Examining Relationships Between Perceived Psychological Need Satisfaction and Behavioral Regulations in Exercise

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The purpose of this study was to examine the proposition that psychological need satisfaction plays a role in the motives regulating exercise behavior. Participants completed self-report instruments assessing perceived psychological need satisfaction and exercise regulation at the outset and end of a 12-week structured exercise class. Greater perceived psychological need satisfaction predicted endorsement of more self-determined exercise regulations in the structural equation modeling analysis. Change score analyses revealed that increased perceived need fulfillment was positively correlated with more self-determined exercise regulations, although this pattern was most prominent for competence and autonomy. Collectively, these findings indicate perceptions of competence and autonomy—and to a lesser extent relatedness—and represent important factors shaping exercise motivation. Continued investigation of basic psychological need fulfillment via exercise appears justified.

Participation in regular physical activity is now considered an integral factor contributing to reduced morbidity and mortality (Katzmarzyk, Gledhill, & Shepherd, 2000), enhanced disease management (Bouchard, Blair, & Haskell, 2007), and improved quality of life (Biddle, Fox, & Boutcher, 2000). Despite public awareness of the benefits stemming from participation in regular physical activity (Craig & Cameron, 2004), current estimates indicate that over half the population in most industrialized countries remain insufficiently active to offset disease occurrence or promote health (Katzmarzyk et al.; Sapkota, Bowles, Ham, & Kohl, 2005). Given the pervasiveness of physical inactivity, research elucidating the motives responsible for physical activity engagement and retention decisions may be useful as a prelude to behavioral change interventions (Biddle

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et al.). One theoretical framework gaining credibility as a way of understanding motivational issues pertinent to a broad spectrum of health promotion behaviors is self-determination theory (SDT; Deci & Ryan, 1985, 2002).

The approach to motivation taken by SDT is appealing, given that Deci and Ryan's (1985, 2002) work specifies the nature and function of motivation in conjunction with the processes responsible for nurturing the internalization of norms and values into more integrated motivational structures. Deci and Ryan contend that motivation is multidimensional in nature and varies along a continuum ranging from highly controlled (external and introjected regulations) to more self-determined (identified, integrated, and intrinsic) regulations that differentially influence behavior and well-being. The approach to motivation embraced within SDT has practical appeal, given that more self-determined motives are theorized to underpin enduring task behavior and psychological well-being (Deci & Ryan, 1985, 2002). Previous studies in both sport and exercise support Deci and Ryan's (2002) contention, given that identified and intrinsic regulations appear to promote enduring patterns of behavior (Mullan & Markland, 1997; Pelletier, Fortier, Vallerand, & Brière, 2001; Wilson, Rodgers, Fraser, & Murray, 2004) and feelings of well-being (Edmunds, Ntoumanis, & Duda, 2007; Wilson & Rodgers, 2002) compared with their controlling external and introjected counterparts.

One integral component of SDT's approach to motivation concerns the relevance of basic psychological needs to the internalization of motivational structures with the self (Deci & Ryan, 1985, 2002; Ryan, 1995). Within the framework of SDT (Deci & Ryan, 1985, 2002), psychological needs represent innate requirements of the self-system that facilitate the internalization of ambient values and foster integration of the self within and between social contexts (Ryan, 1995; Ryan & Deci, 2001). Consequently, the approach to psychological needs embraced by SDT is that social environments that fail to satisfy innate psychological needs contribute to alienation and impede human development, whereas social contexts that fulfill innate psychological needs promote eudaimonic well-being (Deci & Ryan, 1985, 2002; Ryan, 1995). Although the approach to basic psychological needs proposed by Deci and Ryan (2002) within SDT is not without controversy, the inclusion of psychological needs within SDT offers a framework to explain an array of motivational phenomena and highlights intervention targets to promote adaptive behavioral change and to enhance quality of life (Sheldon, Williams, & Joiner, 2003).

Deci and Ryan (1985, 2002) proposed that competence, autonomy, and relatedness represent innate psychological needs facilitating the integrative tendencies of the self within social environments. Competence refers to interacting successfully with one's environment while mastering challenging tasks (White, 1959). Autonomy is characterized by an internal perceived locus of causality and personal ownership, such that behaviors are pursued volitionally without coercion

from external sources (deCharms, 1968). Finally, *relatedness* refers to feeling a sense of meaningful interpersonal connection to those within one's social milieu (Baumeister & Leary, 1995). Despite the controversial nature of innate psychological needs (Deci & Ryan, 2002), the majority of research indicates that experiences contributing to need satisfaction complement rather than antagonize one another (Deci & Ryan, 2002), and, when fulfilled authentically within a given social milieu, exert positive effects on behavioral and well-being markers (Deci & Ryan, 1985, 2002).

Despite the centrality of psychological needs to SDT's framework (Deci & Ryan, 1985, 2002), research applying the theory to exercise has tended to focus more on the relationship between SDT-based motives with behavior (Daley & Duda, 2006; Mullan & Markland, 1997; Wilson et al., 2004) and markers of well-being (Wilson & Rodgers, 2002). Although there is good evidence linking enhanced feelings of competence with more self-determined exercise motives (Frederick-Recascino, 2002; Markland, 1999), there are less convincing data corroborating SDT's claims regarding perceived autonomy and relatedness in exercise contexts, with few studies examining all three need-satisfaction constructs simultaneously (Frederick-Recascino; McDonough & Crocker, 2007; Vallerand, 2001; Wilson, Rodgers, & Fraser, 2002). Recent investigations have noted mixed findings regarding the relationship between satisfying basic psychological needs within exercise and the regulations motivating exercise participation (Edmunds et al., 2007; Wilson et al., 2002; Wilson, Rodgers, Blanchard, & Gessell, 2003). Cross-sectional studies of exercisers indicate that perceived competence, more so than autonomy or relatedness, displays the strongest associations with more self-determined regulations for exercise (Edmunds, Ntoumanis, & Duda, 2006; Wilson et al., 2003). Longitudinal studies, in contrast, indicate that psychological need fulfillment varies across time in exercise settings (Wilson et al., 2003), whereby autonomy and competence both contribute to more self-determined regulation of exercise behavior (Edmunds et al., 2007).

Although increased attention to the role of basic psychological needs in exercise settings with reference to motivation is encouraging, a closer inspection of the available literature suggests considerable scope for further inquiry into the role afforded competence, autonomy, and relatedness perceptions in exercise. First, it seems evident that the measurement of psychological need satisfaction has proved challenging in exercise contexts and thereby constitutes a limitation of the available studies. For example, both Wilson et al. (2003) and Edmunds et al. (2006) noted concerns with the reliability of competence and autonomy items drawn from instruments modified from other domains to assess psychological need satisfaction in exercise (Cronbach's coefficient α's ranging from .53 to .65). Second, a portion of the available literature suggests some disparity concerning the role of perceived relatedness in exercise settings with reference to the behavioral regulations outlined within SDT. For example, Wilson et al. (2003) reported

no statistically significant correlation between perceived relatedness and any behavioral regulation spanning the SDT continuum (*r*'s ranged from .01 to .19), whereas Edmunds et al. (2006) indicated that perceived relatedness did not predict intrinsic motivation or exercise behavior when examined in combination with perceived competence and autonomy. Finally, few studies have used longitudinal designs to examine the pattern of associations between perceived psychological need satisfaction and exercise regulation beyond a single time point. Cross-sectional designs provide a restricted view of relationships among variables of interest by offering no insight into the direction of change over time (Collins, 2006). The proposition that ongoing environmental support fosters motivational development within SDT (Deci & Ryan, 1985, 2002) implies that a greater understanding of the motivational dynamics in exercise settings can be ascertained by examining the changes associated with need satisfaction and behavioral regulations across time. Two recent studies by Edmunds and colleagues (Edmunds et al., 2007; Edmunds, Ntoumanis, & Duda, 2008) have shed initial light on this issue, noting that the interaction of autonomy, and, to a lesser extent, competence, with time, demonstrated the strongest associations with more self-determined exercise motives. Extrapolating from these studies, it appears that the role of perceived relatedness in motivating exercise participation remains unclear in comparison with competence and autonomy perceptions, and warrants further investigation.

Ryan (1995) has called for the application of principles developed under the SDT framework to domains of interest in which they inform social practice and hold practical appeal. Given that public health data suggest that motivating physical activity involvement such as exercise remains challenging (Craig & Cameron, 2004; Katzmarzyk et al., 2000), it would seem reasonable to examine the relationship between satisfaction of psychological needs and behavioral regulations for exercise in more detail to determine the extent to which principles forwarded by SDT with respect to the dynamics of motivational development can be supported in exercise contexts (Ryan). Building upon previous studies (Markland, 1999; Wilson et al., 2002, 2003), the purpose of the present investigation was to examine the relationships between perceptions of competence, autonomy, and relatedness with both controlling and more self-determined forms of exercise motivation in line with SDT (Deci & Ryan, 1985, 2002). To address this purpose, this study examined the relationship between psychological need satisfaction and exercise regulations at the outset and culmination of a self-selected, group-based exercise class. Based on the work of Deci and Ryan, it was hypothesized that greater satisfaction of each psychological need would be associated with more self-determined (identified and intrinsic) than controlling (external and introjected) exercise regulations and that any changes in psychological need satisfaction and exercise regulations would covary in a manner specified by SDT.

Method

Participants

A total of 34 men (M_{age} = 31.79 years, SD = 11.84) and 257 women (M_{age} = 26.15 years, SD = 8.54) provided data for this study. The participants were students and staff enrolled in 21 aerobic exercise classes at a large urban university in Canada. Participants ranged in age from 18 to 74 years, but were predominantly young (79.9% of the sample were 30 years old or younger at the time of data collection). Body mass index values (M = 23.12 kg/m^2; SD = 3.24 kg/m^2) fell within the healthy range for this age cohort (75.9% of this sample fell between 18.00 and 24.99 kg/m^2). Participants reported being physically active during a typical week (M_{mets} = 48.67, SD = 31.63, based upon responses to the Godin Leisure Time Exercise Questionnaire; Godin & Shepherd, 1985), and the majority of participants (51.1%) completed three or more strenuous exercise sessions per week.

Measures

Psychological need satisfaction in exercise. The psychological need satisfaction in exercise (PNSE) is an 18-item self-report measure of psychological need satisfaction experienced in exercise contexts (Wilson, Rogers, Rodgers, & Wild, 2006). The PNSE contains three subscales each comprising six items designed to capture respondents' perceptions of competence, autonomy, and relatedness felt during a typical exercise session. Stem instructions encouraged participants to respond to each item on a 6-point Likert scale (1 = False, . . . , 6 = True) in terms of how they usually feel while exercising (i.e., "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."). The items comprising each PNSE subscale are provided in Table 1. Wilson et al. (2006) provided initial evidence that supported the structural and convergent validity of PNSE scores in physically active young adult exercisers and reported that the internal consistency reliabilities of the PNSE subscales were .90, .90, and .91, respectively. One subsequent investigation using a modified version of the PNSE provided mixed support for the structural and criterion validity of PNSE scores (McDonough & Crocker, 2007) in a sample of adult dragon boat racers. Subscale scores were created by taking the mean of the six-item scores for each subscale (Morris, 1979).

Behavioral regulation in exercise questionnaire. The behavioral regulation in exercise questionnaire (BREQ) is a 15-item self-report measure developed to assess the exercise regulations comprising SDT's motivational continuum

Table 1

Distributional Characteristics of Items Used in Confirmatory Factor Analyses of the PNSE Measurement Model

PNSE variables Item abbreviations	*M*	*SD*	*Skew.*	*Kurt.*	*FL*	*EV*
PNSE—Perceived competence						
I am able to complete challenging exercises	5.26	.83	−.96	.71	.72	.31
I am confident I can do challenging exercises	4.75	1.05	−.79	.76	.80	.36
I feel confident I can perform challenging exercises	5.28	.82	−.81	−.32	.83	.20
I am capable of completing challenging exercises	5.29	.080	−1.01	.77	.88	.14
I am capable of doing most exercises	4.93	.99	−.95	1.17	.86	.24
I feel good about the way I complete exercises	5.32	.84	−1.37	2.47	.69	.34
PNSE—Perceived autonomy						
I feel free to exercise in my own way	5.42	.80	−1.39	1.94	.66	.34
I feel free to make my own exercise decisions	5.35	.88	−1.60	3.12	.84	.22
I feel like I am in charge of my exercise program	5.38	.80	−1.28	1.39	.84	.18
I have a say in choosing the exercises I do	5.39	.82	−1.79	4.68	.79	.23
I feel free to choose which exercise I undertake	5.47	.74	−1.34	1.29	.84	.15
I am the one who decides what exercises I do	5.42	.78	−1.14	.39	.79	.21

PNSE—Perceived relatedness						
I feel attached to my exercise companions	4.28	1.46	−.74	−.10	.75	.85
I share a bond with others when exercising	4.32	1.37	−.66	−.28	.80	.63
I feel a sense of camaraderie with fellow exercisers	4.10	1.38	−.59	−.31	.87	.41
I feel close to my exercise companions	4.27	1.42	−.72	−.17	.84	.54
I feel connected to people I exercise with	4.26	1.36	−.64	−.14	.91	.30
I feel like I get along with fellow exercisers	4.64	1.17	−1.14	1.59	.78	.51
PNSE—Interfactor (ϕ) correlations	1.	2.	3.			
1. PNSE-Competence	—					
2. PNSE-Autonomy	.70	—				
3. PNSE-Relatedness	.31	.20	—			

Note. *FL* and *EV* values are from the CFA of the PNSE measurement model only. All ϕ coefficients are statistically significant at $p < .01$ (two-tailed).
PNSE = psychological need satisfaction in exercise scale (Wilson et al., 2006); Skew. = univariate skewness values; Kurt = univariate kurtosis values; *FL* = factor loading; *EV* = error variance.

(Mullan, Markland, & Ingledew, 1997). The BREQ contains four subscales that measure external, introjected, identified, and intrinsic regulation of exercise behavior. Sample items characterizing each BREQ subscale are: "I exercise because other people say I should" (external regulation; four items); "I feel guilty when I don't exercise" (introjected regulation; three items); "I value the benefits of exercise" (identified regulation; four items); and "I enjoy my exercise sessions" (intrinsic regulation; four items). Following the stem, "Why do you exercise?" participants responded to each item on a 5-point Likert scale anchored at the extremes by 0 (*not true for me*) and 4 (*very true for me*). Previous research supports the structural validity and subscale reliabilities of BREQ scores (all Cronbach's α's $\geq .70$; Mullan et al., 1997), as well as the ability of BREQ scores to discriminate between physically active and inactive groups (Mullan & Markland, 1997) and women reporting low and high physical self-esteem (Wilson & Rodgers, 2002). As with the PNSE, subscale scores were created by taking the mean of the relevant item scores for each BREQ subscale (Morris, 1979).

Data collection procedures. Participants in this study were asked to complete the PNSE and BREQ on two separate occasions separated by a period of 10 weeks. At Time 1, the participants first completed the demographic questions, followed by the PNSE and BREQ in random order to reduce possible order effects. Both the PNSE and BREQ items were randomly ordered within each instrument to further reduce the potential for order effects. At Time 2, the demographic questions were dropped. Participant identification numbers issued by the university were used to match respondents from the initial and final test administrations. All data were collected at the end of a regularly scheduled exercise class by the same investigator. Standard instructions were used on each occasion to reduce the potential for between time effects stemming from test administration. The participants were given the opportunity to ask questions regarding the research project prior to providing informed consent and to completing a questionnaire containing the instruments previously described. All data collection procedures were given ethical clearance by a university-based research ethics board prior to participant recruitment and data collection.

Data analyses. Data analyses proceeded in three stages. First, given the recent development of the PNSE, the three-factor solution reported by Wilson et al. (2006) and McDonough and Crocker (2007) was tested using confirmatory factor analysis (CFA) procedures. Second, the relationship between perceptions of psychological need satisfaction and exercise regulations were examined using structural equation modeling (SEM) techniques advocated for testing psychological models (MacCallum & Austin, 2000). Finally, paired samples *t* tests, intraclass correlation coefficients (ρ), and effect-size estimates (Cohen's *d*; Cohen, 1992) were used to examine the size and magnitude of changes in PNSE and

BREQ constructs over 10 weeks. Pearson (*r*) correlations were computed to evaluate the relationship between change scores calculated for both the psychological need satisfaction and exercise regulation constructs (Schutz, 1989). The SEM analyses were conducted with AMOS (Arbuckle, 1997) using the data collected at Time 1, only while the change score analyses were conducted on a subsample of the original participants, providing data at both time points in this study ($n = 115$).

Conventional standards were specified for the CFA and SEM analyses that involved loading manifest items exclusively on their respective latent factor, freeing latent factors to correlate, constraining uniqueness values to zero, and fixing either an item loading or a factor variance at unity to define the scale for the analysis. Considerable debate exists regarding threshold values indicative of model fit (or misfit) in the context of SEM analyses (Hu & Bentler, 1999; Marsh, Hau, & Wen, 2004) given the sensitivity of different indices to model misspecification or deviations from normality in sample data (Tabachnick & Fidell, 2007). Notwithstanding the nature of this debate, a growing consensus favors the use of multiple indices to gauge model fit in combination with the substantive meaning applied to interpretations from model testing using SEM (Markland, 2007; Marsh et al.). Global model fit was assessed using five indices—the comparative fit index (*CFI*), the incremental fit index (*IFI*), the root mean square error of approximation (*RMSEA*), and the 90% confidence interval surrounding the *RMSEA* point estimate, standardized root mean square residual (*SRMSR*)—recommended for use with small samples in which the data likely deviate from normality (West, Finch, & Curran, 1995). *CFI* and *IFI* values greater than .90 and .95 were deemed to reflect acceptable and excellent fit (Hu & Bentler) whereas *SRMSR* values less than or equal to .05 denote the boundaries of excellent and unacceptable fit between the implied model and the observed data. An observed *RMSEA* value was considered indicative of either good ($RMSEA \leq .05$), reasonable ($RMSEA > .05$ but $\leq .08$), mediocre ($>.08$ but $\leq .10$), or poor ($RMSEA > .10$) fit between the model and the data (Byrne, 1998).

Results

Preliminary Data Screening and Estimator Selection

Inspection of the data indicated that no missing values or out of range responses were present. Minimal univariate distributional concerns in the PNSE data were noted (see Table 1) with mild negative skewness evident in each PNSE item score and with notable multivariate kurtosis present in the sample data (Mardia's coefficient = 294.85). Twelve cases were deemed outliers based on responses provided at Time 1 and were removed from further consideration in these analyses (Mahalanobis d^2 values ≥ 106.75, all $ps < .01$). Although alterna-

tive estimation procedures have been advocated for data that deviate substantially from normality, they require large sample sizes to produce accurate parameter estimates (West et al., 1995). Consequently, maximum likelihood estimation procedures were used in all CFA and SEM analyses.

CFA of the PNSE and BREQ Measurement Models

Whereas the χ^2 goodness-of-fit statistic indicated that the three-factor oblique PNSE measurement model differed from the reference model, ($\chi^2 = 363.71$, $df = 132$, $p < .01$), the global model fit indices (*CFI* = .94; *IFI* = .94; *RMSEA* = .08 [90% *CI* = .07–.09]; *SRMSR* = .05) and pattern of standardized parameter loadings (see Table 1) of manifest items on their target latent factors supported the tenability of the hypothesized measurement model. Minimal evidence of overestimation or underestimation of fitted correlations was noted in the distribution of standardized residuals (81.69% $z < |1.0|$, 1.96% $z > |2.0|$). Interfactor (ϕ) correlations (see Table 1) ranged from low to moderate in magnitude between the latent PNSE factors. Similarly, whereas the χ^2 goodness-of-fit statistic indicated that the four-factor oblique BREQ measurement model differed from the reference model ($\chi^2 = 202.47$, $df = 84$, $p < .01$), the global model fit indices (*CFI* = .94; *IFI* = .94; *RMSEA* = .07 [90% *CI* = .06 to .08]; *SRMSR* = .06), the distribution of standardized residuals (94.28% $z < |2.0|$, .95% $z > |3.0|$), and the pattern of standardized parameter loadings on each latent BREQ factor supported the a priori four-factor structure of the BREQ measurement model. The ϕ coefficients ranged from –.28 to .67, respectively, and represented an ordered pattern of relationships between subscales measuring adjacent constructs along the motivational continuum, which is consistent with SDT (Deci & Ryan, 2002).

Descriptive Statistics, Subscale Reliability, and Bivariate Correlations

The descriptive statistics reported in Table 2 indicate that perceived competence and autonomy were more satisfied in exercise classes at both time points than perceived relatedness. In the case of the BREQ, identified and intrinsic exercise regulations were more strongly endorsed than external and introjected exercise regulations at both time points. The internal consistency reliability estimates (Cronbach's alphas; Cronbach, 1951) ranged between .91 and .93 for the PNSE items across subscales per assessment. In contrast, the internal consistency reliability values of the BREQ items ranged from .65 to .88 across subscales per test administration. The internal consistency reliability estimate for the BREQ-identified regulation scores, particularly at Time 2, were lower than previous research (Mullan et al., 1997).

The correlations among the PNSE and BREQ subscales are reported in Table 3. First, the correlations in Table 3 ranged from weak (i.e., $r_{12} \leq |.20|$) to

Table 2

Descriptive Statistics, Paired Samples t Tests, and Intraclass Correlations for PNSE and BREQ Variables Across 10 Weeks

	Time 1			Time 2						
Variables	*M*	*SD*	α	*M*	*SD*	α	*T*	*95% CI*	*ES*	ρ
1. PNSE-Perceived Competence	5.17	.73	.91	5.39	.64	.93	3.80**	.11–.34	.32	.56**
2. PNSE-Perceived Autonomy	5.38	.70	.91	5.52	.59	.93	2.43**	.03–.27	.23	.52**
3. PNSE-Perceived Relatedness	4.46	1.04	.93	4.62	1.05	.92	2.02*	.00–.27	.19	.69**
4. BREQ-External Regulation	.66	.81	.85	.69	.80	.86	.37	–.11–.16	.03	.62**
5. BREQ-Introjected Regulation	1.99	1.07	.81	2.01	1.09	.86	.27	–.13–.17	.02	.72**
6. BREQ-Identified Regulation	3.49	.56	.73	3.60	.44	.62	2.61**	.11–.34	.24	.53**
7. BREQ-Intrinsic Regulation	3.36	.69	.88	3.46	.64	.85	2.07*	.01–.19	.20	.74**

PNSE = psychological need satisfaction in exercise scale (Wilson et al., 2006); BREQ = behavioral regulation in exercise questionnaire (Mullan et al., 1997); α = Cronbach's (1951) internal consistency reliability coefficient; *t* = paired samples *t* tests over a 10-week period; *ES* = effect size (Cohen's *d*) calculated using the procedures suggested for paired observations (Dunlap, Cortina, Vaslow, & Burke, 1996; Johnson & Eagly, 2000) and the following equation: $(M_1 - M_2)/SD_{difference}$; *95% CI* = 95% confidence interval around the difference score; ρ = intraclass correlation coefficient between Time 1 and Time 2 assessments.
*$p < .05$. **$p < .01$.

Table 3

Bivariate Correlations Between PNSE and BREQ Scores Across Test Administrations

Variables	1	2	3	4	5	6	7
Time 1 data ($n = 279$)							
1. PNSE—perceived competence	—						
2. PNSE—perceived autonomy	.63	—					
3. PNSE—perceived relatedness	.28	.17	—				
4. BREQ—external regulation	−.15	−.15	.08	—			
5. BREQ—introjected regulation	−.00	−.02	.02	.33	—		
6. BREQ—identified regulation	.53	.42	.26	−.21	.19	—	
7. BREQ—intrinsic regulation	.52	.37	.28	−.17	.04	.61	—
Time 2 data ($n = 115$)							
1. PNSE—perceived competence	—						
2. PNSE—perceived autonomy	.55	—					
3. PNSE—perceived relatedness	.26	.17	—				
4. BREQ—external regulation	−.23	−.36	.04	—			
5. BREQ—introjected regulation	−.11	−.14	−.05	.39	—		

6. BREQ—identified regulation	.36	.34	.01	−.23	.27	—	
7. BREQ—intrinsic regulation	.60	.47	.33	−.17	.03	.57	—
Change score data ($n = 115$)							
1. PNSE—perceived competence	—						
2. PNSE—perceived autonomy	.50	—					
3. PNSE—perceived relatedness	.33	.32	—				
4. BREQ—external regulation	−.08	−.24	.05	—			
5. BREQ—introjected regulation	.09	.12	.18	.29	—		
6. BREQ—identified regulation	.21	.34	.03	−.09	.22	—	
7. BREQ—intrinsic regulation	.34	.44	.22	−.08	.11	.47	—

Note. All rs > |.20| are significant at $p < .05$ (two-tailed significance). The ϕ coefficients from the CFA of BREQ scores observed in the Time 1 data were as follows: $\phi_{external.introjected} = .39$; $\phi_{external.identified} = -.28$; $\phi_{external.intrinsic} = -.19$; $\phi_{introjected.identified} = .23$; $\phi_{introjected.intrinsic} = .05$; $\phi_{identified.intrinsic} = .67$. All ϕ's $\geq$ |.10| significant at $p < .05$ (two-tailed significance).
PNSE = perceived psychological need satisfaction in exercise scale (Wilson et al., 2006); BREQ = behavioral regulation in exercise questionnaire (Mullan et al., 1997).

moderately strong (i.e., r_{12} ranging from .55 to .61). Second, as found in Wilson et al. (2006), the correlation between perceived competence and autonomy measured with the PNSE is greater than the correlations between these two variables and perceived relatedness at both test administrations. Third, the correlations between the identified and intrinsic regulations exceeded the magnitude of the correlations between these variables with external and introjected regulations assessed with the BREQ at both times, which is consistent with Mullan et al. (1997). Fourth, the correlations between perceived competence and perceived autonomy with identified and intrinsic regulations are higher than the remaining correlations between the PNSE subscales and the BREQ subscales at Time 1. The same pattern is found at Time 2, with one notable exception, namely, the negative correlation between perceived autonomy assessed with the PNSE and external regulation assessed with the BREQ.

SEM Predicting Exercise Regulations from Psychological Need Satisfaction

Consistent with the recommendations made by Anderson and Gerbing (1988), the full measurement model was tested using CFA procedures prior to evaluating the structural model in this study and consisted of seven weak-to-moderately-correlated factors (four BREQ and three PNSE subscales) and their manifest indicators. An examination of the global model fit indices suggested that the full measurement model appeared tenable; whereas the χ^2 goodness-of-fit statistic suggested differences between the target and reference models ($\chi^2 = 977.22$; $df = 474$; $p < .01$), the remaining fit statistics again suggested good fit of the data to the proposed model (*IFI* = .92; *CFI* = .92; *RMSEA* = .06 [90% *CI* = .06 to .07]; *SRMSR* = .06), with minimal indication of over- and under estimated fitted correlations evident in the distribution of standardized residuals (96.21% $z < |2.0|$), and satisfactory parameter loadings on each latent factor (*M* = .79; *SD* = .08; Range = .58–.91; all *p*s < .05). The ϕ coefficients indicated a general pattern of negative relationships between the PNSE latent factors and controlling exercise regulations assessed with the BREQ, with the exception of perceived relatedness that was weak yet positively correlated with both external and introjected regulations, whereas positive correlations were evident between latent PNSE constructs and both identified and intrinsic exercise regulations.

A structural model based on the tenets of SDT (Deci & Ryan, 1985, 2002) that posited exercise regulations as a function of perceived psychological need satisfaction was evaluated using SEM procedures. This model is presented in Figure 1. As with the CFA results, whereas the χ^2 goodness-of-fit statistic suggested some discrepancy between the proposed model and the observed data ($\chi^2 = 1124.75$; $df = 480$; $p < .01$), the observed model fit indices suggested that the structural model was tenable (*CFI* = .90; *IFI* = .90; *RMSEA* = .07 [90% *CI* = .06 to .07]; *SRMSR* = .08).

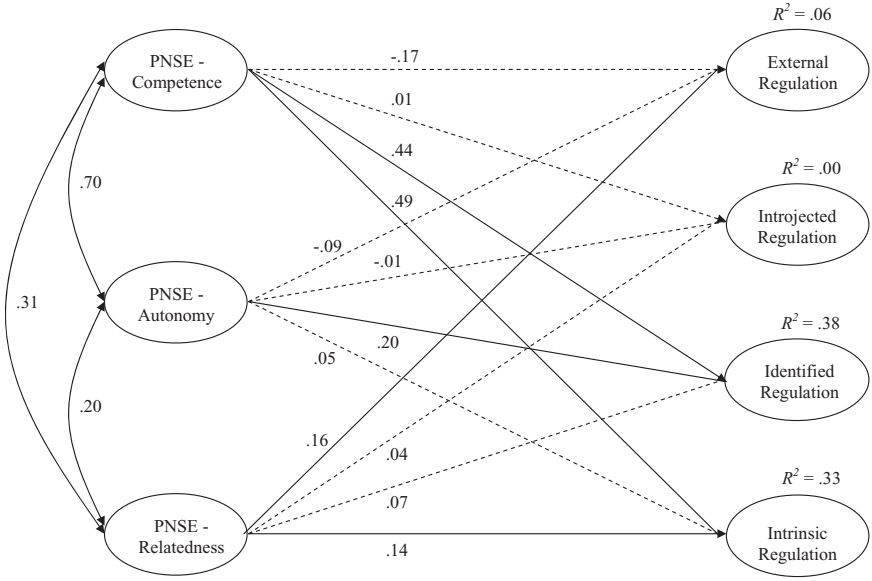

Figure 1. SEM analysis predicting exercise regulations from perceived psychological need satisfaction in exercise.
Note. Large circles represent latent variables. Interfactor correlation (ϕ) estimates are presented between exogenous latent variables. Endogenous latent variables were not correlated in the SEM analysis. Solid lines are statistically significant ($p < .05$). Manifest item loadings per latent factor are not shown for clarity.

An examination of the standardized path coefficients (see Figure 1) indicated several interesting patterns of relationships. First, when considering the joint influence of all PNSE constructs proposed by SDT on exercise motivation, perceived competence predicted identified and intrinsic exercise regulations, respectively, with the standardized path coefficients, suggesting that greater perceived competence was associated with more self-determined regulation of exercise behavior. Second, perceived autonomy predicted only identified exercise regulation. Finally, perceived relatedness was significantly, albeit weakly, associated with external and intrinsic exercise regulations. Overall, the structural model accounted for small to moderate amounts of the variance in exercise regulations (R^2 values ranged from .00 to .38, respectively).

Relationships Between Changes in Psychological Need Satisfaction and Exercise Regulations

The changes in PNSE and BREQ subscale scores were examined over the 10-week period using paired samples *t* tests and the reduced sample of responses

($n = 115$). Effect sizes were calculated following the procedures developed by Johnson and Eagly (2000) for repeated measures designs. Although significant increases in all three PNSE subscales and two of the BREQ subscales—identified and intrinsic regulations—were observed over the 10-week period, the magnitude of these changes was quite small (*ES* varied from .01 to .32; see Table 2). No significant change was evident in the BREQ-external and introjected regulation scores. Change scores were calculated for each PNSE and BREQ subscale by regressing the Time 2 subscale score onto the corresponding Time 1 subscale score for each construct and saving the residual as an index of change estimated within each construct (Schutz, 1989). Pearson correlations were calculated between the change score variables (see third panel, Table 3). The pattern of correlations is similar to that observed for the correlations among the subscales at Time 1 and Time 2. First, the correlations in Table 3 range from weak to moderate in magnitude. Second, the correlations between the perceived competence and perceived autonomy change scores assessed with the PNSE are greater than the correlations between these two variables and perceived relatedness. The magnitude of this difference was statistically significant ($p < .05$) based on t tests used with dependent correlations from a single sample (Blalock, 1972). Third, the correlations between the identified and intrinsic regulation change scores exceeded the correlations of these scores with external and introjected regulation change scores. Fourth, the correlations between perceived competence and perceived autonomy change scores and identified and intrinsic regulation change scores are higher than the remaining correlations between the PNSE subscale change scores and the BREQ subscale change scores.

Discussion

The purpose of this investigation was to examine the role of perceived psychological need satisfaction in the motivational dynamics associated with exercise participation using SDT (Deci & Ryan, 1985, 2002) as a framework for interpretation. The results of this study render support for the psychometric merit of the PNSE given the ability of the a priori measurement model to account for the observed data, the reliability indices ($\geq .90$) observed for scores on each PNSE subscale, and both the pattern and stability of correlations among the three constructs measured by this instrument. Taken together with the observations from the change score analysis, these findings corroborate a number of assertions made by Deci and Ryan within SDT concerning the synergism between fulfillment of competence, autonomy, and relatedness needs within exercise settings. Furthermore, this study provides evidence, at both the bivariate and multivariate levels of analyses, that perceptions of psychological need satisfaction play an integral role in the dynamics of exercise motivation, although it is acknowledged that the predictive influence of satisfying competence, autonomy,

and relatedness needs on controlling motives measured by the BREQ is weak at best given the observed variance accounted for in the SEM.

Consistent with previous research using the PNSE (Wilson et al., 2006), the results of the CFA and reliability analyses conducted in the present study provide additional support for the a priori configuration of the PNSE measurement model. Although the process of construct validation is ongoing (Messick, 1995), the mosaic of evidence generated in this study suggests that the PNSE measures three interwoven yet empirically distinguishable constructs representing perceived competence, autonomy, and relatedness in exercise. Given that the PNSE was developed within an established theoretical framework that posits the complementary nature of need-satisfying experiences (Deci & Ryan, 1985, 2002), it is particularly encouraging to find support for the a priori measurement model that best represents this theoretical contention. Consistent with calls for repeated assessment of scale dimensionality in psychological measurement (Messick), the results of the present study extend Wilson et al.'s (2006) findings by supporting the psychometric properties of PNSE scores in an independent sample of exercise class participants. Collectively, these studies suggest that the PNSE is a useful instrument for measuring perceived psychological need satisfaction experienced in exercise contexts in line with SDT. Future studies may consider extending the PNSE's construct validity evidence by examining the structural validity and invariance of scores across subgroups (e.g., ethnicity) in which exercise participation is an important issue. Additional studies evaluating the change evident within PNSE scores over multiple test administrations of varying length would aid in illustrating the stability of scores derived from this instrument.

Consistent with the original hypotheses, the results of the SEM and change scores analyses indicated that greater perceptions of psychological need satisfaction derived from exercise are associated with more internalized regulation of exercise behavior. More specifically, the results of the SEM indicate that perceived competence is the dominant predictor of exercise regulations; however, perceptions of autonomy and relatedness also appear to play a pivotal role in the internalization of motivational regulations. The results of the change score analysis corroborated the importance of perceived need satisfaction to internalization given the direction of the relationships observed between the transformed variables (see Table 3). Interestingly, increases in perceived autonomy were associated with a decreased endorsement of external regulation over time, suggesting that reliance on sources of interpersonal control for exercise participation diminishes as feelings of personal ownership and volition evolve. Although the importance of personal competence in exercise motivation is not novel, the finding that perceived autonomy accounts for variance in identified exercise regulations despite the contributions of perceived competence corroborates the premise that self-determined motives thrive in contexts that afford opportunities to satisfy the

need for autonomy (Deci & Ryan, 1985, 2002; Ryan, 1995). On the basis of the present study, both promoting perceived competence and promoting autonomy appear to be fruitful avenues to pursue for practitioners interested in optimizing self-determined forms of exercise motivation.

The observation that perceived autonomy, as measured by the PNSE, did not account for variance in intrinsic regulation beyond the contributions of perceived competence and relatedness in the SEM analysis is inconsistent with Deci and Ryan's (1985, 2002) contentions, although it corroborates baseline data reported by Edmunds et al. (2008). This finding adds to the mixed evidence attesting to the importance of perceived autonomy for self-determined motivation in physical activity contexts (McDonough & Crocker, 2007) and reinforces the importance of examining the contribution of each psychological need posited within SDT to further our understanding of exercise motivation using this framework. It is conceivable that the high interfactor correlation between perceived competence and autonomy suppressed the magnitude of the relationship between these variables and intrinsic regulation in the structural model analysis (Cohen, Cohen, West, & Aiken, 2003), an explanation that is partially substantiated by the magnitude of the bivariate correlations presented in Table 2 and that has been noted in previous exercise-based studies (Edmunds et al., 2008). An alternative explanation concerns the degree to which the items comprising the autonomy subscale of the PNSE represent the full conceptual bandwidth of this construct in exercise with reference to the content domain defined within SDT. It is plausible, for example, that participants interpreted the PNSE's autonomy items with a focus on decisional, as opposed to affective, components of autonomy (McDonough & Crocker, 2007), although the available evidence supporting such an assertion is tenuous at best (Wilson et al., 2006). Difficulties with the assessment of perceived autonomy in exercise-based research using SDT are hardly novel (Edmunds et al., 2006; Wilson et al., 2003) and point to the continued importance of construct validation research with instruments such as the PNSE. In particular, future investigations may wish to evaluate the degree of relevance and representation inherent in the PNSE items as well as determine the manner in which each PNSE item is interpreted by exercisers using protocol analysis (Ericsson & Simon, 1993).

Although the findings concerning perceived competence and autonomy's relationship with self-determined exercise regulations appear reasonable and partially consistent with SDT (Deci & Ryan, 1985, 2002), the pattern of results informing the relatedness–motivation link is less straightforward, given that the SEM analysis suggests that perceived relatedness promotes both external and identified forms of exercise regulation. One explanation for these observations is that perceived relatedness lays the "groundwork for facilitating internalization" (Ryan & Deci, 2000, pp. 68–78). On the basis of this argument, enhancing perceived relatedness could promote both controlling and self-determined extrinsic motives

because people seem more likely to regulate their behavior in accordance with those they perceive a connection with than others whom they feel isolated from in social contexts. An alternative explanation for this observation concerns the observed statistical relationship between perceived relatedness and competence as measured by the PNSE at both the bivariate (see Table 3) and multivariate (see Figure 1) levels of analysis. It seems plausible, therefore, that the relationship between perceived relatedness and external regulation observed in this study stems from covariance with perceived competence rather than arguments concerning the importance of different needs for various points along SDT's motivational continuum. Previous studies have noted the presence of net suppression effects when attempting to unravel the relationship between satisfaction of SDT-based needs and motives regulating exercise behavior (Edmunds et al., 2008). These investigations, combined with the results of this study, leave the most suitable method for assessing and analyzing data concerning the need satisfaction–behavioral regulation link in exercise settings ripe for further inquiry.

The results of the subsample analysis concerning change scores suggested that perceived psychological need satisfaction and self-determined exercise regulations increased over time, and relationships among changes in these constructs were largely in line with arguments put forth by Deci and Ryan (1985, 2002). Increases in perceived autonomy were associated with decreased endorsement of external regulation, suggesting that, as people become more volitional in their exercise decisions, they rely less on prompts from other people. Notwithstanding these observations, considerable debate exists around the number of time points necessary to estimate true change (Cronbach & Furby, 1970) and the time frame required to adequately assess the stability of scores from psychological instruments (Crocker & Algina, 1986). Consequently, conclusions regarding the change score analysis should be tempered with caution before the degree of stability inherent in PNSE and BREQ scores is verified, and the relationships between changes in constructs measured by these instruments is replicated in samples exhibiting less susceptibility to ceiling effects than noted within the present data.

Despite the pragmatic and theoretical promise associated with the results of this investigation, a number of limitations should be outlined and future research directions conferred to advance to the study of psychological need satisfaction in exercise contexts using SDT. First, this study used nonprobability-based sampling procedures that restrict the generalizability of the study findings. Consequently, the results of this study should be regarded as tentative prior to further investigations using more sophisticated sampling techniques that examine various demographic (e.g., older adults, symptomatic groups) and physical activity (e.g., resistance training, yoga) cohorts. Attention to sample heterogeneity in terms of exercise status (i.e., initiate vs. habitual exerciser) would be a worthwhile

direction to clarify the role played by competence, autonomy, and relatedness needs as people internalize the motives for exercising over time. Second, the data examined in the present study relied exclusively on self-report methods that are susceptible to contamination from common methods variance. Although objective indicators of need satisfaction would seem difficult to obtain, future research may wish to examine behavioral markers that should be conceptually associated with PNSE scores in accordance with a nomological network extrapolated from SDT (Deci & Ryan, 1985, 2002). Future studies would do well to consider including a range of assessment protocols (e.g., surveys, pedometer-based step counts, energy expenditure values from accelerometers) to determine if psychological need fulfillment impacts exercise behaviors directly or indirectly via motivation. Finally, the design used in this study employed a restrictively short time period with only two data collection points, which makes it difficult to establish the nature and rate of change associated with PNSE and BREQ constructs. Future research would do well to assess perceptions of psychological need satisfaction across three or more time points that are temporally sequenced to capture important transitional periods associated with physical activity participation.

In summary, the major purpose of this study was to examine select psychometric properties of the PNSE and test a proposition drawn from SDT (Deci & Ryan, 1985, 2002) positing that greater perceptions of psychological need satisfaction facilitate internalization exemplified by the endorsement of more self-determined exercise motives. The results of this study suggest that the PNSE displays a number of laudable psychometric properties that render the scale useful for testing or extending the role afforded psychological need satisfaction in exercise according to contentions forwarded by Deci and Ryan. Furthermore, the results of both the SEM and change score analysis suggest partial support for the contention that perceived psychological need satisfaction is linked with the endorsement of different exercise motives in a manner consistent with SDT. Collectively, the results of this study substantiate the proposition that perceived psychological need satisfaction is an integral component of motivational processes in structured exercise contexts, and future research examining this aspect of SDT's framework appears justified.

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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.

Arbuckle, J. L. (1997). *AMOS* (Version 3.6) [Computer software]. Chicago: Smallwaters.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*, 497–529.

Biddle, S. J. H., Fox, K. R., & Boutcher, S. H. (2000). *Physical activity and psychological well-being*. New York: Routledge.

Blalock, H. (1972). *Social statistics*. New York: McGraw-Hill.

Bouchard, C., Blair, S. N., & Haskell, W. L. (2007). *Physical activity and health*. Champaign, IL: Human Kinetics.

Byrne, B. M. (1998). *Structural equation modeling with LISREL, PRELIS, and SIMPLIS: Basic concepts, applications, and programming*. Mahwah, NJ: Lawrence Erlbaum Associates.

deCharms, R. (1968). *Personal causation: The internal affective determinants of behavior*. New York: Academic Press.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*, 155–159.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Collins, L. M. (2006). Analysis of longitudinal data: The integration of theoretical model, temporal design, and statistical model. *Annual Review of Psychology*, *57*, 505–528.

Craig, C. L., & Cameron, C. (2004). *Increasing physical activity: Assessing trends from 1998–2003*. Ottawa, Ontario, Canada: Canadian Fitness and Lifestyle Research Institute.

Crocker, L., & Algina, J. (1986). *Introduction to classical and modern test theory*. Belmont, CA: Wadsworth.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*, 297–234.

Cronbach, L. J., & Furby, L. (1970). How we should measure "change"—or should we? *Psychological Bulletin*, *74*, 68–80.

Daley, A., & Duda, J. L. (2006). Self-determination, stage of readiness to change for exercise, and frequency of physical activity in young people. *European Journal of Sport Science*, *6*, 231–244.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.

Deci, E. L., & Ryan, R. M. (2002). *Handbook of self-determination research*. Rochester, NY: University of Rochester Press.

Dunlap, W. P., Cortina, J. M., Vaslow, J. B., & Burke, M. J. (1996). Meta-analysis of experiments with matched groups or repeated measures designs. *Psychological Methods*, *1*, 170–177.

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2006). A test of self-determination theory in the exercise domain. *Journal of Applied Social Psychology*, *36*, 2240–2265.

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2007). Adherence and well-being in overweight and obese patients referred to an exercise prescription scheme: A self-determination theory perspective. *Psychology of Sport & Exercise*, *8*, 722–740.

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2008). Testing a self-determination theory-based teaching style intervention in the exercise domain. *European Journal of Social Psychology*, *38*, 375–388.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data*. Cambridge, MA: MIT Press.

Frederick-Recascino, C. M. (2002). Self-determination theory and participant motivation research in the sport and exercise domain. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 278–294). Rochester, NY: University of Rochester Press.

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

Hu, L., & Bentler, P. M. (1999). Cut-off criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1–55.

Johnson, B. T., & Eagly, A. H. (2000). Quantitative synthesis of social psychological research. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 529–544). Cambridge, England: Cambridge University Press.

Katzmarzyk, P. T., Gledhill, N., & Shepherd, R. J. (2000). The economic burden of physical inactivity in Canada. *Canadian Medical Association Journal*, *163*, 1435–1440.

MacCallum, R. C., & Austin, J. T. (2000). Applications of structural equation modeling in psychological research. *Annual Review of Psychology*, *51*, 201–226.

Markland, D. (1999). Self-determination moderates the effects of perceived competence on intrinsic motivation in an exercise setting. *Journal of Sport & Exercise Psychology*, *21*, 351–361.

Markland, D. (2007). The golden rule is that there are no golden rules: A commentary on Paul Barrett's recommendations for reporting model fit in structural equation modeling. *Personality & Individual Differences*, *42*, 851–858.

Marsh, H. W., Hau, K. T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling: A Multidisciplinary Journal*, *11*, 320–341.

McDonough, M. H., & Crocker, P. R. E. (2007). Testing self-determined motivation as a mediator of the relationship between psychological needs and affective and behavioral outcomes. *Journal of Sport & Exercise Psychology*, *29*, 645–663.

Messick, S. (1995). Validity of psychological assessment: Validation of inferences from persons' responses and performances as scientific inquiry into score meaning. *American Psychologist*, *50*, 741–749.

Morris, J. D. (1979). A comparison of regression prediction accuracy on several types of factor scores. *American Educational Research Journal*, *16*, 17–24.

Mullan, E., & Markland, D. (1997). Variations in self-determination across the stages of change for exercise in adults. *Motivation & Emotion*, *21*, 349–362.

Mullan, E., Markland, D., & Ingledew, D. K. (1997). A graded conceptualization of self-determination in the regulation of exercise behavior: Development of a measure using confirmatory factor analysis procedures. *Personality & Individual Differences*, *23*, 745–752.

Pelletier, L. G., Fortier, M. S., Vallerand, R. J., & Brière, N. M. (2001). Associations among perceived autonomy support, forms of self-regulation, and persistence: A prospective study. *Motivation & Emotion*, *25*, 279–306.

Ryan, R. M. (1995). Psychological needs and the facilitation of integrative processes. *Journal of Personality*, *63*, 397–428.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*, 68–78.

Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of hedonic and eudaimonic well-being. In S. Fiske (Ed.), *Annual review of psychology* (Vol. 52, pp. 151–166). Palo Alto, CA: Annual Reviews.

Sapkota, S., Bowles, M. P. H., Ham, S. A., & Kohl, H. W. (2005). Adult participation in recommended levels of physical activity—United States, 2001 and 2003. *Morbidity & Mortality Weekly Report*, *54*, 1208–1212.

Schutz, R. (1989). Analyzing change. In M. J. Safrit & T. M. Wood (Eds.), *Measurement concepts in physical education & exercise science* (pp. 207–228). Champaign, IL: Human Kinetics.

Sheldon, K. M., Williams, G. C., & Joiner, T. (2003). *Self-determination theory in the clinic: Motivating physical and mental health*. New Haven, CT: Yale University Press.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston: Allyn and Bacon.

Vallerand, R. J. (2001). A hierarchical model of intrinsic and extrinsic motivation in sport and exercise. In G. C. Roberts (Ed.), *Advances in motivation in sport and exercise* (pp. 263–319). Champaign, IL: Human Kinetics.

West, S. G., Finch, J. F., & Curran, P. J. (1995). Structural equation models with nonnormal variables: Problems and remedies. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications* (pp. 56–75). Thousand Oaks, CA: Sage.

White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review*, *66*, 297–333.

Wilson, P. M., & Rodgers, W. M. (2002). The relationship between exercise motives and physical self-esteem female exercise participants: An application of self-determination theory. *Journal of Applied Biobeahvioral Research*, *7*, 30–43.

Wilson, P. M., Rodgers, W. M., Blanchard, C. M., & Gessell, J. (2003). The relationship between psychological needs, self-determined motivation, exercise attitudes, and physical fitness. *Journal of Applied Social Psychology*, *33*, 2373–2392.

Wilson, P. M., Rodgers, W. M., & Fraser, S. N. (2002). Examining the psychometric properties of the behavioural regulation in exercise questionnaire. *Measurement in Physical Education & Exercise Science*, *6*, 1–21.

Wilson, P. M., Rodgers, W. M., Fraser, S. N., & Murray, T. C. (2004). Relationships between exercise regulations and motivational consequences in university students. *Research Quarterly for Exercise & Sport*, *75*, 81–91.

Wilson, P. M., Rogers, W. T., Rodgers, W. M., & Wild, T. C. (2006). The psychological need satisfaction in exercise scale. *Journal of Sport & Exercise Psychology*, *28*, 231–251.