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Running Head: PROCESSES OF CHANGE AND EXERCISE BEHAVIOR

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Three-Step Validation of Exercise Behavior Processes of Change in an Adolescent Sample

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Abstract

Though the processes of change are conceived as the core constructs of the transtheoretical model (TTM), few researchers have examined their construct validity in the physical activity domain. Further, only one study was designed to investigate the processes of change in an adolescent sample. The purpose of this study was to examine the exercise behavior processes of change in a sample of adolescents using novel three-step confirmatory validation procedures, including: a) the item-level aggregation of processes, b) the higher order structure of aggregation, and c) the discriminant validity of processes across the stages of change. Participants were 15 to 17 year old (N = 284) high school students who completed measures of the exercise behavior processes of change and stages of behavior change. Results using structural equation modeling identified that the processes of Dramatic Relief, Helping Relationships, Environmental Reevaluation, and Self-Reevaluation had acceptable item level measurement properties (p< .01), while the construct of Social Liberation was not supported. Distinct processes structures were a better fit of the observed data than any higher order behavioral or experiential structure (p < .01). Finally, validation tests of the processes of change across stage of change using discriminant function analysis and univariate F-tests supported Counter Conditioning as the critical process of exercise behavior change in adolescents (p < .01) and found no support for the experiential processes. Changes and implications to TTM theory and measurement were discussed as well as practical implications for exercise behavior intervention strategies.

Key Words: transtheoretical model, confirmatory factor analysis, psychometric theory

Substantial evidence is available that physical inactivity is associated with the development of several chronic diseases and premature mortality (Blair & Brodney, 1999; Booth, Gordon, Carlson, & Hamilton, 2000; Katzmarzyk, Gledhill, & Shephard, 2000). Also, extensive literature can be found indicating that physical activity is an effective preventive strategy against cardiovascular disease, obesity, stroke, hypertension, type 2 diabetes, colon cancer, breast cancer, osteoporosis, and several psychological disorders (Blair & Brodney, 1999; U.S. Centers for Disease Control and Prevention, 1996). Despite this information, a majority of adults do not meet the minimal requirements for physical activity wherein health benefits are thought to occur (Canadian Fitness and Lifestyle Research Institute, 2001; U.S. Centers for Disease Control and Prevention, 1996).

The antecedents to adulthood chronic disease are established in childhood and adolescence (U.S. Centers for Disease Control and Prevention, 1996). The steepest decline in physical activity occurs between early high school and young adulthood (Canadian Fitness and Lifestyle Research Institute, 2001; U.S. Centers for Disease Control and Prevention, 1996). Further we know that prior behavior patterns are consistently the best predictor of future behavior (Ouellette & Wood, 1998; Rhodes & Courneya, 2003a), suggesting that curbing this activity decline from adolescence to young adulthood may substantively help promote life long physical activity behavior.

One of the most popular models for understanding behavior in recent years is the transtheoretical model of behavior change (TTM; see Prochaska & Velicer 1997 for a review). The TTM has been applied frequently across a number of health behaviors including exercise and physical activity (Marshall & Biddle, 2001). The TTM posits that people progress through five stages when making a lifestyle physical activity change: Precontemplation (unawareness of the behavior), Contemplation (considering change), Preparation (increasing commitment and taking steps for change), Action (changing behavior), and Maintenance (sustaining a new behavior).

Prochaska and DiClemente (1982) reviewed different schools of psychotherapy to arrive at 10 common processes of change. The processes of change are considered the covert and overt activities that people use to progress through the stages of change. These processes were subsequently considered as either experiential or behavioral. The five experiential processes are Consciousness Raising (gathering information), Self-Reevaluation (reconsidering the consequences of the behavior on oneself), Dramatic Relief (experiencing affect), Environmental Reevaluation (reconsidering the consequences of the behavior on others), and Social Liberation (attending to social norms). The five behavioral processes are Counter Conditioning (substituting new behaviors for old ones), Stimulus Control (controlling environmental cues), Reinforcement Management (rewards), Helping Relationships (social support), and Self-Liberation (committing to change). In TTM theory, processes of change are hypothesized as particularly important targets for intervention programs because individuals use these constructs to move through the stages of change (Prochaska, Redding, & Evers, 1997).

Despite its popularity, few studies have applied the TTM in adolescent samples and only one group of researchers to our knowledge have tested all aspects of the TTM, including the processes of change, for exercise behaviour in adolescents (Nigg & Courneya, 1998). These authors found that all processes of change varied significantly by stage and the strongest size of associations between the processes and stages were for consciousness raising, self-reevaluation, reinforcement management, and stimulus control. Other researchers found support for the stages of motivational readiness for changing physical activity in adolescents (Lee, Nigg, DiClemente, & Courneya, 2001). Although there is preliminary support for applying the TTM to adolescent exercise behaviour, the paucity of existing studies, particularly those concerning the processes of change, warrants further validation research.

Indeed, some authors believe that the TTM has been inadequately researched across all populations (Whitelaw, Baldwin, Bunton, & Flynn, 2000), and that it may lack both internal and external validity (Bunton, Baldwin, Flynn, & Whitelaw, 2000). Particular criticism has focused on the processes of

change constructs in the TTM framework. Although Prochaska and DiClemente (1998) highlight the processes of change as the core of the TTM, it is the least studied and least consistent aspect of the model (Marshall & Biddle, 2001; Plotnikoff, Hotz, Birkett, & Courneya, 2001; Rosen, 2000). Debate over the best aggregation of the processes (e.g., 1-2 constructs or 10 constructs) and their importance across the stages of change is frequent yet largely unexplored (Marshall & Biddle, 2001; Plotnikoff et al., 2001). For example, Marshall and Biddle (2001), in their meta-analysis of 71 TTM studies in the physical activity domain, found the results inconclusive on the use of two item-aggregated (experiential and behavioral processes) processes structures or 10 item-aggregated (all 10 processes) hypothesized structures. The authors also denoted that the relationship of processes with stage transition is inconsistent with TTM narrative (see Prochaska & Velicer, 1997) and needs to be interpreted with caution.

Therefore, the purpose of this present study was to examine the exercise behavior processes of change in a sample of adolescents using a three-step confirmatory validation procedure. Specifically, we designed the study to provide evidence for the validity for: a) the item-level aggregation of processes constructs, b) the higher order structure of aggregation, and c) whether the processes of change discriminate stage of change membership. Our a priori confirmatory hypotheses followed the original conception of the 10 processes of change and their relationship with stage progression (Prochaska & DiClemente, 1982).

Method

Participants and Procedures

Participants were students at a coeducational private high school, aged 15 to 17 years old (N = 328), who participated in career and personal planning classes. As part of the private institution's curricula, students participated in mandatory, daily physical education classes, and sport teams and clubs also provided opportunities for students to be active. Students were asked to respond to the

questions in relation to their exercise behavior experience outside of physical education classes, as there is evidence that compulsory school involvement in physical activity does not translate into activity in leisure time, particularly regular strenuous activity (Kristjansdottir & Vilhjalmsson, 2001; Zakarian, Hovell, Hofstetter, Sallis, & Keating, 1994). Two of the authors (PJN, JWH) distributed informed consent forms and the questionnaires for completion and collected them during the same class; all students agreed to complete the questionnaires. The data presented in this study are part of a larger study in which focus groups consisting of the half male, half female classes, were conducted regarding the perceptions of the teens concerning their health and what health education information they identified as important to improving their health. Presentations to the classes on the identified needs were subsequently delivered by two of the authors (PJN, JWH).

After listwise deletion of missing data, the distribution of participants by stage was 6 in the Precontemplation stage, 18 in the Contemplation stage, 66 in the Preparation stage, 51 in the Action stage, and 143 in the Maintenance stage. Due to the small number in the Precontemplation stage, Precontemplators and Contemplators were collapsed together for the third analysis to give an N of 24 for a stage we called Contemplation (total $N = 284$). The small number of participants in Precontemplation and contemplation was not large enough for group comparison in analysis of variance (ANOVA) or discriminant function analyses (Glass & Hopkins, 1996) without this aggregation, given the typical medium effect sizes found in previous TTM analyses (Marshall & Biddle, 2001). Rather than discard these stages from the analysis, we felt including Precontemplators and contemplators as an aggregated stage of "inaction" was conceptually justified. Plotnikoff et al. (2001) used a similar rationale for aggregating Action and Maintenance as stages of "action" when their sample size was low for the Action stage.

Instruments

Participants completed a questionnaire consisting of an exercise measure (Godin & Shephard, 1985) and the TTM construct measures. In the first section, the participants were asked to think about how many times during a one-week period they participated in strenuous, moderate, or mild exercise for at least 15 min. Strenuous exercise was defined as exercise that made "your heart beat rapidly and you sweat" (e.g., running, soccer, vigorous swimming). Moderate exercise was defined as not exhausting (e.g., fast walking, baseball, volleyball) and mild exercise was characterized by requiring little effort (e.g., yoga, bowling, easy walking). The Godin and Shephard (1985) tool is a well-known and utilized Canadian instrument, based on the 1985 American College of Sport Medicine (ACSM) guideline that recommended 15 to 60 min at 60-90% of maximal aerobic capacity 3-5 times a week. Although the Canadian instrument was developed and validated prior to the release of 1991 ACSM guidelines, and well before Health Canada's Physical Activity Guide for Youth, both advising a minimum of 20 min per exercise session, it is in keeping with the current public health message that health benefits for youth can be realized in activity bouts of 15 min (US Department of Health and Human Services, 1996). The second part of the questionnaire included the TTM constructs. Although only the stages of change and processes of change were used in this paper, a brief outline of the other TTM measures is provided below. Specifically, stages of change, self-efficacy (5 items), and pros (8 items), and cons (5 items) were measured using questionnaires developed by Marcus, Rakowski and Rossi (1992). All measures displayed acceptable internal consistency (self-efficacy $\alpha = .76$; pros $\alpha = .85$; cons $\alpha = .78$).

Processes of Change. Processes of change were assessed using a modification of the Processes of Change Questionnaire (PCQ) developed and validated for the exercise domain (Marcus, Rossi, Selby, & Niaura, 1992). The PCQ contains 40 items that measure the 10 hypothesized processes of change (see Figure 1). The instrument used in this study contained a modified version for adolescents. Modifications included simplifying language (e.g. "Instead of remaining inactive…" was changed to "instead of sitting around…") and changing items to reflect a school rather than a work environment ("I

keep things around my place of work that remind me of exercise" was changed to "I keep things around school that remind me of exercise"). Individuals were asked to recall the past month and to rate the frequency of occurrence of each item with five-point rating scales, ranging from 1 (never) to 5 (very often).

Model Specification and Analysis Procedures

The first two steps of the validation process used structural equation modeling. Structural equation modeling allows for both an assessment of overall model fit and statistical significance tests for the size of each theoretical relation in the model. Further, specific conceptualizations in measurement and structure are estimated simultaneously and free of measurement error when multiple indicators are available. Models were estimated with maximum likelihood procedures and assessed using LISREL 8.20 for Windows (Jöreskog & Sörbom, 1997). Loading for the first indicator for each construct was preset to 1.0 to establish a metric scale for the construct.

Step 1: Item-level validation

The first stage was a test of the unidimensionality of the items within each process scale (i.e., all 10 processes). As unidimensionality is the assumption in item aggregation (Cronbach & Meehl, 1955), acceptable results in this first step are essential for construct scale validation. A common procedure recommended by Anderson and Gerbing (1988) for testing construct discriminant validity was utilized. This procedure tests a model constraining the covariance between constructs to unity, and then compares this chi-square statistic (χ^2) to a χ^2 estimated when this covariance is freed for estimation. However, given that each item was tested for unidimensionality with the other hypothesized scale items, fixed error variance estimates based on the suggested modeling procedures of Hayduk (1996) were also necessary. A priori fixed error estimates on single indicators still allow for the researcher to place constraint within the model (Hayduk, 1996). These fixed error variance estimates were based on the suggested procedures of Schumacker and Lomax (1996) and used an averaged error for each scale item

of 1-α. Specifically, as α represents the proportion of true score variance in a scale (Cronbach & Meehl, 1955), then 1 - α represents the proportion of error variance in the scale. This was considered an appropriate estimate of average inter-item error given the a priori assumption of item aggregation in previous studies using the processes of change (Marshall & Biddle, 2001). Still, a sensitivity analysis of .5 the fixed variance and double (2X) the fixed variance was also estimated in order to examine the stability of results. Given the number of comparison tests estimated, alpha was set at $p<.01$ in order to control for experiment-wise error.

Step 2: Higher order and inter-factor validation

A test of the higher order structure of behavioral and experiential processes was subsequently conducted. We first compared three models to examine the best representation of the observed data. Model 1 followed a single higher order processes construct to explain covariation of the processes of change constructs. Model 2 represented two correlated higher order constructs of experiential and behavioral processes of change. Finally, model 3 followed a correlated structure of all processes with no conceived higher order factor. Higher order factors (models 1 and 2) were created by fixing the variance of these factors to one and freeing all conceived factor loadings for estimation.

Secondary analysis procedures were also employed to examine whether any particular aggregation of processes was better than a correlated structure (model 3). To achieve this test, we utilized the procedures suggested by Anderson and Gerbing (1988) for evaluating discriminant validity of constructs. Specifically, construct distinction was achieved by constraining the correlations between each process to unity, and then comparing this χ^2 to a χ^2 estimated as two correlated concepts (Anderson & Gerbing, 1988).

For all of these step two analyses, processes constructs were modeled according to the results of step one. If item clusters were found unidimensional in the previous analysis, then experiential/behavioral constructs were modeled as latent variables with multiple indicators and error

variances freed for estimation. If, however, unidimensionality was not identified in the previous analysis, then items were removed from subsequent analyses. Each construct's first indicator was preset to 1.0 in the structural equation model. Further, given the number of comparison tests estimated, alpha was set at $p<.01$ in order to control for experiment-wise error.

Step 3: Validation of the processes of change across stage membership

The final validation procedure was used to examine the processes of change as correlates of stage membership. Processes of change scales that performed acceptably in the previous two validation procedures were examined using standard TTM analysis techniques (e.g., Marcus et al., 1992, Plotnikoff et al., 2001). Specifically, discriminant function analysis was utilized as a multivariate analysis to evaluate whether the processes discriminated across stage membership, followed by univariate analysis of variance and post-hoc tests.

Assessment of Model Fit

A number of statistics exist to assess the adequacy of structural models. The most useful statistic for testing nested and alternative models is the chi-square statistic (χ^2). The χ^2 goodness-of-fit test assesses the adequacy of the theorized model's creation of a covariance matrix and estimated coefficients in comparison to the observed covariance matrix. Models that result in a created covariance matrix that deviates from the observed covariance matrix are judged to be inadequate. For comparison of nested and alternative models, the χ^2 difference value versus degrees of freedom provides a statistical test for which model fits the observed data better.

The χ^2 test, however, has been criticized as an insufficient test alone to adequately assess model fit, generally because of power estimation problems or assumptions and sample size (Hu & Bentler, 1995). Therefore, inclusion of absolute and incremental fit indices are recommended (Hu & Bentler, 1999). Absolute fit indices assess how well an a priori model reproduces the sample data, while incremental fit indices measure the proportionate improvement in fit by comparing a target model with

a more restricted baseline model. For the current study, Root Mean Square Error of Approximation (RMSEA) was included as an absolute fit index and the Comparative Fit Index (CFI) was included as an index of incremental fit in the omnibus model fit. General rules of thumb for acceptability of model fit using these indexes are >.94 for the CFI and <.07 for RMSEA (Hu & Bentler, 1999).

Results

Step 1: Item-level validation

Tests of scale unidimensionality for the items of all 10 processes can be found in Table 1. Empirical results supported unidimensionality ($p > .01$) for all of the items measuring Dramatic Relief and Helping Relationships. Overall, Environmental Reevaluation and Self-Reevaluation displayed only one significant ($p < .01$) discriminant inter-item relationship suggesting more evidence for four-item unidimensional structure than a three-item structure. Three of four items supported the unidimensionality ($p>.01$) of measuring Counter Conditioning and Consciousness Raising respectively, while two of four items supported the unidimensional measurement ($p > .01$) of Reinforcement Management, Self-Liberation, and Stimulus Control. Only Social Liberation did not have any support for unidimensionality ($p < .01$) across all items and thus did not represent sufficient psychometric quality to justify an aggregated social liberation scale for any further validation. Sensitivity analysis of the fixed error variance estimates suggested these findings were robust.

Step 2: Higher order and inter-factor validation

In this stage of our analyses, we compared a single higher order processes construct (χ^2 [341, N=284] = 720.20, $p<.001$; RMSEA = .06; CFI = .89), two correlated higher order constructs of experiential and behavioral processes of change (χ^2 [340, N=284] = 716.96, $p<.001$; RMSEA = .06; CFI = .89), and a correlated structure of all processes with no conceived higher order factor (χ^2 [314, N=284] = 596.24, $p<.001$; RMSEA = .06; CFI = .91). This test included all nine processes constructs in their previously supported four-item (Dramatic Relief, Helping Relationships, Environmental

Reevaluation, and Self-Reevaluation), three-item (Counter Conditioning and Consciousness Raising respectively), and two-item (Reinforcement Management, Self-Liberation, and Stimulus Control) latent variable structures. Results identified the correlated processes structure was a significantly better fit of the data than the single higher order construct model ($\chi 2$ difference [27] = 123.96, $p < .001$) and the two correlated higher order experiential and behavioral constructs model ($\chi 2$ difference [26] = 120.72, $p < .001$).

The measurement model for this correlated simple structure of nine constructs is presented in Table 2, while construct inter-factor correlations are detailed in Table 3. All estimated factor loadings and inter-factor correlations were significant ($p < .01$). The overall model fit of this nine construct structure did not quite meet our criteria for a "good" fit but we feel the fit indices suggest a "moderate" fit of the data. Still, observation of standardized residuals and modification indices indicated multiple significant ($p < .01$) changes to the model would improve fit. These changes included numerous correlated measurement error variances and factor cross loadings.

Secondary analysis procedures were also employed to examine whether any particular aggregation of processes was better than a correlated structure (see Table 4). Construct multidimensionality of all nine processes was supported ($p < .01$). Thus all nine processes show evidence of discriminant validity over a simplified aggregated item-structure.

Step 3: Validation of the processes of change across stage membership

Results of the univariate and multivariate analyses of the processes of change across stage membership are presented in Table 5. The multivariate analysis showed one significant discriminant function (χ^2 (27) = 104.33, $p <.001$; eigenvalue = .361, canonical correlation = .515, Wilk's $\Lambda = .69$). The best discriminator of stage membership was Counter Conditioning, followed by Reinforcement Management, Helping Relationships, and Self-Liberation. Classification based on this discriminant

function correctly identified 51.4% of cases. Four cases were ungrouped. Results for the classification are shown in Table 6.

Similar to the discriminant analysis, univariate *F* tests identified the processes that ($p < .01$) discriminated between stages were the behavioural processes of Counter-Conditioning, Helping Relationships, Reinforcement Management, and Self Liberation. Tukey's HSD post-hoc analysis found no differences ($p < .05$) between Contemplation and Preparation due to any of the processes, but identified differences ($p < .05$) between Preparation and Action ($d = .65$), and Action and Maintenance ($d = .48$) based on Counter Conditioning. Less precise discriminations ($p < .05$) across the stages were also found for Self-Liberation, Helping Relationships, and Reinforcement Management (see Table 5).

Discussion

Though the processes of change are conceived as the core constructs of the TTM (Prochaska & Velicer, 1997), few researchers have examined their construct validity in the physical activity domain (Marshall & Biddle, 2001). Further, only Nigg and Courneya (1998) have investigated the processes of change in an adolescent sample. The purpose of this present study was to examine the exercise behavior processes of change in a sample of adolescents using novel three-step confirmatory validation procedures, including: a) the item-level aggregation of processes, b) the higher order structure of aggregation, and c) whether the processes of change discriminate stage of change membership. Our a priori confirmatory hypotheses followed the original conception of the 10 processes of change and their relationship with stage progression according to TTM theory (Prochaska & DiClemente, 1982). Results of this three-step validation lead to interesting findings.

Item-level validation

The first validation step tested the unidimensionality of the items within each scale (i.e., all 4 items for each of the 10 processes scales). As unidimensionality is the assumption in item aggregation (Cronbach & Meehl, 1955), acceptable results in this first step are essential for scale validation.

Empirical results supported the unidimensionality of all of the items measuring Dramatic Relief, Helping Relationships, Environmental Reevaluation and Self-Reevaluation. Therefore, four of the 10 processes structures had a unidimensional item structure. Three of four items supported the unidimensionality assumption for measuring Counter Conditioning and Consciousness Raising. For Consciousness Raising, asking about "memory" recall of exercise behavior information from "friends" appears to measure a different construct than "reading", "seeking out", and "thinking" about "media" information about exercise behavior. TTM theorists will need to decide in the future whether to include a separately measured multi-item processes construct for Consciousness Raising from "friends" and "media". For Counter Conditioning, the item "instead of sitting around I do some exercise behavior" measured a different construct than the other three items asking about the use of exercise behavior for stress relief. Clearly, the incongruent item reflects more of a self-statement of exercise behavior status than a counter conditioning process for stress management. Although replication across other samples, and tests of measurement invariance (both across groups and over time) is warranted, the results suggest minor changes to Counter Conditioning and Consciousness Raising may result in desirable future scale validity.

While six of the previously described processes displayed psychometric quality at the item level, four processes did not display strong unidimensionality across items. Two of four items supported the unidimensional measurement of Reinforcement Management, Self-Liberation, and Stimulus Control. Results of the Reinforcement Management item analysis identified that the external "rewards for exercise" items tapped the same latent variable, but "goal setting" and "self-praise" items tapped other constructs individually. Self-Liberation items assessing self-motivation (i.e., "tell myself I can work hard") tapped the same latent variable, but items assessing "promises to self – or others" and "health appraisal" tapped other constructs. Similarly, Stimulus Control items measuring items placed around "school" or "home" as exercise behavior reminders tapped the same latent variable, but

"changing things to make me active" and "avoiding places that make me sit" items tapped other constructs individually. Finally, Social Liberation did not have any support for unidimensional measurement across all items. Specifically, appraisals of changes in "society", "many people", "schools", and "fitness centres" all measured separate latent constructs.

Clearly, post-hoc analysis of these items suggests obvious problems in psychological scale development (see Borg & Gall, 1989, for a review). For example, many of these items tapped different abstractions of the same category such as Social Liberation's specific "fitness centres" but more general "society" items. These lead to issues of abstraction specificity in the same scale. Given that items are expected to be interchangeable measures of the same latent construct in psychometric theory (Nunnally & Bernstein, 1994), differences in abstraction at the item level are problematic. Another problem in some of the scales reflects double-barreled measurement. For example, the Self-Liberation item "promises to self – or others" creates a potential confound of measurement due to differences between "self" and "others". This is an outlined caveat in scale construction (Borg & Gall, 1989) that warrants correction in the processes of change scales. Finally, many items blatantly measure separate constructs. For example, Reinforcement Management's items regarding "rewards for exercise" have obvious face value distinction from "goal setting" yet are currently used to measure the same construct. Given that items are expected to be interchangeable measures of the same latent construct in psychometric theory (Nunnally & Bernstein, 1994), these items warrant correction in future use of the processes scale.

Higher order and inter-factor processes validation

Debate over the best aggregation of the processes (e.g., 1-2 constructs or 10 constructs) is frequent yet largely unexplored (Marshall & Biddle, 2001; Plotnikoff et al., 2001). Much of this debate for collapsing processes relies on the assumption of higher order behavioral and experiential processes. This assumption requires, however, a temporal causality pattern that may not work in social cognitive constructs (see Rhodes & Courneya, 2003b; Rhodes, Plotnikoff, & Spence in press). Our results

identified that separate correlated processes constructs fit the data better than any higher order behavioral or experiential construct. Further, no evidence was found to suggest that a simple collapsing of constructs fit the data better than specific processes.

Regardless of our results at this step, it is important to note that the omnibus model fit the data only moderately. Observation of standardized residuals and modification indices indicated multiple significant changes to the model would still improve fit. The evidence suggests that the processes of change still lack an elegant simple measurement structure. Therefore, the processes may benefit even more than our step one validation from careful theoretical reinterpretation before continued use. Perhaps more specific processes differ by population or behavior. The TTM framework will undoubtedly benefit by reevaluation of the measurement structure of these processes.

Validation of the processes of change across stage membership

The final validation effort examined the discriminant ability of the processes of change across the stage of change framework. In contrast to the only previous study applying the TTM to adolescent physical activity (Nigg & Courneya, 1998), only four processes discriminated stage membership. Further, classification error appeared particularly problematic for Action stage membership (classification success = 29%), suggesting the processes of change do not discriminate those in the action stage well in comparison to the other stages. Discriminant function analysis and univariate *F* tests found no experiential processes to discriminate stage membership, perhaps due to this population's mandated physical education curriculum. This suggests that experiential processes are not used to move across the stages of exercise behaviour change or even discriminate between physically active adolescents and inactive adolescents in this sample. The failure to replicate previous research certainly indicates the need for more adolescent research with the TTM, but also suggests the experiential processes may not discriminate stage of change for this particular population.

In contrast to the experiential processes, four of the five behavioral processes discriminated stage membership. Specifically, these processes were Self-Liberation, Helping Relationships, Counter Conditioning, and Reinforcement Management. Multivariate analysis and post-hoc tests, however, identified Counter Conditioning as the critical discriminating process. Not only did Counter Conditioning possess the highest correlation with the discriminant function (.83), it also was the only process to delineate mean differences across precise stage membership from preparation to action to maintenance as postulated by TTM theory. This suggests that Counter Conditioning may be the critical process for exercise behavior in adolescents. Using the previous item level analysis (step one), Counter Conditioning, as measured, reflects the use of exercise behavior as a stress and fatigue management strategy. The qualitative data gathered during the focus groups support this finding. The two most common requests for information/presentations from students seeking information to enhance their health were exercise (45%) and stress management/coping strategies (30%). Thus education strategies and planned experiences to demonstrate the effectiveness of exercise behavior as a successful stress management and fatigue management strategy may be a useful intervention approach for exercise behavior among adolescents.

A few important limitations need to be recognized. First, a cross sectional design was used and thus "true" stage transitions can not be reflected from the processes. The cross sectional sample assumes that participants at higher stages of change had actually moved through the stage structure as postulated by TTM theory (Prochaska & Velicer, 1997). Given the novelty of the population and validation procedures, we see the current design as necessary but still insufficient evidence for establishing stage transition of adolescent exercise behavior. Studies examining true stage transitions are actually still sparse and certainly recommended in the future (Marshall & Biddle, 2001; Plotnikoff et al., 2001).

Second, our sample did not contain enough participants categorized as precontemplators and contemplators to examine differences between these stages. As a result, our findings cannot test the complete stage model and can not generalize to how well the processes of change discriminate between group membership of exercise precontemplators and contemplators.

Third, the current analyses assume measurement equivalence for participants in the different stages of change. If differences in measurement meaning and structure have occurred systematically by stage membership, it may have compromised the validity of these analyses.

Fourth, our step one validation procedure is based on the assumption that multiple processes items that demonstrate "clustered" unidimensionality (i.e., demonstrated a nonsignificant χ^2 difference test) are better measures of the conceived construct than processes items that demonstrated multidimensionality (i.e., demonstrated a significant χ^2 difference test). This assumption is guided by TTM theory for the development of the processes scales. Specifically, it is assumed that items were developed for each processes scale that attempt to measure the same underlying concept and items that deviate from this unidimensional measurement are not good measures of the intended concept. If a single item that showed multidimensionality was indeed a better measure of a processes construct than the "clustered" items, our step-wise method would not have been valid, because this item would have been dropped from the step two and step three analyses. This potential limitation of our analysis procedures points to the importance of theory. Specifically, the test of unidimensionality used in step one has utility for testing a priori conceived scales and measurement models, but will not uncover the correct factor structure for any set of items.

In summary, a three-step validation procedure was applied to examining the exercise behavior processes of change. This included validation of: a) the item-level aggregation of processes constructs, b) the higher order structure of aggregation, and c) whether the processes of change discriminate stage of change membership. In conclusion, the processes of Dramatic Relief, Helping Relationships,

Environmental Reevaluation, and Self-Reevaluation had acceptable item level measurement properties, while Social Liberation was unacceptable. Distinct correlated processes structures were a better fit of the observed data than any higher order behavioral or experiential structure, though the distinct processes model still possessed some factor complexity. Finally, tests of the processes of change to discriminate stage of change membership supported Counter Conditioning as the critical process of exercise behavior change in adolescents and found no support for the experiential processes. Changes and implications to TTM theory and measurement were discussed as well as practical implications for exercise behavior intervention strategies.

References

Anderson, J.C., & Gerbing, D.W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*, 411-423.

Blair, S.N., & Brodney, S. (1999). Effects of physical inactivity and obesity on morbidity and mortality: current evidence and research issues. *Medicine and Science in Sports Exercise, 31*, S646-662.

Booth, F. W., Gordon, S. E., Carlson, C. J., & Hamilton, M. T. (2000). Waging war on modern chronic diseases: primary prevention through exercise biology. *Journal of Applied Physiology, 88,* 774-787.

Borg, W.R. & Gall, M.D. (1989). *Educational Research* (5th ed.). New York: Longman.

Bunton, R., Baldwin, S., Flynn, D., & Whitelaw, S. (2000). The 'stages of change' model in health promotion: Science and ideology. *Critical Public Health, 10,* 55–70.

Canadian Fitness and Lifestyle Research Institute (2001). *2001 Physical Activity Monitor*. Ottawa: Canadian Fitness and Lifestyle Research Institute.

Cronbach, L.J. & Meehl, P.E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, *52*, 281-302.

Glass, G.V & Hopkins, K.D. (1996). *Statistical Methods in Education and Psychology* (3rd ed.). Needham Heights, MA: Allyn and Bacon.

Godin, G., & Shephard, R.J. (1985). A simple method to assess exercise behavior in the community. *Canadian Journal of Applied Sport Sciences*, *10*, 141-146.

Hayduk, L.A. (1996). *LISREL issues, debates, and strategies*. Baltimore, MD: Johns Hopkins University Press.

Hu, L. & Bentler, P.M. (1995) Evaluating model fit. In R.H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications (pp.*76-99). Thousand Oaks, CA: Sage.

Hu, L. & Bentler, P.M. (1999). Cutoff criteria for fit indices in covariance structure analysis:

Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1-55.

Jöreskog, K., & Sörbom, D. (1997). *LISREL 8.20 for Windows*. Chicago: Scientific Software International Inc.

Katzmarzyk PT, Gledhill N, & Shephard R.J. (2000). The economic burden of physical inactivity in Canada. *Canadian Medical Association Journal, 163*, 1435-1440.

Kristjansdottir G, & Vilhjalmsson R. (2001). Sociodemographic differences in patterns for sedentary and physically active behavior in older children and adolescents. *Acta Paediatr, 90,* 429-435.

Lee, R.E., Nigg, C. R., DiClemente, C. E., & Courneya, K. S. (2001). Validating motivational readiness for exercise behavior with adolescents. *Research Quarterly for Exercise and Sport, 72,* 401-410.

Marcus, B. H., Rakowski, W., & Rossi, J.S. (1992). Assessing motivational readiness and decision making for exercise. *Health Psychology, 11(4),* 257-261.

Marcus, B.H., Rossi, J.S., Selby, V.C., & Niaura, R.S. (1992). The stages and processes of exercise adoption and maintenance in a worksite sample. *Health Psychology, 11(6),* 386-395.

Marcus, B.H., Selby, V.C., Niaura, R.S., & Rossi, J.S. (1992). Self-efficacy and the stages of exercise behavior change. *Research Quarterly for Exercise and Sport, 63*, 60-66.

Marshall, S. J., & Biddle, S.J.H. (2001). The transtheoretical model of behavior change: A meta-analysis of applications to physical activity and exercise. *Annals of Behavioral Medicine, 23,* 229-246.

Nigg, C. R., & Courneya, K. S. (1998). Transtheoretical model: Examining adolescent exercise behavior. *Journal of Adolescent Health, 22,* 214-224.

Nunnally, J.C. & Bernstein, I.H. (1994). *Psychometric Theory* (3rd ed.). New York: McGraw Hill.

Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological Bulletin, 124*, 54-74.

Plotnikoff, R. C., Hotz, S. B., Birkett, N. J., & Courneya, K. S. (2001). Exercise and the transtheoretical

model: A longitudinal test of a population sample. *Preventive Medicine, 33,* 441-452.

Prochaska, J.O. & DiClemente, C.C. (1982). Transtheoretical therapy: Toward a more integrative model of change. *Psychotherapy: Theory, Research & Practice*, *19*, 276-288.

Prochaska, J.O., Redding, C.A., & Evers, K.E. (1997). The transtheoretical model and stages of change. In K. Glanz, F.M. Lewis, & B.K. Rimer (Eds.), *Health Behavior and Health Education: Theory, Research, and Practice (pp.*60-84). San Francisco, CA: Jossey-Bass Publishers.

Prochaska, J.O. & Velicer, W.F. (1997). The transtheoretical model of health behavior change. A*merican Journal of Health Promotion*, *12*, 38-48.

Rhodes, R.E. & Courneya, K.S. (2003a). Modelling the theory of planned behaviour and past behaviour. *Psychology, Health, and Medicine, 8*, 57-69.

Rhodes, R.E., Plotnikoff, R.C., & Spence, J.C. (In Press). Creating parsimony at the expense of precision? Conceptual and applied issues of aggregating belief-based constructs in physical activity research. *Health Education Research*.

Rosen, C.S. (2000). Is the sequencing of change processes by stage consistent across health problems? A meta analysis. *Health Psychology*, *19,* 593-604.

Schumacker, R.E. & Lomax, R.G. (1996). *A Beginner's Guide to Structural Equation Modeling*. Mahwah, NJ: Lawrence Erlbaum Associates.

U.S. Centers for Disease Control and Prevention (1996). Physical activity and health: A report of the surgeon general. [retrieved November 28, 2002] http://www.cdc.gov/nccdphp/sgr/adults.htm

Whitelaw, S., Baldwin, S., Bunton, R., & Flynn, D. (2000). The status of evidence and outcomes in Stages of Change research. *Health Education Research, 15,* 707-718.

Zakarian J.M., Hovell M.F., Hofsterrer C.R., Sallis J.F., & Keating K.J. (1994). Correlates of vigorous exercise in predominantly low SES and minority high school population. *Preventive Medicine, 23,* 314-321.

Table 1.
Chi Square Difference Tests for the 10 Processes of change constructs at the item level

Consciousness Raising (α = .77)	2	3	4
1. "Q5"	7.33*	14.86*	15.23*
2. "Q8"		1.59	0.54
3. "Q17"			0.68
4. "Q28"			

Dramatic Relief (α = .88)	2	3	4
1. "Q11"	2.98	1.24	0.31
2. "Q12"		0.77	1.42
3. "Q13"			0.93
4. "Q14"			

Environmental Reevaluation (α = .80)	2	3	4
1. "Q30"	1.39	0.22	1.07
2. "Q33"		1.27	6.79*
3. "Q34"			0.40
4. "Q37"			

Self Reevaluation (α = .78)	2	3	4
1. "Q15"	4.53	10.12*	1.30
2. "Q31"		4.87	0.25
3. "Q35"			2.80
4. "Q38"			

Social Liberation (α = .66)	2	3	4
1. "Q10"	11.97*	13.84*	9.66*
2. "Q22"		9.33*	15.23*
3. "Q32"			14.90*
4. "Q36"			

Counter Conditioning (α = .77)	2	3	4
1. "Q1"	15.91*	16.70*	15.77*
2. "Q21"		0.06	1.84
3. "Q39"			0.17
4. "Q40"			

Helping Relationships (α = .78)	2	3	4
1. "Q16"	0.91	2.32	5.17
2."Q19"		1.37	5.74
3."Q24"			0.02
4."Q25"			

Reinforcement Management (α = .71)	2	3	4
1. "Q7"	15.38*	17.79*	0.11
2. "Q18"		15.68*	13.28*
3. "Q20"			9.40*
4. "Q23"			

Self-Liberation (α = .66)	2	3	4
1. "Q2"	4.83	10.04*	27.61*
2. "Q4"		8.18*	31.00*
3. "Q6"			23.65*
4. "Q27"			

Stimulus Control (α = .67)	2	3	4
1. "Q3"	4.16	28.86*	30.63*
2. "Q9"		17.67*	22.18*
3. "Q26"			23.47*
4. "Q29"			

Note: * = p<.01 All tests performed at 1 degree of freedom.

Table 2.
Factor Loadings for the Processes of Change in Step 2

			Factor Loading		
Construct	M	SD	Standardized	Unstandardized	Error Variance
Consciousness Raising					
Q8	2.62	1.33	.66	1.00	.57*
Q17	2.18	1.23	.80	1.11*	.36*
Q28	2.28	1.28	.82	1.17*	.33*
Dramatic Relief					
Q11	2.97	1.26	.88	1.00	.23*
Q12	2.98	1.26	.85	.95*	.28*
Q13	2.77	1.23	.85	.94*	.28*
Q14	3.13	1.29	.67	.78*	.55*
Environmental Reevaluation					
Q30	2.99	1.38	.73	1.00	.46*
Q33	2.47	1.29	.66	.84*	.57*
Q34	2.52	1.32	.76	.99*	.42*
Q37	2.84	1.31	.70	.91*	.52*
Self-Reevaluation					
Q15	3.71	1.20	.73	1.00	.47*
Q31	3.48	1.33	.68	1.01*	.53*
Q35	3.03	1.39	.59	.92*	.65*
Q38	3.68	1.32	.80	1.08*	.36*
Counter Conditioning					
Q21	3.29	1.37	.79	1.00	.47*
Q39	2.95	1.34	.67	.84*	.53*
Q40	3.49	1.36	.75	.93*	.65*
Helping Relationships					
Q16	2.13	1.29	.74	1.00	.46*
Q19	2.87	1.36	.66	.95*	.57*
Q24	2.37	1.37	.67	.98*	.55*
Q25	2.21	1.28	.64	.87*	.59*
Reinforcement Management					
Q7	2.49	1.28	.73	1.00	.47*
Q23	2.72	1.34	.79	1.14*	.38*
Self-Liberation					
Q2	3.53	1.15	.65	1.00	.58*
Q4	3.10	1.26	.78	1.31*	.40*

Stimulus Control					
Q24	2.06	1.24	.66	1.00	.57*
Q30	1.96	1.19	.87	1.26*	.25*

Note. * = p<.01 (two-tailed) for freed estimates

Table 3.
Inter-Factor Correlations for the Experiential and Behavioral Processes

	2	3	4	5	6	7	8	9
1. Consciousness Raising	.42*	.52*	.45*	.44*	.43*	.48*	.37*	.54*
2. Dramatic Relief		.53*	64*	.22*	.36*	.33*	.42*	.35*
3. Environmental Reevaluation			.71*	.56*	.62*	.54*	.47*	.51*
4. Self Reevaluation				.49*	.39*	.41*	.62*	.28*
5. Counter Conditioning					.32*	.51*	.45*	.32*
6. Helping Relationships						.47*	.38*	.58*
7. Reinforcement Management							.45*	.45*
8. Self Liberation								.44*
9. Stimulus Control								

* = $p<.01$

Table 4.
Chi Square Difference Tests for Experiential and Behavioral Processes

	2	3	4	5	6	7	8	9
1. Consciousness Raising	23.61*	18.58*	32.18*	15.81*	22.74*	19.08*	33.75*	19.26*
2. Dramatic Relief		10.94*	7.15*	31.80*	15.31*	20.15*	23.36*	15.47*
3. Environmental Reevaluation			10.14*	7.06*	7.11*	13.05*	25.99*	16.28*
4. Self Reevaluation				16.88*	23.62*	22.77*	11.78*	34.17*
5. Counter Conditioning					20.56*	10.03*	16.49*	28.10*
6. Helping Relationships						12.15*	19.42*	8.33*
7. Reinforcement Management							23.56*	21.81*
8. Self Liberation								23.98*
10. Stimulus Control								

* = $p<.01$. All tests performed at 1 degree of freedom.

Table 5.
ANOVA and Discriminant Analysis: Stage membership and Processes of Change

Process	C	P	A	M	Correlation with function	*F*(3,281)	Post-hoc (p<.05)
1. Consciousness Raising	6.74 (3.12)	6.34 (2.97)	7.19 (3.21)	7.40 (3.41)	.21	1.94	
2. Self Liberation	5.37 (2.20)	6.21 (2.02)	6.67 (2.19)	7.02 (2.02)	.33	6.34*	C<A,M;P<M
3. Dramatic Relief	11.41 (3.85)	12.51 (4.16)	12.06 (3.59)	11.52 (4.61)	-.15	1.01	
4. Environmental Reevaluation	9.70 (3.45)	10.38 (3.83)	10.55 (4.07)	11.17 (4.41)	.18	1.36	
5. Helping Relationships	7.96 (3.33)	8.45 (3.36)	10.02 (4.74)	10.09 (4.17)	.34	4.41*	C< M
6. Stimulus Control	3.89 (2.08)	3.68 (1.79)	3.83 (1.97)	4.22 (2.34)	.20	1.28	
7.Counter Conditioning	7.46 (3.41)	7.68 (2.87)	9.65 (3.01)	11.00 (3.17)	.83	24.63*	C,P<A<M
8. Self Reevaluation	12.93 (3.87)	13.09 (3.94)	14.67 (3.72)	14.11 (4.08)	.13	2.34	
9. Reinforcement Management	5.04 (2.22)	4.41 (1.96)	5.12 (2.45)	5.62 (2.34)	.36	4.92*	P<M

Note: * p<=0.01. C = Contemplation, P = Preparation, A = Action, M = Maintenance.

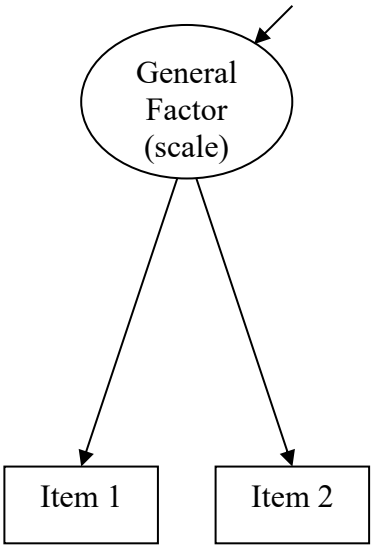
Table 6.
Classification of Processes of Change by Stage

Stages	Predicted Group				
	2	3	4	5	Total
Contemplation (2)	11 (45.8%)	5 (20.8%)	5 (20.8%)	3 (12.5%)	24
Preparation (3)	18 (27.3%)	34 (51.5%)	6 (9.1%)	8 (12.1%)	66
Action (4)	10 (19.6%)	10 (19.6%)	15 (29.4%)	16 (31.4%)	51
Maintenance (5)	16 (11.2%)	15 (10.5%)	26 (18.2%)	86 (60.1%)	143

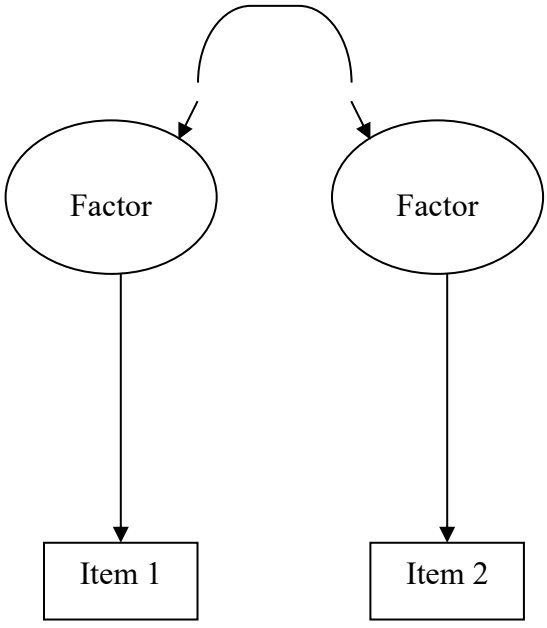
Figure Caption

Figure 1. Processes of Change Questions

A)



B)



1. Instead of sitting around I do some exercise.
2. I tell myself I am able to keep exercising if I want to.
3. I put things around my home to remind me of exercising.
4. I tell myself that if I try hard enough I can keep exercising.
5. I remember things people tell me about the benefits of exercise.
6. I make promises to myself – or others – that I'll exercise.
7. I reward myself when I exercise – I do something nice after I've earned it by exercising
8. I think about information – from magazines, newspapers, radio or TV – on how to make exercise a regular part of my life.
9. I keep things around school that remind me of exercise.
10. I find society is changing in ways that make it easier to exercise.
11. Warnings about being inactive affect how I feel.
12. When I see or hear things that show inactivity is back, it affects how I feel.
13. Warnings about being inactive change my feelings.
14. I worry that inactivity can be harmful to my body.
15. I've started thinking that regular exercise would make me healthier and happier.
16. I have someone who helps me when I have problems exercising.
17. I read about exercise to learn more about it.
18. I try to set realistic goals for myself instead of expecting too much.
19. I have an active friend or relative who encourages me to exercise when I don't feel up to it.
20. When I exercise I tell myself that I am being good to myself by taking care of my body.
21. Exercise is a special time to relax and recover from the day's worries. It's not just something to get out of the way.
22. I am aware of more and more people encouraging me to exercise these days.

23. I do something nice for myself for making the effort to exercise more.
24. I have someone who points out my excuses for not exercising.
25. I have someone who tells me how my exercise is going.
26. I change things that make me inactive.
27. I am the only one in charge of my health.
28. I look for information about exercise.
29. I avoid spending a long time in places that encourage sitting around.
30. I feel I would be a better example for others if I exercised regularly.
31. I think about the type of person I will be if I keep exercising.
32. I notice that more schools are encouraging students to exercise by offering fitness courses.
33. I wonder how sitting around affects people I am close to.
34. I think I might help others to be healthier if I exercise more.
35. I get mad at myself when I don't exercise.
36. I am aware that many sports centres and health clubs offer activities for parents and different activities for people my age.
37. Some of my close friends might exercise more if I did.
38. I think that by exercising more regularly, I would feel more confident about myself.
39. When I'm tired I make myself exercise anyway because I know I'll feel better afterwards.
40. When I'm tense, exercise relieves my worries.