HHS Public Access
Author manuscript
Psychol Health. Author manuscript; available in PMC 2020 April 18.

Published in final edited form as:
Psychol Health. 2012 ; 27(9): 1009–1020. doi:10.1080/08870446.2011.645213.

Are daily fluctuations in perceived environment associated with walking?

Eric B. Hekler[a,b,*], **Matthew P. Buman**[a,b], **David Ahn**[a], **Genevieve Dunton**[c], **Audie A. Atienza**[d], **Abby C. King**[a]

[a]Stanford Prevention Research Center, Stanford University, Stanford, CA USA

[b]School of Nutrition and Health Promotion, Arizona State University, Phoenix, AZ, USA

[c]Department of Preventive Medicine, University of Southern California, Los Angeles, CA, USA

[d]National Cancer Institute, Bethesda, MD, USA

Abstract

The physical environment is thought to influence walking; however, daily variations in perceived environment have received little attention. The current study sought to examine if key within-person factors (i.e., implementation intentions, social support, affect and self-efficacy) would be associated with walking and if perceived access to supportive environments (e.g., access to nice walking paths) and perceived environmental barriers (e.g., bad weather and safety issues) were uniquely associated with walking after controlling for other constructs. Participants ($N = 14$, 50.0% men, 78.6% White, M age = 59.4±6.4) were in the intervention arm of an 8-week controlled trial promoting walking via personal digital assistants. Participants completed electronic surveys twice a day (total entries = 804) in which they reported brisk walking levels and psychosocial and environmental factors. Multilevel modelling was used to examine within-person variations in constructs as determinants of walking. Results suggested that daily variations in implementation intentions, social support and positive affect were positively associated with walking. Further, perceived access to supportive environments, though not perceived environmental barriers, was positively associated with walking after controlling for other constructs ($p < 0.05$). Future research should explore intervention components that target context-specific information about perceived access to supportive environments as part of a broader perspective on intervention development.

Keywords

exercise; ecological momentary assessment; older adults; perceived built environment; social cognitive theory

---

Physical inactivity has been linked with a variety of chronic diseases (e.g., heart disease, type-II diabetes) that account for a significant portion of total global mortality rates (World Health Organization, 2009). Physical inactivity has been linked to mental health issues as

---

*Corresponding author. ehekler@asu.edu.

well, including depression and reduced quality of life (World Health Organization, 2009). Physical inactivity-related problems are particularly pronounced among mid-life and older adults and can be mitigated through moderate-intensity physical activity, with particular focus on increased walking – an appealing and easy way to perform physical activity among aging adults (World Health Organization Ageing Unit, 2008).

Based on the theory of reasoned action/planned behaviour, intentions and perceived behavioural control play central roles in predicting behaviours and promoting behaviour change in intervention research (Darker, French, Eves, & Sniehotta, 2010). Although intentions and perceived behavioural control have been identified as important, estimates from meta-analytic work suggest that models with intentions as the central pathway predicting behaviours significantly accounts for only approximately 27% of the variance in behaviours (Hagger & Biddle, 2002). These results highlight that intentions may be important but not sufficient for promoting increased physical activity.

One possible explanation for this may be the importance of establishing intentions within a given context (i.e., implementation intentions). Gollwitzer (1999) discusses the concept of implementation intentions as being distinct from more general intentions as they include specific stipulations on exactly when and where an action will occur. The enactment of behaviour, therefore, does not simply occur through a person’s intentions but instead is also inspired by one’s context such as the time of day and location. The importance of implementation intentions for carrying out health behaviours, including exercise, has been well documented in previous research (Gollwitzer & Sheeran, 2006). Of particular note, previous research suggests that implementation intentions may be important for initiating increased walking among older adult women after six weeks within an intervention but these implementation intentions do not necessarily translate to sustained increases in walking (e.g., sustained changes by 12 weeks) compared to self-monitoring via a pedometer (Arbour & Ginis, 2009). In addition, previous research examining daily fluctuations of work-stress and physical activity suggests that interventions focused on promoting more ‘planful’ actions may actually hinder engagement in health behaviours based on the stressfulness of an individual’s context (Payne, Jones, & Harris, 2010). Specifically, individuals who were randomised to receive an intervention focused on promoting more planful physical activities engaged in less physical activity compared to the control group who did not receive the intervention, particularly among individuals in the control arm within a ‘low demand’ context as these individuals engaged in more physical activities than those in the intervention arm (Payne et al., 2010). Taken together, these results suggest that intentions may be important but that context may also play an equally, if not more important part, in promoting physical activity.

This fits with research focused on the impact of the built environment on walking. Specifically, previous research has highlighted the influence of objectively measured components of the built environment (e.g., land-use mix and street connectivity) as key predictors of increased walking among adults (Frank et al., 2006; Sallis et al., 2009) and older adults (King et al., in press). Indeed, even perceptions of the built environment have been linked with promoting different types of walking. Specifically, individuals living in more aesthetically pleasing neighbourhoods with good access to walking paths engaged in more leisure walking (i.e., walking for exercise or pleasure) whereas individuals who had opportunities to take long walks to desired locations (e.g., grocery store, coffee shops, etc.) engaged in more utilitarian walking (i.e., walking for transportation or other utilitarian purpose, Hekler, Castro, Buman, and King, in press). A recent clinical trial further confirms the importance of taking into account an individual's context when promoting walking. Specifically, results suggested that maintenance of walking could be improved if a web-based intervention focused more on neighbourhood characteristics (e.g., access to walking paths, creating neighbourhood walking groups) than purely motivationally based messages (Ferney, Marshall, Eakin, & Owen, 2009).

Much of the previous research that has focused on how context interacts with intentions and influences walking has been conducted with between-person methods as the constructs were only measured periodically (e.g., in months, typically, with one notable exception (Payne et al., 2010)). A rapidly growing new methodology, ecological momentary assessment (EMA), focuses on the collection of data in an intensive repeated measures fashion (Shiffman, Stone, & Hufford, 2008), as these data allow for the exploration of not only the relationship between theoretical constructs and walking on a between-person level, but also throughout the day at the within-person level, which may further explain important fluctuations in walking over time (Dunton, Atienza, Castro, & King, 2009). Daily fluctuations in implementation intentions and perceptions of context may reveal more accurate predictive models as they can better account for known daily variations in walking.

The present exploratory investigation had two aims. The first was to examine whether daily variations in implementation intentions along with key psychosocial constructs (i.e., social support, affect and self-efficacy) would be associated with daily variations in walking among mid-life and older adults participating in an 8-week personal digital assistant (PDA) based walking intervention. Second, we sought to examine if daily variations in perceived access to supportive environments (e.g., access to nice walking paths, nice scenery, good locations and exercise facilities) and perceived environmental barriers (e.g., bad weather and safety/crime issues) were uniquely associated with daily variations in walking after controlling for implementation intentions. It was hypothesised that the perceived environment would be a significant predictor of walking even after controlling for implementation intentions and related psychosocial factors.

Methods

Study design

The major experimental study methods and results, which indicated that the intervention arm significantly improved walking and moderate/vigorous physical activity compared to a standard information control arm, have been described in detail previously (King et al., 2008). The intervention arm of the study included 19 participants but PDA data were missing for five participants (two did not return their PDAs and three had corrupt data). As such, the current analyses focused on the participants in the intervention arm that returned their PDAs and had uncorrupted PDA data ($N = 14$). Participants were asked to complete short PDA-based surveys twice per day (2 and 9pm) for eight weeks. Our sample completed a total of 804 entries, which allowed for within-person analyses. There were no significant differences in demographic factors or baseline physical activity levels between those that had complete versus missing PDA data ($p > 0.10$). The Stanford University Panel for Medical Research approved the study protocol. Data were collected in 2005 and analysed for the current study in 2009.

Measures

Electronic log items were based on those used in previous research in the field (King, Oka, & Young, 1994). Test-retest reliability of the electronic log items was high in previous studies, with Pearson Product Moment correlations from 0.7 to 1.0 (King et al., 1994). Brisk walking was assessed with a single item, "How many TOTAL minutes of brisk walking have you engaged in since *[your last log]*? (Add up minutes from all times you walked briskly)'. Descriptive examination of the brisk walking item suggested a nonnormal distribution and therefore it was log transformed for all multivariate analyses. To examine the validity of this single item, the total responses for the first week and last week of the intervention were summed and then correlated with the walking items from the CHAMPS physical activity questionnaire collected at approximately the same time point (Stewart et al., 2001). The CHAMPS is a well-validated measure of the physical activity that includes questions about the total amount of walking a participant engages in each week. Previous research on the CHAMPS indicate that it consistently correlates with objective measures of physical activity including a Mini-Logger 2000 (a device that measures both activity and heart rate) (Harada, Chiu, King, & Stewart, 2001) and accelerometer (Hekler et al., in press). Results suggested a good correlation between the sum of the EMA walking item across one week and the walking items of the CHAMPS both at baseline ($r = 0.76$) and at the end of the intervention ($r = 0.82$), suggesting acceptable concurrent validity.

Implementation intentions, social support and perceived access to supportive environments, were assessed in response to the following question: 'Did any of the following make it *easier* for you to be active since you woke up today? (Choose ALL that apply)' (Atienza, Oliveira, Fogg, & King, 2006). Implementation intentions was assessed with a single dichotomous item asking if scheduling helped individuals walk. A key focus for the intervention was the establishment of implementation intentions, which were labelled to the participants as 'plans' (King et al., 2008). Social support for the physical activity was assessed by summing two dichotomous (yes/no) items: did others join you in walking, and did others encourage you? Perceived access to supportive environments were assessed by summing dichotomous response options worded as: (a) good weather; (b) enjoyable scenery; (c) a walk path; (d) a good location; (e) exercise equipment; (f) a facility. Perceived environmental barriers were assessed using the following question: 'Did any of the following make it *difficult* for you to be active since you woke up today? (choose ALL that apply)'. Specific items included: (a) poor weather; (b) poor safety-crime; (c) poor safety-traffic; (d) stray dogs; (e) no place to walk. Self-efficacy was assessed using a previously validated (Garcia & King, 1991) single item, 'How confident are you that you can engage in physical activity that increases your heart rate for at least 10min between now and [*the next log*]'. As this item was written in a prospective fashion, it could not be used in the primary analyses exploring concurrent associations between key constructs and walking. Nonetheless, exploratory analyses were conducted with a subsample of entries that could be linked prospectively to control for the effects of self-efficacy. Positive affect was assessed using a single item: 'How satisfied or content do you feel now?' (King et al., 1994). Negative affect was assessed by averaging the responses of items focused on being stressed, lonely/alone, annoyed/angry, fatigued/tired, tense/ anxious, and sad/depressed (King et al., 1994) (Cronbach's α in current sample = 0.76).

Statistical analyses

Multilevel modelling (i.e., SAS PROC Mixed) was used to examine the associations between daily variations in key predictors and walking measured twice a day (Singer & Willett, 2003). Multilevel modelling does not assume independence of observations and thus is appropriate for data collected twice daily as it allows within-person variability to be nested within each participant (Payne et al., 2010; Singer & Willett, 2003).

The analyses were conducted in a hierarchical fashion utilising the Full Maximum Likelihood Method and 'variance components' covariance error structure as discussed by Singer and Willett (2003). Both fixed and random effects were explored in the models. There was sufficient power to detect small to medium within-person effect sizes for the primary concurrent analyses (N_{entries} = 804). However, based on the small sample size (N = 14), there was insufficient power to test the between-person effects. As such, between-person effects were included primarily as control variables and actual significance is not readily interpretable. Such effects will not be discussed further. A 'pseudo-R^2' was used to determine model effect size (Bryk & Raudenbush, 1992).

Posthoc analyses were conducted to determine the independent effect of different implementation intentions, social support, and environmental factors on walking. Independent sample t-tests with a Bonferroni adjustment using $\alpha = 0.01$ were used to examine differences between entries in which individuals reported experiencing the factor compared to those days that they did not experience the factor.

Results

Participants (N = 14) were evenly divided between men and women (i.e., 50.0% women). The majority were white (78.6%) and approximately 60 years of age (M age = 59.4±6.4). Most participants (71.4%) completed all 8 weeks of the study, with only one participant completing less than 6 weeks. The average number of entries per person was M = 57.4±28.4, or a 51.3% completion rate of the 112 possible entries. As was reported in the intervention trial, 78.6% of intervention participants reported enjoying using the PDA (King et al., 2008). Demographic factors (i.e., age, gender, race, education level, income, baseline physical activity) were not associated with the total number of entries completed ($p > 0.27$). Participants were more likely to complete surveys during the evening entry and earlier in the intervention period ($p < 0.01$).

Results from the unconditional means model (N_{entries} = 804) suggested that 80.1% of the total variance in walking was within person (ICC = 0.20). As results from the major study suggested that the intervention group significantly improved their physical activity (King et al., 2008), we tested the shape of this change via growth modelling (i.e., steps 1–3), which suggested that the linear model was a better predictor than the quadratic or cubic models, as the quadratic and cubic analyses did not converge. Based on this, only linear time was included in all subsequent models. Steps 4 and 5 of the concurrent models are summarised in Table 1. Step 4, which examined the associations between implementation intentions, social support and positive and negative affect revealed that the fixed effects for all variables were positively associated with daily variations in walking (see Table 1). This model explained approximately 17% of the within-person variance. Results from step 5, which examined if environmental factors significantly improved the overall model fit, suggested that the goodness-of-fit was improved for this model over step 4 (see Table 1). Further, the latter model explained approximately 24% of within-subject variance, suggesting that the addition of environmental factors explained an additional 7% of the within-person variance beyond implementation intentions, social support and affect. Examination of specific variables suggested that the fixed effect of within-person perceived access to supportive environments was positively associated with daily variations in walking whereas perceived environmental barriers were not. In addition, although the fixed within-person influences of social support and planning remained significantly associated with walking, positive affect was no longer positively associated with walking, suggesting that some of the positive association between daily variations in positive affect and daily variations in walking may be at least partially attributable to perceived access to supportive environments.

Posthoc independent sample t-tests were conducted on the concurrent sample of entries ($N = 804$) comparing minutes of reported walking when supportive environment, social support and planning items were endorsed versus those data points when the items were not endorsed (See Table 2). The results suggested that having access to a walking path, enjoyable scenery, good weather and a nice location were all associated with greater reported walking, with the greatest differences occurring on entry episodes when participants reported access to a walking path. Although access to a walking path was not reported very often (i.e., 7.4% of total entries), during those times, participants walked on average 18.5min longer than on times when no access was reported ($p < 0.0001$). Following Bonferroni adjustments ($\alpha = 0.001$), none of the social support items significantly predicted walking, although ‘others encouraged me’ just failed to reach statistical significance (p=0.0012).

Exploratory analyses were conducted with a subsample of entries that could be prospectively linked to determine if the association between perceived access to supportive environments and walking remained even after entering self-efficacy into the model. Because of missing responses, only two-thirds of entries (i.e., 64%) could be prospectively linked with the prior entry. Participants that walked more at baseline completed significantly more entries sequentially and were therefore overrepresented in the exploratory prospective sample ($r = 0.61$, $p < 0.01$). There were no other differences between the full concurrent sample and the exploratory prospective subsample on any other demographic characteristics assessed ($p > 0.14$). Results from these exploratory analyses indicated that the fixed effect of within-person self-efficacy, social support and implementation intentions were all positively associated with daily variations in walking (p’s < 0.05). Similar to the concurrent sample, the fixed effects of within-person supportive environment significantly predicted daily variations in walking even after controlling for the effects of self-efficacy (p’s < 0.05).

Discussion

This study is one of the first to highlight the importance of perceived access to supportive environments as an independent predictor of daily variations in walking, even after controlling for implementation intentions, social support, affect and self-efficacy. Results of this study replicate and expand prior research indicating the importance of implementation intentions by suggesting that implementation intentions was positively associated with daily variations in walking. In addition, this research replicates previous studies suggesting the importance of daily variations of social support and self-efficacy as predictors of walking (Dunton et al., 2009). Contrary to previous research, no association of concurrent negative affect was found with walking measured twice daily. Posthoc analyses revealed that access to a good walking path was not reported very often, but when it was reported, a three-fold increase in walking occurred relative to times when such access was not available. In addition there was a twofold increase in walking when participants reported perceiving enjoyable scenery or a nice location. These results are in line with previous research suggesting the importance of walking paths and neighbourhood aesthetics for promoting increased leisure walking (Hekler et al., in press; King et al., 2006)

To the best of the authors' knowledge, this is the first study that has explored implementation intentions and perceived environmental factors as concurrent predictors of walking within an intervention trial using EMA techniques. These results suggest that perceived access to supportive environments should be examined as a potential focus for future walking interventions in conjunction with promoting implementation intentions, social support, and self-efficacy. This is in line with previous intervention research highlighting the supportive environment in interventions (Ferney et al., 2009). Although much research on the built environment focuses on relatively static factors that are not easily amenable to change (e.g., residential density, street connectivity (King et al., in press; Sallis et al., 2009)), the results from this study suggest that 'real-time' perceptions of the built environment may be useful as another area on which to focus. Specifically, context-specific information about opportunities within a person's environment may be sufficient to increase walking. For example, maps of good nearby walking paths (a key supportive environmental factor based on the current results) could be provided at the time when the decision to walk is taking place (Ferney et al., 2009).

Although our study focused more on promoting initiation of walking, results may have interesting implications for walking maintenance. The present research highlights a potential mechanism for promoting behavioural maintenance via establishing habits linked with an individual's context. The importance of linking desired behaviours with a consistent context (i.e., time, place, with specific others, and as part of a sequence of behaviours) has been discussed in detail by Dr. Wood and colleagues (Wood & Neal, 2007; Wood, Tam, & Witt, 2005). Specifically, in this work there is a strong emphasis on aligning behavioural goals with specific repeatable actions that occur in a set pattern and within a given context, thereby allowing the behaviour to be elicited not simply via conscious intentions but also via external stimuli (i.e., previous behaviours, time, location and other individuals). Results from the present study are in line with this theory as the results highlighted the importance of perceived positive contextual factors as predictors of increased walking.

Contrary to expectations, perceived environmental barriers were not associated with daily variations in walking in this study. These results are counter to research suggesting that negative perceptions of the neighbourhood environment (particularly lack of pedestrian safety) can moderate the impact of physical activity interventions (King et al., 2006). A plausible explanation for this nonsignificant finding is a lack of variability in the perceived environmental barriers variable. Approximately two-thirds of participants never reported any instances of environmental barriers. Therefore, there may have been insufficient instances of perceived environmental barriers for the exploration of the construct's impact on walking. These results also may suggest that positive attributes of the perceived environment may have a stronger influence on walking than negative attributes of the perceived environment. This latter point is would be in line with Dr. Wood's theories related to habits (Wood et al., 2005; Wood & Neal, 2007). If this postulation is true, it suggests an important shift in intervention thinking from finding ways to overcome barriers (a la proactive coping, Aspinwall & Taylor, 1997) to seeking opportunities to increase behaviours via positive elements within the environment.

As this research was conducted mostly among retirement age, largely affluent, white, and motivated (since they agreed to participate in an intervention trial) individuals, these results may not generalise to other populations. In particular, all participants in this study were instructed in ways to plan walking into their daily lives via the PDA system. As such, perceived environmental factors may only have been influential among this group because of their likely link with implementation intentions. Although this cannot be ruled out, results suggesting that perceived positive environment was positively associated with walking even after controlling for implementation intentions provides stronger support to its general utility. Future research should explore the influence of perceived environment among a less motivated group of individuals (e.g., those not actively engaged in attempting to increase their regular walking levels). Beyond motivation, the particular perceptions of the environment may not generalise to other populations, particularly based on previous research suggesting the moderating role of neighbourhood income on walking among older adults (King et al., 2006). Further, previous research has highlighted the potential differential role of objectively measured aspects of the environment on promoting commuter walking between young versus older adults, therefore further emphasising the need to replicate the present results in a younger sample (Shigematsu et al., 2009).

Limitations

This study had several limitations. Although the study had sufficient power to detect associations between within-person predictor constructs and daily variations in walking, there was insufficient power ($N = 14$) to conduct between-person analyses. The between-person variables were only included as control variables for the within-person analyses (i.e., to control for between-person differences at baseline). The original study was an intervention trial but the control arm did not receive PDAs and therefore data for them were not available. Therefore, no conclusions about the influence of the intervention on studied constructs can be made. Although there was no evidence of between-person bias for the sample, results suggested a potential within-person reporting bias as participants tended to complete fewer afternoon (as opposed to evening) entries and complete fewer entries later in the study. Several key variables within this study (i.e., implementation intentions and positive affect) were measured using only a single item. Although this is not uncommon in EMA studies as reliability is often established not via multiple items but by being measured multiple times (Shiffman et al., 2008), it nonetheless suggests potentially less reliability of the measures. In addition, implementation intentions was measured using an item that, although in line with the concept was not developed *a priori* to measure the construct. The EMA measure of walking, although validated against the CHAMPS, has not been validated against an objective measure of walking (e.g., pedometer), which would be a valuable exploration in future research. Finally, this research focused specifically on perceptions of the environment and therefore no conclusions can be drawn about the influence of actual environmental features (e.g., daily variations on actual access to walking paths) on walking. There may have been instances whereby an individual did have access to a supportive environment but did not perceive it as such. Conceptually, the perception of the environment is likely very important for the environment to influence behaviours and thus this research does offer an important initial exploration into the power and influence of daily variations in the built environment.

Conclusions

The study results suggested that individuals' immediate perceptions of access to supportive environments were positively associated with walking after controlling for the effects of implementation intentions, social support, affect and self-efficacy. Specifically, participants reported increased walking during times when they had access to walking paths, enjoyable scenery, good weather and nice locations. Given these results, it might be worthwhile to ascertain whether there are other perceived aspects of the immediate environment that were not included in the current study that would bear additional study. It would also be worthwhile to explore further how such immediate context-specific information about the environment could potentially be utilised to enhance walking interventions via theoretical constructs such as further buttressing implementation intentions for habit formation. Overall, these results suggest the potential utility of EMA as a method to refine theoretical models of walking.

Acknowledgements

Drs. Hekler and Buman were supported by Public Health Service Training Grant 5 T32 HL 007034 from the National Heart, Lung, and Blood Institute while at Stanford University. The funding agency was not involved in the design or conduct of the research. This study was supported by a grant from Stanford University's Office of Technology Licensing. The majority of the work by Drs. Hekler and Buman was conducted while at Stanford, although both Drs. Hekler and Buman are currently faculty members at Arizona State University. The views expressed in this article represent those of the authors and not the National Cancer Institute. No financial disclosures were reported by the authors of this article.

References

Arbour KP, & Ginis KAM (2009). A randomised controlled trial of the effects of implementation intentions on women's walking behaviour. Psychology and Health, 24, 49–65. [PubMed: 20186639]

Aspinwall LG, & Taylor SE (1997). A stitch in time: Self-regulation and proactive coping. Psychological Bulletin, 121, 417–436. [PubMed: 9136643]

Atienza AA, Oliveira BM, Fogg BJ, & King AC (2006). Using electronic diaries to examine physical activity and other health behaviors of adults age 50þ. Journal of Aging and Physical Activity, 14, 192–202. [PubMed: 19462549]

Bryk AS, & Raudenbush SW (1992). Hierarchical linear models for social and behavioral research: Applications and data analysis methods. Newbury Park, CA: Sage.

Darker CD, French DP, Eves FF, & Sniehotta FF (2010). An intervention to promote walking amongst the general population based on an "extended" theory of planned behaviour: A waiting list randomised controlled trial. Psychology and Health, 25, 71–88. [PubMed: 20391208]

Dunton GF, Atienza AA, Castro CM, & King AC (2009). Using ecological momentary assessment to examine antecedents and correlates of physical activity bouts in adults age 50+ Years: A pilot study. Annals of Behavioral Medicine, 38, 249–255. [PubMed: 20052568]

Ferney SL, Marshall AL, Eakin EG, & Owen N (2009). Randomized trial of a neighborhood environment-focused physical activity website intervention. Preventive Medicine, 48, 144–150. [PubMed: 19028519]

Frank LD, Sallis JF, Conway TL, Chapman JE, Saelens BE, & Bachman W (2006). Many pathways from land use to health: Associations between neighborhood walkability and active transportation, body mass index, and air quality. Journal of the American Planning Association, 72, 75–87.

Garcia AW, & King AC (1991). Predicting long-term adherence to aerobic exercise: A comparison of two models. Journal of Sport and Exercise Psychology, 13, 394–410.

Gollwitzer P (1999). Implementation intentions: Strong effects of simple plans. American Psychologist, 54, 493–503.

Gollwitzer P, & Sheeran P (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. Advances in Experimental Social Psychology, 38, 69–119.

Hagger MS, & Biddle SJH (2002). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. Journal of Sport and Exercise Psychology, 24, 3–32.

Harada ND, Chiu V, King AC, & Stewart AL (2001). An evaluation of three self-report physical activity instruments for older adults. Medicine and Science in Sports and Exercise, 33, 962–970. [PubMed: 11404662]

Hekler EB, Buman MP, Haskell WL, Conway TL, Cain KL, Sallis JF,...,King AC (in press). Reliability and validity of champs sedentary to vigorous physical activity in older adults. Journal of Physical Activity and Health.

Hekler EB, Castro CM, Buman MP, & King AC (in press). The choice study: A "taste-test" of utilitarian vs leisure walking in older adults. Health Psychology.

King AC, Ahn DK, Oliveira BM, Atienza AA, Castro CM, & Gardner CD (2008). Promoting physical activity through hand-held computer technology. American Journal of Preventive Medicine, 34, 138–142. [PubMed: 18201644]

King AC, Oka RK, & Young DR (1994). Ambulatory blood pressure and heart rate responses to the stress of work and caregiving in older women. Journal of Gerontology, 49, M239–M245. [PubMed: 7963275]

King AC, Sallis JF, Frank LD, Saelens BE, Cain K, Conway TL,...,Kerr J (in press). Aging in neighborhoods differing in walkability and income: Associations with physical activity and obesity in older adults. Social Science and Medicine.

King AC, Toobert D, Ahn D, Resnicow K, Coday M, Riebe D,...,Sallis JF (2006). Perceived environments as physical activity correlates and moderators of intervention in five studies. American Journal of Health Promotion, 21, 24–35. [PubMed: 16977910]

Payne N, Jones F, & Harris PR (2010). A daily diary investigation of the impact of work stress on exercise intention realisation: Can planning overcome the disruptive influence of work? Psychology and Health, 25, 111–129. [PubMed: 20391210]

Sallis JF, Saelens BE, Frank LD, Conway TL, Slymen DJ, Cain KL,...,Kerr J (2009). Neighborhood built environment and income: Examining multiple health outcomes. Social Science and Medicine, 68, 1285–1293. [PubMed: 19232809]

Shiffman S, Stone AA, & Hufford MR (2008). Ecological momentary assessment. Annual Review of Clinical Psychology, 4(1), 1–32.

Shigematsu R, Sallis JF, Conway TL, Saelens BE, Frank LD, Cain KL,...,King AC (2009). Age differences in the relation of perceived neighborhood environment to walking. Medicine and Science in Sports and Exercise, 41, 314–321. [PubMed: 19127195]

Singer JD, & Willett JB (2003). Applied longitudinal data analysis: Modeling change and event occurrence. New York, NY: Oxford University Press.

Stewart AL, Mills KM, King AC, Haskell WL, Gillis D, & Ritter PL (2001). CHAMPS physical activity questionnaire for older adults: Outcomes for interventions. Medicine and Science in Sports and Exercise, 33, 1126–1141. [PubMed: 11445760]

Wood W, & Neal DT (2007). A new look at habits and the habit-goal interface. Psychological Review, 114, 843–863. [PubMed: 17907866]

Wood W, Tam L, & Witt MG (2005). Changing circumstances, disrupting habits. Journal of Personality and Social Psychology, 88, 918–933. [PubMed: 15982113]

World Health Organization (2009). Global health risks: Mortality and burden of disease attributable to selected major risks. Geneva, Switzerland: WHO Press.

World Health Organization Ageing Unit (2008). WHO global report on falls prevention in older age. Geneva, Switzerland: WHO Press.

Table 1.

Mixed models associated with walking.

Predictor variable	Step 4		Step 5	
Fixed effects	*B* (SE)	*t*	*B* (SE)	*T*
Within-person				
Linear time[a]	<0.00 (0.00)	2.07	0.01 (0.00)	2.16
Imp int$_{centered}$	1.13 (0.25)	4.61**	0.80 (0.25)	3.26**
Soc sup$_{centered}$	0.56 (0.11)	4.87***	0.44 (0.11)	3.86**
Pos affect$_{centered}$	0.13 (0.05)	2.84*	0.08 (0.04)	1.84
Neg affect$_{centered}$	−0.01 (0.06)	−0.14	−0.00 (0.06)	−0.03
Sup env$_{centered}$	n/a	n/a	0.38 (0.09)	4.17**
Env barr$_{centered}$	n/a	n/a	0.17 (0.18)	0.90
Random effects	*var* (SE)	*Z*	*var* (SE)	*Z*
Residual	1.70 (0.09)	19.37***	1.56 (0.08)***	15.3
Linear time[a]	0.00 (0.00)	0.84	0.00 (0.00)	0.68
Imp int$_{centered}$	0.31 (0.29)	1.05	0.28 (0.24)	1.17
Soc sup$_{centered}$	0.00 (0.00)	0	0.00 (0.00)	0.00
Pos affect$_{centered}$	0.00 (0.00)	0.09	0.00 (0.00)	0.00
Neg affect$_{centered}$	0.00 (0.00)	0	0.00 (0.00)	0.00
Sup env$_{centered}$	n/a	n/a	0.05 (0.04)	1.4
Env barr$_{centered}$	n/a	n/a	0.00 (0.00)	0.00
Within pseudo R^2	**0.17**		**0.24**	
	UMM	Step 4	UMM	Step 5
−2 Log likelihood	2890.5	2743.6	2890.5	2678.6
AIC	2896.5	2773.6	2896.5	2718.6
BIC	2898.4	2783.2	2898.4	2731.4

Notes: $N_{entries}$ = 804; Imp int = implementation intentions; Soc sup = social support; Pos affect= positive affect; Neg affect = negative affect; Sup env = supportive environment; Env barr = environmental barriers.

[a]Quadratic and cubic time predictors were nonsignificant and thus dropped.

The above analyses included between-person associations to control for differences between individuals at baseline. As this study included only 14 individuals, between-subject analyses were not readily interpretable and thus were not reported.

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$.

Author Manuscript

Author Manuscript

Author Manuscript

Table 2.

t-tests of supportive environment, social, and planning as correlates of walking.

	$N_{Entries}$ = 804	Not endorsed min. walk/entry		Endorsed min. walk/entry		
Items	**% Endorsed**	**M ±**	**SD**	**M±**	**SD**	**Difference min. walk/entry**
Supportive environment						
Walk path	7.4	11.1±	18.2	29.6±	18.8	+18.5*
Enjoy scenery	19.7	10.6±	19.0	20.1±	16.4	+9.6*
Good location	23.5	10.5±	19.3	18.9±	15.6	+8.4*
Good weather	32.1	10.7±	20.3	16.2±	14.9	+5.5*
Exercise equipment	0.8	12.5±	18.9	2.1±	3.9	−10.4*
Facility available	1.9	12.6±	19.0	6.7±	9.9	−5.9
Implementation intentions Scheduled it in	17.5	11.1±	19.2	18.6±	15.7	+7.4*
Social support						
Others encouraged	7.3	11.8±	18.9	20.1±	17.5	+8.2
Others join you	15.4	11.9±	19.4	15.2±	15.4	+3.2

Note: Significance tests are based on *t*-tests using a Bonferroni adjustment. (i.e., $\alpha = 0.01/9 = 0.0011$).

* $p < 0.0011$.