

## The Psychological Need Satisfaction in Exercise Scale

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The purpose of this study was to provide initial construct validity evidence for scores derived from the Psychological Need Satisfaction in Exercise (PNSE) scale, a multidimensional instrument designed to measure perceived psychological need satisfaction in line with Deci and Ryan's (1985, 2002) self-determination theory (SDT). Participants in two studies ( $n_1 = 426$ ;  $n_2 = 581$ ) completed the PNSE along with proxy measures of need satisfaction. The results of an exploratory factor analysis in Study 1 supported the retention of a 3-factor measurement model underpinning PNSE responses. Confirmatory factor analysis conducted in Study 2 corroborated the tenability of the 3-factor measurement model in males and females and indicated partial support for invariance of PNSE scores across gender. Additionally, the scores on both the PNSE-Competence and PNSE-Relatedness subscales displayed a pattern of convergence with proxy measures. High internal consistency estimates (Cronbach  $\alpha > 0.90$ ) were observed for all PNSE subscale scores, and participants in both studies reported high levels of need satisfaction in exercise contexts. Overall, the findings suggest that the PNSE displays a number of psychometric characteristics that render the instrument useful for examining psychological need satisfaction in exercise contexts.

**Key Words:** self-determination theory, motivation, construct validity

Self-determination theory (SDT; Deci & Ryan, 1985, 2002) has become a popular framework for examining motivational issues in physical activity contexts (Frederick-Recascino, 2002). This is hardly surprising given that the approach to human development proposed within SDT accounts for the nature and function of motivation in conjunction with the psychological foundations from which motives develop (Deci & Ryan, 1985, 2002). According to Deci and Ryan (2002), motivation varies along a regulatory continuum ranging from more controlled to fully self-determined processes, with the latter nurturing positive consequences such as task persistence and eudaemonic well-being. Considering that successful health

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promotion attempts are inextricably linked to relevant theory (Frederick-Recascino, 2002), it appears that the tenets of SDT provide a promising framework for understanding motivational and well-being issues linked with physical activity involvement (Vallerand, 2001).

One integral component of the motivational approach taken by SDT is the concept of basic psychological needs (Deci & Ryan, 1985, 2002). In contrast with other theories that view psychological needs as any motivating force, including personal desires and goals (Ryan, 1995), Deci and Ryan contend that psychological needs represent essential conditions nourishing growth, integrity, and well-being (Deci & Ryan, 2002; Ryan, 1995). Consequently, the approach taken by SDT is that the effects of satisfying basic psychological needs are universal such that environments that nourish these feelings will promote well-being, whereas contexts that hinder need satisfaction will impede motivational development and promote ill-being (Deci & Ryan, 2002; Ryan, 1995; Sheldon, Williams, & Joiner, 2003). Although not without controversy, this aspect of SDT's framework offers a parsimonious explanation for a broad range of human behaviors and emotions (Deci & Ryan, 2002; Ryan, 1995) and suggests a viable route for intervention to foster psychological well-being and promote behavioral change (Sheldon et al., 2003).

The psychological needs for competence, autonomy, and relatedness have been forwarded by Deci and Ryan (1985, 2002) as innate and essential for nurturing optimal development (Ryan, 1995). Competence refers to interacting effectively with one's environment while mastering challenging tasks (White, 1959). Autonomy involves feeling a sense of personal agency and volition such that one's behavior is perceived to emanate from an internal locus of causality (deCharms, 1968). Finally, relatedness refers to a sense of meaningful connection in one's social milieu (Baumeister & Leary, 1995). Although the innate and universal nature of the psychological needs contained within SDT has not gone unchallenged (Iyengar & Lepper, 1999), an emerging body of evidence highlights the complementary nature of need-satisfying experiences and points to the positive effects stemming from need satisfaction on internalization, social adjustment, and psychological health (Deci & Ryan, 2002).

Given that psychological need satisfaction is a central component of SDT, it is surprising that relatively little research has examined the character or outcomes associated with perceived autonomy and relatedness compared with perceived competence in physical activity settings (Vallerand, 2001). That is to say, while sufficient evidence supports the link between perceived competence and positive consequences, such as internalized motives for exercise (Markland, 1999), there is less convincing evidence corroborating the importance of perceived autonomy and relatedness in exercise contexts.

Although previous studies have examined constructs that are conceptually linked with perceived psychological need satisfaction in physical activity settings, such as perceived autonomy support (Hagger, Chatzisarantis, Culverhouse, & Biddle, 2003; VanSteenkiste, Simons, Soenens, & Lens, 2004), self-determined exercise regulations (Mullan & Markland, 1997; Wilson, Rodgers, Fraser, & Murray, 2004), and social support (Li, 1999), it appears that a systematic attempt to measure the degree to which exercise contexts satisfy all three psychological needs has yet to be undertaken. Moreover, the few exercise-based studies that have examined perceived psychological need satisfaction have relied on single-item indexes, which

may not capture the theoretical bandwidth delineated by SDT (Wilson, Rodgers, & Fraser, 2002) or have employed measures of conceptually related constructs (such as social support as an index of relatedness; Li, 1999) that are not wholly consistent with the target domain outlined by SDT (Deci & Ryan, 2002). Considering the empirical support for satisfying SDT's basic psychological needs in other domains (LaGuardia, Ryan, Couchman, & Deci 2000), it is surprising that little attention has been directed toward the measurement of perceived competence, autonomy, and relatedness in exercise contexts where optimizing participant motivation is a central issue (Vallerand, 2001).

Given that measurement has been described as the Achilles' heel of behavioral research (Kerlinger, 1979, p. 141), it seems reasonable to suggest there is considerable scope for further research examining the measurement of psychological need satisfaction in exercise contexts using SDT as a guiding framework. The overall purpose of the present study was to evaluate select psychometric properties of the Psychological Need Satisfaction in Exercise (PNSE) scale. The PNSE scale is an exercise-specific instrument designed within the framework of SDT to measure perceived competence, autonomy, and relatedness. To address this purpose, we conducted two studies evaluating the construct validity of scores derived from the PNSE measurement model.

## Study 1

The purpose of Study 1 was to explore the factorial composition and structure of the PNSE scale to determine the extent to which the set of initial items correspond with Deci and Ryan's (1985, 2002) contentions regarding the measurement of perceived competence, autonomy, and relatedness.

### Method of Study 1

#### Study 1 Sample

A total of 426 students drawn from six undergraduate classes participated in Study 1. The students were in the 10th week of an academic course offered during the fall term at a large urban university in Western Canada. Participants did not receive academic credit for their involvement in this study. Of the total sample, 122 were male (mean age = 21.38 years,  $SD = 2.89$ ) and 170 were female (mean age = 20.59 years,  $SD = 3.02$ ); the remaining students did not indicate their gender. Participants reported body mass index (BMI) values approximating the healthy range for this age cohort (BMI males =  $24.90 \pm 3.34$  kg/m<sup>2</sup>; BMI females =  $22.16 \pm 2.15$  kg/m<sup>2</sup>) and varied involvement in physical activity (metabolic equivalents [METs] for males = 62.47,  $SD = 41.78$ ; METs for females = 58.09,  $SD = 34.27$ ). A total of 74.7% indicated that they had exercised  $\geq 3$  days/week for the past 6 months.<sup>1</sup>

#### Measure

**Psychological Need Satisfaction in Exercise (PNSE) Scale.** The PNSE items were developed in two stages.<sup>2</sup> First, personal accounts of need satisfaction were

**Table 1** Items Means, Standard Deviations, Communalities, and Pattern Coefficients of the Three-Factor Direct Oblimin ( $\delta = 0$ ) Solution of the PNSE

PNSE Item Numbers and Abbreviations	<i>M</i>	<i>SD</i>	<i>R</i> <sup>2</sup>	<b>I</b>	<b>II</b>	<b>III</b>
PNSE—Perceived Competence (Cronbach $\alpha = 0.91$ )	5.36	0.65				
PNSE2 Confident I can do challenging exercise	5.09	0.89	.64	<b>.83</b>	-.00	.00
PNSE5 Capable of doing challenging exercises	5.25	0.87	.66	<b>.80</b>	-.00	.17
PNSE4 Capable of completing exercise challenge	5.45	0.71	.75	<b>.83</b>	-.00	-.01
PNSE1 Able to complete personal exercise challenge	5.43	0.73	.57	<b>.72</b>	.01	.00
PNSE3 Confident in my ability to exercise	5.47	0.69	.66	<b>.75</b>	.00	.16
PNSE6 Feel good about ability to exercise	5.46	0.73	.58	<b>.66</b>	.10	.21
PNSE—Perceived Autonomy (Cronbach $\alpha = 0.91$ )	5.50	0.59				
PNSE11 Free to choose exercises I participate in	5.55	0.66	.65	.01	<b>.80</b>	-.01
PNSE10 Have a say in choosing exercises I do	5.51	0.73	.63	.00	<b>.81</b>	-.00
PNSE9 I am in charge of my exercise program decisions	5.45	0.72	.67	-.00	<b>.80</b>	-.01
PNSE12 I decide what exercises I do	5.33	0.75	.55	-.00	<b>.74</b>	-.00
PNSE8 Free to make my own exercise decisions	5.48	0.72	.62	-.00	<b>.77</b>	-.01
PNSE7 Free to exercise in my own way	5.49	0.71	.53	.01	<b>.64</b>	-.17
PNSE—Perceived Relatedness (Cronbach $\alpha = 0.90$ )	4.57	0.99				
PNSE17 Connected to people I interact with	4.66	1.17	.69	.00	.00	<b>.87</b>
PNSE14 Share a common bond with people	4.45	1.26	.58	.00	.01	<b>.78</b>
PNSE16 Close to my exercise companions	4.55	1.20	.60	-.01	-.01	<b>.78</b>
PNSE15 Sense of camaraderie with companions	4.53	1.20	.54	.00	-.00	<b>.75</b>
PNSE18 Get along with people I interact with	4.89	1.05	.60	-.01	.01	<b>.75</b>
PNSE13 Attached to exercise companions	4.37	1.38	.53	-.01	.00	<b>.73</b>

*Note.* Pattern coefficients in bold represent primary factor loadings of the 18 PNSE items retained in the final solution. Interfactor correlations were as follows: (a)  $r_{I,II} = 0.47$ ; (b)  $r_{I,III} = 0.18$ ; (c)  $r_{II,III} = 0.01$ .  $R^2$  = communality estimates for each PNSE item. Bivariate correlations between scores on PNSE subscales were as follows: (a)  $r_{\text{competence,autonomy}} = 0.46$ ; (b)  $r_{\text{competence,relatedness}} = 0.18$ ; (c)  $r_{\text{autonomy,relatedness}} = 0.09$ .

obtained from a purposive sample of 239 participants currently engaged in structured exercise classes (91.2% female, mean age =  $24.97 \pm 7.77$  years; mean BMI =  $21.36 \pm 3.93$  kg/m<sup>2</sup>; mean METs =  $45.18 \pm 26.51$ ; in all, 61.5% had exercised  $\geq 3$  times/week for the past 6 months). The participants responded to three open-ended questions asking them to describe personal experiences that satisfied competence, autonomy, and relatedness needs in exercise contexts. Their descriptions were used in conjunction with the SDT to create an initial set of six competence, nine autonomy, and seven relatedness items. Second, a panel of 40 experts rated the content relevance and representation of the initial item set and provided written comments in accordance with the recommendations of Dunn, Bouffard, and Rogers (1999). The experts represented proficiency in SDT ( $n = 15$ ), exercise psychology ( $n = 12$ ), exercise instruction ( $n = 13$ ), and exercise participation ( $n = 10$ ). Statistical evidence suggested that the initial items were relevant to and representative of the target need satisfaction domain to which they were initially referenced.<sup>3</sup> Adjustments to the initial PNSE scale item set were made based on the open-ended comments provided by 27 experts to improve item wording.

The final set of 18 PNSE items, with six items referenced to each of the three domains, incorporated (a) the phenomenological accounts provided by active exercisers of their need satisfaction experiences, (b) SDT's arguments concerning the nature of psychological need satisfaction, and (c) expert insight into the nature of item wording and the theoretical universe represented by the PNSE items. The 18 PNSE items were randomly ordered so as to reduce the potential for response set bias. Participants responded to each item via a 6-point Likert scale from 1 = *false* to 6 = *true*. The instructions encouraged participants to respond to each item in terms of how they usually felt while exercising ("The following statements represent different feelings people have when they exercise. Please answer the following questions by considering how you typically feel while you are exercising.").

## Data Collection and Analyses

Data were collected from intact groups ( $n > 100$  each in most instances). Participants were informed about the nature of the study and were given the opportunity to ask questions pertaining to their involvement. They provided written informed consent prior to completing the questionnaires. Standard instructions were given to each group by the same researcher to reduce the potential for between-groups effects associated with test administration.

The data analyses were completed in five sequential steps. First the PNSE's interitem correlation matrix was examined to determine the suitability of the data for exploratory factor analyses (EFA; Dziuban & Shirkey, 1974).<sup>4</sup> Second, the number of factors to retain was determined using Guttman's (1954) rule (eigenvalues  $> 1.0$ ) and Cattell's (1978) scree plot along with theoretical considerations. Third, a principal axes factor extraction (PAF) was completed with the number of factors identified at the second stage. Fourth, the unrotated factor matrix yielded by PAF was rotated using equamax to yield an orthogonal solution and was transformed using direct oblimin ( $\delta = 0$ ) to yield an oblique solution (Gorsuch, 1983). Thurstone's (1947) principle of simple structure, with a pattern coefficient of 0.301 serving as the lower bound of item meaningfulness per factor, and factor interpretability were used to decide on the final solution (Gorsuch, 1983). Subscale scores

for the PNSE variables were computed by averaging the scores for the items that loaded on each factor (Morris, 1979).

## Results of Study 1

### Preliminary Analyses

An inspection of the data indicated that there were no missing values, no values were out of range, and 11 students provided aberrant responses (e.g., outliers  $> 13$   $SD$  from the mean) to the PNSE items. These participants were removed prior to conducting any further analyses. Given that (a) Bartlett's test of sphericity suggested item interdependence ( $\chi^2 = 4896.74, p < 0.01$ ), (b) an acceptable sampling adequacy statistic was observed (Kaiser-Meyer-Olkin = 0.90), and (c) the anti-image covariance matrix approximated a diagonal matrix (less than 4.57% of the off-diagonal elements  $> 0.10$ ), the PNSE interitem correlation matrix was deemed suitable for exploratory factor analysis. Item-level descriptive statistics indicated some departures from univariate normality in the PNSE responses: skewness ranged from  $-2.15$  to  $-0.82$  (94.44%  $< 12.0$ ), kurtosis scores ranged from 0.56 to 7.56 (61.11%  $< 13.0$ ), and notable multivariate kurtosis was evident (Mardia's coefficient = 184.76).

### Main Analyses

Joint consideration of both stopping rules for identifying the number of factors suggested retaining three factors. The first three eigenvalues exceeded 1.0 ( $\lambda_1 = 6.39, \lambda_2 = 3.84, \lambda_3 = 2.22$ ) and the next largest eigenvalue extracted was substantially smaller ( $\lambda_4 = 0.63$ ). Therefore, three factors were extracted using PAF. The equamax solution contained two factorially complex items. In contrast, there were no factorially complex items in the oblique solution. Consequently, the oblique solution was selected as the final solution. An inspection of the transformed pattern matrix (see Table 1) suggested the presence of an interpretable solution. Factor 1 accounted for 33.6% of the total variance, contained six items reflecting effectance and capability associated with meeting personally challenging exercises, and was labeled PNSE-Perceived Competence. Factor 2, labeled PNSE-Perceived Autonomy, contained six items representing volition, choice, and self-determination and accounted for 19.3% of the total variance. Factor 3 accounted for 10.4% of the variance, contained six items representing feelings of connection to others, and was labeled PNSE-Perceived Relatedness. The correlations among the factors were low to moderate (see Table 1).

### Descriptive Statistics and PNSE Subscale Reliability

Descriptive statistics (Table 1) indicated that participants reported high levels of psychological need satisfaction in exercise, although perceived competence and autonomy were more strongly endorsed than relatedness. Internal consistency

estimates (Cronbach's coefficient  $\alpha$ ; Cronbach, 1951) exceeded 0.90 for each PNSE subscale (see Table 1 for specific values).

### Summary of Study 1

The purpose of Study 1 was to explore the latent dimensionality and structure of the PNSE items and examine the interrelationships among PNSE constructs. The results indicated that the 18-item PNSE displayed excellent simple structure, acceptable factor definition, and the transformed solution was interpretable and consistent with SDT (Deci & Ryan, 2002). Further support for the psychometric integrity of the PNSE was evident in the observed reliability estimates. The interfactor correlations were consistent with previous research measuring need satisfaction in exercise using comparable samples (Wilson et al., 2002) and offer preliminary evidence to suggest that need-satisfying experiences are not mutually exclusive psychological processes in exercise contexts.

## Study 2

The purpose of Study 2 was to extend the construct validity evidence for PNSE scores by testing the PNSE measurement model identified in Study 1 using confirmatory factor analysis (CFA) in a separate sample. Additional analyses were also conducted to determine the degree to which PNSE scores were invariant between genders. Measurement invariance refers to the extent to which scores retain equivalent meaning across different conditions or groups (Cheung & Rensvold, 2002) and is an important consideration in scale development where group-based comparisons (such as gender differences) are meaningful considerations (Hoyle & Smith, 1994). The secondary purpose of Study 2 was to extend the PNSE construct validity evidence by examining the relationship between PNSE scores and proxy markers of need satisfaction. It was hypothesized that the three-factor oblique solution obtained in Study 1 would account for the observed PNSE responses, PNSE scores would be invariant between genders, and PNSE scores would correlate positively with scores on conceptually similar proxy markers.

## Method of Study 2

### Study 2 Sample

A total of 223 male (mean age = 22.03 years;  $SD = 4.16$ ) and 358 female (mean age = 21.55 years;  $SD = 3.87$ ) university students enrolled in undergraduate classes at a large university in Western Canada provided data for this study. Participants did not receive academic credit for involvement in this study. Consistent with Study 1, the BMI values approximated the healthy range for this age cohort (BMI of males = 25.01 kg/m<sup>2</sup>,  $SD = 3.28$ ; BMI of females = 22.17 kg/m<sup>2</sup>,  $SD = 3.16$ ), and considerable variability in physical activity behavior was evident (METs for males = 65.64,  $SD = 37.09$ ; METs for females = 57.37,  $SD = 35.00$ ). A total of 69.5% of the overall sample indicated they had exercised  $\geq 3$  times/week for the past 6 months.

## Measures

**PNSE Scale.** The same version of the PNSE retained from the exploratory factor analysis completed in Study 1 was used in Study 2.

**Competence.** An exercise-specific 6-item version of the Intrinsic Motivation Inventory's Perceived Competence (IMI-C) subscale (Ryan, 1982) was used to assess the convergent validity of the perceived competence subscale of the PNSE. Following a stem that contextualized responses to each item in the exercise domain (namely, "The following statements concern your thoughts about exercise. Please circle the number that indicates how strongly you agree or disagree with each of the following statements."), participants provided responses to each IMI-C item on a scale anchored at the extremes by 1 (*strongly disagree*) and 7 (*strongly agree*). Previous research using the IMI-C with adult exercisers indicates that the internal consistency of the IMI-C exceeds 0.80 (Markland, 1999) and that higher IMI-C scores correlate positively with frequency of exercise participation (Oman & McAuley, 1993) and intrinsic motivation (Markland, 1999). An overall perceived competence score was calculated by averaging the IMI-C scores after reverse coding.

**Autonomy.** An exercise-specific 7-item version of the Intrinsic Motivation Inventory's Perceived Choice (IMI-PC) subscale was used to assess the convergent validity of perceived autonomy subscale of the PNSE. Following the same stem as the IMI-C, participants responded to each IMI-PC item on a 7-point Likert scale anchored at the extremes by 1 (*strongly disagree*) and 7 (*strongly agree*). Internal consistency estimates in previous studies using the IMI-PC exceed 0.70 (Ferrer-Caja & Weiss, 2000, reported Cronbach  $\alpha$  values of 0.73 and 0.75 for males and females, respectively). Previous research using modifications of the IMI-PC in physical activity settings indicates that IMI-PC scores predict intrinsically motivated behavior (Ferrer-Caja & Weiss, 2000; Oman & McAuley, 1993). A subscale score was calculated by averaging each IMI-PC item after reverse coding.

**Relatedness.** The Affiliation (EMI-A) subscale of the Exercise Motivation Inventory-2 (EMI-2; Markland & Ingledew, 1997) was used to assess the convergent validity of scores on the perceived relatedness subscale of the PNSE. The EMI-A is 1 of 14 subscales that make up the EMI-2 and assesses the degree to which social belonging motivates exercise participation (Markland & Ingledew, 1997). The items were preceded by a general statement: "The following is a list of reasons people commonly give when asked why they are currently exercising or why they would choose to exercise. Personally, I exercise (or might exercise) because. . . ." A 6-point Likert scale anchored at the extremes by 0 (*not at all true for me*) and 5 (*very true for me*) was used for EMI-A responses. Previous research reports internal consistency reliability estimates ranging from 0.81 to 0.91 (Ingledew & Sullivan, 2002; Markland & Hardy, 1993; Markland & Ingledew, 1997) and modest stability over 4 to 5 weeks ( $r = 0.71$ ; Markland & Hardy, 1993) for EMI-A scores. Higher EMI-A scores have been positively associated with intrinsic motivation for exercise (Markland & Hardy, 1993). Responses to the four EMI-A items were averaged and summed to form an overall affiliation score.



## Data Collection and Analyses

The data collection procedures of Study 2 were identical to those used in Study 1. The data analyses proceeded in sequential steps. First the data were screened to identify potential outliers, missing values, or discrepancies that could adversely influence the subsequent analysis. Second, descriptive statistics were calculated for the PNSE items to select an appropriate estimator for the CFA. Third, a series of CFAs was conducted using AMOS (Arbuckle, 1997) to determine the ability of an oblique three-factor measurement model to account for the observed PNSE data and the sensitivity of the PNSE scores to gender. Conventional standards were specified for all CFA models, including loading items exclusively on relevant factors, correlating latent factors, not freeing error terms to correlate, and setting the loading of the manifest item to 1.0 to define each latent factor's scale.

A selection of fit indices recommended with small samples where data likely deviate from normality were used to assess global model fit of the CFA solutions (i.e.,  $\chi^2$ , comparative fit index [CFI], incremental fit index [IFI], root mean square error of approximation [RMSEA], standardized root mean square residual [SRMSR]; West, Finch, & Curran, 1995). Although values indicative of acceptable model fit in hypothesis-testing approaches to CFA remain controversial (Hu & Bentler, 1999; Marsh, Hau, & Wen, 2004), CFI and IFI values exceeding 0.90 and 0.95 are typically considered indicative of acceptable and excellent fit (Hu & Bentler, 1999). Values less than 0.05 obtained from RMSEA suggest an excellent fit, whereas values exceeding 0.10 are typically undesirable (Browne & Cudeck, 1993). Values approximating 0.08 or less from SRMSR are typically considered satisfactory (Hu & Bentler, 1999). The final stage of the analyses involved calculating descriptive statistics, reliability estimates, and bivariate correlations for PNSE, IMI-C, IMI-PC, and EMI-A responses.

## Results of Study 2

### Preliminary Data Analyses

An inspection of the responses indicated that less than 5% of the data were missing on any one item, with no discernible pattern evident in the missing data. Therefore, the expectation maximization algorithm was used to replace the missing values. An examination of the full data set found no problems based on extreme responses ( $>3$  *SD* away from the mean) on any variable. The item-level descriptive statistics (Table 2) indicated some departures from univariate normality in the PNSE score distributions (skewness values ranged from  $-2.07$  to  $-0.61$  and kurtosis values ranged from  $-0.11$  to  $5.55$ , respectively, across the total and gender-specific subsamples). Notable multivariate kurtosis was evident in the PNSE data provided by the total sample (Mardia coefficient = 294.41), male subsample (Mardia coefficient = 219.83), and female subsample (Mardia coefficient = 255.33). Although alternative estimation procedures have been suggested for nonnormal data, they typically require large sample sizes (Hu & Bentler, 1995) and have been associated with less-desirable estimates of model fit in small samples (Maruyama, 1998). West et al. (1995) recommended the use of maximum likelihood (ML) estimation

**Table 2 Standardized Factor Loadings and Error Variances for PNSE Measurement Model**

PNSE Subscale	Total Sample				Male Subsample				Female Subsample			
	M	SD	FL	EV	M	SD	FL	EV	M	SD	FL	EV
	4.77	1.06	0.73	0.30	5.16	0.94	0.79	0.26	4.76	1.04	0.69	0.32
	4.91	1.03	0.80	0.39	5.21	0.94	0.84	0.26	4.92	1.01	0.77	0.45
	5.18	0.92	0.87	0.20	5.31	0.91	0.87	0.19	5.23	0.87	0.86	0.21
	5.19	0.83	0.87	0.19	5.36	0.85	0.88	0.20	5.23	0.78	0.88	0.17
	5.14	0.95	0.86	0.25	5.34	0.89	0.87	0.21	5.18	0.91	0.85	0.28
	5.15	0.98	0.75	0.37	5.32	0.89	0.80	0.29	5.21	0.94	0.72	0.43
					<b>Perceived Competence</b>							
	5.40	0.88	0.77	0.33	4.95	1.13	0.80	0.31	5.32	0.95	0.75	0.34
	5.42	0.86	0.86	0.22	4.91	1.13	0.87	0.25	5.33	0.94	0.85	0.19
	5.37	0.87	0.86	0.22	4.79	1.20	0.89	0.21	5.25	0.96	0.83	0.23
	5.42	0.87	0.88	0.18	4.96	1.12	0.87	0.22	5.34	0.94	0.89	0.16
	5.42	0.82	0.87	0.19	4.76	1.24	0.87	0.22	5.29	0.95	0.88	0.17
	5.42	0.88	0.88	0.22	4.91	1.14	0.80	0.34	5.32	0.96	0.90	0.14
					<b>Perceived Autonomy</b>							
	4.44	1.29	0.74	0.90	4.46	1.19	0.72	0.90	4.44	1.32	0.75	0.92
	4.43	1.28	0.83	0.49	4.51	1.24	0.82	0.49	4.42	1.28	0.84	0.48
	4.38	1.28	0.73	0.57	4.48	1.21	0.76	0.43	4.35	1.30	0.72	0.67
	4.24	1.36	0.81	0.63	4.36	1.36	0.81	0.60	4.21	1.36	0.81	0.63
	4.69	1.17	0.79	0.56	4.58	1.15	0.76	0.57	4.71	1.18	0.82	0.56
	4.32	1.42	0.89	0.33	4.40	1.24	0.88	0.28	4.30	1.46	0.89	0.35
					<b>Perceived Relatedness</b>							

Note. FL = standardized factor loading; EV = error variance; PNSE = Psychological Need Satisfaction in Exercise scale. Phi-coefficients for the total sample ( $\phi_{\text{pcomp,paat}} = 0.71$ ;  $\phi_{\text{pcomp,prel}} = 0.39$ ;  $\phi_{\text{paat,prel}} = 0.29$ ), male subsample ( $\phi_{\text{pcomp,paat}} = 0.83$ ;  $\phi_{\text{pcomp,prel}} = 0.51$ ;  $\phi_{\text{paat,prel}} = 0.37$ ), and female subsample ( $\phi_{\text{pcomp,paat}} = 0.65$ ;  $\phi_{\text{pcomp,prel}} = 0.31$ ;  $\phi_{\text{paat,prel}} = 0.26$ ). All  $\phi$ -coefficients are statistically significant at  $p < 0.01$ .

in conjunction with the CFI and the IFI to assess model fit when the sample size is small. Therefore, ML estimation procedures were employed for these analyses.

### Confirmatory Factor Analysis of PNSE Measurement Models

The values of the fit indices used to evaluate the PNSE measurement model are listed in Table 3. The CFI and IFI values ranged from 0.92 to 0.94, and the values for both the SRMSR and the point RMSEA estimates are less than 0.10 across the total and gender-specific subsamples. Minimal evidence of over- or underestimation of the fitted correlations was observed in the distribution of standardized residuals ( $z$ ) in the total sample (83.0% < |2.0|; 6.5% > |3.0|); female subsample (89.0% < |2.0|; 2.6% > |3.0|); or male subsample (94.8% < |2.0|; 0.6% > |3.0|). The standardized parameter loadings and error variances are listed for the correlated three-factor model in Table 2. All 18 items loaded positively on their target reference factors (range = 0.69 to 0.90; all  $p$ -values < 0.05). An inspection of the phi-coefficients ( $\phi$ ) indicated a pattern of weak-to-strong positive relationships between latent PNSE constructs (see Table 2) with none of the 95% confidence intervals around any  $\phi$ -coefficient including one. Taken together, these indices suggest that the hypothesized measurement model provides a satisfactory account of the observed PNSE data.

### Sequential Multigroup Covariance Analysis by Gender

Simultaneous multigroup covariance analyses (SMCA) were conducted to assess the sensitivity of PNSE responses to gender. Simultaneous multigroup covariance analysis imposes increasingly restrictive constraints on a model's parameters and evaluates subsequent changes in model fit. A noticeable decrement in model fit following the imposition of an equality constraint within a model is evidence of invariance across groups for the model parameter(s) being tested (Cheung & Rensvold,

**Table 3 Global Indices of Model Fit Across Total and Gender-Specific Subsamples**

	$\chi^2$	<i>df</i>	<i>p</i>	CFI	IFI	SRMSR	RMSEA (90% CI)
Total sample	688.03	132	<0.01	0.94	0.94	0.07	0.09 (0.08–0.09)
Male subsample	406.53	132	<0.01	0.92	0.92	0.08	0.09 (0.08–0.11)
Female subsample	489.59	132	<0.01	0.93	0.93	0.07	0.08 (0.07–0.09)

*Note.* *df* = degrees of freedom; CFI = comparative fit index; IFI = incremental fit index; SRMSR = standardized root mean square residual; RMSEA = root mean square error of approximation; CI = confidence interval for relevant point estimates.

2002). Since the behavior of global model fit indices during SMCA can be distorted when subsamples differ in size (Vandenberg & Lance, 2000), we deleted a random selection of females ( $n = 135$ ) from the sample such that the invariance tests were performed on equivalent numbers of male and female participants ( $n = 223$ ).

Four hypotheses (equality of factor loadings, factor covariances, factor variances, and error variances) were tested in sequential order, with each hypothesis assuming support for the previous measurement model constraint. The results of the SMCA are presented in Table 4. Initial examination of the  $\chi^2_d$  test suggests that only Model B (equality of factor loadings) is tenable across male and female subsamples. However, a closer look at the data suggests minimal deterioration in model fit across Models A through C, indicating support for the equivalence of factor loadings and factor covariances between genders for PNSE scores. It is, however, difficult to suggest there is support for the equivalence of factor variances and error variances associated with the PNSE, given the decrements in model fit observed across these more constrained models evidenced by the large changes in CFI values and the less-than-desirable SRMSR values. Nevertheless, the equality of error variances is considered a restrictive test of measurement invariance that is rarely observed in practice (Vandenberg & Lance, 2000), and the tests of model fit associated with the invariance hypotheses may have been affected by violations of normality present in these data. Although the results of the SMCA are not definitive, it does seem that joint consideration of all fit statistics implies that the PNSE is not overly sensitive to gender.

### **Descriptive Statistics, Scale Reliability, and Relationships With Proxy Markers**

Participants reported greater perceptions of competence and autonomy in exercise settings than perceived relatedness (see Table 5). The internal consistency reliability estimates (coefficient  $\alpha$ ) for the PNSE scores were greater than or equal to 0.90 (see Table 5). The corresponding internal consistencies for the three proxy measures ranged from 0.78 to 0.92. Pearson correlation coefficients (Table 5) indicated that PNSE-Perceived Competence scores correlated most strongly with IMI-C scores ( $r = 0.65$ ). Likewise, though not as strong ( $r = 0.48$ ), the PNSE-Perceived Relatedness scores correlated most strongly with EMI-A scores. In the case of PNSE-Perceived Autonomy, the scores correlated most strongly (albeit weakly) with its proxy measure (IMI-PC,  $r = 0.32$ ), closely followed by IMI-C scores ( $r = 0.30$ ). These data suggest there is stronger convergent validity evidence for scores on the PNSE-Perceived Competence subscale, followed by the PNSE-Perceived Relatedness subscale, and lastly, the PNSE-Perceived Autonomy subscale. These findings agree with the pattern of correlations among the three PNSE scales and suggest that perceived competence and autonomy are more associated with one another than with perceived relatedness.

### **Summary of Study 2**

The purpose of Study 2 was to extend the construct validity evidence of PNSE scores by confirming the tenability of the PNSE measurement model derived in Study 1, and examining patterns of convergence between PNSE scores and proxy

**Table 4 Sequential Multigroup Covariance Analyses Testing Equality of Factor Structures Over Gender-Specific Subsamples (*n* = 223)**

Hypothesis	$\chi^2$	<i>df</i>	$\chi^2_d$	<i>df<sub>d</sub></i>	<i>p</i>	CFI	$\Delta$ CFI	SRMSR	RMSEA (90% CI)
Model A	741.87	264	—	—	—	0.93	—	0.06	0.06 (0.058–0.069)
Model B	763.53	279	21.66	15	>0.05	0.93	-0.001	0.07	0.06 (0.057–0.068)
Model C	774.87	282	11.34	18	<0.01	0.93	-0.001	0.10	0.06 (0.057–0.068)
Model D	790.89	285	16.03	21	<0.01	0.93	-0.002	0.11	0.06 (0.058–0.068)
Model E	854.56	303	63.67	39	<0.01	0.92	-0.007	0.11	0.06 (0.059–0.069)

Note:  $\chi^2_d$  = chi-square difference; *df<sub>d</sub>* = difference in degrees of freedom; CFI = comparative fit index;  $\Delta$ CFI = change in CFI; SRMSR = standardized root mean square residual; RMSEA = root mean square error of approximation; CI = confidence interval for relevant point estimates. A = baseline (unrestricted) model; B = assuming A, testing for equivalence of factor loadings; C = assuming B, testing for equivalence of factor covariances; D = assuming C, testing for equivalence of factor variances; E = assuming D, testing for equivalence of error variances (three-factor correlated model for B, C, D, E).

**Table 5 Descriptive Statistics, Reliability Estimates, and Bivariate Correlations Between PNSE Subscales and Proxy Markers**

Variables	1		2		3		4		5		6	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
1. PNSE—Perceived Competence	5.31	0.68	5.54	0.60	4.48	1.07	5.72	0.82	5.51	0.94	2.40	1.32
2. PNSE—Perceived Autonomy	0.91		0.91									
3. PNSE—Perceived Relatedness	0.25		0.10		0.90							
4. IMI—Perceived Competence	0.65		0.30		0.27		0.82					
5. IMI—Perceived Choice	0.23		0.32		0.05		0.31		0.78			
6. EMI—Affiliation	0.06		-0.01		0.48		0.07		-0.09		0.92	

Note: PNSE = Psychological Need Satisfaction in Exercise; EMI = Exercise Motivation Inventory-2; IMI = Intrinsic Motivation Inventory. All  $r > 0.05$  significant at  $p < 0.05$  (two-tailed). All  $r > 0.10$  significant at  $p < 0.01$  (two-tailed). Skewness values ranged from -1.55 to -0.14. Kurtosis values ranged from 0.69 to 2.39. Internal consistency reliability estimates (Cronbach coefficient  $\alpha$ ) are placed along the principal diagonal.

measures of need satisfaction. The results of the CFA corroborate the utility of the three-factor oblique PNSE measurement model identified in Study 1 in males and females, whereas the SMCA results suggest that PNSE scores are partially invariant across gender. The internal consistency reliability estimates observed in Study 2 corroborate those obtained in Study 1 and provide additional support for the reliability of PNSE subscale scores. The correlations between the PNSE subscales and the external markers of competence and relatedness suggest additional support for the convergent validity of the PNSE-Perceived Competence and PNSE-Perceived Relatedness scores. However, there was less-convincing evidence to support the convergent validity of scores on the PNSE-Perceived Autonomy subscale.

## Discussion

The purpose of this study was to examine select aspects of construct validity associated with PNSE scores. The results of both studies reveal that the factor structure and composition of the PNSE reflect the three-factor model proposed by Deci and Ryan's (1985, 2002) SDT and suggest the PNSE is a congeneric measure whereby each item measures a single latent construct (Anderson & Gerbing, 1988). Congeneric measures are desirable given that such instruments are well defined according to the number of manifest items per latent factor and reduce ambiguity in the interpretation of latent constructs (Anderson & Gerbing, 1988). Combined with the evidence supporting the structural validity of the PNSE scores across two samples, the SMCA supports the partial invariance of PNSE scores across gender, providing initial support for the use of the PNSE with males and females.

The demonstration of invariance at this stage of the PNSE scale's development is encouraging and allows for group-based comparisons between males and females without undue concern for differential item interpretations that might contaminate the comparisons. Both studies provide evidence of discriminant validity for PNSE subscale scores, given that modest interfactor correlations were observed in Study 1 and that the 95% confidence intervals surrounding each  $\phi$ -coefficient in Study 2 failed to encompass unity. Study 2 provided initial evidence of convergent validity particularly for scores on both the PNSE-Competence and PNSE-Relatedness subscales. Overall, these results suggest that PNSE measures three distinct but not mutually exclusive constructs representing perceptions of competence, autonomy, and relatedness in exercise settings.

Despite these encouraging results, the application of CFA methods in Study 2 did identify a potential weakness in the PNSE scale. An examination of the modification indices associated with the CFA suggested that correlating the error terms of two PNSE-Perceived Competence items would have improved overall model fit. Although these modifications were not pursued, the observed modification index does suggest room for improvement in the current version of the PNSE scale. One interpretation of the observed modifications is the presence of residual variance left unexplained by the PNSE-Perceived Competence factor that warrants the inclusion of additional latent factors (Gerbing & Anderson, 1984). Although the content expressed by the PNSE-Perceived Competence items suggests considerable overlap, no additional factors were included given that SDT does not support the multidimensionality of perceived competence, and the pursuit of such

a solution would have capitalized on chance relationships in the sample data that rarely replicate under cross-validation (Anderson & Gerbing, 1988; MacCallum, Roznowski, & Necowitz, 1992). Consequently, it seems prudent to recognize the suggested modifications observed in the present study pertaining to the PNSE-Perceived Competence items, and to examine the suitability of these indicators in future applications of the PNSE.

Consistent with the factor analytic results, the pattern of relationships exhibited by the PNSE-Perceived Competence and PNSE-Perceived Relatedness subscales with proxy markers provides convergent evidence supporting the construct validity of PNSE score interpretations. The strongest correlates of the external markers representing perceived competence (i.e., IMI-C scores) and relatedness (i.e., EMI-A scores) were the corresponding PNSE subscales. Even though the size of these relationships varied considerably, it should be noted that the EMI-A was not originally developed to capture relatedness in exercise contexts, and the size of the relationships exhibited by the PNSE-Perceived Relatedness subscale with EMI-A scores is consistent with previous research (Wilson et al., 2002), suggesting evidence of convergent validity for the PNSE-Perceived Relatedness scores.

Despite these encouraging results, the available data attesting to the convergence of scores on the PNSE-Perceived Autonomy subscale with a conceptually relevant external marker of need satisfaction (namely, IMI-PC) is weak. In Study 2, scores derived from the PNSE-Perceived Autonomy subscale exhibited comparable relationships with both perceived choice and perceived competence, which fail to offer convincing evidence of convergence between PNSE-Perceived Autonomy scores and the corresponding external marker used in this study. One explanation for these aberrant findings is the relatively low internal consistency estimates observed for IMI-PC scores ( $\alpha = 0.78$ ), which can attenuate the value of the convergent validity coefficients (Crocker & Algina, 1986). Correcting the coefficients for attenuation due to unreliability indicated no substantial changes in the validity coefficients ( $r_{\text{PNSE-Autonomy,IMI-PC}} = 0.38$  and  $r_{\text{PNSE-Competence,IMI-PC}} = 0.34$ ) and suggests that the unreliability hypothesis is not tenable in the present data.

Two alternative explanations for the observed relationship between PNSE-Perceived Autonomy and the proxy markers of psychological need satisfaction can be offered. First, the weak relationships could be attributable to a lack of content representation inherent in the IMI-PC items with reference to autonomy. Recent research suggests autonomy is comprised of perceived volition, internal locus of causality, and perceived choice (Reeve, Nix, & Hamm, 2003). Considering Reeve and colleagues' contentions, it seems the magnitude of the observed relationships might have been expected given that the IMI-PC captures only a portion of the content associated with perceived autonomy. An alternative explanation for the present findings concerns the presence of methods effects generated from positive and negatively phrased IMI-PC items. Previous research indicates that the use of items with reverse polarity within the same scale can attenuate relationships between the variables under study (Motl, Conroy, & Horan, 2000; Motl & DiStefano, 2002). Although definitive conclusions on this matter await further research, the evidence highlighting the effects of polarity in item wording contained in the same subscale renders this explanation plausible.



Although the findings from the two studies are informative, a few limitations should be acknowledged and future directions outlined. First, this study employed nonprobability-based sampling procedures that relied on intact groups of young, healthy, and physically active university students. The extent to which these findings will generalize to other groups (e.g., older adults, symptomatic populations) where issues of perceived psychological need satisfaction in exercise are of interest awaits further research. Second, both phases of this study relied exclusively on self-report data, which is susceptible to distortion from common methods effects (Campbell & Fiske, 1959). Future researchers may wish to use objective indicators of relevant constructs (e.g., exercise participation) or consider adaptations of Campbell and Fiske's (1959) multitrait-multimethod procedures to evaluate common methods contamination in PNSE scores. Finally, both phases of this study used cross-sectional designs that focused on a limited array of proxy need satisfaction markers, thereby restricting the range of psychometric issues examined. Future research with the PNSE may consider longitudinal designs to address stability and invariance of PNSE scores, as well as include variables that facilitate stronger evidence of discriminant validity to enhance the breadth of construct validity evidence linked with PNSE scores.

In summary, the purpose of this study was to evaluate the construct validity of scores from the PNSE scale designed specifically to measure perceived competence, autonomy, and relatedness in exercise settings from the perspective of SDT (Deci & Ryan, 1985, 2002). The results of Study 1 provided preliminary support for the structural validity of the PNSE measurement model derived from SDT (Deci & Ryan, 2002), whereas Study 2 confirmed the tenability of the PNSE measurement model and suggested that PNSE scores are partially invariant across gender. The results of both studies provide initial evidence supporting the convergent and divergent validity of PNSE-Competence and PNSE-Relatedness scores, although comparable support was not evident for scores derived from the PNSE-Autonomy subscale. The unique contribution of this study is the creation of a multidimensional instrument designed to measure an understudied aspect of SDT's framework in exercise contexts where issues of motivation and psychological well-being remain important considerations. Collectively, the results of these studies provide evidence supporting the construct validity of PNSE scores and suggest that the instrument appears promising as an exercise-specific measure of psychological need satisfaction developed within the framework of SDT (Deci & Ryan, 1985, 2002).

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## Notes

1. Participants completed a modified version of the Godin Leisure Time Exercise Questionnaire (GLTEQ) as an index of physical activity participation over the previous week (Godin & Shepherd, 1985). The instrument assesses the frequency of mild, moderate, and strenuous exercise completed for a minimum of 20 min per session. A total exercise score (GLTEQ-METs) was calculated on a ratio-level scale by averaging the weighted responses to each question,  $\Sigma[(\text{mild} \times 3) + (\text{moderate} \times 5) + (\text{strenuous} \times 9)]$ , that range theoretically from 0 to  $\infty$ .

2. More information on item development is available in Wilson (2003). The 18 PNSE items used in both the EFA and CFA described in Studies 1 and 2 are listed in Appendix A.

3. The experts rated the initial PNSE item set for the relevance and representation expressed by item content with reference to the target domains specified by SDT comprising the theoretical universe of competence, autonomy, and relatedness. Experts rated each item on a scale anchored by 1 = poor to 5 = excellent. Descriptive statistics from the total sample supported the item content relevance ( $M = 4.68$ ,  $SD = 0.54$ ; range = 3.90–4.95; 94.32% of expert ratings > 4.0) and representation ( $M = 4.48$ ,  $SD = 0.64$ ; range = 4.30–4.68; 100% of expert ratings > 4.0) of the initial set of PNSE items. Aiken's item content validity ( $V$ ) coefficient supported the relevance ( $M_v = 0.92$ ,  $SD = 0.07$ ; range = 0.68–0.98; all  $p$ -values < 0.05) and representation ( $M_v = 0.87$ ,  $SD = 0.05$ ; range = 0.80–0.98; all  $p$ -values < 0.05) of the content expressed in the initial set of PNSE items.

4. The correlation matrices from Studies 1 and 2 are available from the first author upon request.

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## Appendix A

### The Psychological Need Satisfaction in Exercise Scale

#### PNSE-Perceived Competence

- I feel that I am able to complete exercises that are personally challenging
- I feel confident I can do even the most challenging exercises
- I feel confident in my ability to perform exercises that personally challenge me
- I feel capable of completing exercises that are challenging to me
- I feel like I am capable of doing even the most challenging exercises
- I feel good about the way I am able to complete challenging exercises

#### PNSE-Perceived Autonomy

- I feel free to exercise in my own way
- I feel free to make my own exercise program decisions
- I feel like I am in charge of my exercise program decisions
- I feel like I have a say in choosing the exercises that I do
- I feel free to choose which exercises I participate in
- I feel like I am the one who decides what exercises I do

#### PNSE-Perceived Relatedness

- I feel attached to my exercise companions because they accept me for who I am
- I feel like I share a common bond with people who are important to me when we exercise together
- I feel a sense of camaraderie with my exercise companions because we exercise for the same reasons
- I feel close to my exercise companions who appreciate how difficult exercise can be
- I feel connected to the people who I interact with while we exercise together
- I feel like I get along well with other people who I interact with while we exercise together

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*Note.* The *PNSE* was developed as part of the first author's doctoral dissertation (Wilson, 2003) completed under the supervision of Dr. Wendy M. Rodgers (Univ. of Alberta). The doctoral research conducted by the first author was supported by a scholarship from the Killam Foundation.