

Chapter 17

Analyzing the Measurement of Psychological Need Satisfaction in Exercise Contexts: Evidence, Issues, and Future Directions

*Philip M. Wilson¹, Diane E. Mack, Katie Gunnell, Kristin Oster,
and J. Paige Gregson*

Department of Physical Education and Kinesiology,
Faculty of Applied Health Sciences
Brock University, St Catharines, Ontario, Canada, L2S 3A1

Abstract

Background: Perceived competence, relatedness, and autonomy embody the basic psychological needs subtheory housed within Self-Determination Theory (SDT; Deci and Ryan, 2002). Fulfillment of these basic psychological needs represents an important avenue for the promotion of well-being and the optimization of motivation for health behaviors including exercise. Few attempts, however, have been made to systematically measure the fulfillment of basic psychological needs in exercise contexts using a construct validation approach (Wilson, Rogers, Rodgers, and Wild, 2006).

Purpose: The main purpose of this article is to review the available evidence attesting to the measurement of psychological need satisfaction in exercise contexts using SDT as a guiding framework. The subpurposes of this review were to identify key issues associated with the current measurement of psychological need satisfaction in exercise using a construct validation framework (Messick, 1995), and illustrate salient issues pertinent to the selection and development of instruments designed to measure perceived competence, autonomy, and relatedness specific to exercise contexts for future research.

¹ Correspondence concerning this manuscript can be sent to: Philip M. Wilson, PhD, Department of Physical Education and Kinesiology, Faculty of Applied Health Sciences, Brock University, 500 Glenridge Avenue, St Catharines, Ontario, L2S 3A1, Canada. Tel: (905) 688-5550 Ext. 4997. Fax: (905) 688-8364. Email: phwilson@brocku.ca.

Summary: Early work in this area relied on instruments that had not been developed specifically for measuring perceived psychological need satisfaction in exercise contexts. A number of psychometric concerns were evident in the data reported in these studies including reliability issues and a lack of convincing evidence for convergent and nomological validity. More recent construct validation work has produced the Psychological Need Satisfaction in Exercise Scale (Wilson et al., 2006) and the Basic Psychological Needs in Exercise Scale (Vlachopoulos and Michailidou, 2006). Both instruments appear to hold promise for furthering our understanding of the influential role afforded competence, autonomy, and relatedness perceptions in the context of exercise.

“We must believe that even in prehistoric times Og, the cave man, made rudimentary appraisals of his fellows. He saw Zog go by, made some such judgment as “Big, strong, keep out of way,” and acted upon it; or he came upon the campfire of Wog, observed “Small, weak, take dinner,” and did so forthwith. But for much of recorded history, the appraisals that man has made of his fellows have been of this crude and subjective type.” (Thorndike and Hagen, 1955, p.1).

As the foregoing quote suggests, measurement has a long and often controversial history in human development. Measurement is at the heart of any scientific endeavor (Messick, 1995) and refers generally to the process of assigning numbers to variables of interest according to specified rules or conventions (Stevens, 1946). Despite the importance of this process, Kerlinger (1979) noted that “measurement can be the Achilles’ Heel of behavioral research” (p. 141) given that scientists often pay insufficient attention to measurement issues. Marsh (1997) has suggested that theory and measurement are “inexorably intertwined” (p. 27) such that neglecting one aspect during the process of scientific research simultaneously undermines the credibility of the other.

The purpose of this paper is to review the current status of research in exercise contexts that has measured psychological need satisfaction from the perspective of Self-Determination Theory (SDT; Deci and Ryan, 2002). To address this purpose, a brief overview of SDT will be offered highlighting key issues essential to the measurement of psychological need fulfillment (a more complete overview of SDT can be found in Deci and Ryan, 2002). Following this introduction, the measurement of perceived competence, autonomy, and relatedness will be chronicled to illustrate the examples of instrument development using SDT as a framework within exercise psychology. The final section of this review highlights challenges evident in the measurement of psychological need satisfaction in exercise settings and offers suggestions for further instrument development and evaluation research.

Self-Determination Theory: A Brief Overview

SDT is an organismic approach to human development and motivation that concerns the ongoing tensions and struggles between organisms and their surrounding environment (Ryan, 1995). The SDT framework is comprised of four mini-theories that collectively inform different aspects of human development, growth, and assimilation of the self with the social world. Causality orientations theory (COT) concerns the influence of personality traits on

human functioning and more specifically describes individual differences in the degree to which people are orientated towards self-determined or controlled functioning across life domains (Deci and Ryan, 2002). Cognitive evaluation theory (CET) describes the effects attributable to varying social conditions on intrinsic motivation (Deci and Ryan, 1985). Recognizing that not all behaviors are intrinsically motivated (Ryan, 1995), organismic integration theory (OIT) posits a differentiated approach to understanding extrinsic motivation that is unique to SDT. More specifically, OIT concerns the degree of internalization with the self associated with the source of extrinsic motivation that can vary from controlled psychological processes (namely *external* and *introjected* regulations) to more volitionally endorsed or self-determined processes (*identified* and *integrated* regulations). Basic psychological needs theory (BPN) represents the final subtheory comprising the SDT framework. BPN concerns the active role afforded the basic needs for competence, autonomy, and relatedness in motivational development and the promotion of well-being.

The SDT framework has become a popular approach for examining a broad array of motivational issues in physical activity contexts including exercise (see Hagger and Chatzisarantis, 2007, for a review). This is hardly surprising given that the approach to motivation advocated within SDT specifies the regulatory processes whereby motivational orientations and behavioral regulations shape people's actions (namely OIT and COT), as well as, accounting for the processes through which different motives develop and flourish (namely CET and BPN). According to Deci and Ryan (2002), motivation for a given behavior such as exercise participation varies along a continuum from highly controlled to more volitionally endorsed processes with the latter responsible for enduring behavior and greater well-being. Emerging research in exercise settings has supported many of the propositions set forth by Deci and Ryan (2002) within SDT concerning COT (Rose, Markland, and Parfitt, 2001; Rose, Parfitt, and Williams, 2005), CET (Markland, 1999; Markland and Hardy, 1997), OIT, (Wilson, Rodgers, Fraser, and Murray, 2004), and to a lesser extent BPN (Edmunds, Ntoumanis, and Duda, 2007; Vlachopoulos and Michailidou, 2006; Wilson et al., 2006). Consequently, further consideration of the propositions set forth by Deci and Ryan (2002) within BPN seem worthy of additional research in exercise settings.

One issue that warrants careful research in the exercise psychology literature is the measurement of basic psychological need satisfaction. As advocated by Deci and Ryan (2002), basic psychological needs are innate "nutriments" (p. 7) not merely personal desires or goals that when satisfied authentically promote growth, integration, motivational development, and well-being. In contrast, evidence of ill-being such as maladjustment, fragmentation, and psychological maladies will occur when social contexts fail to fulfill basic psychological needs (Deci and Ryan, 2002). Stated differently, Deci and Ryan (2002) recognize that while the manner in which each psychological need is fulfilled may vary considerably as a function of people, context, or time for example, the net effect of satisfying each need is universal in terms of optimizing motivation and promoting well-being. While this approach is not without controversy (Iyengar and DeVoe, 2003), the BPN subcomponent of SDT is attractive given that it offers a parsimonious account for a broad array of human emotions and behaviors, as well as, delineating targets for intervention to change behavior and thereby improve human functioning (Sheldon, Williams, and Joiner, 2003).

The psychological needs for competence, autonomy, and relatedness have long been advocated by Deci and Ryan (1985) as fundamental for understanding a broad spectrum of motivational and well-being issues. *Competence* stems from the seminal work of White (1959) and refers to the extent to which people feel that they can interact with optimally challenging tasks within one's environment in an effective and capable manner. *Autonomy* draws on the work of deCharms (1968) and involves feeling a sense of personal agency or volition with reference to behavior such that one's actions stem from an internal locus of causality as opposed to feeling like a pawn to external incentives or agenda. *Relatedness* refers to feeling a meaningful sense of connection with others within one's social milieu or more globally within life (Baumeister and Leary, 1995). The satisfaction of these innate psychological needs is proposed to be complimentary such that appeasing one psychological need does not occur at the expense of fulfilling another (Deci and Ryan, 2002).

Basic Psychological Need Satisfaction and Exercise

Several distinct phases of research exploring the importance of basic psychological needs appear evident in the literature as applied to exercise settings. During the *initial phase* an emphasis was placed upon examining the effects of one of the three basic psychological needs that produced mixed evidence with reference to SDT. Research encompassing this phase typically used instruments modified from their original context for the purposes of testing SDT in exercise settings as opposed to context-specific instrument development initiatives seen in later phases of research (e.g., McCreedy and Long, 1985). A *second phase* of research emerged characterized by two inter-related themes. The first centers around the creation of instruments designed specifically to measure at least one of the key psychological needs comprising the BPN subtheory of SDT (e.g., Markland and Hardy, 1997; Markland, 1999; Rose et al., 2001).² The second theme concerned adapting instruments developed in other contexts for the assessment of the three basic psychological needs proposed by Deci and Ryan (2002) in exercise (e.g., Li; 1999; Wilson, Rodgers, and Fraser, 2002a; 2002b; Wilson, Rodgers, Blanchard, and Gessell, 2003).

One important contribution from the research comprising *phase two* concerns the increased attention drawn to the instrumentation used to assess fulfillment of basic psychological needs within the SDT framework in exercise contexts. Towards this end, a *third phase* of research has recently begun with the development of two instruments designed specifically to capture variation in basic psychological need satisfaction in a manner consistent with SDT (Deci and Ryan, 2002). Both instruments were developed by independent research groups and appear to show initial promise for measuring perceived competence, autonomy, and relatedness experienced in exercise. Vlachopoulos and colleagues (Vlachopoulos, 2007; in press; Vlachopoulos and Michailidou, 2006;

² Markland and colleagues (Rose et al., 2001; Markland, 1999) recognize that perceived locus of causality does not equate to perceived autonomy or self-determination. The former is concerned largely with the source responsible for initiating the behavior whereas the latter is to a large extent focused on the issue of choice with respect to the target behavior. Notwithstanding this observation, Reeve (2002) indicates that perceptions of volition, choice, and locus of casualty collectively represent the content of perceived autonomy from the SDT perspective.

Vlachopoulos and Neikou, in press) have developed the Basic Psychological Needs in Exercise Scale (BPNES) using a series of sophisticated structural equation modeling studies with Greek exercisers. Wilson and colleagues (Wilson and Muon, in press; Wilson et al., 2006; Wilson, Mack, and Blanchard, in press; Wilson, Mack, and Lighthouse, in press; Wilson, Mack, Muon, and LeBlanc, 2007; Wilson, Rodgers, Murray, Longley, and Muon, 2006) have developed the Psychological Need Satisfaction in Exercise Scale (PNSE) using samples of Canadian exercisers. The BPNES contains 12 items whereas the PNSE contains 18 items equally distributed across one of three subscales per instrument assessing feelings of competence, autonomy, and relatedness experienced in exercise. The initial stages of development for both the BPNES and the PNSE have attended to a number of construct validation steps advocated by measurement experts (Messick, 1995). Consequently, both instruments appear to hold promise for advancing our understanding of the functional role afforded basic psychological need fulfillment in exercise contexts.

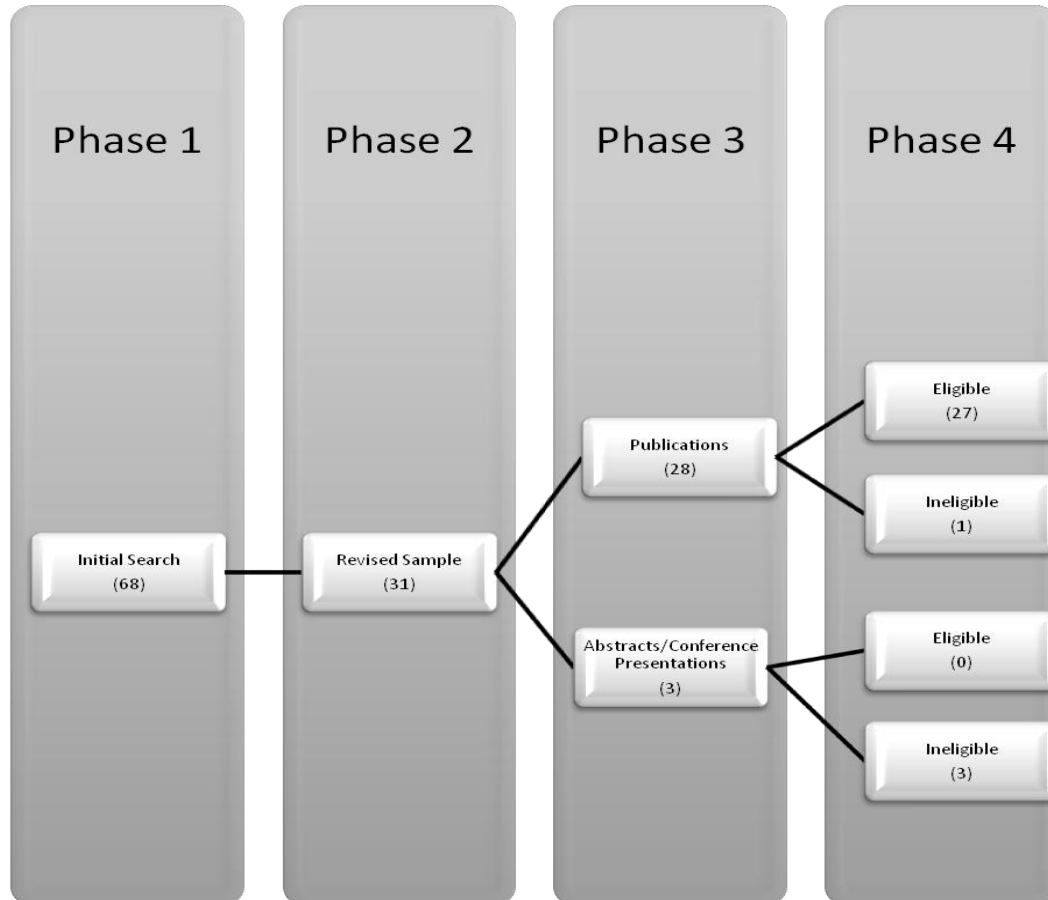
Purpose

Despite the popularity of Deci and Ryan's (2002) SDT framework, the lion's share of research in exercise contexts has focused on the nature and assessment of exercise motivation and the motivation-consequence link (see Markland and Ingledew, 2007, for a review). Less evidence is currently available summarizing the measurement issues central to advancing our understanding of arguments set forth by Deci and Ryan (2002) within the BPN subtheory of SDT. The main purpose of this review, therefore, is to examine the measurement of psychological need satisfaction specific to exercise contexts in studies that have used SDT as a guiding framework. The secondary purpose of this paper is to suggest avenues for further research designed to advance our understanding of the measurement of perceived competence, autonomy, and relatedness needs within exercise contexts.

Method

Selection of the Data

Literature searches were completed to identify studies that measured psychological need satisfaction in exercise settings using both computer- and manual-based searches (see Figure 1). Computer-based searches included a comprehensive examination of the following databases: Academic Search Premier, BioMed Central, MEDLINE, Physical Education Index, PsychLIT, PsychInfo, PubMed, Scholars portal e-journal, SPORTDISCUS, and Web of Science. Keywords entered for the computer-based searches were as follows: Competence, autonomy, relatedness, psychological needs, psychological need satisfaction, psychological need fulfillment, basic psychology needs theory, self-determination theory, belongingness, connectedness, relative autonomy, relative autonomy index, and self-determination index. These key words were selected on the basis of their ability to represent the central concepts proposed by Deci and Ryan (2002) within the BPN subtheory of SDT.



Note. Numbers in parentheses indicate articles selected for retention at each stage of the sampling process. Phase 1 = Number of articles identified based on the initial computer- and manual-based literature searches. Phase 2 = Number of articles retained based on evaluating initial search results against inclusion/exclusion criteria using study abstracts only. Phase 3 = Categorization of articles following review of full-text material/article in the revised sample. Phase 4 = The full-text material for each article was examined against the inclusion/exclusion criteria to determine eligibility for retention in the final review.

Figure 1. Flow chart depicting research article selection and retention.

Manual-based searches involved obtaining articles from reference lists contained in relevant empirical studies identified through the computer-based searches. Two authors were contacted to request additional information which was subsequently provided.

Studies identified in the search process were retained if they met the following inclusion/exclusion criteria: (1) The sampling frame was conducted in exercise settings or from populations of current exercisers (this eliminated sport and physical education settings as the major source from which the sample was drawn); (2) The sample was comprised of adults (defined as those 18 years of age and older); (3) The study measured the satisfaction of at least two of the three psychological needs articulated by Deci and Ryan (2002) within the BPN subtheory of SDT; (4) The authors reported sufficient information regarding the assessment of reliability and/or validity of scores derived from the instrumentation used to measure psychological need satisfaction within the study itself (this excluded scientific

abstracts presented at academic conferences due to a lack of information for the purposes of this review).

Data Coding

Consideration to developing clear and detailed coding rules was afforded a priori to limit concerns over ambiguity and reliability (Cooper, 1982). Variables coded included (1) sample characteristics (sample size, gender, age, race/ethnicity), (2) study characteristics (method of sampling, sampling frame, presence of manipulation, study design), (3) the measurement of psychological need satisfaction within the study (focus of item content, instrument modifications), and (4) the results reported specific to estimating both reliability and construct validity of psychological need satisfaction scores with reference to SDT's nomological network (Cronbach and Meehl, 1955) which included indices of motivation and behavior (drawn mainly from OIT) alongside proxy markers of well-being (drawn mainly from BPN). Assessment of construct validity evidence in this review was based on select aspects of the framework advocated by Messick's (1995) work in the educational testing literature. In brief, Messick (1995) contended that construct validation concerns the suitability of score interpretations derived from tests as opposed to the instruments themselves and outlined six sources of potential construct validity evidence. Our focus in this investigation concerned four of the six (i.e., content, external, structural, and generalizability-based evidence) sources outlined by Messick (1995) given that substantive and consequential-based validity evidence are more applicable to educational testing than exercise psychology research.

Two coders independently coded all studies selected for inclusion in this review. The primary researcher trained each coder with respect to the substantive nature of the constructs of interest (e.g., competence, autonomy, and relatedness) and the assessment procedures outlined in the coding sheet. Training proceeded in sequential stages. First, each coder was asked to code a random sampling of articles ($n = 3$) that served to familiarize coders with the assessment protocol and the foundation to discuss ambiguities that arose during coding. Second, modifications to the coding sheet were discussed and implemented based on experiential feedback from the coders with the intent of providing greater clarity specific to statistical techniques used to examine the psychometric characteristics of test scores and domain clarity with reference to the item content of instruments used in the coded studies. Any discrepancies that were found between the two coders were brought to the primary investigator for discussion, and a decision was made after deliberation. As a final check, one separate member of the research team with formal training and substantive experience in meta-analytic investigations reviewed all studies coded to ensure consistency of data reporting from each coder.

Results

Study Characteristics

Twenty-seven published (including in press) empirical research articles produced thirty-three studies that met inclusion criteria (see Table 1). One study attempted to experimentally

manipulate psychological need satisfaction postulated within SDT using a randomized design with 97.0% ($n = 32$) of the studies classified as non-experimental. Five studies (15.6%) assessed changes in psychological need satisfactions via exercise over time. The majority of studies 84.8% ($n = 28$) utilized purposive sampling, whereas 15.2% ($n = 5$) used convenience sampling techniques.

Participant Characteristics

Studies retained for inclusion yielded an overall sample size of 10,451 ($R = 26 - 1872$). Age was reported in 97.0% ($n = 32$) of studies included in this review ($M_{age} = 30.64$; $SD = 8.01$). Gender was reported in 90.9% ($n = 30$) of studies, with 83.3% ($n = 25$) of these investigations using mixed gender samples and 16.7% ($n = 5$) using women only. All studies reporting sample ethnicity identified participants were of mixed ethnic origin 27.3% ($n = 9$). Exercise mode was not reported in 9.10% ($n = 3$) studies. When reported, participants engaged in various modes of exercise in 70.0% ($n = 21$) of the studies, with 26.7% ($n = 8$) and 3.3% ($n = 1$) reporting participants engaging in aerobic or resistance training exercise only. Two studies examined exercise-specific feelings of psychological need satisfaction in symptomatic populations (i.e., cancer survivors, exercise on prescription affiliates), whereas conclusions derived from 93.9% ($n = 31$) of the studies were from adult populations recording no symptomatic health conditions.

The Measurement of Psychological Need Satisfaction in Exercise

Various instruments were used to measure psychological need satisfaction in exercise across the 33 studies coded. The majority of studies (90.9%; $n = 30$) used varied instruments containing context-specific item content to measure psychological need satisfaction in exercise. Over one-third of the coded studies used instrumentation developed expressly to examine the fulfillment of basic psychological needs in exercise contexts including the PNSE (24.2%; $n = 8$) and the BPNES (15.2%; $n = 5$). The remaining studies incorporated either proxy instruments to measure psychological need satisfaction in exercise (24.2%; $n = 8$), used single item indicators (18.2%; $n = 6$), employed instruments adapted to exercise from other contexts (15.2%; $n = 5$), or used an unpublished instrument (3.0%; $n = 1$).

Table 1. Evidence informing the interpretation of test scores for instruments measuring perceived psychological need satisfaction in exercise (studies are sorted alphabetically by first author)

Author Year	Measure of Psychological Need Satisfaction Reliability	Descriptive Statistics Evidence for score validity derived from psychological need satisfaction instruments
Edmunds, Ntoumanis, and Duda (2006a)	<p>Purpose: Examined the relationship between psychological need satisfaction, motivational regulation, and exercise behavior.</p> <p>Basic Need Satisfaction at Work (Deci et al., 2001) modified for exercise context.</p> <p><i>Reliability</i>[®]</p> <p>Study 1: $\alpha_C = .65$; $\alpha_A = .65$, $\alpha_R = .85$; Study 2: $\alpha_C = .65$; $\alpha_A = .64$, $\alpha_R = >.70$</p>	<p><i>Descriptive Statistics</i></p> <p>Study 1: $M_C = 5.02$; $SD_C = .95$; $M_A = 5.49$; $SD_A = .82$; $M_R = 5.10$; $SD_R = 1.15$.</p> <p>Study 2: $M_C = 5.07$; $SD_C = .90$; $M_A = 5.25$; $SD_A = .82$; $M_R = 5.16$; $SD_R = 1.03$.</p> <p><i>External Validity</i></p> <ol style="list-style-type: none"> 1. Pattern of relationships between PNS sub-scale scores ($r_{A,R} = .37 - r_{C,R} = .52$). 2. Study 1: Pattern of relationships between PNS scores and motivational regulation ($r_{C,ER} = -.22 - r_{C,INT} = .47$; $r_{A,ER} = -.33 - r_{A,INT} = .26$; $r_{R,ER} = -.12 - r_{R,INT} = .34$). Study 2: After controlling for gender, age, and perceived autonomy support, INT was predicted by ($\beta_C = .38$; $\beta_A = .02$; $\beta_R = .02$) and IDENT by ($\beta_C = .45$). 3. Exercise intensity: trend toward stronger correlations with increased intensity ($r_{C,mild} = -.09 - r_{C,strenuous} = .38$; $r_{A,mild} = .02 - r_{A,total} = .16$; $r_{R,moderate} = -.01 - r_{R,strenuous} = .17$). After controlling for gender and age, total exercise was predicted by ($\beta_C = .22$; $\beta_A = .09$; $\beta_R = -.04$) and strenuous exercise by ($\beta_C = .36$; $\beta_A = -.01$; $\beta_R = -.06$).
Edmunds, Ntoumanis, and Duda (2006b)	<p>Purpose: Examined whether those classified as ‘non-dependent-symptomatic’ or ‘nondependent-asymptomatic’ for exercise dependence differed in terms of psychological need satisfaction, self-determined vs. controlling motivation, and exercise behavior.</p> <p>Basic Need Satisfaction at Work (Deci et al., 2001) modified for exercise context.</p>	<p><i>Descriptive Statistics</i></p> <p><i>Symptomatic</i>: $M_C = 5.13$; $SD_C = .90$; $M_A = 5.49$; $SD_A = .83$; $M_R = 5.15$; $SD_R = 1.14$.</p> <p><i>Asymptomatic</i>: $M_C = 4.76$; $SD_C = .94$; $M_A = 5.47$; $SD_A = .82$; $M_R = 4.97$; $SD_R = 1.21$.</p>

Reliability[®]

$\alpha_C = .63$; $\alpha_A = .66$, $\alpha_R = .85$

External Validity

1. Exercise intensity: After controlling for gender and age ($n_{\text{symptomatic}} = 198$), 5% unique variance in total exercise attributed to PNS scores ($R^2_{\text{adj}} = .09$; $\beta_C = .16$; $\beta_A = .16$; $\beta_R = .01$); 8% unique variance in strenuous exercise attributed to PNS scores ($R^2_{\text{adj}} = .15$; $\beta_C = .32$; $\beta_A = .01$; $\beta_R = -.02$). After controlling for gender and age ($n_{\text{asymptomatic}} = 141$), 3% unique variance in strenuous exercise attributed to PNS scores ($R^2_{\text{adj}} = .14$; $\beta_C = .26$; $\beta_A = -.03$; $\beta_R = -.15$).

2. Effect size estimates discriminating between symptomatic and asymptomatic samples ($d_C = .40$; $d_A = .02$; $d_R = .15$).

Edmunds,
Ntoumanis, and
Duda
(2007)*

Purpose: To examine whether overweight/obese individuals who adhered more to their exercise prescriptions reported greater levels of psychological need satisfaction compared to those who adhered less to their exercise program.

9 – Item instrument developed
by Tobin (2003).

Reliability[®]

$\alpha_C = .72 - .83$; $\alpha_A = .55 - .62$; $\alpha_R = .74 - .88$ across three time points.

Descriptive Statistics

Baseline: $M_C = 3.35$; $SD_C = 1.69$; $M_A = 4.01$; $SD_A = 1.62$; $M_R = 3.50$; $SD_R = 1.69$. One month: $M_C = 3.82$; $SD_C = 1.34$; $M_A = 4.15$; $SD_A = 1.53$; $M_R = 3.73$; $SD_R = 1.45$. 3 months: $M_C = 3.66$; $SD_C = 1.05$; $M_A = 4.05$; $SD_C = 1.58$; $M_R = 3.37$; $SD_R = 1.32$.

External Validity

1. Pattern of relationships between PNS sub-scale scores averaged across three test administrations ($r_{A,R} = .10 - r_{C,R} = .49$).

2. Pattern of relationships between PNS scores and motivational regulation averaged across three test administrations ($r_{C,INTR} = .26 - r_{C,IDENT} = .66$; $r_{A,ER} = -.29 - r_{A,INT} = .57$; $r_{R,INTRE} = .08 - r_{R,ER} = .48$). Positive β weights associated with self-determined forms of motivation. Positive and negative β weights predictive of more controlling forms. Effect of autonomy on motivational regulations increased over time ($\beta_{INT} = .10$; $\beta_{IDENT} = .15$; $\beta_{INTRE} = .19$) as did perceptions of competence ($\beta_{INTRE} = .18$).

3. Pattern of relationships with indices of well-being ($r_{C,SWL} = -.09 - r_{C,SV} = .34$; $r_{A,NAffect} = -.35 - r_{A,PAffect} = .38$; $r_{R,NAffect} = -.29 - r_{R,SV} = .46$). Autonomy was a positive predictor of satisfaction with life ($\beta = .36$) and increased over time ($\beta = .20$).

4. Women reported greater increases in relatedness across the 3 month period ($\beta = .51$).

5. Exercise adherence: Small correlations with PNS scores averaged over a 3 month period ($r_C = .13 - r_R = .24$). At 3 months, weak negative relationship with autonomy ($r = -.08$) and

small positive relationships with competence ($r = .13$) and relatedness ($r = .34$). Adherers demonstrated greater increases in relatedness at 1 and 3 months ($\beta = .21$) with women reporting greater increases over time than men.

- Hagger, Chatzisarantis, and Harris (2006) Purpose: To investigate the influence of global level psychological need satisfaction on exercise behavior.
Global measure of psychological needs (Sheldon et al., 2001).
Reliability
Composite $\alpha = .87$
- External Validity*
1. Structural paths between global PNS scores and relative autonomous motives ($\beta = .16$).
2. Factor correlations between global PNS scores and exercise ($\phi = .15$).
Structural Validity
Correlations between latent PNS factors ($\phi_{Mdn} = .54$).
- Kowal and Fortier (1999) Purpose: Examined the relationships between situational motivational determinants and flow.
Adapted versions of the Perceived Competence Scale for Children (Harter, 1982); the Autonomy Perceptions in Life Contexts Scale (Blais and Vallerand, 1992) and; the Perceived Relatedness Scale (Richer and Vallerand, 1998).
Reliability
 $\alpha_C = .69$; $\alpha_A = .54$, $\alpha_R = .81$
- Descriptive Statistics*
Weighted means based on tertile splits: $M_C = 5.24$; $SD_C = .88$; $M_A = 4.64$; $SD_A = 1.37$; $M_R = 5.55$; $SD_R = 1.00$.
External Validity
1. Pattern of relationships between PNS scores and motivational determinants ($r_{C.transformationoftime} = -.07$ - $r_{C.challenge-skillbalance} = .63$; $r_{A.transformationoftime} = -.03$ - $r_{A.concentration} = .25$; $r_{R.transformationoftime} = .11$ - $r_{R.challenge-skillbalance} = .50$).
- Kowal and Fortier Purpose: To test Vallerand's (1997) hierarchical model of intrinsic and extrinsic motivation in a physical activity context.

(2000)	<p>Adapted versions of: Competence (Fortier, Vallerand, and Guay, 1995); the Autonomy Perceptions in Life Contexts Scale (Blais and Vallerand, 1992) and; Perceived Relatedness Scale (Richer and Vallerand, 1998). <i>Reliability:</i> Situational $\alpha_C = .60$; $\alpha_A = .51$; $\alpha_R = .82$. Contextual: $\alpha_C = .83$; $\alpha_A = .79$; $\alpha_R = .86$</p>	<p><i>Descriptive Statistics</i> Situational: $M_C = 5.29$; $SD_C = .85$; $M_A = 4.85$; $SD_A = 1.24$; $M_R = 5.36$; $SD_R = .91$. Contextual: $M_C = 4.89$; $SD_C = 1.16$; $M_A = 4.65$; $SD_A = 1.41$; $M_R = 5.47$; $SD_R = .82$.</p> <p><i>Validity</i> 1. Pattern of relationships between situational PNS sub-scale scores ($r_{A,R} = -.03 - r_{C,R} = .35$) and contextual PNS sub-scale scores ($r_{C,A} = -.14 - r_{C,R} = .27$). 2. Patterns of relationships between situational PNS and situational and contextual motivation ranged from $r_A = .27 - r_C = .54$ and $r_A = .21 - r_C = .36$ respectively. Patterns of relationships between contextual PNS and situational and contextual motivation ranged from $r_C = .28 - r_R = .31$ and $r_C = .20 - r_R = .42$ respectively. Flow was positively associated with all PNS subscale scores with greatest magnitude associated with situational and contextual relatedness ($r_s = .47$ and $.44$ respectively).</p>
Levy and Cardinal (2004)	<p>Purpose: To examine the effect of a mail-mediated intervention based on self-determination theory on adult's exercise behavior. Adapted sport competence subscale of the Physical Self-Perception Profile (Fox, 1990); autonomy via the Locus of Causality for Exercise Scale (Markland and Hardy, 1997); relatedness via the Social Support for Exercise Questionnaire (Sallis et al., 1987). <i>Reliability</i> Specifics not reported.</p>	<p><i>Descriptive Statistics</i> Competence generally increased over time. Autonomy and relatedness increased Baseline – Time 1 and decreased slightly at Time 2.</p> <p><i>Content Validity</i> 1. Specifics not reported.</p> <p><i>External Validity</i> 1. Females: Reported changes in autonomy across the three test administrations ($\eta^2 = .07$). 2. Exercise behavior: Increased exercise behavior for females ($\eta^2 = .20$) only. Interventions based on SDT did not result in significant behavior change compared to control.</p>
Li (1999)	<p>Purpose: To construct an exercise motivation scale and provide initial evidence of its psychometric properties. Contextual competence: Sport competence subscale of the</p>	<p><i>External Validity</i> 1. Competence positively related to exercise motivation ($\gamma_{ER} = .12 - \gamma_{IDENT} .22$); autonomy</p>

<p>Physical Self-Perception Profile (Fox, 1990); autonomy: adapted Exercise Objectives Locus of Control Scale (McCready and Long, 1985); relatedness: adapted Social Support Scale for Children (Harter, 1985). <i>Reliability</i>[@] $\alpha_C = .87; \alpha_A = .87, \alpha_R = .76$</p>	<p>positively related to self-determined forms (γ_s ranged from .16 to .32) and negatively related to non-determined forms (γ_s ranged from -.20 to -.23); relatedness positively related to self-determined forms (γ_s ranged from .15 to .18) and negatively related to non-determined forms (γ_s ranged from -.14 to -.17).</p>
<p>Markland (1999)</p>	<p>Purpose: To determine whether self-determination moderates the effects of perceived competence on intrinsic motivation or whether self-determination and perceived competence have independent effects.</p> <p>Contextual competence: IMI – PC (McAuley et al., 1989); Autonomy: Locus of Causality for Exercise Scale (Markland and Hardy, 1997). <i>Reliability</i> $\alpha_C = .81; \alpha_A = .87$</p> <p><i>Descriptive Statistics</i> $M_C = 4.27; SD_C = 1.30; M_A = 4.20; SD_A = 1.33.$</p> <p><i>External Validity</i></p> <ol style="list-style-type: none"> 1. Factor correlations ($r_{C,A} = .45$) 2. Effect for competence on enjoyment/interest in physical activity ($R^2 = .24$). When autonomy entered, ($R^2 = .52; R^2_{\Delta} = .28$).
<p>Markland and Hardy (1997)</p>	<p>Purpose: The development of a perceived locus of causality scale.</p> <p>Contextual competence: modified IMI – PC (McAuley et al., 1989); Contextual autonomy: Locus of Causality for Exercise Scale (Markland and Hardy, 1997). <i>Reliability</i> $\alpha_C = .81; \alpha_A = .82$</p> <p><i>Descriptive Statistics</i> $M_C = 4.15; SD_C = 1.34; M_A = 4.07; SD_A = 1.42.$</p> <p><i>External Validity</i></p> <ol style="list-style-type: none"> 1. Factor correlations ($r_{C,A} = .62$). 2. Patterns of interrelationships with $r_{C.pressure} = .55 - r_{C.effort} = .68$ and $r_{A.effort} = .75 - r_{A.pressure} = .78$.

Parfitt, Rose, and Markland (2000)	<p>Purpose: To compare the effects of preferred vs. prescribed intensity exercise on affect and enjoyment.</p> <p>IMI - perceived competence and perceived choice (McAuley et al., 1989) modified to the exercise mode.</p> <p><i>Reliability</i> Specifics not reported.</p>	<p><i>External Validity</i></p> <ol style="list-style-type: none"> 1. Discriminant validity supported a large effect ($d = 2.03$) with perceived choice and weak effect ($d = .12$) for perceived competence between preferred and prescribed intensity exercise.
Peddle, Plotnikoff, Wild, Au, and Courneya (in press)	<p>Purpose: To evaluate medical, demographic, and psychosocial correlates of exercise in colorectal cancer survivors.</p> <p>PNSE (Wilson et al., 2006).</p> <p><i>Reliability</i> $\alpha_C = .95$; $\alpha_A = .95$, $\alpha_R = .96$</p>	<p><i>External Validity</i></p> <ol style="list-style-type: none"> 1. Pattern of relationships between PNS sub-scale scores ($r_{A,R} = .38 - r_{C,A} = .59$). 2. Pattern of relationships between PNS scores and motivational regulation ($r_{C,ER} = -.16 - r_{C,INT} = .49$; $r_{A,ER} = -.21 - r_{A,INT} = .35$; $r_{R,ER} = -.07 - r_{R,INT} = .49$). 3. PNS scores predicted INTRO: ($\beta_A = -.19$; $\beta_R = .15$); INDENT ($\beta_C = .27$; $\beta_R = .13$). 4. Exercise Intensity: Pattern of relationships with moderate/vigorous exercise ($r_C = .29$; $r_A = .22$; $r_R = .29$).
Thørgersen-Ntoumani, and Ntoumanis (2007)	<p>Purpose: To examine motivational predictors of body image concerns, self-presentation, and self-perceptions.</p> <p>Basic Need Satisfaction in Life Scale (Gagnè, 2003) as a global measure.</p> <p><i>Reliability</i>[®] $\alpha_C = .60$; $\alpha_A = .76$, $\alpha_R = .75$</p>	<p><i>Descriptive Statistics</i> $M_C = 5.36$; $SD_C = 0.76$; $M_A = 5.27$; $SD_A = 0.85$; $M_R = 5.65$; $SD_R = 0.77$.</p> <p><i>External Validity</i></p> <ol style="list-style-type: none"> 1. Pattern of relationships between PNS sub-scale scores ($r_{A,R} = .48 - r_{C,A} = .54$). 2. Pattern of relationships between PNS scores and motivational regulation ($r_{C,INTRO} = -.36 - r_{C,INT} = .21$; $r_{A,INTRO} = -.29 - r_{A,INT} = .16$; $r_{R,INTRO} = -.26 - r_{R,INT} = .29$). 3. Pattern of relationships with self-esteem ($r_R = .44 - r_A = .58$) and PSW ($r_R = .43 - r_A = .60$). 4. Discriminant validity support demonstrated as those not a risk for eating disorders demonstrated higher PNS scores than those at risk ($d_A = 1.01 - d_R = .56$).
Wilson, Rodgers, and Fraser (2002a)	<p>Purpose: To examine the pattern of relationships between the motivation for physical activity measure and psychological needs satisfaction.</p>	

<p>Three single items measures served as contextual measures of PNS.</p> <p><i>Reliability</i></p> <p>Not applicable given single item indicators.</p>	<p><i>Descriptive Statistics</i></p> <p>$M_C = 5.60; SD_C = 1.05; M_A = 5.62; SD_A = 1.18; M_R = 4.67; SD_R = 1.41.$</p> <p><i>External Validity</i></p> <p>1. Pattern of relationships between PNS sub-scale scores ($r_{C,R} = .19 - r_{C,A} = .47$).</p> <p>2. Pattern of relationships between PNS scores and exercise motivation ($r_{C,appearance} \text{ and } r_{C,social} = .12 - r_{C,enjoyment-interest} = .45; r_{A,appearance} = .07 - r_{A,enjoyment-interest} = .48; r_{R,appearance} = .03 - r_{R,social} = .46$).</p>
<p>Wilson, Rodgers, and Fraser (2002b)</p> <p>Three single items measures Served as contextual measures of PNS.</p> <p><i>Reliability</i></p> <p>Not applicable given single item indicators.</p>	<p>Purpose: To examine the pattern of relationships between the BREQ, psychological need satisfaction and exercise behavior.</p> <p><i>Descriptive Statistics</i></p> <p>$M_C = 5.50; SD_C = 1.07; M_A = 5.56; SD_A = 1.19; M_R = 4.56; SD_R = 1.48.$</p> <p><i>External Validity</i></p> <p>1. Pattern of relationships between PNS sub-scale scores ($r_{C,R} = .23 - r_{C,A} = .49$).</p> <p>2. Pattern of relationships between PNS scores and motivational regulation ($r_{C,ER} = -.18 - r_{C,INT} = .46; r_{A,ER} = -.07 - r_{A,INT} = .40; r_{R,ER} = .02 - r_{R,INT} = .19$).</p>
<p>Wilson, Rodgers, Blanchard, and Gessell (2003)</p> <p>Activity Feeling Scale (Reeve and Sickenius, 1993) served as a contextual measure of PNS.</p> <p><i>Reliability</i>[®]</p> <p>$\alpha_{C,Time1} = .85; \alpha_{C,Time2} = .93;$ $\alpha_{A,Time1} = .74; \alpha_{A,Time2} = .68;$ $\alpha_{R,Time1} = .75; \alpha_{R,Time2} = .81$</p>	<p>Purpose: To examine the relationships between psychological need satisfaction, exercise regulations, and motivational consequences.</p> <p><i>Descriptive Statistics</i></p> <p>$M_C = 5.04; SD_C = 1.01; M_A = 6.51; SD_A = 0.70; M_R = 3.55; SD_R = 1.31.$</p> <p><i>External Validity</i></p> <p>1. Pattern of relationships between PNS sub-scale scores ($r_{A,R} = -.04 - r_{C,R} = .31$).</p> <p>2. Pattern of relationships between PNS scores and motivational regulation ($r_{C,ER} = -.16 - r_{C,INT} = .53; r_{A,ER} = -.18 - r_{A,IDENT} = .33; r_{R,ER} = .01 - r_{R,INTRO} = .19$).</p> <p>3. Changes in PNS scores across the 12 week intervention ($d_C = .69; d_A = -1.19; d_R = 1.46$).</p>
<p>Wilson, Longley, Muon, Rodgers, and Murray (2006)</p> <p>Study 1: Three single items measures served as contextual measures of PNS</p>	<p>Purpose: To examine the relationship between psychological need satisfaction and well-being in exercise.</p> <p><i>Descriptive Statistics</i></p> <p>Study 1; Time 1: $M_C = 5.25; SD_C = 1.42; M_A = 5.29; SD_A = 1.42; M_R = 4.35; SD_R = 1.65.$</p> <p>Study 1; Time 2: $M_C = 5.86; SD_C = 0.80; M_A = 5.97; SD_A = 0.96; M_R = 3.94; SD_R = 1.97.$</p>

Study 2: PNSE (Wilson et al., 2006).	Study 2: $M_C = 5.19$; $SD_C = 0.73$; $M_A = 5.42$; $SD_A = 0.79$; $M_R = 4.49$; $SD_R = 1.20$.
<i>Reliability</i>	<i>External Validity</i>
Study 2: $\alpha_C = .89$; $\alpha_A = .94$; $\alpha_R = .91$	<ol style="list-style-type: none"> 1. Pattern of relationships between PNS sub-scale scores: Study 1; Time 1: $r_{C,R} = .34 - r_{C,A} = .80$; Time 2: $r_{C,R} = .19 - r_{C,A} = .46$; Study 2: $r_{A,R} = .22 - r_{C,A} = .53$. 2. Relationships between PNS sub-scale scores and indices of well-being: Study 1; Time 1: ($r_{R,SV} = .17 - r_{A,SV} = .42$); Study 1; Time 2: ($r_{R,SV} = .15 - r_{C,SV} = .43$); Correlations with residual change scores ($r_{R,SV} = .08 - r_{A,SV} = .29$). Study 2: ($r_{A,PAffect} = .14 - r_{C,PAffect} = .36$) and ($r_{R,NAffect} = -.13 - r_{C,NAffect} = -.34$). 3. Pattern of weak to moderate relationships between PNSE scores and global PNS scores. ($r_{R.BasicPsychologicalNeeds.Popularity} = -.03 - r_{C.BasicPsychologicalNeeds.PhysicalThriving} = .45$). 4. Study 1: Positive changes in the satisfaction of competence and autonomy scores ($d = .33$) and negative change in relatedness ($d = .19$) across the 12 week period.
	<i>Structural Validity</i>
	Factorial composition and structure of PNSE scores $\chi^2 = 340.29$, $df = 132$, $p < .01$, CFI = .93, IFI = .93, RMSEA = .09; 90% CI = .08-.11. Interfactor correlations (ϕ) were moderate to strong.
Wilson, Rodgers, Loitz, and Scime (2006)	<p>Purpose: To examine the pattern of relationships between the BREQ, psychological need satisfaction and exercise behavior.</p> <p>Three single items measures served as contextual measures of PNS</p> <p><i>Reliability</i></p> <p>Not applicable given single item indicators.</p> <p><i>Descriptive Statistics</i></p> <p>$M_C = 5.61$; $SD_C = 1.27$; $M_A = 5.88$; $SD_A = 1.13$; $M_R = 5.61$; $SD_R = 1.25$.</p> <p><i>External Validity</i></p> <ol style="list-style-type: none"> 1. Pattern of relationships between PNS sub-scale scores ($r_{A,R} = .31 - r_{C,A} = .75$). 2. Pattern of relationships between PNS scores and motivational regulation ($r_{C,ER} = -.26 - r_{C,INT} = .54$; $r_{A,ER} = -.17 - r_{A,INTE} = .55$; $r_{R,ER} = .00 - r_{R,INTE} = .29$). 3. Stronger effects were noted between PNS and autonomous ($R^2_{adj} = .19 - .31$) vs. controlled ($R^2_{adj} = .06$) motives. Structure coefficients demonstrated that competence predicted less controlling motives and greater intrinsic regulation, autonomy predicted more autonomous motives, and relatedness both autonomous and controlling motives.
Wilson, Rogers,	Purpose: To provide construct validity evidence for scores derived from the PNSE.

Rodgers, and Wild (2006)	<p>PNSE (Wilson et al., 2006). <i>Reliability</i> $\alpha_C = .91$; $\alpha_A = .91$; $\alpha_R = .90$ for Study 1 and Study 2.</p>	<p><i>Descriptive Statistics</i> Study 1: $M_C = 5.36$; $SD_C = 0.65$; $M_A = 5.50$; $SD_A = 0.59$; $M_R = 4.57$; $SD_R = 0.99$. Study 2: $M_C = 5.31$; $SD_C = 0.68$; $M_A = 5.54$; $SD_A = 0.60$; $M_R = 4.48$; $SD_R = 1.07$.</p> <p><i>Content Validity</i> Forty experts with diverse but relevant content domain expertise rated each item according to item content relevance and representation. Aiken's item content validity (V) coefficient supported relevance ($M_V = 0.92$; $SD = 0.07$) and representation ($M_V = 0.87$; $SD = 0.05$) of PNSE items.</p> <p><i>External Validity</i> 1. Pattern of relationships between PNS sub-scale scores (Study 1: $r_{A,R} = .09$ - $r_{C,A} = .46$; Study 2: $r_{A,R} = .10$ - $r_{C,A} = .46$). 2. Study 2: PNSE scores most highly correlated with proxy measures ($r_{C,IMIcompetence} = .65$; $r_{A,IMIchoice} = .32$; $r_{R,IMIaffiliation} = .48$).</p> <p><i>Structural Validity</i> Study 1: Total variance accounted for 63.3%. Inter-factor correlations ranged from $r_{A,R} = .01$ - $r_{C,A} = .46$). Study 2: Pattern of factor loadings ranged from .69 - .90 on target factors. Measurement model total sample: goodness of fit statistics: $\chi^2 = 688.03$; $df = 132$; $CFI = .94$; $IFI = .94$; $SRMSR = .07$; $RMSEA = .09$; $90\% CI = .08$ - $.09$. Comparable fit indices across gender.</p> <p><i>Generalizability validity</i> Invariance tests suggested PNSE score interpretations are relatively robust to gender.</p>
Wilson, Mack, and Blanchard (in press)	<p>Purpose: To examine the role of psychological need satisfaction on affective responses in an exercise context. Study 1: Three single items measures served as contextual measure of PNS. Study 2: PNSE (Wilson et al., 2006). <i>Reliability</i> Study 1: Global PNS $\alpha = .62$</p>	<p><i>Descriptive Statistics</i> Study 1: $M_C = 5.63$; $SD_C = 0.91$; $M_A = 5.60$; $SD_A = 1.05$; $M_R = 4.68$; $SD_R = 1.39$. Study 2: $M_C = 4.82$; $SD_C = 0.91$; $M_A = 4.96$; $SD_A = 0.99$; $M_R = 4.44$; $SD_R = 1.04$.</p> <p><i>External Validity</i> 1. Pattern of relationships between PNS sub-scale scores (Study 1: $r_{C,R} = .23$ - $r_{C,A} = .54$; Study 2: $r_{A,R} = .58$ - $r_{C,A} = .82$). 2. Relationships between PNS sub-scale scores and indices of well-being: Study 1: ($r_{R,PWB} =$</p>

	Study 2: $\alpha_C = .91$; $\alpha_A = .94$; $\alpha_R = .92$.20 - $r_{C.PWB} = .38$); PNS scores negative relationship with PD ($\phi = .18$) and positive relationship with PWB ($\phi = 2.56$). Study 2: $r_{R.PAffect} = .52$ - $r_{C.PAffect} = .63$; Moderate influence of PNSE scores on positive affect ($\beta_C = .54$; $\beta_A = .52$; $\beta_R = .44$) and a small influence on negative affect ($\beta_C = -.20$; $\beta_A = -.26$; $\beta_R = -.01$). <i>Structural Validity</i> Study 2: Goodness of fit statistics: $\chi^2 = 327.46$; $df = 132$; $CFI = .92$; $IFI = .92$; $SRMSR = .07$; $RMSEA = .09$; $90\% CI = .08 - .11$.
Wilson, Mack, and Lighthart (in press)	Purpose: To examine the importance of basic psychological needs to domain specific well-being in female exercisers. Study 1: Three single items measures served as contextual measure of PNS. Study 2: PNSE (Wilson et al., 2006). <i>Reliability</i> Study 2: $\alpha_C = .90$; $\alpha_A = .90$; $\alpha_R = .87$. $\alpha_{females} = .88 - .92$; $\alpha_{males} = .84 - .87$	<i>Descriptive Statistics</i> Study 1: $M_C = 5.64$; $SD_C = 0.94$; $M_A = 5.68$; $SD_A = 0.98$; $M_R = 4.65$; $SD_R = 1.44$. Study 2: $M_C = 5.21$; $SD_C = 0.68$; $M_A = 5.56$; $SD_A = 0.53$; $M_R = 4.50$; $SD_R = 0.92$. Similar pattern for males and females. <i>External Validity</i> 1. Study 1: Pattern of relationships between PNS sub-scale scores ($r_{C,R} = .24$ - $r_{C,A} = .56$). Study 2: ($r_{A,R} = -.01$ - $r_{C,A} = .42$). Females ($r_{A,R} = .04$ - $r_{C,A} = .43$); Males ($r_{A,R} = -.17$ - $r_{C,A} = .29$). 2. Study 1: PNS scores predicted greater physical self-worth ($\gamma = .43$; $R^2 = .18$). Study 2: Separate analyses of PNS scores predicted greater physical self-worth with competence accounting for the greatest portion of the variance ($R^2_{adj} = .24$; $\beta = .47$) and relatedness ($R^2_{adj} = .08$; $\beta = .13$) the least. Gender was not a meaningful moderator.
Wilson, Mack, Muon, and LeBlanc (2007)	Purpose: To examine whether perceived psychological need satisfaction underpins the endorsement of different motives. PNSE (Wilson et al., 2006) <i>Reliability</i> $\alpha_C = .91$; $\alpha_A = .95$; $\alpha_R = .92$	<i>Descriptive Statistics</i> $M_C = 4.82$; $SD_C = 0.90$; $M_A = 4.97$; $SD_A = 1.00$; $M_R = 4.44$; $SD_R = 1.04$. <i>External Validity</i> 1. Pattern of relationships between PNS sub-scale scores ($r_{A,R} = .59$ - $r_{C,A} = .82$). 2. Pattern of relationships between PNS scores and motivational regulation ($r_{C,ER} = -.22$ - $r_{C,INT} = .67$; $r_{A,ER} = -.30$ - $r_{A,INT} = .67$; $r_{R,ER} = -.06$ - $r_{R,INT} = .63$). PNSE scores predicted a relative autonomy index of motivation ($R^2_{adj} = .42$) with positive associations between

		autonomy ($\beta = .53$) and competence ($\beta = .25$) and autonomous motivation and relatedness negatively associated ($\beta = -.12$).
		<i>Structural Validity</i>
		Measurement model: $\chi^2 = 334.36$; $df = 132$; $CFI = .92$; $IFI = .92$; $RMSEA = .10$; $90\% CI = .08 - .11$.
Wilson and Muon (in press)	Purpose: To examine criterion validity of scores derived from the Exercise Identity Scale. PNSE (Wilson et al., 2006). <i>Reliability</i> $\alpha_C = .91$; $\alpha_A = .92$; $\alpha_R = .89$	<i>Descriptive Statistics</i> $M_C = 5.15$; $SD_C = 0.76$; $M_A = 5.51$; $SD_A = 0.70$; $M_R = 4.60$; $SD_R = 0.95$. <i>External Validity</i> 1. Pattern of relationships between PNS sub-scale scores ($r_{A,R} = .15 - r_{C,A} = .50$). 2. Exercise Intensity: ($r_C = .32$; $r_A = .11$; $r_R = .29$).
Vlachopoulos (2007)	Purpose: To provide structural and predictive validity of test scores. BPNES (Vlachopoulos and Michailidou, 2006). <i>Reliability</i> $\alpha_C = .86$; $\alpha_A = .84$; $\alpha_R = .92$	<i>Descriptive Statistics</i> Descriptive not reported. <i>External Validity</i> 1. Pattern of relationships between PNS sub-scale scores ($r_{A,R} = .63 - r_{C,A} = .74$). 2. IMI interest-enjoyment ($R^2_{adj} = .56$; $\beta_C = .31$; $\beta_A = .34$; $\beta_R = .17$). <i>Structural Validity</i> Pattern of factor loadings ranged from .59 - .90; $\chi^2 = 209.87$; $df = 51$; $CFI = .98$; $NNFI = .97$; $RMSEA = .06$; $90\% CI = .05 - .07$. Three factor model superior fit compared to two and one factor model. <i>Generalizability Validity</i> Measurement invariance noted between community and private exercise participants. #
Vlachopoulos and Michailidou (2006)	Purpose: The development and initial validation of the Basic Psychological Needs in Exercise Scale. BPNES (Vlachopoulos and Michailidou, 2006). <i>Reliability</i>	<i>Descriptive Statistics</i> Time 1: $M_C = 3.80$; $SD_C = 0.57$; $M_A = 3.94$; $SD_A = 0.66$; $M_R = 3.70$; $SD_R = 0.73$. Time 2: $M_C = 3.81$; $SD_C = 0.59$; $M_A = 3.97$; $SD_A = 0.67$; $M_R = 3.74$; $SD_R = 0.75$.

$\alpha_C = .81$; $\alpha_A = .84$; $\alpha_R = .92$
Test-retest Reliability
 ICC = .97 for all scores.

Content Validity:

Item generation resulted in 10, 13, 8 items for competence, autonomy, and relatedness respectively. Items developed examined by 3 judges with expertise in basic psychological needs consistent with SDT. Based on comments 1 item deleted from Competence and Autonomy and two items added to Relatedness. 20 exercise participants evaluated items for writing, clarity, and personal relevance.

External Validity

1. IMI interest-enjoyment: ($R^2_{adj} = .58$; $\beta_C = .51$; $\beta_A = .25$; $\beta_R = .05$)
2. Exercise Frequency: ($R^2_{adj} = .10$; $\beta_C = .21$; $\beta_A = .14$; $\beta_R = -.03$).

Structural Validity

Sample 1: Pattern of factor loadings ranged from .59 - .91; $\chi^2 = 166.43$; $df = 51$; $CFI = .96$; $NNFI = .96$; $SRMR = .04$; $RMSEA = .06$; $90\% CI = .05 - .07$. Sample 2: Pattern of factor loadings ranged from .60 - .89; $\chi^2 = 122.28$; $df = 51$; $CFI = .97$; $NNFI = .97$; $SRMR = .03$; $RMSEA = .05$; $90\% CI = .04 - .06$.

Vlachopoulos
(in press)

Purpose: To examine measurement invariance across gender of scores derived from BPNSE.

BPNS (Vlachopoulos and Michailidou, 2006).

Reliability

Females ($\alpha_C = .83$; $\alpha_A = .84$; $\alpha_R = .92$); Males ($\alpha_C = .84$; $\alpha_A = .83$; $\alpha_R = .92$)

External Validity

1. Pattern of relationships between PNS sub-scale scores: Females ($r_{C,R} = .53 - r_{C,A} = .74$); Males ($r_{A,R} = .56 - r_{C,A} = .84$).

Structural Validity[#]

Females ($n = 1147$): $\chi^2 = 161.75$; $df = 51$; $CFI = .99$; $NNFI = .98$; $RMSEA = .04$; $90\% CI = .04 - .05$. Items loadings ranged from .54 - .91; Males ($n = 716$): $\chi^2 = 145.82$; $df = 51$; $CFI = .98$; $NNFI = .98$; $RMSEA = .05$; $90\% CI = .04 - .06$. Items loadings ranged from .67 - .91.

Generalizability Validity

No support for measurement invariance by gender.

Vlachopoulos and Neikou
(in press)

Purpose: To investigate the relative contribution of each of the three needs to the prediction exercise adherence over 6 months.

BPNS (Vlachopoulos and Michailidou, 2006).

Reliability

Descriptive Statistics

Females: $M_C = 3.39$; $SD_C = 0.92$; $M_A = 3.52$; $SD_A = 0.98$; $M_R = 3.07$; $SD_R = 0.90$. Males: $M_C = 3.59$; $SD_C = 0.62$; $M_A = 3.71$; $SD_A = 0.73$; $M_R = 3.31$; $SD_R = 0.91$.

Females: $\alpha_C = .92$; $\alpha_A = .94$;
 $\alpha_R = .92$; Males: $\alpha_C = .73$; α_A
 $= .81$; $\alpha_R = .93$

External Validity

1. Pattern of relationships between PNS sub-scale scores: Females ($r_{C,R} = .43 - r_{C,A} = .90$); Males ($r_{A,R} = .55 - r_{C,A} = .67$).

2. Exercise Attendance: Females ($\beta_C = .53$; $\beta_A = -.11$; $\beta_R = -.02$); Males ($\beta_C = .31$; $\beta_A = -.07$; $\beta_R = -.02$). After controlling for age and gender OR predicted adherers ($n = 77$) vs. dropouts ($n = 96$) over six months ($OR_C = .32$; $OR_A = .83$; $OR_R = 1.21$).

3. Estimates of effect size discriminating between males and females ($d_C = .25$; $d_A = .22$; $d_R = .27$).

Structural Validity

Females ($n = 120$): $\chi^2 = 76.90$; $df = 51$; $CFI = .98$; $NNFI = .98$; $RMSEA = .07$; $90\% CI = .03 - .09$; Males ($n = 108$): $\chi^2 = 98.74$; $df = 51$; $CFI = .94$; $NNFI = .92$; $RMSEA = .09$; $90\% CI = .07 - .12$.

*Note:** additional analyses provided from first author; @ concerns over reliability expressed and in some cases, items deleted; # = data analyzed on similar participant pool. A = Perceived Autonomy; C = Perceived Competence; R = Perceived Relatedness; ER = External Regulation; INTRO = Introjected regulation; IDENT = Identified Regulation; INTE = Integrated Regulation; INT = Intrinsic Motivation; CFI = Comparative Fit Index; NNFI = Non-Normed Fit Index; IFI = Incremental Fit Index; SRMSR = Standardized Root Mean Square Residual; RMSEA = Root Mean Square Error of Approximation; CI = 90% Confidence Interval for RMSEA; ICC = Intra-class correlation; α = Cronbach alpha (Cronbach, 1951); β = Standardized Beta; d = Cohen's d (Cohen, 1988); η^2 = Eta squared; ϕ = Phi Coefficient; ψ = Standardized Path Coefficient; IMI = Intrinsic Motivation Inventory; ICC = Intra-class correlation coefficient; OR = odds ratio; PD = SEES Psychological Distress; PWB = SEES Positive Well-being; SWL = Satisfaction with Life; PA_{ffect} = Positive Affect; NA_{ffect} = Negative Affect. The purpose statement accompanying each cited article in Table 1 represents the present author's interpretation of the measurement-related focus of the article for the purposes of this review.

Descriptive Statistics

Consideration of descriptive statistics indicated that participants reported moderate-to-high levels of psychological need satisfaction in exercise regardless of the instrument used (see Table 1). Satisfaction of competence and autonomy needs in exercise settings were more strongly endorsed by exercisers than relatedness needs across the majority of coded studies.

Measurement of Psychological Need Satisfaction – Reliability

Where possible, internal consistency reliability estimates (coefficient α ; Cronbach, 1951) were recorded (see Table 1). Examination of the coded studies suggests a trend whereby lower estimates of internal consistency reliability were reported within studies using instrumentation that was either adapted, considered a proxy marker of need fulfillment (e.g., IMI-Perceived Choice subscale), or modified from other contexts (e.g., work) for the purposes of assessing psychological need satisfaction in exercise. More recent studies utilizing instruments developed specifically for exercise settings (i.e., PNSE and BPNES) demonstrated higher reliability coefficients. Three studies using either the PNSE or BPNES reported comparable internal consistency reliability estimates for item scores across gender. Evidence of high score stability in the form of test-retest reliability was documented in one study using the BPNES across a 4 week period.

Measurement of Psychological Need Satisfaction – Validity

Content Validity

Three coded studies (9.1%) reported data suggesting evidence of content validity. Two studies reported information specific to item generation and expert review procedures. One study reported statistical evidence supporting the item content relevance and representation of the initial PNSE items using the procedures advocated by Dunn, Bouffard, and Rogers (1999).

External Validity

Pattern of inter-relationships between psychological need satisfaction scores. Nineteen studies (57.8%) reported inter-factor correlations testing relationships between scores for competence, autonomy, and relatedness in exercise. A consistent pattern of low-to-moderate correlations were observed with the relationship between the fulfillment of autonomy and relatedness needs the weakest in 14 (73.7%) studies and competence and autonomy needs the strongest in 17 (89.5%) studies. The pattern of relationships remained similar across studies

using both the BPNES and PNSE; however, considerable overlap (i.e., correlations ≥ 0.80) between scores from subscales of both instruments has been noted particularly for the relationship between competence and autonomy perceptions.

Psychological need satisfaction scores and exercise motivation. Seventeen studies (51.5%) examined relationships between basic psychological need satisfactions in exercise with indices of motivation. Consistent with SDT (Deci and Ryan, 2002), perceived competence, autonomy, and relatedness demonstrated consistently stronger associations with more self-determined motives (i.e., *identified* and *intrinsic* regulations) than controlling motives (i.e., *introjected* and *extrinsic* regulations). Research examining the predictive nature of basic psychological need satisfaction scores on motivation suggested a homogenous pattern of more positive associations with self-determined motives and a heterogeneous pattern of relationships with controlling motives. The need for competence, followed by autonomy and relatedness respectively, predicted the greatest portion of variance in more self-determined motives.

Psychological need satisfaction scores and well-being. Eight studies (24.2%) examined whether the fulfillment of psychological needs via exercise was related to well-being markers. Small-to-moderate positive relationships were reported between psychological need satisfaction in exercise scores and well-being markers (e.g., positive affect, physical self-worth) and negatively associated with markers of ill-being such as negative affect. Relatedness consistently demonstrated the lowest pattern of relationships in terms of magnitude with indices of well-being.

Psychological need satisfaction scores and exercise behavior. Nine studies (27.3%) examined the relationship between psychological need satisfaction and exercise behavior. In all studies, exercise behavior was assessed through self-report questionnaires with the instrumentation chosen to assess behavior reflecting various markers of intensity, frequency, and adherence. The pattern of inter-relationships suggests a small positive relationship between psychological need satisfaction scores and exercise behavior with perceived competence accounting for the greatest portion of exercise behavior variance. Five studies looked at changes over time in exercise-specific feelings of competence, autonomy, and relatedness. Patterns of change were assessed between one and six months. Available data suggests subtle fluctuations in psychological need fulfillment scores over time with a general trend towards increased perceptions of competence, autonomy, and relatedness from baseline as a result of regular exercise. Two studies noted the greatest increases occurred in perceived relatedness over the course of 12 week exercise programs. Perceptions of competence most strongly discriminated between exercise program adherents and non-adherers.

Structural and Generalizability Validity

A total of 9 studies (27.27%) have tested the structural validity of scores derived from either the PNSE ($n = 5$) or BPNES ($n = 4$) using structural equation modeling procedures. Inspection of the results across the 9 studies indicate consistent support for the structural validity of score interpretations for both the PNSE and BPNES, as well as, the reproducibility of each instrument's proposed factor structure across multiple samples of active exercisers.

Score interpretations from both instruments have demonstrated evidence of invariance across gender and one study documents support for the invariance of BPNES scores across public versus private exercise settings.

Conclusions

The purpose of this review was to summarize and evaluate the development of instruments designed to measure basic psychological need satisfaction in exercise from the perspective of Deci and Ryan's (2002) SDT. Ongoing attention to measurement principles represents an important (and often overlooked) process in advancing scientific knowledge and refining theory (Kerlinger, 1979; Marsh, 1997; Messick, 1995; Stevens, 1946). Construct validation is at the heart of the measurement process (Marsh, 1997; Messick, 1995) and a move towards systematic programs of construct validation that blend applications of relevant theory (such as the BPN subtheory from SDT) with the mosaic of available evidence to inform score interpretations is now recommended (Messick, 1995). In light of this focus, it appears that instrument development research aimed at assessing basic psychological need fulfillment in accordance with SDT (Deci and Ryan, 2002) is progressing towards systematic programs aligned with Messick's (1995) vision. Overall, the results of the present review suggest that the available evidence informing the interpretation of BPNES and PNSE scores is largely consistent with the theory informing the development of both instruments.

What Does the Evidence Tell us About Measuring Psychological Need Satisfaction in Exercise?

Observations noted in this review suggest that the measurement of psychological need satisfaction in exercise from the perspective of Deci and Ryan's (2002) SDT has followed a familiar route for self-perception instruments (Fox, 1997). Results of this review indicate that initial phases of research in this area were dominated by the use of instrumentation developed in an ad hoc fashion to measure concepts integral to the BPN subtheory of SDT which have recently been supplanted by approaches using context-specific instruments to capture variation in psychological need satisfaction experienced by exercisers. Both the BPNES and PNSE have been developed using the approach to construct validation advocated by Messick (1995) and show initial signs of promise as instruments to measure exercise-specific feelings of competence, autonomy, and relatedness in a manner consistent with SDT (Deci and Ryan, 2002). The data noted in this review imply that scores from both instruments can be interpreted meaningfully given the research offering supporting evidence for structural validity (including gender invariance) and criterion validity with reference to a select portion of SDT's nomological network (Cronbach and Meehl, 1955). Combined with evidence that scores from both instruments exhibit minimal error variance in samples of young adult Greek or Canadian exercisers, the addition of both instruments appears promising and provides an avenue to explore Ryan's (1995) contentions regarding the importance of testing of SDT in

applied settings (such as exercise) where contextual nuances alongside relevant theory can inform effective social change.

While the available evidence attesting to the construct validity of scores from both the PNSE and BPNE is favorable, Messick (1995) argued that construct validation requires ongoing attention to the nature and quality of evidence available to inform decisions about test score interpretation. Several issues germane to Messick's (1995) construct validation framework warrant further investigation. A number of anomalies have been noted already in research employing the PNSE and BPNE which do not coalesce easily with propositions set forth by Deci and Ryan (2002). For example, excessively large relationships between scores derived from subscales of both the PNSE (Wilson et al., 2007) and BPNE (Vlachopoulos and Michailidou, 2006) raise questions regarding either instrument's ability to discriminate between relevant constructs embedded within BPN. Further, certain studies report criterion validity coefficients from structural equation modeling analyses with indices of motivation especially for perceived relatedness that appear potentially incongruent with SDT (Vlachopoulos and Michailidou, 2006; Wilson et al., 2007). It seems imprudent to suggest at this juncture that the available evidence provides a forum for distinguishing between the BPNE and the PNSE as the instrument of choice without additional research to address anomalous findings and other components of Messick's (1995) construct validation framework.

What Measurement Issues Require Further Attention in Exercise Psychology Research?

Considering the importance of instrument development and evaluation in science (Kerlinger, 1979; Marsh, 1997; Messick, 1995), it appears that a number of issues pertaining to the measurement of basic psychological need satisfaction in exercise warrant further attention. Such continued focus would be consistent with Messick's (1995) contention regarding the nature of construct validation processes in applied sciences such as exercise psychology. On the basis of the present review, it appears that at least two directions would be useful for future research to consider when measuring the satisfaction of basic psychological needs through exercise participation. These directions represent conceptual and empirical issues that arise from joint consideration of previous studies and the underlying theory providing the framework from which to interpret BPNE and PNSE scores.

One direction worthy of additional inquiry concerns an examination of areas within Messick's (1995) construct validation framework that have yet to be sufficiently addressed in applications of the BPN subtheory of SDT to exercise. Content validity issues have yet to be thoroughly tested for items comprising either the BPNE or PNSE using empirical procedures (Dunn et al., 1999) that could highlight domain clarity issues worthy of attention. Moreover, the focus in previous research on adult samples that appear young and asymptomatic using both the PNSE and BPNE restricts the generalizability of score properties for either instrument. Particular attention could be afforded to issues of measurement invariance across subgroups of interest given that a major claim of Deci and Ryan's (2002) BPN subtheory concerns the universal effects of satisfying key psychological

needs on well-being irrespective of age, gender, or cultural orientation. Minimal evidence attesting to the invariance of PNSE and BPNES scores is currently available. Future studies should establish this important measurement property across subgroups of interest and meaningful time periods given that analysis of variation in basic psychological needs with time has important implications for optimizing motivation and cultivating well-being (Deci and Ryan, 2002).

A second line of empirical research that seems worthwhile concerns accumulating further evidence of external validity (Messick, 1995). Central to this portion of Messick's (1995) construct validation framework is data supporting the convergence and divergence of scores with relevant constructs articulated within the underlying theory informing an instrument's development. Previous studies have focused largely (albeit not exclusively) on providing convergent validity evidence with less attention given to including constructs that should display patterns of divergence with exercise-induced feelings of psychological need satisfaction. Inclusion of such constructs would be invaluable especially at this early stage of research with both the PNSE and BPNES given that Messick (1995) noted that divergent evidence is important in discounting (or affirming) alternative explanations for the focal constructs of interest. Arguments set forth concerning the nature of perceived autonomy (Ryan and Deci, 2007), for example, could be used to evaluate both PNSE and BPNES subscales assessing this portion of SDT's nomological network by examining relationships with perceived choice, volition, internal/external locus of causality, and coercion to more fully inform the interpretations of scores from both instruments.

Corroborating the empirical avenues for further inquiry, the results observed in this review suggest attention to a number of conceptual issues may also be worthwhile. One important conceptual issue concerns the selection and justification of criterion variables used in predictive studies to evaluate the contributions of psychological need satisfaction in exercise. Pedhazur and Pedhazur Schmelkin (1991) have suggested that a program of prediction is only as good as the quality of the criterion variable. Messick (1995) further noted that consideration of the substantive theory underlying instrument development should be given when selecting constructs to include in criterion-validity studies to prevent obfuscation. While this review indicates that an emerging body of research has examined relationships between satisfying competence, autonomy, and relatedness needs through exercise with markers of well-being, it appears that instruments used to assess well-being have been restrictive in scope. Conceptual distinctions have been made between hedonic and eudaimonic forms of well-being with the former focusing on maximizing pleasure or minimizing pain whereas the latter centers on the overall healthy functioning of the organism (Ryan and Deci, 2001). Deci and Ryan (2002) articulated clear links between the satisfaction of basic needs and eudaimonic well-being. In line with this contention, it seems reasonable to suggest that future research estimating criterion validity of either PNSE or BPNES scores give careful consideration to the selection of instruments capable of capturing eudaimonic rather than hedonic well-being.

A second conceptual challenge evident in this review concerns advancing recommendations for the most appropriate statistical treatment of data derived from instruments such as the BPNES and PNSE. Clearly the development of both the instruments has been based on SDT that suggests a multi-dimensional model comprised of three

interrelated constructs, namely perceived competence, autonomy, and relatedness experienced when exercising. The conceptual challenge here centers on analyzing data in an appropriate manner to test SDT such that resultant appraisals of construct validity evidence clarify rather than confound the development of literature in this area. One approach would be to model subscales of instruments like the BPNES and PNSE as a series of first-order factors subordinate to a second-order factor representing global need satisfaction within exercise. An alternative approach concerns modeling an instrument's subscale scores individually to evaluate the unique influence attributable to satisfying each psychological need on motivation and well-being issues within exercise settings. Both approaches have merit and appear justifiable theoretically given Deci and Ryan's (2002) contention regarding the complementary nature of satisfying basic psychological needs. Empirical justifications for the first approach could also be advanced given the high relationships noted in select studies reviewed herein amongst indices of exercise-induced feelings of competence, autonomy, and relatedness. Justifications of this variety suffer greatly from beliefs regarding the merits of data-driven refinements to theory (Pedhazur and Pedhazur Schmelkin, 1991). While this conceptual challenge is hardly novel and is likely to pervade, consideration of substantive theory and relevant arguments rather than blind reliance on the 'in vogue' method of data analysis should be the pivotal factor considered in future work.

Limitations and Summary Reflections

While the results of this review are informative and provide a platform for future research with respect to the measurement of basic psychological need satisfaction in exercise, several limitations should be acknowledged pertaining to the nature of the review. First, the review focused on published (or in press) data that is susceptible to publication bias (Bennett, Latham, Stretton, and Anderson, 2004). Second, the focus of this review was restricted to the context of exercise at the expense of other physical activity settings where instrumentation used to measure the fulfillment of SDT-based psychological needs warrants careful attention (e.g., sport, physical education). Finally, no empirical analysis of the available evidence was undertaken in this review. Future research would do well to consider meta-analytical reviews of research applying the BPN subtheory proposed by Deci and Ryan (2002) to issues of exercise motivation as the wealth of available evidence in this area accumulates.

In summary, the purpose of this review was to examine the status of measurement with respect to basic psychological need satisfaction in exercise using SDT as a guiding theoretical framework. The observations gleaned from this review suggest that the measurement of competence, autonomy, and relatedness needs in exercise has matured rapidly since the *initial phase* of research started in the 1980's. The most contemporary phase of research in this area has produced the BPNES (Vlachopoulos and Michailidou, 2006) and the PNSE (Wilson et al., 2006). Both instruments were developed using an approach to construct-validation advocated by measurement experts (Marsh, 1997; Messick, 1995) and appear to hold promise for advancing our understanding of SDT in health promotion initiatives where exercising regularly is pivotal. It seems reasonable to suggest on the basis of this review that attention to measurement principles is crucial to further advancement of SDT-based knowledge in

exercise psychology. Perhaps the current phase of research in this area signals ‘the end of the beginning’ (Churchill, 1942) with respect to our attempts to measure this important subtheory of SDT.

Authors Note

The first and second authors were supported by grants from the Social Sciences and Humanities Research Council of Canada during the preparation of this manuscript. The third and fourth authors made equal contributions to this article and as such their names appear in alphabetical order in accordance with convention. The fifth author was completing an undergraduate honors thesis under the supervision of the first author at the time of writing this article.

References

‡ Denotes research articles used in this review.

- Baumeister, R. F., and Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*, 497-529.
- Bennett, D. A., Latham, N. K., Stretton, C., and Anderson, C. S. (2004). Capture-recapture is a potentially useful method for assessing publication bias. *Journal of Clinical Epidemiology*, *57*, 349-357.
- Blais, M. R., and Vallerand, R. J. (1992). *Développement et validation de l'échelle des perceptions d'autonomie dans les domaines de vie* [Development and validation of the Autonomy Perception in Life OCNtexts Scale]. Unpublished manuscript. Université du Québec à Montréal.
- Churchill, W. (1942). “The end of the beginning”. Retrieved September 9th, 2007, from The Churchill Centre. Web site: <http://www.winstronchurchill.org/i4a/pages/index.cfm?pageid=1>.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.
- Cooper, H. (1982). Scientific guidelines for conducting integrative research reviews. *Review of Educational Research*, *52*, 291-302.
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*, 297-334.
- Cronbach, L. J., and Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, *52*, 281-302.
- deCharms, R. (1968). *Personal causation: The internal affective determinants of behavior*. New York, NY: Academic Press.
- Deci, E. L., and Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.

- Deci, E. L., and Ryan, R. M. (2002). *Handbook of self-determination research*. Rochester, NY: University of Rochester Press.
- Deci, E. L., Ryan, R. M., Gagné, M., Leone, D. R., Usunov, J., and Kornazheva, B. P. (2001). Need satisfaction, motivation, and well-being in the work organizations of a former Eastern Bloc country. *Personality and Social Psychology Bulletin*, 27, 930-942.
- Dunn, J. G. H., Bouffard, M., and Rogers, W. T. (1999). Assessing item content relevance in sport psychology scale-construction research: Issues and recommendations. *Measurement in Physical Education and Exercise Science*, 3, 15-36.
- ‡Edmunds, J. K., Ntoumanis, N., and Duda, J. L. (2006a). A test of self-determination theory in the exercise domain. *Journal of Applied Social Psychology*, 36, 2240-2265.
- ‡Edmunds, J. K., Ntoumanis, N., and Duda, J. L. (2006b). Examining exercise dependence symptomatology from a self-determination perspective. *Journal of Health Psychology*, 11, 887-903.
- ‡Edmunds, J. K., Ntoumanis, N., and Duda, J. L. (2007). Adherence and well-being in overweight and obese patients referred to an exercise on prescription scheme: A self-determination theory perspective. *Psychology of Sport and Exercise*, 8, 722 – 740.
- Fortier, M. S., Vallerand, R. J., and Guay, F. (1995). Academic motivation and school performance: Toward a structural model. *Contemporary Educational Psychology*, 20, 257-274.
- Fox, K. R. (1990). *The Physical Self-perception Profile Manual*. Dekalb, IL: Office for Health Promotion, Northern Illinois University.
- Fox, K. R. (1997). *The physical self: From motivation to well-being*. Champaign, IL: Human Kinetics.
- Gagné, M. (2003). The role of autonomy support and autonomy orientation in prosocial behavior engagement. *Motivation and Emotion*, 27, 199-223.
- Hagger, M. S., and Chatzisarantis, N. L. D. (2007). *Intrinsic motivation and self-determination in exercise and sport*. Champaign, IL: Human Kinetics.
- ‡Hagger, M. S., Chatzisarantis, N. L. D., and Harris, J. (2006). From psychological need satisfaction to intentional behavior: Testing a motivational sequence in two behavioral contexts. *Personality and Social Psychology Bulletin*, 32, 131 – 148.
- Harter, S. (1982). The perceived competence scale for children. *Child Development*, 53, 87–97.
- Harter, S. (1985). *Manual of the Self-Perception Profile for Children*. University of Denver, Denver, CO.
- Iyengar, S. S., and DeVoe, S. E. (2003). Rethinking the value of choice: Considering cultural mediators of intrinsic motivation. In V. Murphy-Berman and J. Berman (Eds.), *Cross-Cultural Differences in Perspectives on the Self* (pp. 129-174). London: University of Nebraska Press.
- Kerlinger, F. N. (1979). *Behavioural research: A conceptual approach*. New York, NY: Holt, Rinehart, and Winston.
- ‡Kowal, J., and Fortier, M. S. (1999). Motivational determinants of flow: Contributions from self-determination theory. *The Journal of Social Psychology*, 139, 355 – 368.

- ¥Kowal, J., and Fortier, M. S. (2000). Testing relationships from the hierarchical model of intrinsic and extrinsic motivation using flow as a motivational consequence. *Research Quarterly for Exercise and Sport*, 71, 171 – 181.
- ¥Levy, S. S., and Cardinal, B. J. (2004). Effects of a self-determination theory based mail-mediated intervention on adults' exercise behaviour. *American Journal of Health Promotion*, 18, 345-349.
- ¥Li, F. (1999). The exercise motivation scale: It's multifaceted structure and construct validity. *Journal of Applied Sport Psychology*, 11, 97-115.
- ¥Markland, D. (1999). Self-determination moderates the effects of perceived competence on intrinsic motivation in an exercise setting. *Journal of Sport and Exercise Psychology*, 21, 351-361.
- ¥Markland, D., and Hardy, L. (1997). On the factorial and construct validity of the intrinsic motivation inventory: Conceptual and operational concerns. *Research Quarterly for Exercise and Sport*, 68, 20-32.
- Markland, D., and Ingledew, D. K. (2007). Exercise participation motives: A self-determination theory perspective. In M. Hagger and N. L. D. Chatzisarantis (Eds.), *Intrinsic Motivation and Self-Determination in Exercise and Sport* (pp. 23-34). Champaign, IL: Human Kinetics.
- Marsh, H. W. (1997). The measurement of physical self-concept: A construct validation approach. In K. R. Fox (Ed.), *The physical self: From motivation to well-being* (pp. 27-58). Champaign, IL: Human Kinetics.
- McAuley, E., Duncan, T., and Tammem, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, 60, 48-58.
- McCready, M. L., and Long, B. C. (1985). Locus of control, attitudes towards physical activity, and exercise adherence. *Journal of Sport Psychology*, 7, 346-359.
- 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.
- Mullan, E., Markland, D., and Ingledew, D. K. (1997). A graded conceptualisation of self-determination in the regulation of exercise behaviour: Development of a measure using confirmatory factor analytic procedures. *Personality and Individual Differences*, 23, 745-752.
- ¥Parfitt, G., Rose, E., and Markland, D. (2000). The effect of prescribed and preferred intensity exercise on psychological affect and the influence of baseline measures of affect. *Journal of Health Psychology*, 5, 231-240.
- ¥Peddle, C. J., Plotnikoff, R., Wild, C., Au, H., and Courneya, K. S. (in press). Medical demographic and psychosocial correlates of exercise in colorectal cancer survivors: An application of self-determination theory. *Supportive Care in Cancer*.
- Pedhazur, E. J., and Pedhazur Schmelkin, L. (1991). *Measurement, design, and analysis: An integrated approach*. Hillsdale, NJ: Lawrence Erlbaum.
- Reeve, J. (2002). Self-determination theory applied to educational settings. In E. L. Deci and R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 183-204). Rochester, NY: University of Rochester Press.

- Reeve, J., and Sickenius, B. (1993). Development and validation of a brief measure of the 3 psychological needs underlying intrinsic motivation: The AFS scales. *Educational and Psychological Measurement*, 54, 506-515.
- Richer, S. F., and Vallerand, R. J. (1998). Construction et validation de l'Échelle du sentiment d'appartenance sociale. *Revue européenne de psychologie appliquée*, 48, 129-137.
- Rose, E. A., Markland, D., and Parfitt, G. (2001). The development and initial validation of the Exercise Causality Orientations Scale. *Journal of Sports Sciences*, 19, 445-462.
- Rose, E. A., Parfitt, G. and Williams, S. (2005). Exercise causality orientations, behavioural regulation for exercise and stage of change for exercise: exploring their relationships. *Psychology of Sport and Exercise*, 6, 399-414.
- Ryan, R. M. (1995). Psychological needs and the facilitation of integrative processes. *Journal of Personality*, 63, 397-428.
- Ryan, R. M., and Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. In S. Fiske (Ed.), *Annual Review of Psychology* (Vol. 52; pp. 141-166). Palo Alto, CA: Annual Reviews, Inc.
- Ryan, R. M., and Deci, E. L. (2007). Self-regulation and the problem of human autonomy: Does psychology need choice, self-determination, and will? *Journal of Personality*, 74, 1557-1586.
- Sallis, J. F., Grossman, R. M., Pinski, R. B., Patterson, T. L., and Nadar, P. R. (1987). The development of scales to measure social support for diet and exercise behaviours. *Preventive Medicine*, 16, 825-836.
- Sheldon, K. M., Elliot, A. J., Kim, Y., and Kasser, T. (2001). What is satisfying about satisfying events? Testing 10 candidate psychological needs. *Journal of Personality and Social Psychology*, 80, 325-339.
- Sheldon, K. M., Williams, G., and Joiner, T. (2003). *Self-determination theory in the clinic*. New Haven, CT: Yale University Press.
- Stevens, S. S. (1946). On the theory of scales of measurement. *Science*, 103, 677-680.
- ¥Thørgersen-Ntoumani, C., and Ntoumanis, N. (2007). A self-determination theory approach to the study of body image concerns, self-presentation, and self-perceptions in a sample of aerobic instructors. *Journal of Health Psychology*, 12, 301-315.
- Thorndike, R. L., and Hagen, E. (1955). *Measurement and evaluation in psychology and education*. New York, NY: Wiley.
- Tobin, V. (2003). *Facilitating exercise behavior change: A self-determination theory and motivational interviewing perspective*. Unpublished doctoral dissertation. University of Wales, Bangor.
- White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review*, 66, 297-333.
- ¥Wilson, P. M., Rodgers, W. M., and Fraser, S. N. (2002a). Cross-validation of the revised motivation for physical activity measure in active women. *Research Quarterly for Exercise and Sport*, 73, 471-477.
- ¥Wilson, P. M., Rodgers, W. M., and Fraser, S. N. (2002b). Examining the psychometric properties of the Behavioral Regulation in Exercise Questionnaire. *Measurement in Physical Education and Exercise Science*, 6, 1-21.

- ¥Wilson, P. M., Rodgers, W. M., Blanchard, C. M., and 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., and Murray, T. C. (2004). The relationship between exercise regulations and motivational consequences. *Research Quarterly for Exercise and Sport*, 75, 81-91.
- ¥Wilson, P. M., Rodgers, W. M., Loitz, C. C., and Scime, G. (2006). "It's who I am really!" The importance of integrated regulation in exercise contexts. *Journal of Applied Biobehavioral Research*, 11, 79-104.
- ¥Wilson, P. M., Longley, K., Muon, S., Rodgers, W. M., and Murray, T. C. (2006). Examining the contributions of perceived psychological need satisfaction to well-being in exercise. *Journal of Applied Biobehavioral Research*, 11, 243 – 264.
- ¥Wilson, P. M., Rogers, W. T., Rodgers, W. M., and Wild, C. (2006). The Psychological Need Satisfaction in Exercise Scale. *Journal of Sport and Exercise Psychology*, 28, 79-104.
- ¥Wilson, P. M., Mack, D. E., and Blanchard, C. (in press). The role of perceived psychological need satisfaction in exercise related affect. *Hellenic Journal of Psychology*.
- ¥Wilson, P. M., Mack, D. E., and Lighthead, V. (in press). How important are basic psychological needs to women's well-being? In J. P Coulter (Ed.), *Progress in Exercise and Women's Health Research*. Hauppauge, NY: Nova Science.
- ¥Wilson, P. M., Mack, D. E., Muon, S. and LeBlanc, M. (2007). What role does psychological need satisfaction play in motivating exercise participation? In L. A. Chiang (Ed.), *Motivation of Exercise and Physical Activity* (pp.1-18). Hauppauge, NY: Nova Science
- ¥Wilson, P. M., and Muon, S. (in press). Psychometric properties of the Exercise Identity Scale in a university sample. *International Journal of Sport and Exercise Psychology*.
- ¥Vlachopoulos, S. P. (2007). Psychometric evaluation of the Basic Psychological Needs in Exercise Scale in Community Exercise Programs: A cross validation approach. *Hellenic Journal of Psychology*, 4, 52-74.
- ¥Vlachopoulos, S. P., and Michailidou, S. (2006). Development and initial validation of a measure of autonomy, competence, and relatedness in exercise: The Basic Psychological Needs in Exercise Scale. *Measurement in Physical Education and Exercise Sciences*, 10, 179 – 201.
- ¥Vlachopoulos, S. P. (in press). The Basic Psychological Needs in Exercise Scale: Measurement invariance over gender. *Structural Equation Modeling*.
- ¥Vlachopoulos, S. P., and Neikou, E. (in press) . A prospective study of the relationships of autonomy, competence, and relatedness with exercise attendance, adherence and dropout. *Journal of Sports Medicine and Physical Fitness*.