

Examining the Contributions of Perceived Psychological Need Satisfaction to Well-Being in Exercise¹

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This investigation examined the relationship between perceived psychological need satisfaction and well-being in exercise. Participants in Study 1 were women enrolled in a resistance-training program who completed instruments on two occasions across 12 weeks. Changes in perceived need satisfaction and subjective vitality were evident, and residual change score analyses supported covariation between variables over time. Participants in Study 2 were patrons of a university fitness facility who completed instruments once following an exercise session. Canonical correlation analyses indicated that perceived need satisfaction was differentially associated with positive and negative affect. These results suggest that perceived psychological need satisfaction in exercise contributes to global and contextual well-being.

Self-determination theory (SDT; Deci & Ryan, 1985, 2002; Ryan, 1995) has become a popular framework for examining motivational issues in physical activity contexts (see Frederick-Recascino, 2002 for a review). This is not surprising given that the organismic integration (OIT) subcomponent of SDT's framework delineates the nature and function of motives responsible for behavior

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regulation (Deci, 1992; Deci & Ryan, 1985, 2002; Ryan). According to Deci and Ryan (1985, 2002), motivation varies along a continuum ranging from highly controlled to more self-determined structures, with the latter promoting more positive consequences than the former, including persistence behavior. The practical importance of this distinction between motives forwarded by OIT has emerging support in the physical activity domain, with more self-determined motives distinguishing physically active from inactive adults (Landry & Solomon, 2004; Mullan & Markland, 1997), predicting greater frequency of weekly exercise participation (Wilson, Rodgers, Fraser, & Murray, 2004) and underpinning prolonged sport involvement (Pelletier, Fortier, Vallerand, & Brière, 2001).

Despite the growing support for OIT's propositions, Vallerand (2001) has indicated that limited attention has been afforded to other aspects of SDT's framework in physical activity research. One subcomponent of SDT's framework that has been overshadowed by the focus on OIT in physical activity research to date is the notion of basic psychological needs (Deci & Ryan, 1985, 2001, 2002; Ryan, 1995). In addition to specifying the nature and function of motives residing along the continuum, Deci and Ryan (1985, 2002) assert that the degree to which social contexts satisfy the basic psychological needs for competence, autonomy, and relatedness will nourish development and promote well-being. Competence draws on White's (1959) work and concerns feeling effective and capable in meeting challenging tasks within one's environment. Autonomy stems from deCharms's (1968) research on internal perceived locus of causality and concerns feeling agentic and volitional in one's behavioral endeavors, as opposed to a pawn to external agents or agendas. Finally, the notion of relatedness is concerned with feeling meaningfully connected to others or a heightened sense of belonging to one's community at large (Baumeister & Leary, 1995; Ryan).

Central to SDT is the notion that satisfaction of these basic psychological needs is fundamental to promoting the internalization of cultural norms and values into a coherent self-structure (Deci & Ryan, 1985, 2002; Ryan, 1995). SDT's conception of needs considers these psychological forces to be innate and universal in their positive influence on well-being (Deci & Ryan, 2002; Ryan). The notion of well-being, from an SDT perspective (Deci & Ryan, 1985, 2002), is not concerned exclusively with hedonic principles that restrict their focus to the pursuit of pleasure/happiness or the prevention of pain (Ryan & Deci, 2001). On the contrary, SDT focuses on eudaimonic well-being, which is concerned with organismic functionality and self-actualization that flourishes when social contexts facilitate the satisfaction of basic psychological needs (Ryan & Deci, 2001). Research in various physical activity domains supports the link between satisfaction of basic psychological needs and enhanced internalization (Sarrazin, Vallerand, Guillet, Pelletier, & Cury, 2002) and well-being (Ntoumanis, 2001; Reinboth & Duda, 2006). In sport settings, for example, Sarrazin et al. demonstrated that satisfying SDT's psychological needs underpins positive

consequences in terms of sustained behavior and self-determined motivation for sport participation in young female handball players. Similar findings were noted by Ntoumanis) in physical education students, although some discrepancies were evident, with perceived relatedness appearing more strongly linked with controlling than self-determined motivational regulations. More recent studies by Reinboth, Duda, and Ntoumanis (2004) suggest that perceived competence and autonomy are the dominant predictors of well-being in British athletes; however, this relationship appears to be influenced by age (Reinboth & Duda, 2006) .

Ryan (1995) acknowledged that domain-specific studies of SDT principles are useful in terms of advancing theoretical development and offer practical information that can be used to promote social change. Subtle differences in motivational processes have been noted between sport and exercise in applications of SDT to the study of well-being (Frederick & Ryan, 1993). Complementing the aforementioned studies in sport settings, research by Markland supports the contributions of perceived competence and autonomy to intrinsically motivated exercise participation (Markland, 1999; Markland & Hardy, 1997), and a series of laboratory-based experiments illustrated the positive effects on psychological well-being attributable to perceived autonomy (Daley & Maynard, 2003; Parfitt & Gledhill, 2004). Consistent with Vallerand's (2001) concerns, however, these investigations have focused predominantly on the effects of satisfying competence and autonomy needs in exercise settings, with little consideration of perceived relatedness. Wilson, Rodgers, and Fraser (2002) have conducted preliminary research to address the importance of all three psychological needs proposed within SDT. In their first study, greater perceptions of need satisfaction were associated with endorsement of more self-determined than controlled exercise motives. These findings were partially corroborated by a second study of adults enrolled in a supervised aerobic exercise training program, although concerns with the measurement of perceived relatedness were evident (Wilson, Rodgers, Blanchard, & Gessell, 2003). Although these studies are informative, they only indirectly address Deci and Ryan's (2002, p. 22) contention that the satisfaction (or thwarting) of basic psychological needs "must have a direct relation to well-being." This lack of attention to the psychological need satisfaction (PNS)–well-being relationship in exercise is surprising, given the longstanding interest in promoting mental health through exercise (Fox, 1997) and the appeal of SDT as a framework that accounts for why exercise participation promotes well-being (Deci & Ryan, 1985, 2002).

Considering the scarcity of research examining SDT's basic psychological needs subtheory in relation to well-being within exercise contexts, the overall purpose of this investigation was to examine the link between perceived PNS and well-being using SDT as a guiding framework (Deci & Ryan, 1985, 2002; Ryan, 1995). To address this purpose, two studies were conducted to examine the

relationships between perceived competence, autonomy, and relatedness for exercise participation with indices of global (subjective vitality) and context-specific (positive and negative affect) well-being. Subjective vitality and exercise-specific affect were chosen as the criterion indicators for several reasons. First, positively activated affective states represent hallmark characteristics of well-being (Russell, 2003; Yik, Russell, & Feldman Barrett, 1999). Second, subjective vitality was developed within the framework of SDT (Ryan & Frederick, 1997) as a global assessment of the energy available to the self that reflects eudaimonic health. Finally, although there is little consistency in the measurement of psychological well-being (Diener, Suh, Lucas, & Smith, 1999), it is generally accepted that well-being is best represented by multiple indicators encompassing global and domain-specific indices, and such approaches have been advocated for research specific to exercise settings (Thøgersen-Ntoumani, Fox, & Ntoumanis, 2005). This approach to measuring well-being is consistent with the SDT literature, in which a combination of affective and mental health indicators has been employed to assess eudaimonic well-being (Deci & Ryan, 2002).

Study 1

The purpose of Study 1 was to establish preliminary evidence for the association between perceived PNS in exercise and well-being represented by subjective vitality. Our hypotheses were based on arguments concerning the function of satisfying psychological needs outlined within SDT by Deci and Ryan (1985, 2002). First, it was hypothesized that elevations in perceived PNS would be associated with greater well-being indexed by higher subjective vitality (Ryan & Frederick, 1997). Second, it was hypothesized that variation in perceptions of competence, autonomy, and relatedness over time would be associated with changes in vitality after controlling for the influence of demographic considerations commonly associated with subjective well-being (Diener et al., 1999).

Method

Participants. Fifty women recruited from the university and local communities completed a 12-week supervised resistance-training program in a university-based fitness facility. Participants were predominantly young to middle-aged ($M_{\text{age}} = 35.99 \pm 11.14$ years; range = 19–65 years) and healthy for this age cohort on the basis of their self-reported body mass index (BMI) values ($M_{\text{BMI}} = 24.29 \pm 3.89$; 66.9% ≤ 25.00 kg/m²). Eighty-three percent of the women indicated that they were employed full time, and 88.7% of the sample reported engaging in three or more strenuous physical exercise sessions per week prior to starting the resistance-training program.

Measures

Psychological Needs in Exercise. PNS was assessed with three single-item indicators used to represent perceived competence (“feeling competent and capable in the exercises I attempt”), autonomy (“feeling autonomous and choiceful in the exercises I do”), and relatedness (“feeling related and connected to the people I exercise with”). Following the stem “To what extent do you typically have these experiences when you exercise . . . ,” participants responded to each item on a scale anchored at the extremes by 1 (*very little*) and 7 (*very much*). Although the use of single-item indicators is controversial (Crocker & Algina, 1986), an empirical study examining the utility of such indicators suggests that normally distributed scores from single-item indicators that adequately represent the focal construct of interest can be as useful as their multi-item counterparts (Gardner, Cummings, Dunham, & Pierce, 1998). Previous research using both the original (Sheldon & Elliot, 1999) and domain-specific (Wilson et al., 2002) versions of these items offers evidence of the criterion validity associated with scores from these indices predicting both well-being and exercise motivation. Given that the items were developed within the framework of SDT for the purpose of testing theoretical propositions, and demonstrated satisfactory distributional properties in this sample (see Table 1), their inclusion in this study appears warranted.

Subjective Vitality Scale (SVS). Participants completed the individual difference version of the original SVS as an index of eudaimonic well-being, which concerns feeling alive and having energy available to the self (Ryan & Frederick, 1997). Following a stem that situated the items globally within each participant’s life (“To what extent are the following statements true or not true of your life at the present time?”), responses were provided to seven items on a Likert scale anchored at the extremes by 1 (*not at all true*) and 7 (*very true*). Previous research has supported the convergent validity of SVS scores by demonstrating that elevated SVS scores are associated with greater self-esteem and self-actualization (Ryan & Frederick) and reduced perceptions of physical pain in adults (Nix, Ryan, Manly, & Deci, 1999). An overall SVS score was created by averaging all seven items (Morris, 1979).

Data Collection Procedures and Analyses. Participants were recruited using advertisements posted to an electronic mailing list and snowball sampling techniques from those responding to the initial message. All recruitment materials indicated that participants had the opportunity to engage in a 12-week structured resistance-training program that included an educational phase (first 4 weeks) and a monitoring phase (last 8 weeks) under the supervision of qualified professionals at no financial cost. Interested participants contacted the researchers by telephone or e-mail to express interest, ask questions, and collect further information. Upon initial contact, each participant was given the opportunity to ask questions about the study and were screened based upon the study’s inclusion

Table 1

Descriptive Statistics and Correlations between Perceived Psychological Need Satisfaction (PNS) and Subjective Vitality Scores

Variables	<i>M</i>	<i>SD</i>	Skew.	Kurt.	1	2	3	4
Time 1								
1. PNS—Competence	5.25	1.42	-.93	.34	—			
2. PNS—Autonomy	5.29	1.42	-.85	.23	.80	—		
3. PNS—Relatedness	4.35	1.65	-.49	-.45	.34	.42	—	
4. Subjective vitality	4.47	1.32	-.20	-.63	.41	.42	.17	—
Time 2								
1. PNS—Competence	5.86	0.80	-.08	-.75	—			
2. PNS—Autonomy	5.97	0.96	.96	.29	.46	—		
3. PNS—Relatedness	3.94	1.97	-.16	-1.23	.19	.21	—	
4. Subjective vitality	5.48	0.85	.25	.21	.43	.14	.15	—

Note. Correlation matrix is based upon pairwise comparisons between each variable set, and sample sizes are consistent across each comparison made in the matrix. All r 's $> |.30|$ statistically significant at $p < .01$ (two-tailed significance). All r 's $> |0.20|$ but $< |.30|$ statistically significant at $p < .08$ (two-tailed significance).

M = item/subscale mean; *SD* = item/subscale standard deviation; Skew. = univariate skewness; Kurt. = univariate kurtosis.

criteria: participants must be (a) adults (i.e., ≥ 18 years old); (b) healthy to the degree that maximal exercise testing and supervised resistance training would not exacerbate any existing medical condition; (c) not currently engaged in organized/competitive sport; and (d) willing to commit to the length of the study and receive physician clearance to participate. Participants meeting these criteria were scheduled for an information session and initial strength test using maximal resistance exercises. At the orientation session, the overall purpose of the study was explained in greater detail, informed consent was provided from each participant, and a survey packet containing Time 1 instruments was distributed and completed in small groups ($n < 25$ in each instance).³ The same instruments and

³The resistance-training program was designed to increase physical strength and improve the lean:fat mass ratio. Participants engaged in three training sessions/week for the duration of the study under the supervision of trained exercise professionals. Each training session included a warm-up and

physical strength tests were administered 12 weeks later at the culmination of the study.

Data analysis proceeded in sequential stages. First, the data were inspected for missing cases and extreme responders. Second, the descriptive statistics and internal consistency estimates were calculated for Time 1 and 2 assessments. Third, paired samples *t* tests examined the mean change in perceived PNS and subjective vitality across time. Fourth, variation over time was analyzed by calculating the residual change scores in accordance with Schutz's (1989) recommendations using multiple regression techniques. Estimates of change were calculated using a simple regression equation, whereby the Time 2 score for each variable was regressed onto the Time 1 score, and the standardized residual was saved as an estimate of change over time associated with each variable (Schutz). Bivariate correlations were then computed to examine the covariation between change scores as a function of time.

Results

Preliminary Data Analyses. Initial recruitment resulted in a sample of 162 agreeing to participate in the study. Complete data at Time 2 were available on 50 participants, resulting in a retention rate of 30.86%. Multivariate analyses of variance examining the differences between study completers and noncompleters showed no substantial differences in the perceptions of PNS scores, Wilks's, $\Lambda(3, 113) = .99, p = .83$; partial $\eta^2 = .01$, and an independent samples *t* test indicated no substantial differences in SVS scores, $t(161) = 1.77, p = 0.08$.⁴ An inspection of distributional statistics indicated no evidence of extreme responding in the final sample ($n = 50$). Descriptive statistics (see Table 1) calculated at both time points indicated that participants reported greater satisfaction of competence and autonomy than relatedness needs in exercise contexts and provided estimates of subjective vitality that were above the theoretical midpoint of the scale. The observed internal consistency reliability estimates (Cronbach's α ; Cronbach, 1951) for the SVS scores in the present study were: (a) Time 1, $\alpha_{SVS} = .93$, and (b) Time 2, $\alpha_{SVS} = .89$.

Main Analyses. Changes in perceived PNS and subjective vitality were examined across the 12-week training period using paired samples *t* tests and effect size

cool-down period followed by the following exercises that also comprised the pre- and poststudy maximal exercise tests: (a) leg press; (b) hamstring curl; (c) chest press; (d) lat pull-downs; and (e) shoulder press. Incremental changes in the training programs across the 12 weeks were individualized based on prestudy strength test scores.

⁴Independent samples *t* tests indicated that there were no differences between those participants completing the study and noncompleters in terms of age, $t(161) = -.03, p = .98$, BMI, $t(161) = 1.11, p = .27$, or exercise behavior, $t(161) = 1.04, p = .30$ measured by the summary score from the Godin Leisure Time Exercise Questionnaire (Godin & Shepherd, 1985).

Table 2

Correlations between Standardized Residual Change Scores

Variables	1	2	3	4
1. PNS—Competence	—	.49	.03	.24
2. PNS—Autonomy	.65	—	.17	.30
3. PNS—Relatedness	.20	.34	—	.00
4. Subjective vitality	.24	.29	.08	—

Note. Correlation matrix is based upon pairwise comparisons between each variable set and sample sizes are consistent across each comparison made in the matrix. Correlations in the lower triangle of the matrix are Pearson correlations between standardized residual change scores for each study variable. Correlations in the upper triangle of the matrix are partial correlations between need satisfaction and well-being indices controlling for the influence of age and body mass index. All $r_s > .|23|$ statistically significant at $p < .01$ (two-tailed significance).

PNS = perceived psychological need satisfaction.

calculations advocated for use in within-groups designs (Johnson & Eagly, 2000). Examination of these data indicated that changes were evident across the 12-week period for both PNS and SVS scores. Specifically, perceptions of competence, $t(49) = -4.21$, $p < .05$, $ES = -.33$ and autonomy, $t(49) = -4.13$, $p < .05$, $ES = -.33$ demonstrated positive changes along with increased subjective vitality, $t(49) = -4.52$, $p = .94$, $ES = -.61$ across the 12 weeks. Interestingly, perceived relatedness, $t(49) = 2.15$, $p < .05$, $ES = .19$ declined across the study period.

Pearson correlations (r ; see Table 1) depicted that perceived PNS indices were weakly to strongly associated with one another, with the strongest relationships evident between perceived competence and autonomy. It was also noted that greater satisfaction of psychological needs is associated with greater subjective vitality, with the strongest relationship emerging for the satisfaction of competence needs. Examination of relationships between standardized residual change scores (see Table 2) corroborated individual time point estimates, with weak to moderate associations evident between changes in perceived PNS and elevations in perceived competence and autonomy associated with greater subjective vitality that remained robust after controlling for the influence of BMI and age (see Table 2).

Summary

The purpose of Study 1 was to examine the relationship between perceptions of competence, autonomy, and relatedness as outlined by Deci and Ryan (1985,

2002) within SDT and an index of eudaemonic well-being in the form of subjective vitality. Our initial hypotheses were only partially supported, with modest changes evident in mean PNS and subjective vitality scores over time. Elevations in perceived competence and autonomy were positively associated with increased subjective vitality. Substantial increases were evident in subjective vitality across 12 weeks, and comparable increases in perceived competence and autonomy were noted, along with a significant decline in perceived relatedness in exercise. Collectively, these data provide initial support for SDT's argument that indices of domain-specific PNS were associated with a hallmark of well-being in the form of subjective vitality. Further, positive changes across time in the satisfaction of competence and autonomy needs in particular were associated with elevations in feelings of subjective vitality irrespective of select demographic considerations.

Study 2

The purpose of Study 2 was to extend the available literature examining perceived psychological need fulfillment in exercise contexts by evaluating the contributions of satisfying each SDT-based need to exercise-specific affect while controlling for the influence of other candidate psychological needs. The intent of Study 2 was to offer preliminary evidence in exercise contexts justifying the importance of satisfying SDT-based needs compared with other candidate psychological needs proposed to influence well-being (Sheldon, Elliot, Kim, & Kasser, 2001). Drawing from the work of (Sheldon et al.), it seems reasonable to suggest that testing other plausible psychological needs beyond the purview of SDT is relevant to advancing knowledge pertaining to basic PNS within exercise in several ways. First, psychological needs, according to Deci and Ryan (2002), are innate and exert positive influences on well-being and internalization that are universal. Given the appeal of psychological needs for explaining a broad spectrum of human functioning (Sheldon et al.), the defining characteristics of psychological needs forwarded by Deci and Ryan (2002) suggests that other psychological needs meeting these definitional requirements be considered. Second, this study extends previous literature examining perceived PNS in exercise contexts by examining the contributions to well-being made by SDT's needs compared with other "candidate" psychological needs drawn from a larger nomological network (Cronbach & Meehl, 1955; Sheldon et al.). Finally, the inclusion of candidate psychological needs external to SDT's framework provides an initial opportunity to highlight potential redundancy among psychological needs. Such an endeavor appears fruitful, given that Sheldon et al. noted that one of the major criticisms of this literature concerns the abundance of candidate psychological needs proposed and the lack of consensus around the primacy of psychological needs in the promotion of well-being or motivation of human behavior. Our hypotheses were based on SDT (Deci & Ryan, 2002) and research

by Sheldon et al. and contend that greater perceptions of competence, autonomy, and relatedness in exercise would be associated with more positive and less negative affect typically experienced during exercise participation despite the contributions of other candidate psychological needs.

Method

Participant. Participants ($n = 198$; 51.5% female) were patrons of a fitness facility housed at a small university in central Canada. Participants were predominantly young (76.0% aged 18–22 years) and ranged in age from 18 to 58 years ($M = 22.04 \pm .89$). BMI values suggested that the majority of participants ($M_{\text{BMI}} = 24.01 \pm 3.29$, 66.0% fell between 18.00 and 24.99 kg/m²) were healthy for their age cohort. At the time of data collection, participants indicated that they were physically active during the past 7 days ($M_{\text{METS}} = 80.78 \pm 51.37$) based on a summary score derived from the Godin Leisure Time Exercise Questionnaire (Godin & Shepherd, 1985). The majority (84.3%) of these participants were considered frequent exercisers using the criteria forwarded by Rodgers and Gauvin (1998) of engaging in three or more exercise sessions a week.

Measures

Psychological Need Satisfaction in Exercise Scale (PNSE). Participants completed the 18-item PNSE as a measure of PNS developed within the SDT framework that is specific to exercise contexts (Wilson, Rogers, Rodgers, & Wild, 2006). A stem statement (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.”) was developed that encouraged participants to respond to each item in terms of how they usually felt while exercising. Participants’ responses were made on a scale anchored at the extremes by 1 (*false*) and 6 (*true*). Confirmatory factor analysis of the three-factor PNSE measurement model proposed by Wilson et al. (2006) supported the factorial composition and structure of PNSE scores in the present sample, $\chi^2 = 340.29$, $df = 132$, $p < .01$, CFI = .93, IFI = .93, RMSEA = .09 (90% CI = .08–.11). Interfactor correlations (ϕ) were moderate to strong in nature and all in a direction that resonates with SDT (Deci & Ryan, 2002).⁵

⁵The PNSE is a new measure of PNS and initial construct validity evidence for PNSE scores including convergent and divergent validity with external scores has been provided by Wilson et al. (2006). Sample items were: (a) *competence* (“I feel that I am able to complete exercises that are personally challenging.”); (b) *autonomy* (“I feel free to exercise in my own way.”); and (c) *relatedness* (“I feel connected to the people who I interact with while we exercise.”). The PNSE is available from the first author upon request.

Positive Affect Negative Affect Schedule (PANAS). Participants completed the 10-item short form of the PANAS (Mackinnon et al., 1999) as an index of affect typically experienced during exercise. Participants responded to each item on a 5-point Likert scale anchored at the extremes by 1 (*very slightly or not at all*) and 5 (*extremely*). Previous research suggests that the short form of the PANAS has a tenable factor structure and composition, is less burdensome to respondents than longer versions of the instrument, and is invariant across age (Mackinnon et al.). Five PANAS items were used to capture positive and negative affect experiences typically felt with exercise participation. The five PANAS items pertinent to each subscale were averaged to form an overall positive (inspired, alert, enthusiastic, excited, determined) and negative (afraid, upset, nervous, scared, distressed) affect scale score. Confirmatory factor analysis of the oblique two-factor PANAS measurement model supported the factorial composition and structure of scores derived from this instrument in the present sample, $\chi^2 = 86.04$, $df = 34$, $p < .01$, CFI = .95, IFI = .95, RMSEA = .09 (90% CI = .07–.12); $\phi_{\text{positive,negative affect}} = -.27$, $p < .01$.

Basic Psychological Needs Questionnaire (BNQ). Participants completed 12 items drawn from Sheldon et al. (2001) to assess the degree to which exercise participation satisfied four additional psychological needs external to SDT's framework. Three items/subscale measured perceptions of self-actualization (sample item: “. . . a deeper purpose in life”), physical thriving (sample item: “. . . a strong sense of physical well-being”), security (sample item: “. . . safe from threats and uncertainties”), and popularity (sample item: “. . . that I was a person whose advice others seek out and follow”). The stem statement (i.e., “During this event I felt . . .”) used by Sheldon et al. was modified to highlight the salience of exercise as the context satisfying these psychological needs (i.e., “Typically when I exercise, I feel . . .”). Participants responded to each BNQ item on a Likert scale anchored by 1 (*not at all*) and 5 (*very much*). In their original study, Sheldon et al. provided evidence for the simple structure of responses to the BNQ items used in this study via exploratory factor analysis (principal components with Varimax), and linked higher BNQ scores with more positive and less negative affect reported during satisfying events.

Procedures and Analyses. Participants were recruited postexercise session while exiting the fitness facility. Prior to data collection, participants were informed about the purpose of the study, given an opportunity to ask questions regarding the study, and provided written informed consent prior to administration and completion of the study questionnaires. Scores for PNSE, PANAS, and BNQ subscales were created by averaging the relevant items for each instrument (Morris, 1979). Data analysis proceeded in three stages. First, the data were screened for discrepant or absent responses and examined for conformity with relevant statistical assumptions. Second, descriptive statistics and internal con-

sistency estimates were computed for all study variables. Finally, a canonical correlation analysis was used to examine the contributions of PNSE and BNQ scores to affect experienced during exercise.

Results

Preliminary Data Analyses. No out-of-range responses were evident, and the small amount (<5%) of missing data appeared random in nature and was replaced using the expectation maximization algorithm generated from the sample data. A scatterplot of residuals suggested that both linearity and homoscedasticity were tenable assumptions. Internal consistency reliability (Cronbach's α ; Cronbach, 1951) estimates for subscale scores (Table 3) ranged from 0.52 to 0.94, with lower estimates evident for BNQ and PANAS subscale scores. Descriptive statistics indicated that participants in this study reported greater satisfaction of competence and autonomy than relatedness needs based on the observed PNSE scores, moderate satisfaction of security, self-actualization, and popularity needs, and high satisfaction of physical thriving needs based on the observed BNQ scores. Moreover, participants reported greater experience of positive than negative affect following one's typical exercise session. Pearson correlations (r) revealed that indices of PNS were all positively correlated with one another and were all positively associated with more positive affect and less negative affect during a typical session of exercise (see Table 3). With the exception of perceived security, BNQ scores were correlated with increased positive affect and uncorrelated with negative affect, except for the weak association with physical thriving.

Main Data Analysis. Canonical correlation (R_c) analysis was used to examine the multivariate contributions of perceived PNS to typical exercise affect. R_c coefficients provide an assessment of the relationship between two composite sets of synthetic variables (Thompson, 2000). Canonical loadings represent the correlation between the original variable and their canonical variates and provide the relative contribution of each variable to the definition of the canonical function (Thompson). In these analyses, the positive and negative affect subscales of the PANAS served as the criterion set, whereas the subscales of the PNSE (perceived competence, autonomy, and relatedness) and BNQ (security, self-actualization, physical thriving, and popularity) served as the predictor set. Consistent with convention (Pedhazur, 1997; Thompson), only canonical functions that exceeded the minimum threshold value ($R_c \geq |.30|$) were interpreted.

The overall multivariate test revealed two canonical functions that represented a moderate degree of association between perceived psychological need fulfillment and typical exercise affect, $R_{c1} = .57$, Wilks's $\Lambda = .61$, $F(14, 176) = 3.47$, $p < .05$; $R_{c2} = .31$, Wilks's $\Lambda = .39$, $F(7, 88) = 19.52$, $p < .05$. Table 4

Table 3

Descriptive Statistics for Psychological Need Satisfaction Indices and Criterion Variables in Study 2

Variables	M	SD	Skew.	Kurt.	α	1	2	3	4	5	6	7	8	9	10
1. PNSE—Competence	5.19	.73	-.90	.30	.89	—									
2. PNSE—Autonomy	5.42	.79	-1.75	3.52	.94	.53	—								
3. PNSE—Relatedness	4.49	1.20	-1.15	1.12	.91	.31	.22	—							
4. BNQ—Self-actualization	3.17	.97	-.21	-.48	.76	.05	.06	.25	—						
5. BNQ—Physical thriving	4.24	.58	-.73	.70	.58	.45	.30	.33	.35	—					
6. BNQ—Security	3.62	.77	-.46	.15	.52	.14	.09	.31	.44	.43	—				
7. BNQ—Popularity	2.81	1.03	.05	-.68	.84	.11	-.03	.24	.49	.30	.40	—			
8. PANAS—Positive affect	3.30	.60	-.74	.94	.69	.36	.14	.20	.33	.33	.10	.26	—		
9. PANAS—Negative affect	1.31	.44	1.83	3.61	.63	-.34	-.33	-.13	.04	-.23	-.03	.09	-.08	—	

Note. Correlation matrix is based upon pairwise comparisons between each variable set, and sample sizes are consistent across each comparison made in the matrix. All r 's > |.19| statistically significant at $p < .01$ (two-tailed significance) and all r 's > |.13| but <|.19| statistically significant at $p < .05$ (two-tailed significance).
 PNSE = Perceived Psychological Need Satisfaction in Exercise Scale (Wilson et al., 2006); PANAS = Positive Affect Negative Affect Schedule; M = item/subscale mean; SD = item/subscale standard deviation; Skew. = univariate skewness; Kurt. = univariate kurtosis; α = internal consistency reliability coefficient (Cronbach, 1951).

Table 4

Canonical Loadings of PANAS and Perceived Psychological Need Satisfaction Dimensions

Variables	Canonical Loadings	
	Function 1	Function 2
Affective experiences		
PANAS—Positive affect	.90	.44
PANAS—Negative affect	-.52	.86
Perceived psychological need satisfaction		
PNSE—Competence	.85	-.35
PNSE—Autonomy	.49	-.64
PNSE—Relatedness	.41	-.03
BNQ—Self-actualization	.49	.62
BNQ—Physical thriving	.70	-.10
BNQ—Security	.19	.06
BNQ—Popularity	.36	.59

PNSE = Psychological Need Satisfaction in Exercise Scale (Wilson et al., 2006);
 BNQ = Basic Psychological Needs Scale (adapted from Sheldon et al., 2001);
 PANAS = Positive Affect Negative Affect Scale (Mackinnon et al., 1999).

presents the canonical loadings for both canonical functions retained from the R_c analysis. An inspection of the loadings on R_{c1} indicates that strong contributions to this canonical function were made by scores on positive affect, perceived competence, and physical thriving, whereas moderate contributions were made by scores on perceived autonomy, perceived relatedness, popularity, self-actualization, and negative affect, although the direction of the contribution for negative affect on this canonical function was negative. In contrast to R_{c1} , the observed loadings on R_{c2} revealed that negative affect was the dominant PANAS score contributing strongly to the canonical function, whereas perceived competence and autonomy scores contributed negatively and self-actualization and popularity scores contributed positively to this canonical function. The multivariate combination of canonical loadings accounted for 32% of the variance in R_{c1} and 10% of the variance in R_{c2} .

Summary

The purpose of Study 2 was to examine the contribution of satisfying competence, autonomy, and relatedness needs to positive and negative affective experiences typically felt in exercise contexts when controlling for the influence of select candidate psychological needs external to SDT's framework (Deci & Ryan, 1985, 2002; Ryan, 1995). Consistent with our original hypotheses, the bivariate analyses indicated that elevated satisfaction of the psychological needs for perceived competence, autonomy, and relatedness were associated with experiencing more positive than negative affect during a typical exercise session. Moreover, multivariate analyses indicated that these relationships remained robust after controlling for the influence of self-actualization, security, popularity, and physical thriving within exercise settings.

General Discussion

The purpose of this investigation was to examine the relationship between perceptions of competence, autonomy, and relatedness and indices of well-being as a preliminary evaluation of the function of basic psychological needs in exercise contexts from the perspective of SDT (Deci & Ryan, 1985, 2002; Ryan, 1995). Participants in both studies reported greater satisfaction of perceived competence and autonomy needs in exercise settings than perceived relatedness, along with relatively high indices of psychological well-being. The results of Study 1 make it apparent that satisfaction of psychological needs fluctuates across time in exercise contexts and that greater satisfaction of perceived competence and autonomy needs, especially in female exercisers, is associated with enhanced subjective vitality. These relationships were not altered substantially after controlling for the influence of age and BMI. The results of Study 2 corroborated the link between satisfaction of basic psychological needs proposed by SDT and more positive than negative affect experienced during one's typical exercise session, and suggested that these links remained tenable after controlling for the influence of candidate psychological needs external to SDT's framework that were drawn from Sheldon et al. (2001).

The finding that participants reported greater satisfaction of perceived competence and autonomy than relatedness needs in exercise contexts is consistent with previous research using Canadian exercisers (Wilson et al., 2003, 2002). Although not hypothesized in this investigation, this pattern of findings is not entirely inconsistent with arguments concerning the function of relatedness as forwarded within the SDT framework by Deci and Ryan (2002). For example, Deci and Ryan (2002) argued that perceived relatedness instigates the internalization process within domains such as exercise. Considering that the participants examined in this investigation, and in previous exercise-based studies

(Wilson et al., 2003, 2002), were all physically active, it seems reasonable to suggest that they have already internalized exercise to form an integral component of their self-system. Individuals who have already internalized exercise into a coherent portion of their self-identity seem unlikely to require the support for well-being that an enhanced sense of meaningful connection to others could afford those initiating exercise for the first time. Future research may wish to address this issue concerning the importance of satisfying relatedness needs in people at different stages of exercise adoption and participation to ascertain if enhancing relatedness is a useful route for encouraging initiation and sustenance of exercise behavior and, ultimately, promoting psychological well-being. One useful direction for this line of inquiry to consider would be qualitative investigations that attempt to unravel the key processes responsible for shaping psychological well-being through exercise participation in people at various stages of exercise adoption.

One interesting finding emerging from this study concerns the nature of the relationship between satisfying the psychological needs for competence, autonomy, and relatedness proposed within SDT (Deci & Ryan, 1985, 2002; Ryan, 1995) and measured using two different self-report instruments in this investigation. One criticism of SDT's basic psychological needs subtheory concerns the degree of antagonism associated with need satisfying experiences, with particular reference to the incompatibility of perceived autonomy and relatedness needs within domains (Schwartz, 2000). Our data from both studies provide evidence that the processes contributing toward the satisfaction of the psychological needs proposed by SDT are neither mutually exclusive nor independent in nature. This is in line with Deci and Ryan's (2002) contentions given that PNS is seen to be the cornerstone associated with the integration of the self within social environments and promotion of eudaimonic well-being (Ryan & Deci, 2001). An examination of the data from both studies indicates that feeling effective in one's exercise environment is more strongly associated with a sense of volition and agency than with feeling connected in meaningful ways to others while exercising. This finding is consistent with previous literature examining the interrelationship between psychological need-satisfying experiences proposed within SDT in exercise domains (Wilson et al., 2003, 2002). Future research would do well to consider these interrelationships carefully in predictive analyses, in which the possibility of confounding effects stemming from colinearity is likely, and attempt to unravel the unique and combined effects of PNS on well-being.

One aim of this study was to examine the relationship between satisfaction of the psychological needs proposed by SDT (Deci & Ryan, 1985, 2002; Ryan, 1995) and indices of well-being captured by self-report levels of subjective vitality and positive affect. Evidence across both studies is consistent with SDT and emerging literature in other domains (Deci et al., 2001; La Guardia, Ryan, Couchman, & Deci, 2000; Sheldon et al., 2001) and indicates that greater satisfaction of

perceived competence, autonomy, and relatedness in exercise settings is associated with enhanced reports of subjective vitality in one's life overall and the degree of positive affect typically experienced within one's exercise session. These relationships were further corroborated for perceived competence and autonomy given the results of the change score analysis reported in Study 1. No supporting evidence in Study 1 was provided for changes in perceived relatedness in relation to subjective vitality. Although the role of perceived relatedness within the internalization process offers a tenable explanation for these observations, another possible explanation concerns the extent to which domain-specific feelings of connection with others contribute to global feelings of psychological well-being in comparison with domain-specific perceptions of competence and autonomy. This represents an interesting avenue for future research to consider with reference to determining the scope of influence attributable to satisfying basic psychological needs within domains such as exercise on global markers of well-being. Such endeavors may wish to consider assessing psychobiological indices of well-being alongside self-report estimates to gain greater insight into the fundamental mechanisms influencing well-being via exercise.

Two additional findings emerged from Study 2 that appear worthy of consideration. First, although perceived competence was the strongest correlate of positive affect among SDT-based needs in both the bivariate and multivariate analyses, the relationship between perceived autonomy and negative affect was stronger particularly when considering the joint influences of all need satisfaction constructs on well-being at the multivariate level. These results are largely in line with Sheldon et al. (2001) and suggest that although feeling effective in one's environment is likely to prompt positive feelings, an enhanced sense of volition is likely to counteract feelings of ill-being such as negative affect. Second, although the contributions of SDT-based needs to positive and negative affect remained robust after controlling for the influence of other candidate psychological needs, the influence of self-actualization in particular was quite strong, which is consistent with the data reported by Sheldon et al. (2001) in their cross-cultural research. It is conceivable that self-actualization as measured in the present study is a proxy indicator of eudaimonic well-being (Ryan & Deci, 2001), and therefore represents a criterion of mental health as opposed to a psychological foundation upon which well-being resides. Future research could expand upon the present study by testing the relationship between the satisfaction of SDT-based needs in conjunction with other candidate needs on well-being markers, given that the boundaries defining the characteristics of a psychological need proposed by Deci and Ryan (2002) within SDT remain flexible enough to incorporate other psychological needs were justified. Such endeavors, however, should not confuse the measurement of basic psychological needs with indicators of well-being where possible, given that such an approach would likely obfuscate rather than clarify the mechanisms promoting mental health.

Although the findings of this investigation are theoretically informative, a number of limitations should be recognized along with future research directions offered to advance the study of PNS in exercise. First, this study used nonprobability sampling techniques to recruit participants from a single context (namely exercise settings) that do not afford the same confidence in external validity as their probability-based counterparts. Future studies would do well to consider using either probability- or purposive-based sampling techniques to determine the external validity of the present findings to other groups (e.g., patients living with acute/chronic diseases, children, older adults) and contexts (e.g., sport, recreation) in which links between psychological well-being and exercise are important. Second, an examination of the descriptive statistics for PNS, PNSE, and BNQ scores in this investigation suggests minimal variance around the experience of psychological needs in exercise contexts. This is consistent with previous literature measuring PNS in general (Sheldon et al., 2001), and within exercise contexts in particular (Wilson et al., 2003), and suggests that the measurement of PNS remains a critical avenue for future SDT-based research, given that restriction of range can unduly influence score reliability and covariation between variables under study (Tabachnik & Fidell, 2007). Finally, these studies relied on nonexperimental designs to examine the relationship between PNS and well-being indices, which offer limited insight into the direction of causal flow between variables encompassing the nomological network of psychological needs suggested by Sheldon et al. Future research may wish to collect data across multiple time periods (i.e., ≥ 3 assessments) to elucidate directional changes between well-being and perceived PNS using more sophisticated data analytical methods such as latent growth curve modeling (Duncan, Duncan, & Stryker, 2006).

In conclusion, the results of this investigation make it apparent that satisfaction of basic psychological needs for competence, autonomy, and relatedness promotes an enhanced sense of psychological well-being in the form of subjective vitality and positive versus negative affect in exercise contexts. These findings represent a preliminary attempt to evaluate the contention that satisfaction of basic psychological needs formulates the roots of well-being in exercise contexts from the perspective of SDT (Deci & Ryan, 1985, 2002; Ryan, 1995). The practical importance of these results is tied to the significance of understanding the processes contributing to enhanced well-being in exercise domains in which such feelings will likely influence initiation and persistence with this important health behavior. Understanding the mechanisms underpinning well-being will be useful for practitioners interested in maximizing the contributions of exercise participation to health promotion. The results of this investigation suggest that professionals may consider structuring exercise contexts such that they satisfy competence, autonomy, and relatedness needs, which influence positive affect and subjective vitality in a manner that is likely to enhance participation.

Explicating the causal links between perceived satisfaction of psychological needs, exercise participation, and the subsequent promotion of well-being is clearly the next step for research in this area, and consideration of the framework provided by SDT in such endeavors appears justified on the basis of the present investigation.

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