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Using self-determination theory to understand motivation for walking: Instrument development and model testing using Bayesian structural equation modeling

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Abstract

Objective: The motivational processes underpinning walking behaviour are not well understood. This study aimed to develop walking-specific motivation measures drawn from self-determination theory (SDT), assess the psychometric properties of the measures, incorporating Baysesian structural equation modelling (BSEM), and examine how these variables relate to walking behaviour.

Method: Participants (n=298; mean age=41.69; S.D.=11.06; male =57) completed the Behavioural Regulations in Walking Questionnaire (BRWQ), Psychological Needs Satisfaction for Walking Scale (PNSWS) and the IPAQ-long form, from which measures of workplace, transport and leisure walking were extracted. BSEM was used to test the hypothesized factor structures of the BRWQ and PNSWS. Internal reliabilities were assessed using the composite reliability coefficient. Convergent and discriminant validity were assessed by examining the relationships between the variables in relation to established theory.

Results: BSEM showed excellent fit for the BRWQ and PNSWS measurement models. The scales demonstrated good internal consistency. The associations within and between the BRWQ and PNSWS subscales were generally as expected. The relationship between the BRWQ subscales and walking for transport and leisure were also generally as expected, but there were no significant relationships for walking at work. Two PNSWS subscales were significantly related to walking for leisure, but no significant relationships were evident for walking for transport and at work.

Conclusions: There is preliminary evidence for the acceptable psychometric properties of instruments to measure SDT constructs in walking, and the findings highlight the advantages of BSEM. The findings also suggest that the motivational processes underpinning walking may vary by type of walking.

Introduction

Walking is a physical activity behaviour that can be undertaken in the different domains of work, home and community, and for different reasons such as transport, recreation, exercise and health. Regardless of the location and purpose behind walking, it has established health benefits (Murphy, Donnelly, Shibli, Foster, & Nevill, 2012; Murphy, Nevill, Murtagh, & Holder, 2007; Murtagh et al., 2015), even at relatively low levels (Ekelund et al., 2015). Moreover, walking has been identified as the 'nearest activity to perfect exercise' (Morris & Hardman, 1997) because of its health benefits and also because it requires no special skills or equipment, and is convenient and accessible to many people. For these reasons, increased walking has been identified as the most likely way that adults can achieve healthy levels of physical activity. Walking has become a key component of many physical activity promotion strategies (e.g., Bull et al., 2010), in which authors advocate creating opportunities for people to have physically active lifestyles.

In order to effectively promote walking, there is a need to identify the determinants of walking behaviour (Sallis, Owen, & Fotheringham, 2000). In line with the social ecological model (Sallis, Owen, & Fisher, 2008) it is likely that walking behaviour is influenced by individual, social and physical environmental, and policy factors. From an individual perspective, motivation is an individual's drive to act and is clearly a key influence on behaviour; however, few researchers have considered walking behaviour from a theoretical perspective. Whilst a number of psychological theories of motivation exist, self-determination theory (SDT) (Ryan & Deci, 2000) has become increasingly popular in the field of physical activity (Teixeira, Carraca, Markland, Silva, & Ryan, 2012). SDT offers a comprehensive explanatory framework to study antecedents and outcomes of motivation to be physically active (Ng et al., 2012), incorporating many of the variables that have been identified as being relevant to physical activity (Sebire, Jago, Fox, Edwards, & Thompson, 2013). A further strength of SDT is that it can be readily applied to physical activity interventions (Standage & Ryan, 2012). Although limited research has examined walking behaviour from a SDT theoretical basis, a recent qualitative study showed that SDT offers researchers a relevant perspective for understanding adoption of walking for physical activity (Kinnafick, Thogersen-Ntoumani, & Duda, 2014)

Self-Determination Theory

SDT is a macro theory of human motivation that includes five mini-theories (Ryan & Deci, 2000). One mini-theory is organismic integration theory (OIT; (Deci & Ryan, 2000) that considers not just the *amount* of motivation an individual has towards behaviour but also the *quality* of the motivation, which results in different outcomes. According to OIT, there are three types of motivation including intrinsic and extrinsic motivation, and amotivation. Specifically, intrinsic motivation is based on inherent interest and satisfaction from the activity (e.g., I walk because it is fun). Integrated, identified, introjection and external behavioural regulations are all forms of extrinsic motivation because they focus on consequences that are separate from the activity itself. Integrated regulations relate to engaging in the activity because it is *integrated* with the individual's goals and values (e.g., I consider walking to be part of my identity). Identified regulations are based on consciously valuing and *identifying* with the benefits of the activity (e.g., I value the benefits of walking). Intrinsic, integrated and identified regulations are all considered autonomous forms of motivation. Introjected regulations are based on being motivated to avoid feelings of guilt, or to enhance one's self-worth (e.g., I walk because I feel guilty if I don't). External regulations relate to being motivated to obtain an external contingency (e.g., I walk because other people say I should). Both external and introjected behavioural regulations are associated with controlled forms of motivation, where behaviour is governed by external or internal pressures. Finally, amotivation relates to a lack of intention to act and a lack of motivation.

These different types of motivation are often conceptualised as lying along a continuum of relative autonomy (Ryan & Connell, 1989). According to this conception, correlations between measures of behavioural regulations should exhibit a simplex pattern whereby motivation types more proximally located on the continuum are more strongly associated than with those more distally located. In fact, such SDT-based measures often do not conform to this pattern (Guay, Morin, Litalien, Valois, & Vallerand, 2015). Chemolli and Gagné (2014) argued that the continuum conception, with the regulatory types ordered along a single dimension representing individual differences in autonomy, is not consistent with the idea that the forms of regulation described by SDT are qualitatively different, nor with the fact that individuals can endorse more than one form of regulation for a behaviour at the same time. Using Rasch analysis, these authors found no support for the continuum conception for measures of behavioural regulation in the work and academic domains.

Within SDT, it is hypothesised that more autonomous motivation is associated with adaptive cognitive, affective and behavioural outcomes, whereas controlled motivation is associated with maladaptive outcomes (Deci & Ryan, 2000). A recent systematic review of 53 exercise studies provided some support for these hypotheses in relation to the outcome behaviour of exercise (Teixeira et al., 2012) . Specifically, there was consistent evidence to support a positive predictive relationship between all autonomous forms of regulation and exercise behaviour. However, the findings for controlled motivation were less clear with the majority of studies reporting no relationships between external and introjected regulation and exercise behaviour, but other studies reporting either positive or negative relationship.

Whilst this systematic review is of value and adds some support for the use of SDT in understanding exercise behaviour, it was noted by the authors that the large majority of the studies focused on ‘exercise’ (i.e., ‘a purposeful and formalized leisure time activity, often with the goal of improving fitness and health’; p.27 (Teixeira et al., 2012)) as an outcome variable. However, there are differences between formalized exercise, and the cluster of behaviours that can be classified as walking. Although walking can be undertaken as purposeful exercise, it can also include walking for transport, recreation or health, and whilst at work, in the community or at home. Furthermore, opportunities for walking may occur more regularly, be of shorter duration and generally require less physical effort than a formalized exercise bout. Therefore, it may be premature to extrapolate the findings of exercise studies to inform the promotion of the activity of walking within a physically active lifestyle

Researchers have undertaken limited walking specific studies to examine behavioural regulations; however other studies have shown that the hypothesized relationships between behavioural regulations and physical activity are evident for structured and strenuous exercise, but not for lifestyle physical activity behaviours (e.g., walking instead of taking motorized transport, easy walking) or mild exercise in the same sample (Edmunds, Ntoumanis, & Duda, 2006a, 2006b; Silva et al., 2010; Vlachopoulos, Ntoumanis, & Smith, 2010). As suggested by Silva et al. it is possible that engaging in lifestyle behaviours may require less cognitive effort and therefore be regulated by more automatic and habitual processes (Silva et al., 2010). However, although lifestyle behaviours like walking may become habitual over time, they would not be automatic at the adoption stage (Verplanken & Melkevik, 2008). Furthermore, some forms of walking, such as deliberately choosing to walk for leisure or for transport may be more purposeful than others, such as incidental walking associated with one's occupation. Therefore understanding the contribution of more deliberative processes like behavioural regulations to purposeful walking behaviours is likely to be important in effectively promoting walking, and worthy of further research. Additionally, it is also evident that there were methodological issues with each of these studies that may partly explain the lack of associations. Specifically, each study used measures of behavioural regulations that related to exercise, and not the targeted behaviour of lifestyle physical activity. This lack of correspondence between the predictor and target behaviour could partly explain the lack of associations. In order to credibly investigate the role of behavioural regulations in walking behaviour it is necessary to develop appropriate instruments.

Basic Needs Theory

SDT has particular value in its application to physical activity promotion because it identifies the conditions that underpin the nature of motivation and those that will nurture or thwart more adaptive autonomous motivation. According to the mini-theory of basic needs theory (BNT), all individuals have an innate need to feel autonomous, competent and related to others in their social environment (Deci & Ryan, 2000). Within an exercise context, a social environment that is perceived by participants to provide needs satisfaction is likely to be associated with more autonomous motivation (Markland & Tobin, 2010; Vlachopoulos et al., 2010; Wilson & Rogers, 2008; Wilson, Rogers, & Todd, 2008)).

Teixeira et al. (2012) undertook a review of studies examining the relationship between needs satisfaction and exercise behaviour and reported that there was a relatively limited number of studies (K=17) and findings were mixed. Nevertheless, there was consistent support for a positive relationship between competence need satisfaction and exercise. The findings for autonomy need satisfaction were mixed, and it was suggested that studies using bivariate analysis were more likely to report a positive relationship. There was limited evidence of a strong relationship between relatedness need satisfaction and exercise, although there was some evidence of a trend towards a positive relationship.

There is little research examining psychological needs satisfaction in walking. An exception is a series of studies conducted by Kinnafick and colleagues using SDT to examine the motivational processes in physically inactive participants who joined a 16-week walking programme (Kinnafick, Thogersen-Ntoumani, & Duda, 2014; Kinnafick, Thogersen-Ntoumani, Duda, & Taylor, 2014). In a qualitative study, Kinnafick et al. provided some support for the role of needs satisfaction in improving the quality of motivation and walking adherence (Kinnafick, Thogersen-Ntoumani, & Duda, 2014). In a quantitative study Kinnafick et al. reported that changes in autonomy but not relatedness need satisfaction were related to total physical activity (Kinnafick, Thogersen-Ntoumani, Duda, et al., 2014). In this study, the researchers adapted a previous measure of psychological needs satisfaction (the Basic Need Satisfaction at Work Scale (Deci et al., 2001)) and related it to walking. Unfortunately, the researchers were not able to assess the influence of each of the basic needs because the measure for competence satisfaction had poor internal consistency and was dropped from the study. This again highlights the need for more comprehensive measures in order to fully examine the motivational processes involved in walking.

Developing SDT walking-specific measures: Consideration of analytical strategies to assess factorial validity

In order to fully examine the motivational processes underpinning walking behaviour, there is a need to develop appropriate instrumentation. For the present study, established measures of behavioural regulations and psychological need satisfaction were adapted for the domain of walking behaviour and their hypothesised factor structures were tested using Bayesian structural equation modelling (BSEM; Muthén and Asparouhov, 2012). BSEM for the assessment of factorial validity is only just beginning to appear in the sport and exercise psychology literature (Barnett et al., in press; Gucciardi & Jackson, 2015; Gucciardi, Peeling, Ducker, & Dawson, 2014; Jackson, Gucciardi, & Dimmock, 2014; Stenling, Ivarsson, Johnson, & Lindwall, in press) but is not yet widely adopted. Therefore, we have included detailed consideration and justification for the usefulness and advantages of the BSEM approach adopted in this study to assess the factorial validity of the new instruments.

The typical contemporary approach to assessing the factorial validity of theoretically-grounded multidimensional measures is to employ confirmatory factor analysis (CFA) using a maximum-likelihood (ML) approach and imposing an independent clusters model (ICM) or simple factor structure, with indicators free to load on their intended factors and cross loadings and residual correlations fixed at zero. This approach almost always leads to rejection of the model by the likelihood ratio χ2 test (Marsh et al., 2009). Consequently, most researchers rely exclusively on approximate fit indices to justify acceptance of a model, often arguing that the χ^2 test is oversensitive to trivial discrepancies between the model-implied and observed covariances (Fong & Ho, 2013). However, it can still be difficult to obtain a well-fitting model judged by approximate indices, particularly with a large number of indicators (Marsh, Hau, & Wen, 2004), so researchers often relax the conventionally accepted criteria (e.g., those proposed by Hu and Bentler (1999)), and/or engage in post hoc model modifications or item elimination in order to improve the fit.

In recent years it has become increasingly recognized that a reason for the less than optimal fit often found for CFA models is that they are typically mis-specified in the first place, by imposing the parsimonious but highly restrictive ICM when in reality the factor structure is more complex with many small cross-loadings (Asparouhov & Muthén, 2009; Browne, 2001; Marsh et al., 2009). Furthermore, in ICM-CFA covariances between indicators are held to be entirely accounted for by their latent variables. In reality indicators will often also covary due to shared method factors, and the usual practice of constraining most or all residual correlations to zero can bias the factor loadings and change the meaning of the latent variables (Cole, Ciesla, & Steiger, 2007; Kolenikov, 2011). In addition to presenting problems with model fit, the ICM-CFA approach also channels the ‘hidden’ covariation between indicators through their factors, upwardly biasing the inter-factor correlations and distorting structural relations in subsequent structural equation models (Asparouhov & Muthén, 2009).

The standard ML-CFA approach allows for the specification of some cross-loadings and/or correlated residuals. However, allowing too many will at some point lead to a non-identified model. A solution to these problems that has begun to appear in the literature is exploratory structural equation modelling (ESEM: Asparouhov and Muthén (2009); (Marsh et al., 2009; Myers, Chase, Pierce, & Martin, 2011). ESEM integrates aspects of exploratory factor analysis (EFA) and CFA. Like EFA, ESEM allows non-zero cross-loadings and rotation of factor matrices. Like CFA, ESEM provides standard errors for the parameters and conventional fit indices. Mechanical rotation methods are used to approximate a simple factor structure. A refinement available for ESEM is target rotation

(Asparouhov & Muthén, 2009) where cross-loadings are estimated under the restriction that their values are as close as possible to zero.

ESEM provides a useful alternative to the restrictive ICM-CFA approach. However, although target rotation allows some control over the specification of the model, it does not allow specification of how close to zero cross-loadings should be, and ESEM does not allow for correlated residuals (Muthén & Asparouhov, 2012). Muthén and Asparouhov (Muthén & Asparouhov, 2012) have recently introduced the Bayesian approach (Bayesian Structural Equation Modeling; BSEM) as an alternative method that is strictly confirmatory in nature and less restrictive than ICM-CFA (Golay, Reverte, Rossier, Favez, & Lecerf, 2013). The Bayesian approach views parameters as variables with a mean and a distribution of values rather than as constants, as in ML analysis (Yuan & MacKinnon, 2009). This allows specification of informative priors on cross-loadings and residual correlations with approximate zero means and small variances, within an identified model. The variances are specified a priori to set limits on the amount of deviation from zero in the parameter estimates that the user is prepared to tolerate. Specifying small variances implies that the estimates are close to zero, but not exactly zero (with 'close' defined by the user), in effect specifying an approximation to a pure simple structure. Informative priors for cross-loadings and correlated residuals may be combined with informative priors for the major loadings, based on substantive theory and/or previous empirical findings, or with non-informative priors that place no restrictions on the estimated parameter distributions.

Allowing large prior variances may lead to cross-loadings and residual correlations that have a high probability of having substantive values that the user is not prepared to tolerate and, because they are less informative than small variance priors, can lead to an under-identified model (Muthén & Asparouhov, 2012). For all parameters in the model, 95% credibility intervals for estimates that do not encompass zero indicate that the parameter is statistically significant. For parameters with zero mean and small variance priors specified, 95% credibility intervals that do not encompass zero indicate that the values for these estimates are larger than the researcher is prepared to tolerate (i.e., that they are not close enough to zero). This provides useful diagnostic information on the behaviour of the indicators. For example, the researcher may want to subsequently freely estimate such a parameter or eliminate poorly performing indicators. This is an advantage of BSEM over ML-CFA, where modification indices are often used to identify problematic indicators (e.g., those with large cross-loadings on non-intended factors). Modification indices provide information on the improvement in model fit that would be obtained by freeing one parameter at a time, and making a sequence of such modifications risks capitalizing on chance (MacCallum, Roznowski, & Necowitz, 1992). In contrast, BSEM with small variance priors provides information about potential modifications with all the parameters estimated simultaneously (Muthén & Asparouhov, 2012). A further advantage of BSEM over ML-CFA is that it is not reliant on large sample normal theory, and Bayesian credibility intervals, unlike ML confidence intervals, are not assumed to be symmetric. Thus it can accommodate parameters with highly skewed distributions (Muthén & Asparouhov, 2012). Moreover, BSEM has been shown to perform better than ML at small sample sizes (Lee & Song, 2004).

Aims of this Study

In order to effectively promote walking, there is a need to more fully understand the motivational factors influencing walking behaviour and the SDT framework potentially offers an avenue to do this. However, the limited efforts to date have been hindered by lack of comprehensive instrumentation. Therefore the aim of this study was to adapt existing well-established measures of behavioural regulations and psychological need satisfaction in exercise for the context of walking behaviour and also to provide a further illustration of the advantages of BSEM over the ML-CFA approach in assessing the psychometric properties of the new scales. Specific objectives were:

1) To modify existing established measures of behavioural regulations and psychological need satisfaction to be relevant to walking behaviour.
2) For the revised measure of behavioural regulations, to use BSEM to assess the factorial validity in relation to the hypothesised 6-factor structure, the internal consistency of the measure, and the convergent and discriminant validity in relation to existing SDT theory (i.e., relationships with needs satisfaction and walking behaviour).
3) For the revised measure of psychological needs satisfaction, to use BSEM to assess the factorial validity in relation to the hypothesised 3-factor structure, the internal consistency of the measure and the convergent and discriminant validity in relation to existing SDT theory (i.e., relationships with behavioural regulations and walking behaviour).
4) Through achievement of the above objectives, to gain preliminary insight into the motivational processes underpinning walking behaviour.

Method

Participants

Participants were employees from 232 Scottish workplaces who had volunteered to take part in a Workplace Step Count Challenge, which is a government funded physical activity intervention delivered by Paths for All (http://www.pathsforall.org.uk/stepcount). From the possible 3370 participants in the intervention 298 (8%) participants (mean age=41.69; S.D.=11.06 years; male=57) provided a full baseline data set. The majority of respondents (88%) indicated that they were participating in the Challenge in order to increase their physical activity through walking. The data used in this study represented the baseline data collected to evaluate the effectiveness of the intervention (not reported).

Instruments

Behavioural Regulations in Walking Questionnaire (BRWQ).

The BRWQ was adapted from the Behavioural Regulations in Exercise Questionnaire-2 (BREQ-2; (Markland & Tobin, 2004), which is the most widely used measure of behavioural regulations in exercise (Teixeira et al., 2012). The BREQ-2 includes subscales tapping amotivation, external regulation, introjection, and identified and intrinsic regulation. A further subscale was later added to assess integrated regulation (Wilson, Rodgers, Loitz, & Scime, 2006). For the purpose of the current study, the questionnaire was revised so that the term 'exercise' in the BREQ-2 was replaced with 'walk' or 'walking'. The BRWQ included 23 items assessing the 6 subscales of amotivation (e.g., I don't see why I should have to walk), external regulation (e.g., I walk because other people say I should), introjected regulation (e.g., I feel like a failure when I haven't walked in a while), identified regulation (e.g., It's important to me to walk regularly), integrated regulation (e.g., I consider walking to be part of my identity) and intrinsic regulation (e.g., I walk because it is fun) (see Table 2 for list of items). Participants were asked to respond to items on a 5-point scale (0=not true for me; to 4=very true for me). The readability of the scale was assessed by researchers, practitioners and walkers to determine if the items were understandable within the context of walking, and minimal changes were made.

Psychological Needs Satisfaction for Walking Scale (PNSWS).

The PNSWS was adapted from the Psychological Need Satisfaction for Exercise Scale (PNSES; (Wilson, Rogers, Rodgers, & Wild, 2006), which was developed to assess feelings of competence, autonomy and relatedness usually experienced by adults during structured exercise. The PNSES was identified as the most commonly used scale in a recent systematic review of relevant research (Teixeira et al., 2012). For the purpose of the current study the questionnaire was revised so that the items related specifically to walking, with the terms 'exercise' or 'exercises' replaced with 'walk' or 'walking'. The PNSWS included 18 items assessing the three subcales of competence (e.g., I feel confident I can do even the most challenging walking), autonomy (e.g., I feel like I am the one who decides what walking I do) and relatedness (e.g., I feel connected to the people who I interact with while we walk together) satisfaction (see Table 3 for list of items). Participants were asked to respond to items on a 5-point scale (1 = disagree to 5 = agree), which differed from the original PNSES 6-point scale. Like the BRWQ, the readability of the scale was assessed by researchers, practitioners and walkers, and some minor changes were made. For example, the item 'I feel free to walk in my own way' from the autonomy scale was modified to include direction in relation to what 'in my own way' meant. Specifically, the item was revised to read 'I feel free to walk in my own way (i.e., where, when, how)'.

Walking behaviour.

The walking data were extracted from the self-report International Physical Activity-Questionnaire-long form (IPAQ-LF; (Craig et al., 2003)). The IPAQ-LF consists of questions relating to the frequency (days) and duration (hours and minutes) of moderate and vigorous physical activity in the last 7 days in four specific domains, including job-related, transportation, domestic, and leisure as well as a measure of sitting time. The IPAQ also assesses the frequency and duration of walking behaviour in the job-related, transportation and leisure domains, and the data from responses to these items were extracted to provide continuous measures of the number of weekly minutes of walking in each of these domains.

Procedure

Following institutional ethical approval from the (detail to be added following blind review) (Ref#295; March, 2014), all participants who had registered for the Workplace Step Count Challenge were invited by e-mail to participate in a research project designed to evaluate the effectiveness of the intervention. Interested participants were directed to an online questionnaire and asked to indicate their full informed consent on the first page of the questionnaire. The questionnaire included demographic questions and the IPAQ-LF, BRWQ, and PNSWS. Prior to completing the BRWQ and PNSWS questionnaires, participants were instructed to respond to their feelings when walking and that walking included any walking they did either for transport or recreation purposes, and whilst at work or at home. In order to enhance the response rate we used previously identified effective techniques (e.g., provide non-monetary incentives) (Edwards et al., 2009).

Analysis

Model testing strategy.

A series of three BSEM models were estimated for both the BRWQ and PNSWS (MPlus Syntax included as supplementary file). First, models with non-informative priors for the major loadings, exact zero cross-loadings and zero residual correlations (i.e., ICMs). Next, models with non-informative priors for the major loadings, informative approximate zero cross loadings and exact zero residual correlations were estimated. Finally, models with non-informative priors for the major loadings, informative approximate zero cross loadings and residual correlations were estimated. For comparison purposes, we report the results of the ML-CFA analyses using the robust ML estimator and with exact zero cross-loadings and correlated residuals. For the BSEM analyses, prior variances for cross-loadings and residual correlations were specified at ± .01. With the indicators and factors standardized, this corresponds to factor loadings and residual correlations with a 95% limit of ±.20, thus representing substantively small cross-loadings and residual correlations (Muthén & Asparouhov, 2012). The choice of priors can influence the parameter estimates. In order to assess the stability of the estimates, it is recommended that a sensitivity analysis is performed by examining the effects of varying the variance of the priors on the parameter estimates (Gucciardi & Zyphur, in press; Muthén & Asparouhov, 2012; van de Schoot & Depaoli, 2014). For the present study, the final models were re-run with smaller (.005) and larger (.015) prior variances for the cross-loadings, and the parameter estimates compared for discrepancies with those obtained with a prior variance of .01. Non-informative priors were specified for the major loadings because (a) we were unable to find prior publications with the different versions of the BREQ that had reported factor analyses using both the amotivation and integration subscales; (b) we did not necessarily expect that previously reported factor loadings for the BREQ and PNSES in exercise contexts would replicate in a walking context; and (c) informative priors for cross-loadings and correlated residuals are typically combined with non-informative priors for parameters that would not be restricted in a corresponding ML analysis (Muthén & Asparouhov, 2012).

The model was estimated with the Markov chain Monte Carlo algorithm with the Gibbs sampler and two chains to ensure convergence on stable estimates. Estimation was performed initially with 50,000 iterations and then 100,000 to check convergence and the stability of the estimates. A variety of convergence diagnostics are available (Kaplan & Depaoli, 2012). In the present study, convergence was assessed by the potential scale reduction factor (PSR) and Kolomogorov-Smirnov (K-S) tests. Evidence for convergence is provided when the PSR lies between 1.0 and 1.1 (Gelman, Carlin, Stern, & & Rubin, 2004) and when the K-S tests indicate no significant differences between the estimated parameter distributions across multiple chains. In addition, trace plots for each parameter were visually inspected in order to assess the stability of the means and variances across each chain. Model fit was assessed with posterior predictive checks, which indicate the degree of discrepancy between the model generated and observed data using the likelihood ratio $\chi 2$ test and its associated posterior predictive p value (PPP). For a well-fitting model, PPP should be around .50 and with a symmetric 95% confidence interval for the difference between the observed and replicated $\chi 2$s centred around zero (Muthén & Asparouhov, 2012). Finally, for comparison purposes, we briefly report the results of ML-CFA analyses using the robust ML estimator and with exact zero cross-loadings and correlated residuals centred around zero (Muthén & Asparouhov, 2012).

Internal consistency, convergent validity and discriminant validity.

Internal consistency of the BRWQ and PNSWS subscales was assessed with the composite reliability coefficient (Fornell & Larcker, 1981). Convergent and discriminant validity were assessed to determine if the measures demonstrated the relationships that would be expected among and between the BRWQ and PNSWS subscales and between the BRWQ and PNSWS subscales and the measures of walking behaviour, based on existing SDT exercise literature and theory. Latent variable correlations obtained from the BSEMs were used to examine the relationships among the BRWQ subscales and the PNSWS subscales. Relationships between aggregated means for the BRWQ and PNSWS subscales and the walking behaviours were assessed by examining the correlations among the measures

Results

Factorial Validity

Table 1 shows the fit of the BRWQ and PNSWS models. Adequate convergence was achieved for all models. For both instruments the restrictive independent clusters BSEM models with zero cross-loadings and zero residual correlations converged on a solution but improper values (>1.0) were evidenced for the correlation between identified regulation and intrinsic motivation in the BRWQ (1.06) and for the PNSWS, all three correlations among the latent variables were greater than 1.0. The PPP for the model indicated a poor fit to the data. Fit was also unacceptable for the models with informative small variance priors on the cross-loadings. In both cases, however, models with informative small variance priors on the cross-loadings and residual correlations had an excellent fit to the data, with PPPs around .5 and symmetric 95% posterior predictive confidence intervals centered around zero. PSR values for the final models reached the 1.1 criterion after 33400 iterations (BRWQ) and 15500 iterations (PNSWS). K-S tests for all parameters for both instruments were non-significant ($p > .05$). Visual inspection of the trace plots (BRWQ: 452 parameters; PNSWS: 246 parameters) all showed a stable process with no upward or downward trends in the means and the two chains overlapping in their variability. Mirroring the results for the independent clusters BSEM models, the ML-CFA models failed to converge on proper solutions, both having non-positive definite latent variable correlation matrices. For the BRWQ, the correlation between identified regulation and intrinsic motivation was 1.06. For the PNSWS, all three correlations among the latent variables were greater than 1.0.

The items, standardized factor loadings and 95% credibility intervals for the BRWQ and PNSWS are shown in Tables 2 and 3. For both measures all major loadings were significant and mostly acceptable by conventional criteria (e.g., >.4; Ford, MacCallum, and Tait (1986)). However, although significant Item 4 of the PNSWS autonomy subscale (*I feel like I have a say in choosing the walking that I do*) and item 1 of the PNSWS relatedness subscale (*I feel attached to my walking companions because they accept me for who I am*) had relatively low loadings of .34 and .42 respectively. For the BRWQ, all cross-loadings and residual correlations were shrunk toward their zero prior means and were within their a priori limits of ± .20. Similarly, for the PNSWS, none of the cross loadings nor the residual correlations escaped their a priori bounds except for the correlation between the residuals for item 4 of the autonomy subscale and item 1 of the relatedness subscale (95% CI [.75,.88]).

Sensitivity analyses indicated that the factor loadings and cross-loadings were relatively stable when specifying prior variances for cross-loadings at smaller (.005) and greater (.015) values. For the BRWQ, 97.4% of the discrepancies fell between ± .05 and the maximum discrepancy was -.12 with prior variances set at .005; 97.1% of the discrepancies fell between ± .05 and the maximum discrepancy was .13 with prior variances set at .015. For the PNSWS, 96.4% of the discrepancies fell between ± .05 and the maximum discrepancy was -.07 with prior variances set at .005; 99.6% of the discrepancies fell between ± .05 and the maximum discrepancy was .052 with prior variances set at .015.

Internal Consistency, Convergent and Discriminant Validity

Table 4 shows the latent factor subscale means, standard deviations, composite reliabilities and latent factor inter-correlations for the BRWQ and PNSWS. For both measures, all subscales demonstrated acceptable reliabilities. Subscale means were very low for amotivation and external regulation, below the scale midpoint for introjected and integrated regulation and above the midpoint for identified and intrinsic regulations. For the PNSWS subscales, mean scores were all above the scale midpoint.

Relationships among BRWQ and PNSWS subscales.

For the BRWQ, the autonomous subscales (i.e., identified, integrated and intrinsic) were strongly positively intercorrelated but none of the upper bounds of their 95% credibility intervals encompassed unity, indicating discriminant validity of these subscales with respect to each other. Introjection was moderately positively correlated with the autonomous subscales and uncorrelated with amotivation and external regulation. External regulation was correlated, moderately and positively, with only amotivation. Amotivation was negatively correlated with intrinsic regulation and identified regulation and uncorrelated with introjection and integrated regulations. There were strong positive intercorrelations among the PNSWS subscales but again none of the upper bounds of their 95% credibility intervals encompassed unity.

Relationships between BRWQ and PNSWS, and walking behaviour.

Table 5 shows the correlations among the BRWQ and PNSWS subscales and the measures of walking behaviour. The measures of autonomous motivation exhibited small to moderate positive and significant relationships with autonomy, competence and relatedness. Introjected regulation was significantly related to competence and relatedness need satisfaction, but not to autonomy. Amotivation and external regulation were predominantly negatively and significantly related to each of the needs, with the exception of external regulation and relatedness.

In relation to the behaviours of walking for transport and leisure, the results showed consistent significant negative relationships for amotivation and external regulation, no relationship for introjection, and positive relationships for identified and intrinsic regulation. The pattern was different for integrated regulation, which was positively related to transport walking but not walking for leisure. There were no significant relationships between behavioural regulations, need satisfaction and walking at work.

Need satisfaction was significantly related to walking for leisure with both autonomy and competence exhibiting positive correlations, but relatedness was unrelated. There were no significant relationships between need satisfaction and walking at work and walking for transport.

Discussion

In order to effectively promote walking as physical activity, it is important to understand the motivational processes involved in walking and adequate instrumentation is required to do this effectively. This study illustrates the value of adopting the recently developed BSEM approach to the assessment of the factorial validity of measurement instruments and the findings provide initial support for the psychometric properties of two motivational measures adapted for the domain of walking.

Factorial Validity of BRWQ and PNSWS

For both the BRWQ and the PNSWS, as expected, the imposition of independent clusters models produced poorly fitting models, as did models with small variance priors on the cross-loadings alone. Taking full advantage of the flexibility of BSEM by allowing small variance priors on both cross loadings and residual correlations, however, produced excellent model fits for both instruments, giving a more empirically and theoretically realistic (in comparison to the ICMs) but still parsimonious solution and indicating that the sources of misfit in the ICMs lay in the imposition of unwarranted exact zero restrictions on cross-loadings and residual correlations. More importantly in the case of the current data, both the BSEM and ML-CFA ICMs produced improper estimates with latent variable correlations greater than 1.0. As noted earlier, the ICM approach channels unspecified covariation between indicators through their factors, upwardly biasing inter-factor correlations. Given the current ICM findings, if one only had recourse to ML-CFA one would have to conclude that the offending subscales lacked discriminant validity. In this case, the only solution would be to collapse or remove subscales, departing from the theoretical basis for the instruments and discarding important information. By employing BSEM with small variance priors this problem was not met and the resultant models provided a better representation of their underpinning theory than would be the case if the subscales were collapsed or eliminated.

For the BRWQ, all cross-loadings and residual correlations fell within their pre-specified 95% limits of ± .20, indicating substantively trivial deviations from exact zeros. Results were similar for the PNSWS with the exception that the residual correlation between one autonomy and one relatedness item escaped its small variance prior. Factor loadings for both these items were also relatively low. Because the global fit of the model and internal reliabilities of the subscales were good we retained these items for the subsequent correlation analyses but future research is needed to evaluate the performance of these indicators. In summary, the results from the BSEM analysis indicate that the BRWQ and PNSWS have good factorial validity.

Internal Consistency, Convergent and Discriminant Validity

As indicated above, both the BRWQ and PNSWS exhibited good internal reliability providing additional confidence in the credibility of the measures. Further support for the psychometric properties of new measures can be gained by demonstrating that they have convergent and discriminant validity; that is, measures relate to other relevant variables in a manner that is consistent with current theoretical perspectives.

Relationships among BRWQ subscales.

As noted in the Introduction, recent theorizing and empirical work has suggested that a simplex-like pattern of correlations among measures of behavioural regulations is not consistent with the notion that regulations differ in quality rather than quantity (Chemolli & Gagne, 2014), and so is not necessarily to be expected. In the present study, there was no evidence for a simplex-like pattern and no other consistent pattern of intercorrelations was evident. The autonomous subscales (identified, integrated and intrinsic) were positively intercorrelated but not to the extent that they lacked discriminant validity with respect to each other. Intrinsic regulation was more strongly correlated with identified regulation than with integrated regulation. Wilson, Rodgers, et al. (2006), using the BREQ from which the BRWQ was adapted, also found that integrated regulation was less strongly correlated with identified regulation than with intrinsic regulation. Intrinsic and identified regulations, but not integrated regulation, were negatively correlated with amotivation. None of the autonomous subscales were correlated with external regulation but all three were moderately positively correlated with introjection, which was uncorrelated with external regulation. The latter is consistent with most of the literature which shows introjection to be more highly correlated with identified regulation than with external regulation in other behavioural domains (c.f., (Chemolli & Gagne, 2014) and with previous research using the BREQ-2. (e.g., Edmunds et al., 2006a; Markland, 2009; Markland & Tobin, 2004; Markland & Tobin, 2010; Wilson et al., 2008). Taken together, these findings are broadly in harmony with previous studies and support Chemolli and Gagné's contention that evidence for a continuum conception of self-determination is weak and inconsistent with the broader tenets of SDT.

Relationships among PNSWS subscales.

The three PNSWS subscales were strongly correlated but, as with the BRWQ, not to the extent that they lacked discriminant validity with respect to each other. The empirical literature is inconsistent with regard to the strength of the inter-correlations between the three dimensions of need satisfaction. In the exercise domain, for example, whereas some studies have found small to moderate inter-correlations (Edmunds et al., 2006b; Wilson, Rodgers, et al., 2006) others have found them to be more strongly associated (e.g., Hagger, Chatzisarantis, & Harris, 2006; Markland & Tobin, 2010; Vlachopoulos et al., 2010). The strong relationships between the three subscales of the PNSWS observed here suggest that in the context of walking behaviour, the three needs are complementary (Hagger et al., 2006) with satisfaction of any one need being associated with satisfaction of the others.

Relationships between BRWQ and PNSWS subscales.

The relationships between the behavioural regulations and needs satisfaction were generally as expected and consistent with previous research in adult exercise samples (Vlachopoulos et al., 2010; Wilson et al., 2008) providing some support for the convergent and discriminant validity of the measures. Specifically, needs satisfaction was positively associated with more autonomous motivation, and negatively associated with external behavioural regulations and amotivation. Although none of the correlations were strong, and these findings are based on cross-sectional data, they could suggest that in promoting walking for health it would be valuable to create a social environment that provides opportunities for feeling competent, autonomous and related in order to encourage autonomous motivation. This finding support previous research (Kinnafick, Thogersen-Ntoumani, & Duda, 2014). However, due to the limited number of studies to date, more research would be useful to consider further the direction and nature of this relationship and also examine how needs satisfaction influences walking behaviour over time.

The relationship between introjection and needs satisfaction appears more complex. The findings of the current study showed that introjected regulation is positively and significantly related to competence and relatedness, but not autonomy. Previous studies in exercise contexts have reported inconsistent findings with some showing non-significant relationships between introjection and needs satisfaction (Vlachopoulos et al., 2010; Wilson et al., 2008), significant negative associations for autonomy only, or significant positive associations with competence only (Markland & Tobin, 2010). The current findings suggest that in the context of walking, introjected regulation is not incompatible with perceptions of competence and relatedness but it is not compatible with feelings of autonomy. According to Deci and Ryan (2000) introjection represents a relatively unstable basis for behavioural regulation because the resulting behaviours are not autonomously enacted. Thus one would not expect walking behaviour to be sustained in the long-term if it is regulated by introjection, even if the needs for competence and relatedness were satisfied. .

Relationships between BRWQ and PNSWS and walking behaviour.

Additional evidence for the convergent and discriminant validity of measures can be obtained by demonstrating that they are also related to an outcome behaviour in a theoretically meaningful way. In this study there was a mixed picture regarding the relationships between behavioural regulations and walking behaviours, dependent on the type of walking. For the behaviours of walking for transport and walking for leisure, the relationships were similar and were generally in the expected direction based on previous research. Specifically, regulations reflective of more autonomous motivation were positively related, there was no relationship for introjection, and amotivation and external regulations were negatively related to the behaviours (Teixeira et al., 2012) . There was one exception to this consistent patterning between the two behaviours, as walking for transport was significantly associated with integrated regulation, but walking for leisure was not (although the difference in size of associations was relatively small). Previous research has also shown inconsistent findings in relation to the relationship between integrated regulation and behaviour (Teixeira et al., 2012) , perhaps suggesting other variables such as the specific nature of the behaviour (e.g., type of exercise) or sample characteristics may influence the relationship. Overall, these findings could suggest that the motivational processes underpinning walking for transport and walking for leisure are very similar, although individuals who more strongly identify with walking may be more likely to walk for transport. It is notable that the size of the associations between the BRWQ subscales and walking for leisure and transport were relatively small ($rs \leq 0.20$), These findings reinforce the social ecological perspective (Sallis et al., 2008) that although motivational processes are important, other factors (e.g., physical environment) are also influential on walking behaviour.

With regards to walking at work, there were no significant relationships between any of the behavioural regulations and the behaviour, suggesting different motivation processes may underpin this specific behaviour. As noted in the Introduction, some forms of walking may be more purposeful than others. It is likely that walking at work is not a volitional activity that is influenced by deliberative motivational processes, but instead is more influenced by the physical and social environment in which one works. Thus the lack of significant relationships between the BRWQ subscales and walking at work provides some evidence of the discriminant validity of the BRWQ. Specifically, the findings demonstrate that behavioural regulations were significantly associated with behaviours that are dependent on cognitive motivational processes, but *not* with a behaviour that is less volitional. Furthermore, although additional research is clearly needed, these differential findings highlight the importance of being wary of using composite measures of walking and the need to carefully consider the domain and reasons for walking in order to fully understand the determinants of this behaviour.

In relation to the PNSWS**,** previous exercise based research has been relatively limited and shown mixed findings for the relationship between needs satisfaction and behaviour (Teixeira et al., 2012), therefore it is less clear what may be expected in order to support convergent validity. In this study there were no significant relationships between needs satisfaction and walking at work or for transport. This suggests that satisfaction of these needs may not be needed in order to engage in these behaviours. However, walking for leisure was significantly related to competence and autonomy, but not relatedness. Previous research has shown that competence satisfaction is consistently related to exercise behaviour (Teixeira et al., 2012). Previous findings relating to autonomy are more inconsistent, but in the current study the feeling that one can freely choose to engage in leisure walking behaviour appears to be important. Consistent with some previous studies, there was no relationship between relatedness satisfaction and walking for leisure (Teixeira et al., 2012), suggesting that this need was not important, perhaps because people may choose to walk on their own. It was evident that the relationships between needs satisfaction and behaviour varied by walking type, again reinforcing the need to consider the nature and measurement of walking carefully in future research.

Limitations and future directions

The findings of this study provide some preliminary support for the credibility of the psychometric properties of the walking measures; however instrument development is an on-going process and further research is needed to corroborate these findings. Particularly, additional research is needed to consider the fit of two items on the PNSWS that performed poorly in the current analysis. Further research is also needed in order to consider factorial invariance in different groups as this was not feasible in this sample due to a large proportion of female participants.

A strength of this study was the focus specifically on the behaviour of walking as opposed to general physical activity, however the use of a self-report measure of walking is a limitation. Although the measure used, the IPAQ, has established reliability and validity (Craig et al., 2003) and provided important information relating to the context of walking, there are recognized shortcomings with self-report measures of physical activity including inaccuracy of recall and social desirability (Standage & Ryan, 2012). Future research using objective measures of walking as an outcome measure, with additional measures relating to the context of walking, would be valuable.

From this study, instruments have been developed that can be used to investigate further the motivational processes underpinning the important health behaviour of walking. Future research should consider further the relationship between needs satisfaction, behavioural regulations and actual short-term and long-term walking behaviour in different groups (e.g., older adults). Importantly, future research should consider carefully the different types and domains of walking, as they appear to be underpinned by different motivational processes. The findings of such research could be used to inform walking interventions in order to promote optimal motivation and behaviour change. Finally, these measures could also be used to examine the motivational mechanisms underpinning changes in walking behaviour following interventions.

Conclusions

The findings of this study provide initial evidence that the BRWQ and PNSWS have acceptable psychometric properties and demonstrate the advantages of BSEM as a theoretically-grounded but empirically more realistic method over the traditional ICM approach. Thus the study contributes to the literature both by providing measures that can be used to credibly examine the motivational processes related to walking and methodologically. This study also provides some preliminary insight into the motivational processes related to walking and some support for the usefulness of SDT in understanding walking behaviours. Importantly, it was evident that the nature of walking behaviour must be considered carefully in future research because different types and domains of walking may be influenced by different motivational processes.

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Table 1

BSEM fit and convergence

Model	No. free parameters	PPP	Difference between observed and replicated χ^2 95% CI Lower 2.5%	Upper 2.5%	PSR
BRWQ					
Non- informative	84	.000	489.04	605.28	1.00
Informative priors (crossloadings)	199	.000	241.77	373.20	1.01
Informative priors (cross-loadings + residual correlations)	452	.575	-76.16	61.03	1.01
PNSWS					
Non- informative	57	.000	2037.07	2131.83	1.00
Informative priors (crossloadings)	93	.000	348.60	498.54	1.01
Informative priors (cross-loadings + residual correlations)	246	.536	-57.29	54.66	1.01

Note: PPP = posterior predictive p value; PSR = potential scale reduction

Table 2

BRWQ standardized factor loadings with 95% credibility intervals in brackets

Item	Amotivation	External	Introjected	Identified	Integrated	Intrinsic
I don't see why I should have to walk	**.65 [.37,.93]**	.09 [-.16,.29]	.00 [-.19,.19]	-.02 [-.28,.23]	-.03 [-.23,.19]	-.02[-.27,.24]
I can't see why I should bother walking	**.78 [.56,1.0]**	.02 [-.20,.22]	.00 [-.17,.21]	.03 [-.23,.28]	.02 [-.19,.23]	-.03[-.28,.24]
I don't see the point in walking	**.77 [.51,1.0]**	-.01[-.26,.20]	.02 [-.20,.20]	.02 [-.24,.29]	.00 [-.22,.21]	-.06 [-.20,.32]
I think walking is a waste of time	**.75 [.54,.98]**	.03 [-.19,.23]	.00 [-.19,.18]	.00 [-.27,.27]	.01 [-.19,.22]	.00 [-.26,.27]
I walk because other people say I should	-.06 [-.29,.15]	**.78 [.53,.99]**	.02 [-.18,.19]	-.01 [-.21,.20]	.02 [-.17,.20]	-.01[-.21,.20]
I take part in walking because my friends/family/work colleagues say I should	.00 [-.21,.21]	**.79 [.57,.98]**	.00 [-.19,.17]	.00 [-.20,.20]	-.02 [-.20,.17]	.03 [-.17,.23]
I walk because others will not be pleased with me if I don't	.05 [-.20,.29]	**.61[.35,.82]**	.01[-.18,.19]	.03[-.23,.30]	.05[-.16,.25]	-.07[-.33,.19]
I feel under pressure from my friends/family/work colleagues to walk	.17 [-.09,.40]	**.55[.27,.79]**	.04 [-.16,.22]	-.01[-.25,.23]	.00 [-.19,.19]	.02 [-.22,.26]
I feel guilty when I don't walk	.00 [-.15,.15]	.00 [-.15,.14]	**.80 [.60,.97]**	.01 [-.14,.15]	.00 [-.14,.14]	.00 [-.14,.15]
I feel ashamed when I miss a walking session	-.01 [-.17,.16]	.03 [-.13,.19]	**.80 [.59,.96]**	.01 [-.15,.16]	.01 [-.14,.16]	-.02 [-.22,.26]

I feel like a failure when I haven't walked in a while	.00 [-.16,.16]	-.01 [-.18,.16]	**.77 [.55,.95]**	.00 [-.15,.15]	.01 [-.14,.15]	-.01 [-.16,.14]
I value the benefits of walking	-.01 [-.20,.19]	.01 [-.18,.18]	-.01 [-.17,.15]	**.68 [.34,.99]**	-.03 [-.22,.15]	.03 [-.20,.25]
It's important to me to walk regularly	.00 [-.15,.15]	-.01 [-.16,.13]	.02 [-.11,.10]	**.83 [.56,1.0]**	.00 [-.16,.15]	-.01 [-.18,.16]
I think it is important to make the effort to walk regularly	-.09 [-.29,.11]	-.01 [-.18,.16]	-.06 [-.22,.20]	**.63 [.22,1.0]**	-.02 [-.23,.16]	.19 [-.12,.49]
I get restless if I don't walk regularly	.03 [-.12,.17]	.00 [-.14,.14]	.03 [-.11,.15]	**.85 [.62,1.0]**	.05 [-.09,.19]	-.03 [-.18,.11]
I walk because it is consistent with my life goals	-.02 [-.16,.14]	.01 [-.13,.14]	.02 [-.11,.16]	.01 [-.13,.16]	**.75 [.53,.96]**	.02 [-.13,.16]
I consider walking to be part of my identity	.00 [-.12,.12]	-.01 [-.12,.20]	.00 [-.11,.10]	.02 [-.10,.14]	**.86 [.71,1.0]**	.02 [-.10,.14]
I consider walking a fundamental part of who I am	.00 [-.11,.12]	-.02 [-.13,.09]	-.01 [-.12,.09]	-.04 [-.16,.08]	**.96 [.80,.1.0]**	-.03[-.15,.09]
I consider walking consistent with my values	.01 [-.13,.14]	.03 [-.09,.15]	-.01 [-.13,.10]	.01 [-.12,.15]	**.86 [.68,1.0]**	.01 [-.13,.15]
I walk because it's fun	.02 [-.16,.20]	.01 [-.15,.17]	-.04 [-.19,.11]	.01 [-.12,.15]	.06 [-.12,.22]	**.77 [.47,1.0]**
I enjoy my walking sessions	-.02 [-.18,.16]	.01 [-.15,.17]	.01 [-.14,.15]	.04 [-.20,.26]	-.03 [-.21,.13]	**.81 [.50,1.0]**
I find walking a pleasurable activity	-.02 [-.22,.18]	.02 [-.15,.19]	.01 [-.09,.24]	.03 [-.19,.24]	.01 [-.18,.18]	**.70 [.35,1.0]**
I get pleasure and satisfaction from participating in walking	-.01 [-17,.16]	-.05 [-.20,.09]	-.01 [-.15,.13]	.05 [-.17,.25]	.03 [-.13,.17]	**.74 [.46,1.0]**

Note: Loadings and 95% CIs on intended factors in bold text.

Table 3

PNSWS standardized factor loadings with 95% credibility intervals in brackets

Item	Autonomy	Competence	Relatedness
I feel free to walk in my own way (i.e., where, when, how)	**.69 [.32,.99]**	-.03 [-.23,.17]	-.04[-.23,.73]
I feel free to make my own walking program decisions	**.65 [.23,.99]**	-.02 [-.22,.18]	-.02 [-.23,.17]
I feel like I am in charge of my walking program decisions	**.59 [.17,.95]**	-.02 [-.22,.18]	-.03 [-.23,.17]
I feel like I have a say in choosing the walking that I do	**.34 [.07,.67]**	.06 [-.12,.24]	.13 [-.23,.17]
I feel free to choose which walking I participate in	**.62 [.27,.96]**	.05 [-.16,.25]	.04[-.17,.24]
I feel like I am the one who decides what walking I do	**.51 [.17,.87]**	.05 [-.15,.24]	.06 [-.15,.25]
I feel that I am able to complete walking that is personally challenging	.01 [-.18,.20]	**.73 [.40,.99]**	-.04 [-.23,.14]
I feel confident I can do even the most challenging walking	.05 [-.15,.25]	**.66 [.31,.97]**	-.17 [-.21,.18]
I feel confident in my ability to perform walking that personally challenges me	-.01 [-.20,.18]	**.60 [.26,.93]**	.07 [-.14,.26]
I feel capable of completing walking that is challenging to me	-.02 [-.20,.16]	**.64 [.29,.93]**	.02 [-.17,.20]
I feel like I am capable of doing even the most challenging walking	.01 [-.20,.20]	**.68 [.30,.99]**	.04 [-.17,.24]
I feel good about the way I am able to complete challenging walking	.00 [-.20,.20]	**.66 [.24,.98]**	-.03 [-.22,.17]
I feel attached to my walking companions because they accept me for who I am	.11 [-.08,.29]	.03 [-.15,.21]	**.42 [.12,.73]**

I feel like I share a common bond with people who are important to me when we walk together	.01 [-.19,.21]	-.01 [-.20,.18]	**.72 [.39,.99]**
I feel a sense of camaraderie with my walking companions because we walk for the same reasons	.04 [-.15,.22]	.04 [-.16,.22]	**.57 [.25,.89]**
I feel close to my walking companions who appreciate how difficult walking can be	-.02 [-.22,.17]	.02 [-.19,.22]	**.71 [.36,.99]**
I feel connected to the people who I interact with while we walk together	-.07 [-.26,.14]	.01 [-.22,.18]	**.71 [.28,.99]**
I feel like I get along well with other people who I interact with while we walk together	.04 [-.16,.22]	.00 [-.20,.18]	**.64 [.27,.97]**

Note: Loadings and 95% CIs on intended factors in bold text.

Table 4

Means, SDs, Composite Reliabilities (CR) and Latent Factor Inter-correlations, and their 95% Credibility Intervals [in brackets] for the BRWQ and PNSWS

	M	*SD*	CR	Amotivation	External	Introjected	Identified	Integrated	Competence	Relatedness
Amotivation	0.16	0.47	.83							
External	0.33	0.54	.78	.42 [.10,.68]*						
Introjected	1.20	1.01	.83	.01 [.32,.32]	.23 [-.07,.49]					
Identified	2.74	0.92	.84	-.35 [.65,.02]*	-.19 [-.50,.18]	.43 [.18,.64]*				
Integrated	1.86	1.24	.92	-.23 [-.54,.12]	-.11 [-.41,.23]	.43 [.21,.60]*	.76 [.65,.85]			
Intrinsic	2.96	0.87	.91	-.44 [.74,.06]*	-.17 [-.50,.20]	.34 [.04,.58]*	.88 [.71,.96]	.67 [.50,.80]		
Autonomy	4.35	0.69	.75						.84 [.70,.92]	.82 [.66,.91]
Competence	3.95	0.91	.82							87 [.76,.93]
Relatedness	3.36	1.01	.80							

Table 5

Bivariate Correlations Between BRWQ and PNSWS Subscales and the Measures of Walking Behaviour

	Autonomy	Competence	Relatedness	Amotivation	External	Introjected	Identified	Integrated	Intrinsic
Amotivation	-27**	-.27**	-.16**						
External regulation	-.26**	-.20**	.02						
Introjected regulation	.01	.16**	.23**						
Identified regulation	.23**	.35**	.22**						
Integrated regulation	.18*	.34**	.27**						
Intrinsic regulation	.28**	.38	.29**						
Walking work	.05	.07	.00	.02	.02	.03	-.02	.10	-.02
Walking transport	.09	.10	-.04	-.11*	-.12*	.02	.19**	.12*	.15**
Walking leisure	.16*	.21**	.02	-.14*	-.17**	-.09	.21**	.09	.20**

Note: * $p < .05$; ** $p < .01$