 (37%)</td>
</tr>
<tr>
<td>Cloudy and wind</td>
<td>62 (28%)</td>
</tr>
<tr>
<td>Rain shower or rain snow</td>
<td>11 (5%)</td>
</tr>
<tr>
<td>Snow or hailing</td>
<td>11 (5%)</td>
</tr>
</tbody>
</table>
Table 4.3. Correlation coefficient matrix of the pre-post walking session variables.

<table>
<thead>
<tr>
<th></th>
<th>M (SD)</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
<th>7.</th>
<th>8.</th>
<th>9.</th>
<th>10.</th>
<th>11.</th>
<th>12.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age</td>
<td>73.2 (6.47)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Gender</td>
<td>-</td>
<td>-0.04</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3. Sequence of</td>
<td>-</td>
<td>-0.01</td>
<td>-0.03</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>walking session</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Day of the</td>
<td>-</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>week</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5. Average</td>
<td>40.6 (8.36)</td>
<td>0.10</td>
<td>0.07</td>
<td>-0.36**</td>
<td>0.01</td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Temperature (°F)</td>
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</tr>
<tr>
<td>6. Survey time</td>
<td>11.78 (1.57)</td>
<td>0.03</td>
<td>0.01</td>
<td>-0.05</td>
<td>-0.28**</td>
<td>0.08</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(hour)</td>
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<td></td>
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<tr>
<td>7. Sleep quality</td>
<td>5.40 (1.38)</td>
<td>-0.11</td>
<td>0.05</td>
<td>0.04</td>
<td>0.08</td>
<td>-0.02</td>
<td>-0.06</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Baseline</td>
<td>4.98 (0.78)</td>
<td>0.11</td>
<td>-0.06</td>
<td>-0.01</td>
<td>0.02</td>
<td>-0.01</td>
<td>0.16*</td>
<td>0.19**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Pre-session</td>
<td>8.22 (4.49)</td>
<td>0.05</td>
<td>-0.13*</td>
<td>0.05</td>
<td>-0.01</td>
<td>-0.07</td>
<td>-0.06</td>
<td>-0.17*</td>
<td>-0.29**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative affect</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>10. Post-session</td>
<td>5.78 (3.29)</td>
<td>0.04</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>-0.09</td>
<td>-0.04</td>
<td>-0.17*</td>
<td>-0.33**</td>
<td>0.60**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative affect</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Pre-session</td>
<td>9.46 (2.23)</td>
<td>0.03</td>
<td>-0.21**</td>
<td>0.19**</td>
<td>-0.03</td>
<td>0.01</td>
<td>0.06</td>
<td>0.02</td>
<td>0.10</td>
<td>0.13</td>
<td>0.02</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>mindful level</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Post-session</td>
<td>10.52 (2.08)</td>
<td>-0.09</td>
<td>-0.17**</td>
<td>0.14*</td>
<td>-0.03</td>
<td>-0.01</td>
<td>-0.08</td>
<td>0.17*</td>
<td>0.01</td>
<td>0.01</td>
<td>-0.17*</td>
<td>0.54**</td>
<td>1</td>
</tr>
<tr>
<td>mindful level</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Note: *p < .05; **p < .01; N=222.
Table 4.4. Result of multilevel model examining associations between mindfulness level and negative affective reactivity

<table>
<thead>
<tr>
<th>Model</th>
<th>Coefficient</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>6.69</td>
<td>4.39</td>
</tr>
<tr>
<td>Age</td>
<td>-0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Gender</td>
<td>0.55</td>
<td>0.72</td>
</tr>
<tr>
<td>Number of walking session</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>Day of the week</td>
<td>-0.01</td>
<td>0.09</td>
</tr>
<tr>
<td>Average temperature</td>
<td>-0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Baseline attention</td>
<td>-0.60</td>
<td>0.38</td>
</tr>
<tr>
<td>Survey time</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td>Previous day sleep quality</td>
<td>-0.20</td>
<td>0.14</td>
</tr>
<tr>
<td>Average pre-walking negative affect</td>
<td>0.55**</td>
<td>0.09</td>
</tr>
<tr>
<td>Deviations from average negative affect</td>
<td>0.22**</td>
<td>0.05</td>
</tr>
<tr>
<td>Average mindfulness change (pre-walk to post-walk)</td>
<td>-0.31</td>
<td>0.24</td>
</tr>
<tr>
<td>Deviations from average mindfulness change (pre-walk to post-walk)</td>
<td>-0.27**</td>
<td>0.09</td>
</tr>
</tbody>
</table>

| Random Effect                              |             |     |
| Variance Intercept                         | 1.35        |     |
| Residual Variance                          | 4.41        |     |

Note: Analysis was based on 7 walking sessions with mindfulness practice incorporated. *p < .05; **p < .01.
Chapter 5: Conclusions
This dissertation investigated relations between physical activity and mindfulness to understand how their interaction influenced well-being in college students and older adults. Findings from this dissertation can be applied to inform future research on mindfulness and physical activity, as well as to guide the development of mind-body approaches to improve health and well-being. Specific contributions of this work are reviewed below.

This dissertation provided the first systematic review on the association between physical activity and mindfulness. Previous reviews have briefly synthesized the salutary impact of mindfulness on cardiovascular disease risk, physical and mental health and provided several supporting studies (Gilbert & Waltz, 2010; Kennedy & Resnick, 2015; Loucks et al., 2015). These reviews provided evidence on the positive relation between physical activity and mindfulness but did not investigate the strength of the relation based on all available quantitative studies. This dissertation presented current evidence of physical activity-mindfulness association through a systematic literature search of quantitative studies in major academic databases. After screening over 1500 articles, 13 studies generally supported the conclusion that physical activity level is positively related to people’s mindfulness level, but there was a lack of evidence from experimental studies. Future research should be devoted to conduct more quantitative studies including randomized controlled trials to provide stronger evidence on how mindfulness may impact individual’s physical activity level.

This review also identified critical gaps in the literature that may hinder the advance of studying the role of mindfulness in physical activity. Mindfulness is a mental construct that involves both between-person and within-person variation (Bishop et al., 2004; Brown & Ryan, 2003). Current studies exclusively focused on people’s trait mindfulness level and failed to consider the variability of people’s mindfulness levels that are context- and situational-
dependent. Without highlighting the trait and state differences, we are not able to obtain accurate and precise understanding of the association between physical activity and mindfulness. The proposed three-level hierarchical framework is a specific contribution of this work. This model differentiates between global, contextual, and situational forms of mindfulness based on the contextual and temporal specificity of the phenomenon. To enhance communication and advance knowledge in the field, future studies should study the association between physical activity and the contextual or situational mindfulness. Measures are needed to assess contextual and situational levels of mindfulness. These developments will facilitate research on within-person associations between mindfulness, physical activity, and health and well-being outcomes.

This dissertation also revealed the within-person association between daily activity (posture) and mindfulness in predicting negative affect among college students. Previous experience sampling studies reported mixed findings regarding the impact of daily physical activity level in predicting subsequent negative affect. Some studies suggested an inverse association whereas others found no significant results between the two variables (Liao, Shonkoff, & Dunton, 2015). This dissertation expended previous work by exploring the role of mindfulness during physical activity and its association with negative affect. A clear inverse relation between daily activity and negative affect was observed and different levels of situational mindfulness may moderate momentary activity (posture) in predicting negative affect in college students. Students with higher situational mindfulness while moving or standing (compared to sitting) experienced greater reductions in negative affect in their daily life. This finding indicated that interventions may lead to greater mental health benefits by integrating mindfulness practices with physical activity.
Additionally, the research in this dissertation established a negative association between daily postures and negative affective states. Relative to being sedentary, when college students move or stand more in their daily life, they reported lower levels of negative affect. The physical activity literature thus far has documented the effect of moderate to vigorous physical activity on well-being and mental health (Ensari, Greenlee, Motl, & Petruzzello, 2015; Penedo & Dahn, 2005; Rebar et al., 2015). The preliminary effect of low-intensity physical activity on physical health has also been investigated in recent years (Bann et al., 2015; Carson et al., 2013; Herzig et al., 2014). This dissertation provided extra contribution to the physical activity literature by showing that low-intensity daily activities were positively related to college student’s psychological well-being. Most importantly, a useful public health message can be implied from this result was that simply by moving or standing more and not sitting in everyday life may reduce negative affect and thus improve well-being in the college population.

The final study in this dissertation evaluated the feasibility of implementing a mind-body intervention program based on the premise that combining physical activity and situational mindfulness may decrease negative affect among older adults. In this mindful walking program, an integration of mindfulness practice with walking activity was delivered to older adults to evaluate its feasibility, acceptability, and sustainability in reducing negative affect. This feasibility study was initiated because none of the mindful walking programs to date have targeted psychological well-being in the non-clinical older adult populations. The major hypothesis that an outdoor mindful walking program was well-accepted, engaged, and maintained were later supported by both the self-report ratings and the written feedback from older adults. The secondary hypothesis that mindful walking program could show preliminary
efficacy in decreasing older adults’ negative affect was also suggested by the analysis from the repeated measures across mindful walking sessions.

Finally, this dissertation demonstrated that this mind-body intervention with eight 30-minutes mindful walking within one month is feasible to deliver to healthy, community-dwelling older adults. Based on the positive results of program feasibility, future experimental studies should be developed and executed to test the effect of mindful walking in improving well-being and healthy aging in the older population. Randomized controlled trials with different control arms are also needed to disentangle the relative effectiveness of mindful walking intervention with other individual or environmental factors. For example, outdoor physical activities have been reported to impact negative affective response greater than indoor physical activities (Dunton, Liao, Intille, Huh, & Leventhal, 2015). Different control arms such as sitting meditation, indoor mindful walking, and walking with cognitive training may help to further elaborate whether different types of mindful activity, or different mindful walking environments, or different forms of mental task engaged during walking may play relatively critical roles in explaining the beneficial psychological effect.

**Limitations, Future Directions, and Conclusion**

Although this dissertation achieved its scientific objectives, several limitations should be noted to guide future research. First, the associations between mindfulness, physical activity, and negative affect identified in this dissertation were based on self-report measures exclusively. The systematic review reported in Chapter 2 did not identify any studies that applied objective measures of mindfulness in relation to physical activity. In the experience sampling study reported in Chapter 3, two items from a validated scale were used to assess situational mindfulness. This ecological momentary assessment of mindfulness was recommended by
Davidson and Kaszniak (2015) to minimize retrospective bias from self-reporting mindfulness. In the feasibility study reported in Chapter 4, the same two mindfulness items were included in the pre-walk and post-walk surveys. Mindfulness has been conceptualized as both a unidimensional and multidimensional phenomenon and there is no consensus on the necessary components or the number of facets that should be included in a mindfulness scale. The validity of assessing subjective mindfulness experience with self-report questionnaires is also under discussion (Baer, 2016; Bergomi, Tschacher, & Kupper, 2012; Davidson, 2010; Goldberg et al., 2015; Sauer et al., 2012). Physical activity researchers should strive to include objective measures of mindfulness based on cognitive and attentional tasks, neuroimaging or neuropsychological measures to strengthen conclusions about the association between physical activity and mindfulness.

Similarly, physical activity measures have largely relied on self-report methods in this literature. Only one study in our literature review provided accelerometry-based data on participants’ physical activity level (Kangasniemi, Lappalainen, Kankaanpää, & Tammelin, 2014). Although our ecological momentary assessment on physical activity and postural patterns exhibited similar results as population-based studies, future studies should consider device-based measures of physical activity when studying the within-person relation between physical activity and subjective experiences (Kanning, Ebner-Priemer, & Schlicht, 2013).

The subjective negative affect assessed in the studies reported in Chapters 3 and 4 involved stress, anxiety, and depression. The common component of this selective set of negative affective states involves a generalized sense of distress (Akin, 2007). There are in fact other common aspects of negative affect (e.g., anger, fatigue, upset, disappointed) which have been assessed in other studies (Kuppens, Van Mechelen, Nezlek, Dossche, & Timmermans, 2007;
Future studies should include different negative affective states in mindfulness and physical activity research to investigate whether the results may differ when different aspects of negative affect are assessed.

Second, the participants were relatively homogeneous in each of the empirical studies reported here. The younger sample in Chapter 3 was mostly White, not Hispanic, and educated. Findings may not generalize to college student samples from other geographical locations, to people from more diverse racial and ethnic backgrounds, or to young adults who do not attend college or university. Young adults without college experience likely encounter different stressors in daily life and may have different affective patterns. Likewise, the older sample in Chapter 4 was mostly White, healthy, and affluent. Results may differ if the program is launched in an urban area with a more diverse population, or in older adults with clinical issues. For example, urban environments pose an extra threat on people’s well-being (Lederbogen et al., 2011; Matheson et al., 2006). The limited green space and the crowded environment in the city also may limit opportunities to implement this mindful walking program in urban environments. Future research should target more diverse samples and test whether the beneficial outcomes identified in this dissertation may vary as a function of demographic factors.

Third, this dissertation mainly focused on intrapersonal factors and did not assess many other external factors that may also regulate negative affect. Data analyses adjusted for variation associated with the temporal factors that may impact negative affect in college students, but did not involve other interpersonal factors such as the presence of others (classmates, friends, or family members), or contextual factors such as the location (classroom, dorm, or home) at the time of daily prompts. These factors may influence or interact with students’ mindfulness and physical activity in predicting negative affect. Temporal factors and environmental conditions
were also modeled in the feasibility study, however, unexpected life events can also influence older adult’s affective states. For example, one participant acknowledged in her written feedback that her mood seemed to be dampened by a major political event – the US presidential election – that occurred during the study. Thus, the adoption of a more complete social-ecological perspective in future studies could advance understanding of the interpersonal, intrapersonal and external factors that regulate individual’s affective states (Evans, 2003; Lakhan & Ekúndayò, 2013).

Finally, the mindful walking program designed in this dissertation cultivated participants’ attention, awareness, acceptance, and non-judgmental attitudes to their mental or physical experiences. These techniques are basic and fundamental mindfulness practices (Hart, Ivtzan, & Hart, 2013), however, other mindfulness components such as curiosity, empathy, and compassion have also been applied in mindfulness programs and were not included in this study (Birnie, Speca, & Carlson, 2010; Greeson, 2009; Langer, 1992). Mindfulness interventions emphasizing self-compassion have previously shown promise for regulating negative affect (Van Dam, Sheppard, Forsyth, & Earleywine, 2011). It would be interesting to examine whether mindful walking programs consisting of different mindfulness components yield similar findings in future studies. Experimental studies can also can be conducted to explore the relative impact of different mindfulness components in reducing negative affect.

People face a variety of stressors across adulthood and stress can detract from health and well-being. There is great interest in mind-body approaches to promote health and well-being and both physical activity and mindfulness represent promising strategies. This dissertation enriched understanding of how physical activity and mindfulness can be used to promote well-being. The proposed three-level framework of mindfulness can be used to direct future studies
and advance understanding of relations between mindfulness and physical activity. This
dissertation further investigated the interplay between physical activity and mindfulness in
reducing negative affect. Knowing that negative affect may decrease to a greater degree by being
more active and mindful momentarily provides a foundation for designing just-in-time
interventions to improve well-being in our everyday life. Furthermore, the potential impact of
non-exercise-related bodily postures on negative affect converges with assertions that, “some
activity is better than none” (Physical Activity Guidelines Advisory Committee, 2008). Finally,
this dissertation demonstrated that an outdoor mindful walking program can be delivered to
community-dwelling older adults. The ease of combining mindful practice with daily walks, and
the minimal fitness level required for mindful walking makes it a viable preventative strategy for
improving well-being and promoting healthy aging in older adults. The efficacy of this program
for reducing negative affect and improving other indicators of health and well-being remains to
be determined and should be a logical next step in this rapidly-developing literature on mind-body approaches to improve health and well-being.
References


### Curriculum Vitae

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#### AWARDS AND FUNDINGS

- Student Mentoring and Travel Grant, The 5th International Conference on Ambulatory Monitoring of Physical Activity and Movement. The National Science Foundation’s Smart and Connected Health Program. **2017**
- Highly-Cited Paper, Essential Science Indicators/Web of Science, based on Conroy, Yang & Maher (2014) receiving enough citations by June 2017 to place it in the top 1% of the academic field of Social Sciences. **2017**

#### RESEARCH


