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Health-Enhancing Physical Activity: Associations with Markers of Well-Being

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Background: The association between health-enhancing physical activity (HEPA) and well-being was investigated across a cross-sectional (Study 1; $N = 243$) and a longitudinal, two-wave (Study 2; $N = 198$) design. Study 2 further examined the role played by fulfilling basic psychological needs in terms of understanding the mechanisms via which HEPA is associated with well-being. **Methods:** Women enrolled in undergraduate courses were surveyed. **Results:** In general, greater HEPA was associated with greater well-being (Study 1; *r*s ranged from .03 to .25). Change score analyses revealed that increased HEPA positively predicted well-being (Study 2; $R^2_{adj} = 0.03$ to 0.15) with psychological need fulfilment underpinning this relationship. **Conclusions:** Collectively these findings indicate that increased engagement in health-enhancing physical activity represents one factor associated with greater well-being. Continued investigation of basic psychological need fulfilment as one mechanism underpinning the HEPA–well-being relationship appears justified.

Keywords: health-enhancing physical activity, self-determination theory, well-being

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INTRODUCTION

Increased interest in the promotion of well-being (e.g. Breslow, 2006; Diener, Lucas, Schimmack, & Helliwell, 2009) has presented new opportunities for health researchers to investigate factors that enhance (or diminish) optimal well-being across the lifespan. Contemporary conceptualisations of well-being have defined the construct as "a dynamic and relative state where one maximizes his or her physical, mental, and social functioning in the context of supportive environments to live a full, satisfying, and productive life" (Kobau, Sneizek, & Zack, 2009, p. 4). Diverse factors engendering well-being include personal accomplishment, social relationships, physical health, and mortality (Kimiecik, 2010; Kobau, Sniezek, Zack, Lucas, & Burns, 2010). Sheldon and Lyubomirsky (2004) have advocated for increased understanding of intentional activities that individuals engage in, as opposed to more stable influences (e.g. gender) or life circumstances (e.g. employment status), in an effort to understand the factors associated with enhanced well-being.

Participation in regular physical activity is one factor linked with well-being across a range of indices over the lifespan (Fox & Wilson, 2008; Reed & Ones, 2006). Cross-sectional (Bize, Johnson, & Plotnikoff, 2007) and longitudinal (Wendel-Vos, Schuit, Tijhuis, & Kromhout, 2004) investigations have provided support for the association between regular physical activity and higher levels of well-being. Complementing this line of evidence, randomised controlled trials with a variety of symptomatic (e.g. Courneya et al., 2011) and asymptomatic (Gillison, Skevington, Sato, Standage, & Evangelidou, 2009) populations have consistently indicated the beneficial effects of physical activity on a broad array of constructs representing well-being.

Despite the growth in research focusing on physical activity and well-being, a number of issues warrant further investigation on the basis of current evidence. First, our understanding of well-being in the physical activity literature has largely ignored the distinction between hedonic and eudaimonic forms of well-being (Ryan, Huta, & Deci, 2008; Ryff & Singer, 2008; Wilson, Mack, Blanchard, & Gray, 2009). Hedonic well-being (HWB) concerns "people's cognitive and affective evaluations of their lives" (Diener, 2000, p. 34) and comprises three primary components: greater satisfaction with life, higher positive affect, and low levels of negative affect. In contrast, eudaimonic well-being (EWB) is reflected in developing one's true potential or human flourishing (Ryff, 1989) and is associated with engagement in activities deemed congruent with deeply held values and activities which challenge one's abilities. Ryff (1989) has conceptualised EWB as being represented through six dimensions: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance. Although

the distinction between hedonic and eudaimonic well-being is not uniformly endorsed (Kashdan, Biswas-Diener, & King, 2008), support for the distinctive nature of these constructs has been gained (e.g. Gallagher, Lopez, & Preacher, 2009; Ryff & Singer, 2006; Ryff, Singer, & Deinberg Love, 2004). With research supportive of the association between increased physical activity behaviour and greater HWB (Oztekin & Tezer, 2009; Wilson et al., 2009), this line of inquiry has only recently been extended to consider EWB with equivocal results emanating. For example, increased physical activity was associated with greater perceptions of EWB in a sample of adolescent women (e.g. Brassai, Piko, & Steger, 2011) and individuals living with osteoporosis (Gunnell, Mack, Wilson, & Adachi, 2011). Conversely, Ferguson, Kowalski, Mack, Wilson, and Crocker (in press) found no support for the physical activity–EWB relationship, suggesting that continued research is warranted to further clarify the nature of this relationship.

A second issue worthy of further examination concerns the type (or mode) of physical activity linked with well-being. The dominant approach to examining well-being in relation to physical activity behaviour has focused on the role afforded by structured exercise as opposed to health-enhancing physical activity (HEPA; Acevedo & Ekkekakis, 2006). HEPA reflects any form of physical activity that benefits health and functional capacity of the organism without undue harm or risk (Bouchard, Blair, & Haskell, 2007) and can be achieved by engaging in moderate intensity activities at the recommended frequency regardless of context (e.g. commuting, leisure time, household). With compelling evidence demonstrating positive biological health changes (e.g. cardiorespiratory, metabolic) stemming directly from HEPA (Bouchard et al., 2007), it remains unclear whether HEPA can contribute to well-being in the same manner as structured exercise.

A final issue that warrants consideration concerns the mechanisms responsible for transmitting the positive influence of engagement in HEPA to optimal well-being. Plausible mechanisms have been advanced based on relevant theory (e.g. Dual Mode Theory; Acevedo & Ekkekakis, 2006), or those confined to specific constructs (e.g. self-efficacy, fatigue; McAuley, White, Rogers, Motl, & Courneya, 2010; Motl & McAuley, 2009). One theory that may be advanced for explaining the role played by HEPA in relation to well-being is Basic Psychological Needs Theory (BPNT; Deci & Ryan, 2002). Embedded within BPNT, Deci and Ryan (2002) contend that the basic psychological needs for competence, autonomy, and relatedness serve as the foundation that nurtures adaptive growth, integrity, and well-being. The fulfilment of each psychological need is considered innate and is posited to exert universally positive effects on well-being when fulfilled (Deci & Ryan, 2002). Consequently people are oriented towards situations that allow for the satisfaction of psychological needs. BPNT has become a popular theoretical framework to explain variation in well-being in varied

contexts (Deci & Ryan, 2002) including exercise (Wilson, Mack, & Grattan, 2008a; Wilson, Mack, Gunnell, Oster, & Gregson, 2008b) and sport (Gagné & Blanchard, 2007). However, it remains unclear whether HEPA impacts markers of well-being via satisfaction of one or more of the fundamental psychological needs proposed by Deci and Ryan (2002).

The overall purpose of this study was to ascertain the relationship between participation in HEPA and markers of well-being. To address this purpose, two studies were conducted using (a) a cross-sectional design (Study 1), and (b) a longitudinal, two-wave design (Study 2). In Study 1, the relationship between participation in HEPA and global (i.e. trait) markers of well-being were examined. Variation in HEPA across a 6-month period in relation to markers of well-being and psychological need satisfaction was examined in Study 2. Study 2 also tested the potential role of fulfilling basic psychological needs as a framework accounting for the influence of HEPA on well-being criteria.

STUDY 1

The purpose of Study 1 was to examine patterns of association between HEPA and global markers of well-being. Based on suppositions advanced in the well-being and physical activity literature (Ekkekakis & Backhouse, 2009; Fox & Wilson, 2008) combined with previous empirical research (e.g. Brassai et al., 2011; Wilson et al., 2009), a small positive relationship between engagement in HEPA and markers of hedonic and eudaimonic well-being was hypothesised.

METHODS

Measures

Demographics. Participants provided self-reported data pertaining to gender, height/weight, marital status, and ethnicity.

Physical Activity. The Short Questionnaire to Assess Health-Enhancing Physical Activity (SQUASH; Wendel-Vos, Schuit, Saris, & Kromhout, 2003) was used as to assess HEPA. The SQUASH consists of questions to assess (a) commuting activities, (b) leisure time activities, (c) household activities, and (d) activities at work and school. Questions elucidate the frequency, duration, and intensity of physical activities engaged in across a typical week in the previous months. Total minutes of activity were calculated for each question by multiplying frequency (days/week) by duration (min/day). Intensity scores for each domain of HEPA were calculated in metabolic equivalent units (METS) representing energy expenditure for each activity listed using

Ainsworth et al.'s (2000) guidelines. Total HEPA scores were calculated by multiplying total minutes of activity by the METs score. Preliminary support for the construct validity and test–retest reliability of SQUASH scores have been documented (Wendel-Vos et al., 2003; Winter et al., 2008).

Hedonic Well-Being (HWB). Consistent with the conceptual definition, HWB was assessed using two instruments, namely the Satisfaction with Life Scale (SWLS; Diener Emmons, Larsen, & Griffin, 1985) and the Positive Affect Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The SWLS is a self-report instrument comprising five items designed to measure subjective evaluations of one's overall life (sample SWLS item: "In most ways the conditions of my life are ideal"). Participants responded to each SWLS using a 7-point Likert scale anchored at the extremes by "1" (*Strongly Disagree*) and "7" (*Strongly Agree*). The PANAS (Watson et al., 1988) is a 20-item, self-report instrument designed to capture the intensity associated with both positive (sample PANAS item: "Enthusiastic") and negative (sample PANAS item: "Afraid") dimensions of global affect. Participants were asked to respond to each PANAS using a 5-point Likert scale ranging from "1" (*Not At All or Very Slightly*) to "5" (*Very Much*). Previous studies have provided support for the construct validity and reliability of test scores for both the SWLS and the PANAS (Pavot & Diener, 2008; Ryff et al., 2004).

Eudaimonic Well-Being (EWB). A modified version of the Scales of Psychological Well-Being (SPWB; Ryff, 1989) was adopted to assess indices of EWB in this study. The modified SPWB consisted of six seven-item subscales representing the dimensions of EWB proposed by Ryff (1989) including: autonomy (sample item: "I have confidence in my opinions even if they are contrary to the general consensus"); environmental mastery (sample item: "I am quite good at managing the many responsibilities of my daily life"); personal growth (sample item: "I think it is important to have new experiences that challenge how you think about the world"); positive relations with others (sample item "Most people see me as loving and affectionate"); purpose in life (sample item: "I enjoy making plans for the future and working to make them a reality"); and self-acceptance (sample item: "In general, I feel confident and positive about myself"). Participants responded to each item on a scale ranging from "1" (*Strongly Disagree*) to "6" (*Strongly Agree*). Twenty SPWB items comprised positive item content, with the remaining 22 having negative item content. Prior to analysis, all negatively worded items were reverse scored such that higher scores were reflective of greater EWB. Structural and construct validity for scores derived from the 42-item SPWB have been demonstrated in a sample of adult women (Abbott, Ploubidis, Huppert, Kuh, & Croudace, 2010; Abbott et al., 2006).

Procedures

Following institutional ethical clearance, participants enrolled in first year university courses were approached by members of the research team during a regularly scheduled class. A standardised script was used to introduce the purpose and participant requirements for the study in an attempt to reduce potential response bias associated with test administration (Pedhazur & Pedhazur-Schmelkin, 1991). Participants then received a standardised e-mail from the first author directing them to a website consisting of all study materials including a Letter of Invitation. Once informed consent was obtained, participants were automatically directed to the study instruments. Study involvement took approximately 20 minutes to complete and the opportunity to receive group-level summary feedback was offered to each participant who requested such information.

Data Analysis

Data were initially screened for non-response errors, statistical outliers, and tested for conformity with relevant assumptions underpinning inferential tests. Second, internal consistency score reliability estimates (Cronbach's coefficient α; Cronbach, 1951) and summary descriptive statistics were calculated for each study variable. Third, a series of bivariate correlations and 95 per cent confidence intervals between study variables were calculated.

RESULTS

Participants

Participants were 243 women[1] enrolled in first year undergraduate classes ($M_{age} = 18.61$ years; $SD_{age} = 1.05$ years). The majority of participants indicated that their cultural origin was "Caucasian" (92.20%) and their current marital status as "single" (97.10%). Those providing self-report data ($n = 209$) for height and weight indicated a range of Body Mass Index (BMI; kg/m^2) values that were, on average, classified as "normal" ($M_{BMI} = 22.85$ kg/m^2; $SD_{BMI} = 3.00$) at the time of data collection based on the guidelines advocated by Health Canada (2011).

[1] Women served as the sampling frame for the present investigation as research has reported lower levels of physical activity participation (Caspersen, Pereira, & Curran, 2000) including HEPA (Wang et al., 2010) in comparison to men. Further, complex psychological profiles in women have been demonstrated that vary depending on the conceptualisation of well-being consistent with the hedonic or eudaimonic tradition (Ryff, 1989).

Preliminary Data Screening and Descriptive Statistics

Initial inspection of the data indicated the presence of minimal non-response error with no more than 3.39 per cent of data missing on any individual item. Missing data were replaced using the within-person mean substitution procedure advocated by Hawthorne and Elliot (2005). Following the imputation of missing data, an inspection of the distributional properties (see Table 1) suggested minimal concerns in terms of univariate normality of the distribution (Glass & Hopkins, 1996). Estimates of internal consistency reliability of responses to well-being instruments in the present sample were in the range $0.70 \leq \alpha \leq 0.85$ (see Table 1 for specific values).

Descriptive statistics were calculated for scores derived from indices of HEPA, HWB, and EWB (see Table 1). Participants reported expending on average 3829.04 ($SD = 2964.83$) METS per week as measured by the

TABLE 1
Descriptive Statistics and Internal Consistency Reliability Estimates

Variables	M	SD	R	Skew.	Kurt.	α
Study 1						
1. HWB—Satisfaction with Life	5.23	1.00	1–7	–0.95	1.36	0.83
2. HWB—Positive Affect	3.76	0.62	1–5	–0.77	0.91	0.85
3. HWB—Negative Affect	2.04	0.64	1–5	0.93	0.49	0.85
4. EWB—Autonomy	4.28	0.79	1–6	0.09	–0.46	0.73
5. EWB—Environmental Mastery	4.43	0.79	1–6	–1.01	1.59	0.79
6. EWB—Personal Growth	4.75	0.67	1–6	–0.24	–0.48	0.70
7. EWB—Purpose in Life	4.78	0.75	1–6	–0.70	0.60	0.77
8. EWB—Positive Relations	4.86	0.86	1–6	–0.88	0.27	0.81
9. EWB—Self-Acceptance	4.70	0.85	1–6	–0.82	0.53	0.83
10. HEPA	3829.04	2964.83	0–∞	1.08	0.28	–
Study 2						
1. HWB—Satisfaction with Life	5.70	1.21	1–7	0.05	–0.18	0.87
2. HWB—Positive Affect	3.31	0.78	1–5	–0.25	0.69	0.88
3. HWB—Negative Affect	1.76	0.80	1–5	1.71	3.45	0.83
4. EWB—Positive Growth	4.76	0.60	1–6	–0.19	–0.52	0.74
5. EWB—Purpose in Life	4.30	0.45	1–6	–0.33	–0.21	0.76
6. PNSE—Competence	4.48	0.77	1–6	–0.66	1.85	0.86
7. PNSE—Autonomy	5.30	0.60	1–6	–0.72	–0.36	0.83
8. PNSE—Relatedness	4.36	0.86.	1–6	–0.53	–0.25	0.88
9. HEPA—Time 1	2911.74	2404.74	0–∞	1.48	2.10	–
10. HEPA—Time 2	2950.10	2237.54	0–∞	1.47	2.64	–

Note: *M* = Mean. *SD* = Standard deviation. *R* = Range. *Skew.* = Univariate Skewness. *Kurt.* = Univariate Kurtosis. α = Cronbach's (1951) internal consistency reliability coefficient. HWB = Hedonic well-being; EWB = Eudaimonic well-being; PNSE = Psychological Need Satisfaction in Exercise; HEPA = Health-enhancing physical activity. HEPA scores reflect estimates of energy expenditure expressed in MET minutes/week.

SQUASH.[2] Well-being estimates were on average above the theoretical mid-point of their respective scales, with the exception of negative affect.

Main Analyses

Bivariate correlations and corresponding 95 per cent confidence intervals can be found in Table 2. A pattern of small-to-large relationships was noted between positive indices of HWB (i.e. positive affect and satisfaction with life) and EWB (*r*s ranged from 0.19 to 0.77). A pattern of weak-to-small relationships between HEPA and global markers of well-being were noted (*r*s ranged from 0.03 to 0.25). Negative affect was negatively related to all well-being markers (*r*s ranged from –0.39 to –0.57) and HEPA ($r = –0.11$). Consideration of 95 per cent confidence intervals spanning each bivariate correlation indicated that HEPA was associated with six of the nine well-being dimensions assessed, the exceptions being negative affect, autonomy, and positive relations with others.

Summary of Study 1

The purpose of Study 1 was to examine the pattern of relationships between HEPA and well-being in women enrolled in university. Overall, the findings reported in Study 1 were generally in line with a priori hypotheses, indicating that HEPA was associated with higher well-being in both hedonic and eudaimonic forms. Conclusions are tempered given the cross-sectional nature of the design and the descriptive nature of the study.

STUDY 2

Study 2 was designed to complement and extend conclusions derived from Study 1 through (a) consideration of the relationship between changes in HEPA across time in relation to hedonic and eudaimonic forms of well-being and (b) to elucidate the role played by fulfilling each psychological need outlined by Deci and Ryan (2002) within BPNT in terms of understanding the mechanisms via which HEPA impacts well-being. Consistent with Study 1 and existing literature (Brassai et al., 2011; Wilson et al., 2009), it was hypothesised that greater HEPA would be associated with higher scores on well-being. Based on Deci and Ryan's (2002) theorising, and previous

[2] Varied scoring protocols for the SQUASH have been reported including reporting adherence to physical activity guidelines (Wendel-Vos et al., 2004) and number of minutes of HEPA per week (e.g. Hurkmans et al., 2010). Research reporting SQUASH scores in METs have reported higher values in university students (e.g. $M = 6{,}457.57$; $SD = 9{,}380.84$; Ferguson et al., in press) and adult populations ($M = 7{,}850$; $SD = 3{,}066$; Wendel-Vos et al., 2003).

TABLE 2
Bivariate Correlations between Study Variables—Study 1

Variables	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. HWB—SWL	–									
2. HWB—Positive Affect	.54 (.45–.62)	–								
3. HWB—Negative Affect	−.53 (−.61–−.43)	−.46 (−.55–−.36)	–							
4. EWB—Autonomy	.41 (.30–.51)	.41 (.30–.51)	−.39 (−.49–−.28)	–						
5. EWB—EM	.58 (.49–.66)	.65 (.57–.72)	−.58 (−.66–−.49)	.35 (.25–.46)	–					
6. EWB—Positive Growth	.39 (.28–.49)	.52 (.42–.61)	−.40 (−.50–−.29)	.39 (.28–.49)	.53 (.43–.61)	–				
7. EWB—Purpose in Life	.59 (.50–.67)	.68 (.61–.74)	−.56 (−.64–−.47)	.43 (.32–.53)	.71 (.64–.77)	.60 (.51–.67)	–			
8. EWB—Positive Relations	.54 (.45–.62)	.45 (.34–.54)	−.51 (−.60–−.41)	.19 (.07–.31)	.60 (.51–.67)	.51 (.41–.60)	.53 (.43–.61)	–		
9. EWB—Self-Acceptance	.73 (.67–.78)	.63 (.55–.70)	−.57 (−.65–−.48)	.44 (.33–.54)	.71 (.64–.77)	.54 (.45–.62)	.72 (.65–.78)	.56 (.47–.64)	–	
10. HEPA	.18 (.06–.30)	.25 (.13–.36)	−.11 (−.23–.02)	.03 (−.10–.16)	.13 (.01–.25)	.20 (.08–.32)	.17 (.05–.29)	.12 (−.01–.24)	.15 (.03–.27)	–

Note: HWB = Hedonic well-being; SWL = Satisfaction with Life; EWB = Eudaimonic well-being; EM = Environmental Mastery; HEPA = Health-enhancing physical activity. Sample size ($N = 243$) is consistent across each element in the lower diagonal and principal diagonal of the matrix. All r's greater than |.11| significant at $p < .05$ (one-tailed) and |.15| significant at $p < .01$ (one-tailed).

research (Gunnell et al., 2011), it was hypothesised that indices of perceived psychological need satisfaction would mediate the HEPA–well-being relationship.

METHODS

Measures

Instruments used were similar to those adopted in Study 1. Briefly, demographic variables, including height/weight, marital status, and ethnicity were assessed. HEPA was assessed via the SQUASH (Wendel Vos et al., 2003) and the PANAS (Watson et al., 1988), and SWLS (Diener et al., 1985) served as markers of HWB. Two dimensions of EWB embedded within the SPWB (Ryff, 1989) were assessed—notably Purpose in life and Personal growth.[3]

Psychological Need Satisfaction. Participants completed a modified version of the 18-item Psychological Need Satisfaction in Exercise Scale (PNSE; Wilson, Rogers, Rodgers, & Wild, 2006). The PNSE is a self-report instrument designed to measure feelings of competence, autonomy, and relatedness in line with BPNT specific to exercise settings (Wilson et al., 2006). Substantial evidence has supported the construct validity and score reliability of data collected using the PNSE particularly in samples of young adults comparable to the sample used in Study 2 of this investigation (see Wilson et al., 2009, for a review). Given the focus of the present investigation on HEPA, the stem and relevant items of the PNSE were modified to reflect the contextual change. Following the instructional stem "The following statements represent different feelings people have when they engage in physical activity. Please answer the following questions by considering how you typically feel while you are being physically active", with item responses anchored by "1" (*False*) and "6" (*True*). An illustration of the minor wording modifications made from the original version of the PNSE is as follows: (a) Original PNSE item "I feel good about the way I am able to complete challenging exercises" was altered for this study to (b) Modified PNSE item: "I feel good about the way I am able to complete challenging physical activities". Evidence for the construct validity and score reliability of modifications to the original PNSE have been documented (Gunnell et al., 2011; McDonough & Crocker, 2007).

Procedure

Participant recruitment for Study 2 followed a similar protocol to that outlined in Study 1, including obtaining informed consent prior to participation.

[3] Participants in Study 1 and Study 2 represented different cohorts.

A follow-up e-mail was delivered 6 months after initial test administration to the same individuals inviting them to complete an additional questionnaire. At the first test administration, participants' HEPA and psychological need satisfaction were assessed. HEPA and markers of HWB and EWB were examined at the second test administration.

Data Analysis

Following the analytic strategies identified in Study 1, a series of simple regression models were calculated to examine whether changes in HEPA across a 6-month period predicted well-being. Change in HEPA across the 6-month time frame was calculated as the standardised residuals of Time 1 SQUASH scores – Time 2 SQUASH scores. Finally, multiple mediation with bootstrapping procedures (Preacher & Hayes, 2008) was employed to examine the role of all three psychological needs in the HEPA–well-being relationship. Evidence for mediation in the bootstrap samples (k = 5,000) is observed with the absence of zero in the 95 per cent bias corrected and accelerated confidence interval (BCa CI; Preacher & Hayes, 2008). Specific indirect effects and pairwise contrasts were examined through the use of BCa CIs to examine the unique contribution and strength of each psychological need in the multiple mediator model analysis.

RESULTS

Participants

The sample consisted of 198 women enrolled in first year undergraduate classes ($M_{age} = 19.76$ years; $SD_{age} = 2.21$).[4] The majority of participants ($n = 195$) indicated that their cultural origin was "Caucasian" (98.50%) and their current marital status as "single" (97.00%). With self-reported height and weight reported at the first test administration period, estimated BMI values indicated that, on average, this sample of young women were classified as "normal" ($M_{BMI} = 23.12$ kg/m^2; $SD_{BMI} = 2.82$) using the classification scheme advocated by Health Canada (2011).

[4] Previous research (e.g. Keyes, Shmotkin, & Ryff, 2002; Miquelon & Vallerand, 2008) has adopted select dimensions of the SPWB. Keyes et al. (2002) argued that Purpose in Life and Positive Growth were distinct from other aspects of EWB measured by the SPWB, with Ryff and Singer (2008) contending that Positive Growth is closest in meaning to Aristotle's conceptual definition of eudaimonic well-being. Further, due to conceptual similarities between dimensions of EWB assessed in the SPWB (i.e. Environmental Mastery, Autonomy, and Positive Relations) and the three psychological needs advanced by Deci and Ryan (2002), Purpose in life and Positive Growth were retained.

Preliminary Data Screening, Descriptive Statistics, and Bivariate Correlations

Six per cent ($n = 12$) of individuals providing data at Time 1 did not provide data at the second test administration and were classified as dropouts from this study and removed from further consideration in the analyses. Differences between those providing data only at Time 1, as opposed to both time points were minimal across demographic and all study variables ($p > .05$; Cohen's d (Cohen, 1988) ranged from 0.03 to 0.09). Subsequent analyses were conducted on a final sample size of 198. Initial inspection of the sample data indicated the presence of minimal non-response error with no more than 1.50 per cent of data missing on any individual item. Missing data were replaced using a within-person mean substitution protocol (Hawthorne & Elliot, 2005). Following the imputation of missing data, inspection of the distributional properties (see Table 1) indicated that skewness values ranged from –0.72 to 1.71 and kurtosis values ranged from –0.52 to 3.45 in this sample. Estimates of internal consistency reliability of responses to psychological need satisfaction and well-being instruments in the present sample were in the range $0.74 \leq \alpha \leq 0.88$ (see Table 1).

Participants reported engaging in an average of 2,911.74 METS ($SD = 2404.74$) per week at Time 1 and 2,950.10 METS ($SD = 2237.54$) per week as measured at Time 2 ($t(198) = –0.28$, $p = .78$; $d = 0.02$; see Table 1). Save for negative affect, this sample reported HWB, EWB, and psychological need satisfaction in physical activity contexts above the theoretical midpoint per instrument (see Table 1). Bivariate correlations with corresponding confidence intervals (see Table 3) indicated a pattern of small-to-moderate positive relationships between all study variables. The notable exception was the divergent relationships found when well-being was conceptualised as negative affect, as weak negative associations with change in HEPA and psychological need satisfaction ($p > .05$) were evident.

Main Analyses

A series of simple linear regression analyses were used to investigate whether change in HEPA (ΔHEPA) over a 6-month period was associated with hedonic and eudaimonic well-being. Data were screened for outliers and cases deleted if values exceeded |3.30| standard deviations from the mean variable score (Tabachnick & Fidell, 2007). In total, seven cases for negative affect were removed.[5] Results of the analyses demonstrated that ΔHEPA

[5] Linear regression analyses were conducted with the seven outliers for negative affect included. Results of the analyses demonstrated that change in HEPA accounted for negligible variance in negative affect ($R^2_{adj} = .01$; $F(1, 196) = 1.90$; $p = .17$). The beta coefficient was ($\beta = –.10$).

TABLE 3
Bivariate Correlations between Study Variables—Study 2

Variables	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1. HWB—Satisfaction with Life	–								
2. HWB—Positive Affect	.22 (.08–.35)	–							
3. HWB—Negative Affect	.03 (–.11–.17)	–.11 (–.25–.03)	–						
4. EWB—Positive Growth	.21 (.07–.34)	.22 (.08–.35)	–.08 (–.22–.06)	–					
5. EWB—Purpose in Life	.33 (.20–.45)	.23 (.09–.36)	–.27 (–.39––.14)	.57 (.47–.66)	–				
6. PNSE—Competence	.33 (.20–.45)	.27 (.14–.39)	.07 (–.07–.21)	.18 (.04–.31)	.29 (.16–.41)	–			
7. PNSE—Autonomy	.25 (.12–.38)	.20 (.06–.33)	.02 (–.12–.16)	.26 (.13–.39)	.30 (.17–.42)	.38 (.26–.49)	–		
8. PNSE—Relatedness	.23 (.09–.36)	.17 (.03–.30)	.00 (–.14–.14)	.23 (.09–.36)	.31 (.18–.43)	.21 (.07–.34)	.22 (.08–.35)	–	
9. ΔHEPA	.36 (.23–.48)	.39 (.27–.50)	–.10 (–.24–.04)	.29 (.16–.41)	.34 (.21–.46)	.46 (.34–.56)	.30 (.17–.42)	.19 (.05–.32)	–

Note: HWB = Hedonic well-being; EWB = Eudaimonic well-being; PNSE = Psychological Need Satisfaction in Exercise; ΔHEPA = Standardised Residual of Health-enhancing physical activity Time 1—Time 2. Sample size ($N = 198$) is consistent across each element in the lower diagonal and principal diagonal of the matrix. All r's greater than |.12| significant at $p < .05$ (one-tailed) and |.15 | significant at $p < .01$ (one-tailed).

TABLE 4
Multiple Regression Analysis Predicting Well-Being from Change in HEPA across a 6-Month Period

Variable	R^2_{adj}	β	p	η^2	*95% CI*
HWB—Satisfaction with Life:		Model (F(1, 196) = 24.73, p = .01)			
	0.11	0.34	0.01	0.11	0.25– 0.57
HWB—Positive Affect:		Model (F(1, 196) = 36.02, p = .01)			
	0.15	0.39	0.01	0.16	0.21–0.41
HWB—Negative Affect:		Model (F(1, 189) = 7.03, p = .01)			
	0.03	–0.19	0.01	0.04	–0.21––0.03
EWB—Positive Growth:		Model (F(1, 196) = 18.10, p = .01)			
	0.08	0.29	0.01	0.08	0.09–0.26
EWB—Purpose in Life:		Model (F(1, 196) = 25.99, p = .01)			
	0.11	0.34	0.01	0.11	0.10–0.22

Note: HWB = Hedonic well-being; EWB = Eudaimonic well-being. *N*s ranged from 191 to 198 depending on analysis; R^2_{adj} = Adjusted *R*-squared value from each regression model. β = Standardised Beta Coefficients. p = Probability value. F = F-statistic. η^2 = partial eta squared. 95% CI = Confidence Intervals surrounding β.

predicted a proportion of the variance accounted for in each well-being index (R^2_{adj} values ranged from 0.03 to 0.15; p = .01; η^2 = 0.04–0.16). All relationships were in the expected direction (see Table 4) such that increases in HEPA across the 6-month period were associated with increases in positive well-being markers (βs ranged from 0.29 to 0.39). Increased HEPA was further associated with lower negative affect (β = –0.19), with the 95 per cent confidence interval spanning zero in this regression model.

Results of the bootstrapping procedure to test for multiple mediation can be found in Table 5. With HWB markers serving as the criterion variables, psychological need satisfaction mediated the ΔHEPA–satisfaction with life (R^2_{adj} = 0.16; point estimate = 0.1628; BCa CI = 0.0771 to 0.2613) and ΔHEPA–negative affect relationships (R^2_{adj} = 0.05; point estimate = 0.0581; BCa CI = 0.0152 to 0.1135). The BCa CI spanned zero (–0.0009–0.1250) when examining the ΔHEPA–positive affect relationship (R^2_{adj} = 0.16; point estimate = 0.0548). Interpretation of the specific indirect effects indicated that perceived competence and relatedness served as unique mediators in the relationship between ΔHEPA and satisfaction with life. The fulfilment of competence in physical activity contexts was a unique mediator in the ΔHEPA–negative affect relationship. However, consideration of the pair-wise contrasts for each psychological need suggested that the magnitude of the effects was comparable (i.e. the BCa 95 per cent CI spanned zero, and therefore was deemed not statistically significant) regardless of HWB marker.

Results revealed that psychological need satisfaction mediated the ΔHEPA–purpose in life relationship (R^2_{adj} = 0.20; point estimate = 0.0575; BCa CI = 0.0198 to 0.1009). In contrast, the ΔHEPA–personal growth

TABLE 5
Bootstrapped Indirect Effects of Change in HEPA on Well-Being through Psychological Need Satisfaction

Variable	*Point Estimate*	*BCa CI*	R^2_{adj}
HWB—Satisfaction with Life			.16**
Total	.163	.077–.261	
PNSE—C	.095	.009–.195	
PNSE—A	.036	–.024–.107	
PNSE—R	.032	.006–.079	
C1	.058	–.075–.198	
C2	.063	–.027–.166	
C3	.004	–.070–.079	
HWB—Positive Affect			.16**
Total	.054	–.001–.125	
PNSE—Competence	.031	–.021–.092	
PNSE—Autonomy	.012	–.026–.059	
PNSE—Relatedness	.012	–.004–.039	
C1	.020	–.006–.105	
C2	.019	–.038–.081	
C3	–.001	–.045–.050	
HWB—Negative Affect			.05*
Total	.058	.015–.114	
PNSE—Competence	.047	.003–.103	
PNSE—Autonomy	.013	–.016–.044	
PNSE—Relatedness	–.001	–.020–.016	
C1	.034	–.026–.102	
C2	.048	–.001–.107	
C3	.014	–.024–.053	
EWB—Positive Growth			.12**
Total	.045	–.004–.099	
PNSE—Competence	–.004	–.050–.043	
PNSE—Autonomy	.030	.006–.062	
PNSE—Relatedness	.019	.003–.047	
C1	–.034	–.094–.024	
C2	–.022	–.076–.028	
C3	.012	–.024–.047	
EWB—Purpose in Life			.20**
Total	.058	.020–.100	
PNSE—Competence	.017	–.015–.052	
PNSE—Autonomy	.021	.003–.048	
PNSE—Relatedness	.019	.005–.043	
C1	–.005	–.052–.039	
C2	–.002	–.042–.035	
C3	.002	–.029–.029	

Note: HWB = Hedonic well-being; EWB = Eudaimonic well-being; PNSE = Psychological Need Satisfaction in Exercise. C1 = contrast between competence and autonomy, C2 = contrast between competence and relatedness and C3 = contrast between autonomy and relatedness. Number of bootstrap resamples = 5,000. BCa CI = Bias Corrected and Accelerated Confidence Intervals. * $p = .01$; ** $p = .001$.

($R^2_{adj} = 0.12$; point estimate = 0.0450; BCa CI = –0.0035 to 0.0994) relationship was not mediated by psychological need fulfilment. Regardless of EWB criterion, perceived autonomy and relatedness demonstrated unique effects. Interpretation of the pair-wise contrasts for each psychological need suggested that the magnitude of the effects was comparable (i.e. the BCa 95 per cent CI spanned zero).

Summary of Study 2

The aim of Study 2 was to examine whether changes in HEPA across a 6-month period were associated with well-being. Results of the regression analyses revealed that increases in HEPA were associated with greater levels of well-being in women enrolled in undergraduate courses. Changes in HEPA were differentially linked with markers of HWB and EWB in this sample of young women. Study findings are consistent with Deci and Ryan's (2002) contention that the fulfilment of each psychological need has a direct relationship with well-being. Of further theoretical interest, the satisfaction of the psychological needs for competence, autonomy, and relatedness mediated the HEPA–well-being relationship across many of the well-being indices (Study 2).

GENERAL DISCUSSION

The relationship between HEPA and well-being in a sample of undergraduate women was investigated in two studies. Consistent with our original hypotheses and existing literature (Gunnell et al., 2011; Wilson et al., 2009), results suggested that physical activity was associated with feelings of satisfaction with life, positive affect, and EWB. Negligible associations were evidenced between HEPA and negative affect. Addressing calls for the inclusion of theory in research (e.g. Bauman, Sallis, Dzewaltowski, & Owen, 2002), results of this study based on BPNT (Deci & Ryan, 2002) supported study hypotheses, as HEPA contexts which facilitate the satisfaction of the need for competence, autonomy, and relatedness are associated with greater well-being. As such, study findings lend credence to Deci and Ryan's (2002) contention that satisfaction of key needs in a given domain exerts a universal effect on promoting feelings of well-being.

Consistent with the hypothesised relationship, greater HEPA was generally associated with higher well-being. However, considerable variation was evident with respect to the magnitude with observed relationships corresponding with weak-to-moderate effect sizes (Cohen, 1988). While speculative, the stronger magnitude of association between HEPA and well-being observed in Study 2 may be associated with the lower (on average) physical activity levels of individuals comprising this sample. The nature of the

physical activity–well-being relationship in the present investigation is aligned with conclusions derived from exercise interventions in healthy individuals (Gillison et al., 2009). One finding of note in the present investigation was the support for the relationship between naturally occurring changes in HEPA on well-being, as opposed to structured exercise interventions. This finding offers increased flexibility for health promotion specialists when recommending strategies to increase well-being. Given the diverse activities comprising HEPA, recommendations specific to active transportation and strategies at work (e.g. taking the stairs as opposed to the elevator) can be encouraged as ways of increasing physical activity levels. Further, activities tailored to an individual's preferences and interests (e.g. gardening) can be built into any physical activity programme.

Two notable exceptions to the HEPA–well-being relationship warrant additional consideration. Aligned with existing literature (e.g. Oztekin & Tezer, 2009; Watson, 1988; Wilson et al., 2009), negative affect was not associated with HEPA, with some variability in direction and magnitude noted across the two studies comprising this investigation. Increases in HEPA across the 6-month time period were minimally (albeit significantly) associated with lower negative affect. The above may be perceived as surprising given the magnitude of the relationship between increased physical activity and decreased ill-being symptomology (e.g. depression; Barbour, Edenfield, & Blumenthal, 2007) reported in the literature. Additional insight into the nature of the physical activity–ill-being relationship was advanced by Conn (2010) who suggested that physical activity may be associated with greater mood improvement in individuals living with a clinical diagnosis of depression as opposed to findings emanating from "healthy" individuals. Given the cohort recruited in the present investigation, the nature of the observed relationship between HEPA and negative affect may not be surprising, and warrants further clarification in the literature.

A second inconsistency to hypotheses guiding the present investigation was the non-significant association between HEPA and the EWB marker of autonomy (Study 1). As defined by Ryff (1989), autonomy includes perceptions of personal conviction and independence. When considered with diverse estimates of health (e.g. waist to hip ratio, cholesterol levels, markers of inflammation), no association with autonomy has been demonstrated (Friedman, Hayney, Love, Singer, & Ryff, 2007; Ryff et al., 2004). Extending to the broader physical activity–well-being literature, the relationship between fulfilment of the psychological need for autonomy as advanced by Deci and Ryan (2002) and physical activity behaviour (Wilson et al., 2008b) has been demonstrated. The conceptualisation of autonomy across studies may be at the root of differences noted. Consistent with Deci and Ryan (2002), an individual is autonomous if behaviour is willingly enacted and is in accord with personal interests, values, and desires. Conclusions resulting from the

slightly discrepant conceptualisations advanced (i.e. Deci & Ryan, 2002; Ryff, 1989) should not be confounded. Thus, the association between the EWB of autonomy as conceptualised by Ryff (1989) on health-related variables deserves further elucidation.

Deci and Ryan (2002) assert that the fulfilment of the psychological needs for competence, autonomy, and relatedness represent necessary conditions for the promotion of well-being. An examination of the data in Study 2 indicates that greater experiences of need satisfaction in HEPA contexts were associated with greater well-being. Again, when negative affect served as the index of HWB, a divergent pattern of results was noted in comparison to those reported for positive affect or satisfaction with life. This finding may be linked to arguments advanced by Sheldon and Bettencourt (2002) suggesting that psychological needs may be associated with maximising well-being as opposed to the absence of negative well-being.

Feeling competent, a sense of autonomy, and being securely related to others is essential as each psychological need is hypothesised to exert a unique direct effect on markers of well-being (Deci & Ryan, 2002). When interpreting results of the meditational models, the three psychological needs mediated the HEPA–well-being relationship with the exception of positive affect and positive growth. Reasons for these discrepant findings may be linked to the dynamic nature of positive affect and positive growth[6] in comparison to well-being markers aligned with cognitive evaluations (e.g. satisfaction with life and purpose in life; Ryan et al., 2008; Ryff & Singer, 2008). A second possibility is the confounding influence of personality traits on specific aspects of well-being. For example, introverts are less likely than extraverts to experience positive affect (DeNeve & Cooper, 1998). Consideration of personality characteristics may have implications for understanding factors associated with the promotion of positive affect including the fulfilment of psychological needs.

It has been suggested (e.g. Waterman, 1993) that the fulfilment of specific individual psychological needs (e.g. competence) may lead to HWB but represent insufficient conditions for the promotion of EWB. Simple consideration of point estimates and their corresponding BCa CIs embedded within the multiple mediation analyses may lend some credence to the above contentions. When HWB markers were considered, feelings of effectance and skill mastery, which defines perceived competence, emerged as the dominant predictor, with significance noted for satisfaction with life and negative affect. The influence of

[6] Some debate in the literature exists as to whether positive growth reflects a dynamic (Ryff & Singer, 2008) or a more stable construct (Vittersø, Søholt, Hetland, Thoresen, & Røysamb, 2010). Given the conceptualisation of positive growth guiding study objectives and the selection of instrumentation, we have retained Ryff and Singer's (2008) identification of the dynamic nature of positive growth.

the psychological need for competence as being associated with well-being outcomes in the exercise literature is not uncommon (Wilson et al., 2008b). Experiences of social connectedness (i.e. relatedness) served as a unique mediator when satisfaction with life served as the outcome variable of interest. Finally, feelings of being autonomous and socially connected with others in physical activity contexts were the strongest mediators when eudaimonic outcomes were considered. Results of the present investigation, in tandem with Reinboth, Duda, and Ntoumanis (2004), suggested that the fulfilment of the need for autonomy may be a necessary condition for the promotion of EWB. Future research may want to continue to examine the unique role of each psychological need in the promotion of hedonic and eudaimonic outcomes.

While the results of this investigation hold theoretical and practical merit, a number of limitations require acknowledgement to advance our understanding of psychological need fulfilment and well-being in physical activity contexts. First, conclusions are advanced based on a posited unidirectional relationship between HEPA and well-being (i.e. changes in HEPA are associated with increased well-being) and precludes the possibility of a bi-directional relationship. Consistent with their review, Lyubomirsky, King, and Diener (2005) suggested that those who report greater well-being are more likely to engage in physical activity. Such a conclusion cannot be ruled out given the design of the present investigation. Second, data collection procedures included non-probability based sampling which limits inferences that can be drawn from statistical tests and claims of external validity. Consequently, conclusions warrant replication and extension adopting greater diversity in demographic cohorts and sampling procedures. Third, the present investigation relied exclusively on self-report methods, which are susceptible to response bias and distortion from common methods variance (Campbell & Fiske, 1959). Finally, in the absence of an instrument to assess psychological need satisfaction in HEPA, a modified instrument (i.e. PNSE; Wilson et al., 2006) was adopted. Measurement experts (Crocker & Algina, 1986) have discouraged the use of modified instruments over concerns to item content relevance and representation that may translate into confounded appraisals of construct validity.

Overall, the results of the present studies make it apparent that engagement in HEPA was associated with well-being, with variation in the magnitude of the relationship noted. These findings were supported through interpretation of study findings when considering both a cross-sectional design and changes in HEPA across a 6-month time period. Study findings further supported the role of psychological need satisfaction in the HEPA–well-being relationship. Given the nature of study designs and the homogeneous sampling frame, continued investigation into the HEPA–well-being relationship is warranted. Future calls examining the role of unique individual needs, relative to others, in the promotion of well-being are advocated.

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