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Postpartum Physical Activity: Measuring Theory of Planned Behavior Constructs

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Abstract

Objective—top develop and examine evidence for factor validity and longitudinal invariance of scales used to measure theory of planned behavior constructs applied to physical activity.

Methods—Self-report questionnaires were administered at 3- (n=267) and 12-months (n=333) postpartum. Longitudinal data were available for 185 of these women.

Results—A single factor model fit data from the normative beliefs, perceived behavioral control, and behavioral beliefs scales. Attitude and control beliefs were found to be multidimensional. Longitudinal invariance of all scales was supported.

Conclusions—Each scale had strong validity evidence. Future research using these measures will help identify areas for intervention and reveal how changes in constructs influence physical activity over time.

Keywords

postpartum; exercise; physical activity; theory of planned behavior; validity; invariance

Introduction

Despite research indicating that physical activity benefits women both during and after pregnancy¹⁻³, many women stop exercising or substantially reduce physical activity levels during this time.⁴⁻⁶ In addition, excess weight gained during pregnancy is often retained because women do not return to previous physical activity levels postpartum. While, it is generally accepted that the unique physical and psychological demands during pregnancy and postpartum increase a women's risk of becoming and remaining inactive, there is limited information concerning the determinants of this change in physical activity. Studies in this area are often small, cross-sectional and lack measures adequate to explore theories of this behavioral change.⁶⁷⁻⁹ Public health messages and interventions for pregnant and postpartum women would benefit greatly from research that examines the predictors of

physical activity over time, is grounded in behavioral theory, and includes sound measurement of underlying theoretical constructs.¹⁰

One theoretical model that has been applied to understanding physical activity behavior in other populations is the theory of planned behavior (TPB).¹¹ This theory proposes that intention is the central determinant of a given behavior. If an individual evaluates the behavior positively (positive attitude), believes that important others think they should perform it (positive subjective norm), and perceive it to be under their control (positive perceived behavioral control), their intention to perform the behavior will be higher. In addition, attitudes, subjective norms, and perceived behavioral control are thought to be influenced by population- and situation-specific belief structures.^{10, 12} Measures of these underlying behavioral, normative, and control beliefs are rarely included in studies examining the TPB⁷, even though some researchers suggest that these measures are extremely important to understanding the specific factors that drive behavior¹³.

During recent years, constructs included in the TPB have been shown to influence, or mediate, physical activity to varying degrees¹⁴, including in pregnancy and postpartum.⁶ While differences across studies can be partially attributed to sample or outcome specific variation, errors of measurement likely play a role in the inconsistent findings. It is common for researchers to have content experts review construct measures and report internal consistency, but few examine factor validity or factor invariance. Tests of factor validity are used to determine if the relationships among the items match with the hypothesized theory of the construct, or how we think they represent a given construct.^{15, 16} When we add or average a set of items to obtain a single scale score, we imply that all items indicate a single latent factor and that all items are equally important to the definition of that factor. We have, in effect, imposed a factor structure on those items, which may or may not be correct. Tests of factor invariance are used to examine the extent to which the relationships among items are comparable over time or between groups (i.e., similarity of the factor structure and parameter values).¹⁷ If the relationship among items changes over time or is different between groups of people, then it is difficult to conclude that we are measuring the same thing even if the items are identical.

Of the studies found using the TPB to study exercise or physical activity among pregnant and postpartum women, none reported factor validity or invariance.^{8, 18-20} If scale scores are used to compare groups, model behavior, or examine change over time, it is necessary to first establish evidence of these measurement properties. Omitting integral steps in the instrument development process may leave researchers with inadequate construct measures for theory testing. Based on these limitations, the primary purpose of this paper was to produce and examine evidence for factor validity and longitudinal invariance of construct measures included in the TPB applied to physical activity in a sample of postpartum women. It was our intention to create measures to assess all hypothesized constructs included in the TPB and to create scales useful to other researchers.

Methods

The third phase of the Pregnancy, Infection, and Nutrition (PIN3) Study recruited pregnant women less than 20 weeks' gestation seeking prenatal care at clinics associated with the University of North Carolina Hospitals. Trained staff identified women through review of all medical charts of new prenatal patients. Women were not enrolled if they were non-English speaking, under the age of 16 years, carrying multiple gestations, not planning to continue care or deliver at the study hospital, or did not have a telephone from which they could complete the phone interviews. Recruitment began in January 2001 and continued through July 2005, with the last birth occurring in December 2005. During pregnancy, women were

asked to complete two telephone interviews, two clinic visits, two self-administered questionnaires, and a food frequency questionnaire. After delivery, a subset of women were asked to complete an in-home visit and a mail-back questionnaire at 3- and 12-months postpartum. More information on the PIN3 Study and protocols is available elsewhere⁴ (<http://www.cpc.unc.edu/projects/pin>). The procedures followed for this study were in accordance with the ethical standards of the Institutional Review Board of the University of North Carolina and all participants provided written informed consent.

Theory of Planned Behavior Measures

A self-administered questionnaire which included items from the TPB was given to women during the 3-month and 12-month postpartum in-home visit. They were asked to mail the questionnaire back in a pre-paid envelope and were paid \$5 for each questionnaire completed. For the purpose of this project, items were developed to measure seven constructs: behavioral beliefs, normative beliefs, control beliefs, attitude, subjective norms, perceived behavioral control, and intention. Item development was based on early recommendations of Ajzen¹¹ and on more current applications by Courneya and Friedenreich.²¹ Although we did not conduct an elicitation study per se, item content was based on a review of the literature and qualitative work done with pregnant women.²² Items for all scales were derived to be specific to postpartum women and were reviewed by the research team before distribution. Each item was rated on a 7-point scale (−3 to 3) anchored at each end by a descriptor (e.g., strongly disagree to strongly agree). A summary of the scales can be found in Table 1.

Other Measures

Women were asked about their race/ethnicity, education, and parity (live plus still births) during pregnancy. At the 3- and 12-month postpartum in-home interview, women were asked to report their work, marital, and breastfeeding status. Physical activity was also measured at this time using a one-week recall developed specifically for this study population.^{4, 23} The questionnaire assessed frequency and duration of all moderate and vigorous physical activities, including those done at work, leisure, for transportation, childcare, adult care, and indoor/outdoor household activities. Weight and height were measured during the 3- and 12-month postpartum in-home visit. Body mass index (BMI) was categorized as low ($<18.5 \text{ kg/m}^2$), normal ($18.5\text{--}25.0 \text{ kg/m}^2$), overweight ($25.0\text{--}30.0 \text{ kg/m}^2$), and obese ($\geq 30.0 \text{ kg/m}^2$).²⁴

Data Analysis

All models were tested with full-information maximum likelihood estimation in AMOS 5.0 (SmallWaters Corp., Chicago, IL; Arbuckle & Wothke, 1999). Item/scale descriptive statistics were obtained using SAS 9.0 (SAS, Inc., Cary, NC; 2005). The 3- and 12-month postpartum samples consisted of $n=267$ and $n=333$ women, with $n=185$ completing measures at both time points. Prior to factor validity and invariance analyses a random holdout sample was selected from both the 3- and 12-month data. The two holdout samples included 50% of the women from the 3 and 12-month samples ($n = 133$ and $n = 167$). The holdout samples were used to conduct exploratory analyses when the hypothesized factor structure failed to provide adequate fit to the data. Changes suggested by the exploratory findings were then cross-validated with the other half of the sample. Given the size of the exploratory and confirmatory samples and the number of items, the subject-to-item ratios ranged from 14:1 to 55:1. This is more than adequate to have confidence in the results.²⁵

Factor validity and model selection—The factor validity of scales was examined first by fitting the hypothesized model to the data using confirmatory factor analysis. The

behavioral beliefs, normative beliefs, control beliefs, attitudes, and perceived behavioral control were each hypothesized to be multiple item indicators of single latent factors (Table 1). Because the subjective norms and intentions scales are composed of only one item each, factor validity and invariance were not examined. The adequacy of each model was assessed separately at 3- and 12-months postpartum. Model misfit was assessed by examining global fit indices, parameter estimates, and standardized residual estimates.^{26, 27} If the hypothesized model was not supported, modification indices, standardized residuals, exploratory techniques, and the interrelationships among items were examined in a hold out sample to determine if misfit was a function of a problem item or the hypothesized factor structure. Model modifications were limited to adjustments due to features of the indicators (e.g., misfit due to similar responses formats), previous research, and theoretical considerations. Because scales will ultimately be used to test the TPB over time, the same model modifications were applied to both 3- and 12-month data to assure scales had the same factor structure at both time points. The revised model was then fit to data from the cross-validation sample (3 month n=134; 12 month n=166).

Model fit—The root mean square error of approximation (RMSEA), non-normed fit index (NNFI), comparative fit index (CFI), and the chi-square statistic were used to evaluate and compare model fit. These fit indices complement one another, and each reflects a unique and important property of overall model fit.²⁸ The RMSEA is a standardized estimate that indicates closeness of fit of population data to the model. It is widely used and is considered one of the most informative fit criteria.²⁶ Values of the RMSEA less than or equal to 0.05 reflect close fit of the model.^{27, 29} The 90% confidence interval (CI) for the RMSEA is also presented. The NNFI and CFI indicate proportionate improvement in fit by comparing the hypothesized model to a null baseline model.^{30, 31} The NNFI is affected by model parsimony (more complex models are penalized), whereas the CFI is not. Values for the NNFI and CFI greater than or equal to 0.95 indicated good fit.^{27, 30} The χ^2 statistic was used to assess absolute fit of the model to the data. This statistic is very sensitive to sample size and suggests rejection of the hypothesized model in most cases.^{15, 32} For this reason, it is reported but used with other indicators to draw specific conclusions about model fit. In addition, parameter estimates, standard errors, t-values, and squared multiple correlations were inspected for sign and magnitude.

Longitudinal invariance—After establishing a good fitting model, the longitudinal factor invariance for each scale was examined in the women that completed each measure at both 3- and 12-months postpartum (n = 185). Measurement invariance should be established to support conclusions drawn about group differences or longitudinal change. The invariance analysis involved testing and comparing a series of nested models using standard procedures.^{15, 17, 33} Models were considered nested if a simpler model could be obtained by imposing a set of restrictions on a more complex model. The only difference between the models was the number of free and fixed parameters estimated (i.e., the nested, or simpler, model has more fixed, or constrained parameters). The general model used to test longitudinal invariance of each scale is displayed in Figure 1. The model depicted is a two-wave (3-month and 12-month) single factor model which includes autocorrelated errors.³⁴ The measurement error terms were allowed to covary, because some of the systematic variance unaccounted for by the latent factor should be the same for a given item over time. The stability, or the extent participants remain in the same order over time, was also assessed. The stability coefficient was estimated as the correlation between the latent factors over the two time points.

The invariance analysis involved testing and comparing three models. Each model included previous model restrictions (i.e., model 3 included restrictions from model 2) plus additional constraints, resulting in a series of nested models. In model 1, all parameters were freely

estimated, but the pattern of paths, factors, and variances terms were the same for 3- and 12-months groups. In model 2, factor loadings were held equivalent over time. For model 3, the factor variance and covariance terms were added to those set as invariant. When fit indices are compared across the 3 models we can determine if model fit is affected by constraining sets of parameters. The equivalence of models 1 and 2 was considered sufficient evidence to conclude longitudinal invariance (i.e., that the underlying construct had the same “meaning” over time).²⁶

Nested models were compared based on χ^2 difference tests and changes in the values of the RMSEA, NNFI, and CFI. Although χ^2 difference tests were conducted and reported, examining differences in the RMSEA, NNFI, and CFI has been found to be superior to interpretations based strictly on χ^2 difference tests.^{35, 36} Absolute change in CFI of 0.01 and RMSEA of 0.01 to 0.015 between nested models was used to judge meaningful change in fit between models. These criteria have been reported to work well for testing multi-group invariance.³⁶

Results

At 3-months postpartum women were 31.0 ± 5.5 years of age with an average body mass index of 28.0 ± 7.4 kg/m². Most were white (75.3%) or African American (15.0%), only 14.6% had less than a high school education, and about half were working at the 3 month interview. For 49.1% of women this was their first pregnancy and most women participated in less than 4 hours of moderate or vigorous physical activity per week. Additional sample descriptive statistics can be found in Table 2.

The proportion of women missing a response for a given TPB item ranged from 0% to 1.1% at 3 months and 0% to 1.8% at 12 months. At both time points, most women had no missing responses (3 months = 92.5%; 12-months = 89.2%). Items from the three belief scales (behavioral, normative, and control) were originally rated on both an expectancy scale and value scale. Based on previous research³⁷ and our preliminary analysis, the inclusion of the value ratings in the scoring of the beliefs scales (expectancy x value) did not add information or change the results. For this reason value ratings were not used to calculate scores for the belief scales. Item means, standard deviations, and correlations are shown in Table 3. In general, women rated items greater than 1 suggesting that they believed physical activity was enjoyable, helped them look and feel better, and that significant others approved of their physical activity level.

Factor Validity

Fit indices for the final model for each scale can be found in Table 4. The hypothesized single factor model fit well for both normative beliefs and perceived behavioral control at 3- and 12-months postpartum. For normative beliefs, factor loadings ranged from 0.59 to 0.87 with squared multiple correlations above 0.34. Standardized factor loadings in the model for perceived behavioral control were also good, ranging from 0.68 to 0.98. It should be noted that the error variance for one item (“If I wanted to I could easily engage in physical activity”; PBC3) was not significantly different from zero at 3- and 12-months postpartum.

For behavioral beliefs the fit of the hypothesized 6-item single factor model was questionable at both 3-months (CFI=0.928, NNFI=0.832, RMSEA [90% CI] = 0.148 [0.114 – 0.184]) and 12-months postpartum (CFI=0.956, NNFI=0.897, RMSEA [90% CI] = 0.103 [0.072 – 0.136]). Exploratory analysis conducted with data from the holdout samples at 3- and 12-months postpartum suggested that substantial error covariance existed between the item “relieve stress” and the items “look better”(BB3) and “manage responsibilities”(BB5). Removing “relieve stress” resulted in a good fitting model in the holdout samples. Adequate

fit for this model was also found in the 3- and 12-month postpartum cross validation samples. Fit indexes for the new 5-item single- factor model can be found in Table 4.

The hypothesized model for the attitude scale did not adequately fit the data at 3-months (CFI=0.769, NNFI=0.653, RMSEA [90% CI] = 0.310 [0.283 – 0.337]) or 12-months postpartum (CFI=0.874, NNFI=0.811, RMSEA [90% CI] = 0.272 [0.247 – 0.297]). The exploratory analysis revealed two groups of related items. The items beneficial, wise, and foolish have, in the past, been classified as instrumental, while enjoyable, interesting, and pleasant represent more affective attitudes. Instrumental attitudes are thought to have a more cognitive focus whereas affective attitudes tend to be more emotional. . One item “useless/useful” had a moderate loading with both instrumental and affective items. For this reason it was dropped and the model was respecified as a two-factor model. While the two factor model fit quite well in both the hold out and cross-validation samples (Table 4), the correlation among the factors at 3-months (0.721) and 12-months postpartum (0.842) suggest that a single higher order factor may best represent these two factors. A higher order factor model includes a group of latent factors which are interrelated in a way that suggests they are indicators of a higher order latent factor. Although a correlated two-factor and a higher-order model can not be compared for 3- or 12-month data separately (not enough degrees of freedom), comparisons between the two models can be made using the longitudinal data. Figure 2 shows the general form of the correlated factors and higher order model using longitudinal data. In the higher-order model the second order factor, “Attitudes” is indicated by two first order factors (instrumental and affective attitudes). The results comparing the two models using the longitudinal data suggests that a 2nd-order model is simpler and explains the relationship among the items just as well as the correlated two-factor model (see Table 4). In this model the factor loadings for the higher-order “attitudes” were > 0.78 and the correlation between the latent “attitudes” factor at 3-month and 12-months was 0.438.

The fit of the hypothesized model for control beliefs was poor at 3-months (CFI=0.664, NNFI=0.552, RMSEA [90% CI] = 0.162 [0.142 – 0.183]) and 12-months postpartum (CFI=0.703, NNFI=0.506, RMSEA [90% CI] = 0.149 [0.131 – 0.167]). After the exploratory analyses a two factor model which included 5 of the original items was specified and found to fit well in both the holdout and cross-validation samples. The final model included two items reflecting ability related control beliefs (tired[AC1] and not feeling best[AC2]) and three items reflecting resource related control beliefs (people[RC1], places[RC2], child care[RC3]). This revised model fit reasonably well for women at 3- and 12-months postpartum in the cross-validation sample (CFI > 0.95, NNFI > 0.93, RMSEA < 0.090). The correlations among the factors were 0.44 and 0.581 at 3- and 12-months. For control beliefs, the longitudinal data was also used to examine whether the multidimensional nature of each scale is best represented by two distinct but correlated factors or a single higher order factor indicated by the ability related and resource related control belief factors. The results obtained from the post-hoc analysis indicate that the correlated factors model fit the data better than the higher order model. This suggests that ability related and resource control beliefs should be modeled separately.

Invariance

Results of the invariance analysis can be found in Table 5. The fit of the longitudinal model for each scale was good (CFIs > 0.95, RMSEA < 0.090). With the exception of the behavioral beliefs scale, restricting the factor loading and factor variance to be equivalent over time did not substantial change the values of the CFI or RMSEA. For behavior beliefs, restricting all factor loadings resulted in a slight, but significant ($|\Delta\text{CFI}| > 0.01$) decrease in the model fit. Post-hoc analysis (comparing loadings in the unconstrained model) revealed that the loading for item 2 (“feel better”) was lower at 12-months compared to 3-months

postpartum (0.786 vs 0.499). Freeing this one loading resulted in a model with partial measurement invariance.

Internal Consistency and Longitudinal Stability

The range in standardized regression weights, squared multiple correlations, and internal consistency (Cronbach's alpha) for the indicators of each construct are presented in Table 6. All loadings and squared multiple correlations were in the expected direction and of acceptable magnitude. The internal consistency reliabilities for scales ranged from 0.579 to 0.958. Most values were above 0.750. The lowest values were for the resource control belief scale (3-month alpha = 0.605; 12-month alpha = 0.579). The high internal consistency reliabilities for affective and instrument attitudes suggest some redundancy in the information obtained from the three items. Correlation between each factor at 3- and 12-months postpartum are also presented in Table 6. The factor correlations represent the stability of the measured construct over the 9 month postpartum period. Factor correlations ranged from 0.236 to 0.802, with most values above 0.55 indicating moderate to substantial stability.

Discussion

To our knowledge this is the first study to test the factor structure and longitudinal invariance of constructs used to examine the TPB for physical activity in a group of postpartum women. Results support the factor validity of all scales. While the hypothesized factor structure was not found to fit data from responses to each scale, a good fitting and theoretically sound model was developed and cross-validated for each construct. Single factor models were found for perceived behavioral control, normative beliefs, and behavioral beliefs. The attitude and control beliefs scales were found to be multidimensional. Subjective norms and intentions were measured as single item indicators therefore no evaluation of factor structure or invariance could be made.

Results also supported the longitudinal invariance of all scales, suggesting that the interrelationship among items was similar over time. Factor invariance is important to establish before scores (item or scale) are used to model theoretical relationships over time or across groups. If the meaning of a scale, or group of items, changes (e.g., over time or from group to group) then comparisons are somewhat meaningless because the same construct is not being measured. Our results indicated that no substantial changes occurred in how women interpreted items from 3- to 12-months postpartum. Considering the vast literature using the TPB,^{7, 14} very few studies have examined measurement invariance. It is obvious that more work is needed in this area.

There is a growing body of research examining the multidimensionality of the TPB.^{38, 39} Our results add to this literature by suggesting that the attitudes and control beliefs scales are multidimensional. Similar to others, we found that postpartum women make distinctions between instrumental and affective attitudes.⁴⁰ While our data suggests these factors are highly correlated and may be best represented by a single higher order factor, others have reported that the two attitude factors relate differently to intentions and should be modeled separately.³⁹⁻⁴¹ The two-factor model found to fit best for control beliefs also lends support to a multidimensional model at the belief structure level. While it is likely that people differentiate various control beliefs, this may also reflect the multidimensionality of perceived behavioral control.^{12, 13} Unfortunately, because measures in this study were not conceptualized and constructed to be multidimensional (e.g., the perceived behavioral control scale was comprised of items which reflect controllability and not self-efficacy) conclusions about the dimensionality of each TPB scale could not be made.

Given that multidimensionality of the TPB is rarely considered when measures are created, more work is needed to fully develop the various dimensions and items used as indicators in this theory. For example, in the current study the modification to the control beliefs scale resulted in dropping items related to time, injury, and safety. It is possible that these concepts are legitimate beliefs that may impact perceived behavioral control, but the construct, or dimensions to which they “belong” need to be better developed. For example, safety beliefs may be distinct from ability and resource beliefs, but because we measured safety with a single item, its construct was underrepresented resulting in an item that did not relate strongly with other items and decreased model fit. In order to test this hypothesis additional safety items would have to be developed.

While creating new indicators may improve the predictive power of the TPB, researchers must also be aware that even theoretically sound and logical items can be problematic or unnecessary. For example, time is often reported as a significant barrier to physical activity. Therefore we assumed that beliefs about time should be included when measuring control beliefs. But in our final model, the control belief item related to time was eliminated. While initially troubling, a possible explanation emerged as the analysis progressed. Beliefs about time are a *function* of more specific control beliefs. This makes sense when we consider that being “tired” may result in more sleeping during free time and having “no child care” results in less free time. Both contribute to one's belief about free time to be physically active. In effect, a large part of the variance in the time item is modeled within the two more specific factors. In our sample this resulted in an item (time) that added very little to the construct. In the end it is possible that more indicators are needed to fully capture the multidimensionality of the TPB, but it is also important to realize that more items do not always equal better measures.

We were unable to find a single study of physical activity behavior in pregnant or postpartum women that included measures of the antecedent belief structures thought to underlie attitudes, subjective norms, and perceived behavioral control.^{8, 18, 20} This is unfortunate given the fact that targeting specific beliefs is thought to have the most behavioral impact.^{13, 42} Perhaps the fact that researchers have found many of these underlying belief structures to be population or situation specific has limited their use by making them difficult to identify and quantify. At least one study has made important strides in this area by identifying exercise beliefs in 74 postpartum women.⁶ In this elicitation study, open ended questions were used to identify the top normative, behavioral, and control beliefs underlying women's pregnancy and postpartum exercise. The normative (e.g., husband, other family, children, friends) and behavioral (e.g., control weight, stay fit, better mood and energy) beliefs were very similar to those measured and retained in our final models. For control beliefs the ability related control beliefs (tired and not feeling best) were also reported by Downs and Hausenblas⁶ (2004), but the three resource related control beliefs (no partner, no place, and no child care) were not. “Lacking time” was noted by Downs and Hausenblas⁶ (2004) and may correlate substantially with presence or absence of exercise partners, places, and childcare serving as a more general surrogate. Based on Ajzen^{11, 12} conceptualization of control beliefs (i.e. factors that may facilitate or impede performance), the high stability of the factor, and the distribution of responses in our sample it seems that resource control beliefs should not be overlooked when examining the beliefs underlying perceived behavioral control in postpartum women. While studies have reported significant relationships among constructs measured in the TPB many instruments used to quantify these constructs are not completely developed. Whether it be not measuring all constructs within the theory or lack of validity or reliability evidence inadequate measurement limits the theory testing process.

This study is an important step to better understanding exercise behavior in postpartum women, and like all studies, strengths and limitations should be acknowledged. While all TPB constructs were measured in the sample, scales were not created to be multidimensional and several included only one item. It is not uncommon for constructs within this theory to be measured with a single item,^{9, 20} but multi-item scales are generally considered more reliable and will be needed if a more complex multidimensional model is to be tested. Another possible limitation is generalizability. The sample that completed 3- and 12-month postpartum measurement were slightly different than the total population of women eligible to participate. A comparison of sociodemographic data from 710 women that did not complete the 3- or 12-month follow-up shows that women in our sample (n=415) were more likely to be married (84% vs 71%), NonHispanic white (78% vs 68%), college graduates (68% vs 56%), have normal BMI (57% vs 47%), and exercise before (73% vs 62%), but not during (43% vs 41%) pregnancy. This suggests that future work should focus on measurement invariance of the scales between groups (i.e., obese vs normal BMI, White vs Black vs Hispanic). While the sample may constrain the generalizability, it was diverse and its size allowed us to evaluate factor validity and cross-validate the exploratory results. The sample size was also adequate to examine the longitudinal measurement properties of the scales.²⁵ Having measures at two distinct postpartum periods adds strength to the study. Another unique aspect is that the reference behavior is “regular physical activity” and not “exercise”. While these two reference behaviors are similar, they are not the same. Exercise behavior is considered a subset of physical activity. Because the current public health message is focused on accumulating moderate to vigorous physical activity not specifically exercise, this may be a better reference behavior to investigate.

The benefits of being physically active during and after pregnancy¹ highlights the importance of understanding the factors associated with this health behavior. Through this study, scales have been created to measure constructs included in the TPB. Each is supported with strong evidence of factor validity and longitudinal invariance. Follow-up work using these measures should strive to identify areas for intervention and how changes in the constructs influence changes in behavior over time.

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References

1. ACOG. Exercise during pregnancy and the postpartum period. *Obstet Gynecol.* 2002; 99(1):171–173. ACOG Committee Opinion No. 267. [PubMed: 11777528]
2. Kaiser L, Allen LH. Position of the American Dietetic Association: Nutrition and lifestyle for a healthy pregnancy outcome. *Journal of the American Dietetic Association.* Mar; 2008 108(3):553–561. [PubMed: 18401922]
3. Pivarnik JM, Chambliss HO, Clapp JF, et al. Impact of physical activity during pregnancy and postpartum on chronic disease risk. *Medicine and Science in Sports and Exercise.* 2006; 38(5):989–1006. [PubMed: 16672855]
4. Borodulin KM, Evenson KR, Wen F, Herring AH, Benson AM. Physical Activity Patterns during Pregnancy. *Medicine and Science in Sports and Exercise.* Nov; 2008 40(11):1901–1908. [PubMed: 18845974]

5. Pereira MA, Rifas-Shiman SL, Kleinman KP, Rich-Edwards JW, Peterson KE, Gillman MW. Predictors of change in physical activity during and after pregnancy - Project viva. *American Journal of Preventive Medicine*. Apr; 2007 32(4):312–319. [PubMed: 17383562]
6. Downs DS, Hausenblas HA. Women's exercise beliefs and behaviors during their pregnancy and postpartum. *Journal of Midwifery & Womens Health*. Mar-Apr; 2004 49(2):138–144.
7. Armitage CJ, Conner M. Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology*. 2001; 40:471–499. [PubMed: 11795063]
8. Hausenblas H, Downs DS, Giacobbi P, Tuccitto D, Cook B. A multilevel examination of exercise intention and behavior during pregnancy. *Social Science & Medicine*. 2008; 66(12):2555–2561. [PubMed: 18372085]
9. Scott EJ, Eves FF, French DP, Hoppe R. The theory of planned behaviour predicts self-reports of walking, but does not predict step count. *British Journal of Health Psychology*. 2007; 12:601–620. [PubMed: 17931476]
10. Courneya K, Friedenreich C. Utility of the theory of planned behavior for understanding exercise during breast cancer treatment. *Psycho-oncology*. 1999; 8:112–122. [PubMed: 10335555]
11. Ajzen I. The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*. Dec; 1991 50(2):179–211.
12. Ajzen I. Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology*. 2002; 32(4):665–683.
13. Montano, DE.; Kasprzyk, D. The theory of reasoned action and the theory of planned behavior. 3rd ed. Jossey-Bass; San Francisco, CA: 2002.
14. Downs DS, Hausenblas HA. The theories of reasoned action and planned behavior applied to exercise: a meta-analytic update. *Journal of Physical Activity and Health*. 2005; 2(1):76–97.
15. Bollen, KA. Structural Equations With Latent Variables. John Wiley; New York: 1989.
16. Messick S. Validity of Psychological-Assessment - Validation of Inferences from Persons Responses and Performances as Scientific Inquiry into Score Meaning. *American Psychologist*. 1995; 50(9):741–749.
17. Vandenberg RJ, Lance CE. A Review and Synthesis of the Measurement Invariance Literature: Suggestions, Practices, and Recommendations for Organizational Research. *Organizational Research Methods*. 2000; 3(1):4–70.
18. Downs DS. Understanding exercise intention in an ethnically diverse sample of postpartum women. *Journal of Sport & Exercise Psychology*. 2006; 28(2):159–170.
19. Downs DS, Hausenblas HA. Exercising for two: Examining pregnant women's second trimester exercise intention and behavior using the framework of the theory of planned behavior. *Womens Health Issues*. Nov-Dec; 2003 13(6):222–228. [PubMed: 14675791]
20. Hausenblas HA, Downs DS. Prospective examination of the Theory of Planned Behavior applied to exercise behavior during women's first trimester of pregnancy. *Journal of Reproductive and Infant Psychology*. 2004; 22(3):199–210.
21. Courneya KS, Friedenreich CM. Utility of the theory of planned behavior for understanding exercise during breast cancer treatment. *Psycho-Oncology*. Mar-Apr; 1999 8(2):112–122. [PubMed: 10335555]
22. Evenson KR, Moos MK, Carrier K, Siega-Riz AM. Perceived barriers to physical activity among pregnant women. *Matern Child Health J*. May; 2009 13(3):364–375. [PubMed: 18478322]
23. Evenson, K. [Accessed February 9, 2009] The Pregnancy, Infection, and Nutrition Study. Documentation for PIN3 and PIN3plus. http://www.cpc.unc.edu/projects/pin/design_pin3/docs_3
24. National Institutes of Health NHLBI. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report Obesity Research. 1998; 6:S51–S209.
25. Costello AB, Osborne WO. Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research, and Evaluation*. 2005; 10(7)
26. Byrne, BM. Structural Equation Modeling with LISREL, PRELIS, and SIMPLIS: Basic Concepts, Applications, and Programming. Lawrence Erlbaum Associates; Mahwah, N.J.: 1998.

27. Hu L, Bentler PM. Cutoff criteria for fit indices in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*. 1999; 6:1–55.
28. Tanaka, JS. Multifaceted conceptions of fit in structural equation models. Sage Publications; Newbury Park, CA: 1993.
29. Browne MW, Cudeck R. Alternative Ways of Assessing Model Fit. *Sociological Methods & Research*. Nov; 1992 21(2):230–258.
30. Bentler PM, Bonett DG. Significance Tests and Goodness of Fit in the Analysis of Covariance-Structures. *Psychological Bulletin*. 1980; 88(3):588–606.
31. McDonald RP, Marsh HW. Choosing a Multivariate Model - Noncentrality and Goodness of Fit. *Psychological Bulletin*. Mar; 1990 107(2):247–255.
32. Joreskog, K. Testing structural equation models. In: Bollen, K.; Long, J., editors. *Testing Structural Equation Models*. Sage Publications; Newbury Park: 1993. p. 294–316.
33. Horn JL, Mcardle JJ. A Practical and Theoretical Guide to Measurement Invariance in Aging Research. *Experimental Aging Research*. 1992; 18(3-4):117–144. Fal-Win. [PubMed: 1459160]
34. Pitts SC, West SG, Tein JY. Longitudinal measurement models in evaluation research: Examining stability and change. *Evaluation and Program Planning*. Nov; 1996 19(4):333–350.
35. Chen FF. Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling-a Multidisciplinary Journal*. 2007; 14(3):464–504.
36. Cheung GW, Rensvold RB. Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling*. 2002; 9(2):233–255.
37. Gagne C, Godin G. The theory of planned behavior: Some measurement issues concerning belief-based variables. *Journal of Applied Social Psychology*. 2000; 30(10):2173–2193.
38. Hagger MS, Chatzisarantis NLD. First- and higher-order models of attitudes, normative influence, and perceived behavioural control in the theory of planned behaviour. *British Journal of Social Psychology*. Dec.2005 44:513–535. [PubMed: 16368017]
39. Rhodes RE, Blanchard CM, Matheson DH. A multicomponent model of the theory of planned behaviour. *British Journal of Health Psychology*. Feb.2006 11:119–137. [PubMed: 16480559]
40. Rhodes RE, Blanchard CM. Conceptual categories or operational constructs? Evaluating higher order theory of planned behavior structures in the exercise domain. *Behavioral Medicine*. 2006; 31(4):141–150. [PubMed: 16526348]
41. French DP, Sutton S, Hennings SJ, et al. The importance of affective beliefs and attitudes in the theory of planned behavior: Predicting intention to increase physical activity. *Journal of Applied Social Psychology*. 2005; 35(9):1824–1848.
42. Downs DS, Hausenblas HA. Elicitation studies and the theory of planned behavior: a systematic review of exercise beliefs. *Psychology of Sport and Exercise*. 2005; 6(1):1–31.

Figure 1.

General model used to test longitudinal invariance for each scale. The model depicts the factor structure of a hypothetical 3-item scale measured at two time points (3 months postpartum and 12 months postpartum). Circles represent latent factors, while rectangles represent the observed items. In each model the item level error variance ("e" to left of item boxes) are allowed to correlate over time. This shows that the variance not explained by the model for a given item will be similar at the two time points. The covariance between the latent factor at 3- and 12-months postpartum is also estimated.

Figure 2.

General form of the correlated factors and higher order model. Each model depicts the factor structure of a hypothetical 6-item scale measured at two time points (3 months postpartum [3M] and 12 months postpartum [12M]). Circles represent latent factors, while rectangles represent the observed items. In each model the item level error variance ("e" to left of item boxes) are allowed to correlate over time. This shows that the variance not explained by the model for a given item will be similar at the two time points. In the higher order model the two first order factors (factors 1 and 2) are modeled as indicators of the higher order factor.

Table 1

Summary of the scales used in this study to quantify hypothesized constructs from the theory of planned behavior.

Scale	Definition of what scale is measuring	# of items	Hypothesized factor structure
Behavioral Beliefs	Perceived advantages and disadvantages of performing a behavior	6	single latent factor indicated by 6 items
Normative Beliefs	Approval of behavior by spouse, family, friends, and physician	4	single latent factor indicated by 4 items
Control Beliefs	Impediments and opportunities/resources available for performing the behavior	9	single latent factor indicated by 9 items
Attitude	Overall feeling toward performing a given behavior	7	single latent factor indicated by 7 items
Subjective Norm	Perceived social pressure to perform a behavior	1	single item indicator with error variance fixed based on previous research
Perceived Behavioral Control	Perceived difficulty of performing a behavior	3	single latent factor indicated by 3 items
Intention	Plan or goal for performing a behavior in a given time period	1	single item indicator with error variance fixed based on previous research

Table 2

Descriptive statistics for women at 3- and 12-months postpartum

Variable	Categories	3-month postpartum (n=267)		12-month postpartum (n=333)	
		n	%	n	%
Age (years)	<20	5	1.9	1	0.3
	20-<35	195	73.0	209	62.8
	≥35	67	25.1	123	36.9
Race/Ethnicity	Nonhispanic White	201	75.3	267	80.4
	Nonhispanic Black	40	15.0	33	9.9
	Other	26	9.7	32	9.6
Education (years)	≤12 years	39	14.6	40	12
	13 to 15 years	56	21.0	54	16.2
	16+ years	172	64.4	239	71.8
Partnered	No	23	8.6	20	6
	Yes	244	91.4	313	94
Parity (# of children)	1	131	49.1	162	48.7
	2	90	33.7	122	36.6
	3+	46	17.2	49	14.7
Working	No	134	50.2	118	35.4
	Yes	133	49.8	215	64.6
BMI (kg/m ²):	Low/Normal (<25.0)	113	42.3	192	59.8
	Overweight (25.0-29.9)	77	28.8	70	21.8
	Obese (≥30.0)	77	28.8	56	18.4
Breastfeeding	No	90	33.7	141	60.3
	Yes	177	66.3	93	39.7
Self-reported hours per week in moderate or vigorous physical activity		Median IQ range		Median IQ range	
		1.2	0.0-4.3	1.7	0.0-4.0

Table 3

Mean, standard deviation (SD), and Pearson correlations at 3- and 12-months postpartum for items included in the measures of the theory of planned behavior.

		3-month		Items					12-month	
		Mean	STD	1	2	3	4	5	Mean	STD
Behavioral Beliefs	Thinking about the time since your [delivery/3-month] interview, PA does/would help me ...									
	BB1 ... get back to my pre-pregnancy weight.	2.35	1.28		0.45**	0.54**	0.41**	0.36**	2.17	1.37
	BB2 ... feel better.	2.46	0.90	0.62**		0.56**	0.59**	0.39**	2.51	0.73
	BB3 ... look better.	2.50	0.99	0.68**	0.74**		0.56**	0.34**	2.40	0.93
	BB4 ... improve my health.	2.62	0.85	0.46**	0.64**	0.63**		0.28**	2.63	0.69
	BB5 ... manage my responsibilities as a mother.	1.20	1.67	0.25**	0.36**	0.30**	0.22**		1.28	1.45
Normative Beliefs	How strongly do you think the following people approve or disapprove of you being physically active since your [delivery/3 month interview]?									
	NB1 Your spouse or partner	2.35	1.04		0.59**	0.54**	0.52**		2.27	1.09
	NB2 Other family members	2.06	1.11	0.56**		0.74**	0.59**		1.87	1.19
	NB3 Your friends	1.87	1.17	0.47**	0.72**		0.56**		1.76	1.25
	NB4 Your physician	2.27	1.11	0.42**	0.57**	0.54**			2.20	1.20
Control Beliefs	Since your [delivery/3 month interview], how true is it that you ...									
	AC1 ... are too tired to be active?	1.06	1.63		0.56**				0.86	1.61
	AC2 ... are not feeling your best physically to be active?	-0.20	1.79	0.53**					-0.39	1.82
	RC1 ... don't have anyone to be active with?	-0.03	2.07		0.38**	0.29**			0.02	1.93
	RC2 ... don't have any places to be active?	-1.48	1.82	0.41**		0.29**			-1.66	1.70
Resource Control Beliefs	RC3 ... don't have child care when you want to be active?	0.85	2.13	0.34**	0.26**				0.99	1.96
Attitude	Thinking about the time since [delivery/3 month interview], PA was....									
	IA1 ... harmful.	1.99	1.27		0.83**	0.86**			2.06	1.19
	IA2 ... foolish.	1.93	1.33	0.68**		0.87**			2.05	1.20
	IA3 ... bad.	1.97	1.33	0.66**	0.89**				2.08	1.22

	3-month			Items			12-month		
	Mean	STD	1	2	3	4	5	Mean	STD
Affective Attitude	AA1 ...un enjoyable.	1.58	1.36	0.86**	0.91**			1.67	1.26
	AA2 ...boring.	1.33	1.43	0.79**	0.88**			1.46	1.28
	AA3 ...unpleasant.	1.60	1.35	0.84**	0.80**			1.65	1.24
Subjective Norm	Most people who are important to me think that I should engage in PA.	1.55	1.49					1.42	1.46
Thinking about the time since your [delivery/3 month interview],									
Perceived Behavioral Control	PBC1 How much control do you have over whether or not engage in PA	1.44	1.46	0.57**	0.68**			1.32	1.45
	PBC2 Engage in PA is extremely difficult	0.36	1.60	0.52**	0.74**			0.39	1.54
	PBC3 If wanted, could easily engage in PA	0.67	1.73	0.66**	0.77**			0.77	1.63
Intention	I intend to engage in regular physical activity during the next 9 months.	1.81	1.47					1.77	1.40

Note: PA = Physical activity;

The correlations among items are presented for 3 and 12 months separately. Item number along top corresponds to items within a given scale. Correlations for data collected at 3-months are below diagonal.

* p-value < 0.01;

** p-value < 0.05;

Table 4

Results from the confirmatory factor analysis for the final models fit to data from the holdout, cross validation, and full samples at 3-months (n= 267) and 12-months (n=333) postpartum.

Scale	Sample	X ²	DF	p	NNFI	CFI	RMSEA (90% CI)
Behavioral Beliefs							
	3-months	13.87	5	0.016	0.953	0.984	0.082 (0.032 - 0.134)
	holdout	7.87	5	0.163	0.973	0.991	0.066 (0.000 - 0.149)
	cross-validation	8.74	5	0.12	0.955	0.985	0.075 (0.000 - 0.156)
	12-months	19.21	5	0.002	0.914	0.971	0.093 (0.051 - 0.138)
	holdout	6.214	5	0.286	0.992	0.996	0.038 (0.000 - 0.120)
	cross-validation	13.339	5	0.02	0.881	0.96	0.101 (0.036 - 0.168)
Normative Beliefs							
	3-months	1.35	2	0.509	1.008	1.000	0.000 (0.000 - 0.023)
	12-months	7.02	2	0.030	0.957	0.991	0.087 (0.023 - 0.161)
Control Beliefs							
	3-months	7.52	4	0.111	0.933	0.982	0.058 (0.000 - 0.120)
	holdout	6.30	4	0.175	0.877	0.967	0.067 (0.000 - 0.159)
	cross-validation	7.50	4	0.112	0.932	0.973	0.081 (0.000 - 0.170)
	12-months	3.59	4	0.464	1.006	1.000	0.000 (0.000 - 0.079)
	holdout	1.23	4	0.874	1.091	1.000	0.000 (0.000 - 0.059)
	cross-validation	4.39	4	0.356	0.989	0.997	0.024 (0.000 - 0.122)
model comparison							
	Correlated factors	28.96	27	0.363	0.991	0.996	0.020 (0.000 - 0.062)
	Higher-order	37.07	28	0.117	0.962	0.981	0.042 (0.000 - 0.075)
Attitudes							
	3-months	23.71	8	0.003	0.970	0.989	0.085 (0.047 - 0.125)
	holdout	10.35	8	0.242	0.992	0.997	0.047 (0.000 - 0.119)
	cross-validation	19.48	8	0.013	0.955	0.983	0.104 (0.045 - 0.163)
	12-months	13.81	8	0.087	0.994	0.998	0.046 (0.000 - 0.086)
	holdout	6.50	8	0.586	1.003	1	0.000 (0.000 - 0.080)
	cross-validation	18.54	8	0.018	0.973	0.99	0.089 (0.035 - 0.143)
model comparison							

Scale	Sample	X ²	DF	p	NNFI	CFI	RMSEA (90% CI)
	<i>Correlated factors</i>	71.99	46	0.008	0.98	0.988	0.055 (0.028 - 0.079)
	<i>Higher-order</i>	74.46	48	0.009	0.98	0.988	0.055 (0.028 - 0.078)
Perceived Behavioral Control							
	3-months	Model is Saturated. DF equal 0 so no fit indices calculated.					
	12-months	Model is Saturated. DF equal 0 so no fit indices calculated.					

Note: X² = chi square, DF = degrees of freedom, NNFI = Non-normed fit index, CFI = comparative fit index, RMSEA = root mean squared error of approximation, 90% CI = 90% confidence interval;
*The “model comparison” section for attitudes and perceived behavioral control contain the fit of the correlated factors and higher order models pictured in figure 2.

Table 5

Model fit and comparisons for the invariance analysis among women who participated at both 3- and 12-months postpartum (n = 185).

Scale/Invariance model	X ²	DF	P	NNFI	CFI	RMSEA (90% CI)	ACFI	ARMSEA
Behavioral Beliefs								
Factor Structure	48.29	29	0.014	0.951	0.974	0.060 (0.027 - 0.089)		
Factor Loadings	61.87	33	0.002	0.936	0.962	0.069 (0.042 - 0.095)	-0.012	-0.009
Factor Loadings (item 2 free)	52.19	32	0.014	0.954	0.973	0.059 (0.027 - 0.086)	-0.001	-0.001
Factor Variance	54.41	33	0.011	0.952	0.971	0.059 (0.029 - 0.087)	-0.002	0.000
Normative Beliefs								
Factor Structure	21.31	15	0.127	0.978	0.991	0.048 (0.000 - 0.091)		
Factor Loadings	23.37	18	0.177	0.984	0.992	0.040 (0.000 - 0.082)	0.001	-0.008
Factor Variance	27.52	19	0.093	0.976	0.988	0.049 (0.000 - 0.087)	-0.004	0.009
Control Beliefs								
Factor Structure	25.38	24	0.385	0.993	0.997	0.018 (0.000 - 0.063)		
Factor Loadings	28.96	27	0.363	0.991	0.996	0.020 (0.000 - 0.062)	-0.001	-0.002
Factor Variance	31.46	29	0.344	0.99	0.995	0.021 (0.000 - 0.062)	-0.001	-0.001
Attitudes								
Factor Structure	63.53	42	0.018	0.982	0.990	0.053 (0.023 - 0.078)		
Factor Loadings	71.99	46	0.008	0.980	0.988	0.055 (0.028 - 0.079)	-0.002	0.002
Factor Variance	72.57	48	0.013	0.982	0.989	0.053 (0.025 - 0.076)	0.001	-0.002
Perceived Behavioral Control								
Factor Structure	10.51	6	0.105	0.977	0.993	0.064 (0.000 - 0.126)		
Factor Loadings	12.46	8	0.132	0.983	0.993	0.055 (0.000 - 0.111)	0.000	0.009
Factor Variance	12.48	9	0.188	0.988	0.995	0.046 (0.000 - 0.101)	0.002	0.009

Note: X² = chi square, DF = degrees of freedom, NNFI = Non-normed fit index, CFI = comparative fit index, RMSEA = root mean squared error of approximation, 90% CI = 90% confidence interval

Table 6

Standardized regression weights, squared multiple correlations, internal consistency (Cronbach), and factor correlations for the final models selected for each scale. Ranges are for 3- and 12-month postpartum models.

Scale/Factor (# items)	Standardized Regression Weights (range)	Squared Multiple Correlations Mean (range)	Factor Correlations	Internal Consistency (alpha)	
				3-month	12-month
Behavioral Beliefs (5)	0.465 - 0.859	0.486 (0.216-0.737)	0.659	0.773	0.754
Normative Beliefs (3)	0.585 - 0.861	0.563 (0.342-0.741)	0.557	0.831	0.852
Control Beliefs (5)					
Ability Beliefs (tired/not feeling best)	0.715 - 0.782	0.550 (0.391-0.697)	0.580	0.692	0.715
Resource Beliefs (no one, no place, no child care)	0.500 - 0.681	0.330 (0.219-0.502)	0.802	0.605	0.579
Attitudes (6)					
Instrumental (harm, foolish, bad)	0.759 - 0.968	0.804 (0.486-0.944)	0.236	0.899	0.945
Affective (enjoy, boring, unpleasant)	0.891 - 0.953	0.847 (0.738-0.910)	0.448	0.926	0.958
Perceived Behavioral Control (3) (controllability)	0.696 - 0.961	0.676 (0.486-0.925)	0.629	0.850	0.856
Subjective Norms (1) (injunctive)			0.778	n/a	
Intentions (1)			0.685	n/a	

Note: For subjective norms and intentions the factor correlation between 3 and 12 months was estimated by specifying a single item indicator model with the error variance fixed based on internal consistency reliability estimates (0.79 for subjective norms and 0.83 for intentions) from previous research.