Health Education Research Advance Access published October 1, 2014
HEALTH EDUCATION RESEARCH 2014
Pages 1–12

Short- and long-term theory-based predictors of physical activity in women who participated in a weight-management program

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Received on March 18, 2014; accepted on August 28, 2014

Abstract

This study analyzed psychosocial predictors of the Theory of Planned Behavior (TPB) and Self-Determination Theory (SDT) and evaluated their associations with short- and long-term moderate plus vigorous physical activity (MVPA) and lifestyle physical activity (PA) outcomes in women who underwent a weight-management program. 221 participants (age 37.6 ± 7.02 years) completed a 12-month SDT-based lifestyle intervention and were followed-up for 24 months. Multiple linear regression analyses tested associations between psychosocial variables and self-reported short- and long-term PA outcomes. Regression analyses showed that control constructs of both theories were significant determinants of short- and long-term MVPA, whereas affective and self-determination variables were strong predictors of short- and long-term lifestyle PA. Regarding short-term prediction models, TPB constructs were stronger in predicting MVPA, whereas SDT was more effective in predicting lifestyle PA. For long-term models, both forms of PA were better predicted by SDT in comparison to TPB. These results highlight the importance of comparing health behavior theories to identify the mechanisms involved in the behavior change process. Control and competence constructs are crucial during early adoption of structured PA behaviors, whereas affective and intrinsic sources of motivation are more involved in incidental types of PA, particularly in relation to behavioral maintenance.

Background

Although overweight and obesity were identified as an international public health problem a decade ago, subsequent strategies to reduce these levels have failed to make a significant impact [1]. The prevalence among European adults is increasing and Portugal is no exception, with a combined prevalence of overweight and obesity of 58% in females and 66% in males (18–64 years) [2]. Portugal also displays the highest percentage (88%) of sedentary lifestyles [3] and lowest prevalence (41%) of physical activity (PA) during leisure time [4] in Europe.

Since the effects of theory-driven PA interventions are generally short-lived, identification of mechanisms associated with behavioral 'maintenance' is crucial [5, 6]. Despite the existence of numerous health behavior theories, no agreement exists on which of these theories are most valuable in explaining behavior change, particularly in the long term. Comparing theories might be a promising

doi:10.1093/her/cyu060

approach, as it helps to better understand the multiple processes by which people change behavior—which different theories describe in partially unique ways—while it may potentially improve the development of theory-driven interventions. Despite their potential usefulness, few empirical theory comparisons exist [7]. In investigating the predictive ability of four health behavior theories regarding weight control, a study revealed that theories comprising self-efficacy were the most predictive of short-term weight change, whereas exercise-related psychosocial, especially SDT-based, variables became more relevant regarding long-term weight outcomes [8]. Furthermore, examining how self-determined motivation changed as diabetes type 2 patients moved through the exercise stages of change within 6 months, showed that those patients who progressed further expressed more self-determined regulations, in comparison to those that did not progress through the stages of change [9].

These findings emphasize that while some theories might contribute to our understanding of how best to encourage an individual to initially adopt a new behavior, a second theory (or set of theories) might further contribute to our understanding of how an individual maintains that acquired behavior over time [10]. Two popular health behavior theories are the Theory of Planned Behavior (TPB, [11]), focusing on predicting behavioral intention and initiation [12], and Self-Determination Theory (SDT, [13, 14]), often proposed to explain behavioral maintenance.

The TPB, a social-cognitive theory, posits that an individual's expectations and values about engaging in a certain behavior form their behavioral, normative and control beliefs. These beliefs, in turn, influence people's 'attitude' (a person's overall positive or negative evaluation of the target behavior), 'subjective norm' (a person's expectations that significant others want one to engage in the target behavior) and 'perceived behavioral control' (a person's overall judgment as to whether one has the ability to engage in the target behavior) toward their 'intention', an indication of an individual's readiness to perform a given behavior. Intention then predicts behavior, an individual's observable response in a given situation with respect to a given target [11]. Apart from its interactive effects (with intentions) on behavior, perceived behavioral control is held to exert also a direct effect on behavior [11, 12]. The TPB has been applied extensively in the domain of exercise, with reviews confirming consistent associations between TPB constructs and PA [15, 16]. Despite this supporting evidence considering the ability of TPB to predict the initiation of behavior, its predictive ability of long-term behavioral sustainment is limited [17].

SDT, a theory of human motivation, states that motivation varies to the extent to which it is perceived as controlled or autonomous. Consequently, insight into long-term behavior change requires an understanding of the underlying internalization process; a process by which individuals assimilate and transform formerly external regulations into regulations that are more integral to the self [18]. Consequently, SDT accounts for the quality of motivation, and can be depicted on a continuum from higher self-determined forms of motivation to the least autonomous forms. 'Intrinsic motivation' exists when people engage in activities that they find pleasurable and interesting, in the absence of separable outcomes; 'integrated regulation' is characterized by accepting the importance of a certain behavior and the integration of this importance with other meaningful aspects of life; 'identified regulation' is present when one identifies with the behavior's value and accepts it as one's own; 'introjected regulation' reflects engagement in behavior to gain approval/praise, to protect self-esteem, or to avoid feelings of guilt; 'external regulation' involves acting to obtain external rewards, to avoid punishment or to comply with social pressure. 'Amotivation' is present when one displays a lack of motivation, and acts without intending to achieve an outcome [13].

SDT additionally addresses the mechanisms that facilitate the development of motivation, suggesting that even controlled regulations can be transformed into autonomous motivation if the social context is successful in satisfying the needs for autonomy, competence and relatedness [13]. Previous SDT-focused exercise research revealed that an autonomy-supportive environment is positively associated with need satisfaction and self-determined regulations for

exercise [13, 19]. If need satisfaction is perceived, internalization of behavior and behavioral maintenance occurs [20].

Despite the support for both theories in predicting exercise behavior, empirical and methodological limitations still exist [12]. The majority of research is cross-sectional in type, thus limiting the ability to confirm causal links between constructs. In the few existing prospective studies, time frames between initial and subsequent assessment of behavior rarely exceeded 1 month [12]. Therefore, longitudinal studies are required that allow more time to observe changes in motivational and behavioral processes [21].

This study aims at comparing the predictive ability of the TPB and SDT for short- and long-term adherence to two types of PA in overweight women that underwent a weight-management program. The following hypotheses have been established: (i) it is expected that perceptions of control and self-efficacy predict short-term PA outcomes better than intrinsic and affective constructs and (ii) it is assumed that intrinsic and affective constructs are stronger in predicting long-term PA outcomes. No specific hypotheses are formulated regarding the two types of activity.

Method

Study design

The study was set within the context of a longitudinal randomized controlled trial, involving a 1-year behavior change intervention aimed at weight control management and a 2-year follow-up period without intervention. A detailed description of the study protocol, the intervention and the applied behavior change strategies are described elsewhere [22]. The Ethics Committee of the Faculty of Human Kinetics in Lisbon approved the study and participants gave written informed consent prior to participation.

Intervention

Participants were randomly assigned to an intervention or control group. The controls received a general health education curriculum, developed for ethical reasons and attrition prevention. The intervention sessions, aiming to increase PA and adopt a diet consistent with a moderate energy deficit, were delivered in compliance with SDT tenets, focusing on enhancing autonomous regulation and competence toward exercise and weight control [23]. An autonomy-supportive environment was created by providing participants with structure and options to choose from, supporting their autonomous decisions during the program, and encouraging them to explore their own goals for treatment while limiting external contingencies and controls (e.g. rewards and praise).

Participants

Participants were recruited from the community by means of media and web advertisements and had to be female, between 25 and 50 years old, premenopausal, with a body mass index (BMI) between 25 and 40 kg/m^2 (BMI $>30.0\,kg/m^2$ regarded as obesity), disposed to attend weekly meetings (for 1 year), free from major disease and not taking medication known to interfere with weight regulation. A total of 239 women were available for the study (valid sample). Follow-up data were available for 4 ($n = 220$), 12 ($n = 208$, intervention's end) and 36 months ($n = 156$; 24 months after the intervention's end). Overall retention rate was 71%.

Measurements

A large battery of psychometric instruments was used; of which all were validated Portuguese-language versions for the constructs under investigation. Preliminary validations of the selected psychometric battery proved to be reliable, internally consistent and valid (P. A. Vieira, C. S. Minderico, M. N. Castro, *et al.*, unpublished results). Exercise-related SDT variables were grouped into three categories: needs satisfaction, motives and regulations for exercise. Since the present study is merely interested in self-determined predictors of PA behavior, only autonomous regulations and intrinsic motives were used. Demographic variables were assessed at baseline; psychosocial variables at 4 and 12 months. PA outcomes were measured

at 12 months (short-term PA outcomes) and 36 months (long-term PA outcomes).

Needs satisfaction for exercise

The 'locus of causality for exercise scale' [24] measured the perceived autonomy of the participants regarding the performance of PA with three items ($\alpha = 0.81$). Participants for example indicated the degree to which they felt that they chose themselves to exercise, rather than being forced to do it. Response options were scored on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), resulting in a total score (range from 3 to 21), with higher scores indicating a more internally perceived locus of causality (or greater autonomy).

The 'intrinsic motivation inventory' [25] assessed participants' subjective experience related to exercise in the dimension of perceived competence (e.g. 'I think I do pretty well at physical activities compared with others'; $\alpha = 0.74$) by means of four items. Response options ranged from 1 (strongly disagree) to 5 (strongly agree) on a 5-point Likert scale, resulting in a total score where higher scores indicated a more self-regulated type of motivation (greater control).

The need for relatedness was omitted since engaging in solitary exercise is a frequent occurrence, and these are situations in which the need for relatedness is largely irrelevant for motivation.

Motives for exercise

The 'exercise motives inventory-2' [26] assessed motives for exercise participation. The total scale includes 51 items, which can be grouped into 14 different subscales. The following statement was given: 'Personally, I exercise (or might exercise) . . .' and the response options ranged from not at all true for me (0) to very true for me (5) on a 5-point Likert scale. Of the 14 subscales, only the motives of stress management ($\alpha = 0.87$), revitalization ($\alpha = 0.83$), enjoyment ($\alpha = 0.87$), challenge ($\alpha = 0.75$), affiliation ($\alpha = 0.84$), ill-health avoidance ($\alpha = 0.76$), nimbleness ($\alpha = 0.83$) and positive health ($\alpha = 0.83$) were used, with ill-health avoidance, nimbleness and positive health combined to an additional subscale reflecting health/fitness motives ($\alpha = 0.90$) for exercise. Each subscale was scored separately, with higher values representing more intrinsic motives for exercise.

Exercise regulations

The 'exercise self-regulation questionnaire' [27] measured domain-specific individual differences in regulations. Autonomous regulation ($\alpha = 0.91$), defined by identified regulation (e.g. 'Because it feels important to me personally to accomplish this goal'; $\alpha = 0.79$) and intrinsic motivation (e.g. 'Because it is a challenge to accomplish my goal', 'Because it is fun'; $\alpha = 0.83$), was assessed by means of eight items. Each subscale contained four items and participants indicated how they felt on a 7-point Likert scale, with response options ranging from 1 (not at all true) to 7 (very true). Each subscale was scored separately, with higher scores indicating a more identified or intrinsic type of regulation, respectively.

TPB measures

The TPB exercise-related variables were assessed by means of 18 items, measuring 'attitude' (7 items; $\alpha = 0.84$; e.g. 'For me, exercising regularly within the next six months will be . . .' on a 7-point Likert scale, ranging from 1 [very pleasant] to 7 [very unpleasant]), 'subjective norms' (3 items; $\alpha = 0.86$; e.g. 'People that are important to me, think that I should engage in regular PA within the next six months'; on a 7-point Likert scale, ranging from 1 [totally disagree] to 7 [totally agree]), 'perceived behavioral control' (5 items; $\alpha = 0.86$; e.g. 'For me personally, engaging in regular PA within the next six months will be . . .' on a 7-point Likert scale, ranging from 1 [very easy] to 7 [very difficult]) and 'intention' (3 items; $\alpha = 0.56$; e.g. 'My personal goal is, to engage in regular PA within the next six months'; on a 7-point Likert scale, ranging from 1 [totally disagree] to 7 [totally agree]). Each scale was scored separately. Higher scores represented more positive attitudes, stronger subjective norms, more perceived behavioral control and stronger intentions toward PA, respectively.

Physical activity

To determine duration and intensity of PA, the 7-day PA recall (7 Day-PAR [28, 29]) was used. Trained interviewers asked the participants to recall time spent doing PA for the past 7 days (or a typical week of the last month, if the last week was an atypical one), thereby guiding the participants through the recall process, day by day. The reliability and validity of the 7 Day-PAR as a mean to assess PA have been supported by previous studies [27]. Activity reports were converted into total minutes of moderate plus vigorous physical activity (MVPA) (metabolic equivalent [METs] [>3.0] in a week [30]).

The lifestyle physical activity index (LPAI) was developed to assess the extent to which women choose effortful—yet mindful and volitional—physically active behaviors during daily life routines, over less demanding sedentary behaviors; a dimension frequently omitted by self-reported PA assessments, as those do not account for lower-intensity daily PA [22]. Initial validation of the LPAI is available elsewhere (S. P. Mullen, M. N. Silva, P. J. Teixeira, in preparation). The LPAI is a self-administered instrument that assesses habitual lifestyle physical activities typical of the last month. A score is used based on seven questions ($\alpha = 0.83$) to compute the index (using stairs instead of escalators; walking instead of using transportation; parking away from a destination; being physically active during work breaks; choosing to stand up instead of seated; choosing hand work instead of mechanical/automatic and choosing to be physically active whenever possible). Participants in this study completed the LPAI to indicate how often they had chosen each of the activities described within the previous month. Response options ranged from 'never' (1) to 'always' (5) on a Likert-type scale. Higher scores indicated more engagement in lifestyle PA.

Statistical analysis

Analyses were carried out using IBM SPSS 20.0 software. Descriptive analyses were conducted using baseline data and internal consistency estimates were calculated using 4-month data. Our sample size ($N = 239$) was above minimal required levels for power for 0.8, and a two-tailed $P < 0.05$, based on changes in moderate and vigorous and in SDT-based motivational variables (for which we had related data previous to the trial). Analyses were conducted for completers-only since data would be missing for both independent and dependent variables in multiple imputation intention to treat models; this would render analyses with imputed data redundant with completers-only analyses. Independent sample *t*-tests were carried out to analyze differences between SDT and TPB variables, and PA between intervention and control groups, at 4 and 12 months and for PA levels additionally at 36 months. These time points are justified by the absence of several SDT measurement constructs at baseline and missing TPB follow-up data. Given that most participants were sedentary at baseline, responses to self-regulation (I exercise because I . . .) and perceived need support (I feel that the staff has . . .) were deemed as less valid at baseline and consequently not used for further analysis. Partial correlations were computed and adjusted for group participation.

Multiple regression models were used to produce multivariate estimates of the associations between psychosocial predictors and PA changes, each corrected for age, educational level and group allocation; with group explaining a great amount of the variance in PA behavior (both types) across all assessed time points and analyzed theory-based constructs. *A priori* hierarchical regression models were used, entering variables in successive blocks, either forced in or presented to the model in stepwise fashion. TPB and SDT variables were presented separately to the multivariate models for 12 and 36 months PA outcomes. After forced entry of demographic variables, needs for exercise, followed by motives, regulations and finally the full SDT model were presented separately to the model (stepwise) in Step 2, which allows assessing the relative contribution of each block of variables and the predictive ability of the overall model. TPB variables were presented to the model in the same way. As intention is regarded as the most proximal predictor

of behavior within the TPB, functioning like a mediator while capturing the influences of attitude, subjective norm, and perceived behavioral control, two different models were established, one excluding intention and one including it.

Results

No significant differences in demographics (age, marital status and education), weight, BMI or PA levels at baseline were found between the intervention group and control group ($P > 0.05$). The average age of the final sample was 37.6 (SD 7.02) years. Mean weight was 81.9 (SD 12.0) kg and 62.4% of participants were obese. At baseline, women reported to engage in an average of 99.66 min/week (SD 138.9) of MVPA and scored an average of 2.71 (SD 0.80) for lifestyle PA. For the purpose of the present analysis, all further results are presented with the two groups collapsed.

Short-term PA outcomes

Bivariate analyses

Results of partial correlations are given in Table I. Most SDT and TPB variables were positively associated with short-term MVPA. Perceived competence, intrinsic motivation, perceived behavioral control and intention showed stronger associations with short-term MVPA than motives and attitude for exercise did.

Positive and significant associations were found for most self-determination and affective constructs regarding short-term lifestyle PA. Autonomous regulations, enjoyment and revitalization motives, perceived autonomy, attitude and intention showed the strongest partial correlations.

Multivariate analyses

Results of multiple regression analyses for MVPA are presented in Table II. Control constructs and self-determination motivational constructs explained engagement in short-term MVPA. Regarding SDT models, perceived autonomy and intrinsic motivation explained similar amounts of the total variance in PA behavior; the full SDT model (R^2 22.8%; $P < 0.001$) however showed that perceived competence and intrinsic motivation explained PA behavior. TPB regression analyses indicated that engagement in MVPA at 12 months was explained by more perceived behavioral control toward exercising.

Results regarding multiple regression analyses for lifestyle PA are shown in Table III. Self-determination and affective constructs explained short-term lifestyle PA exclusively. SDT models explained similar amounts of variance in lifestyle PA, with

Table I. *Correlation between psychosocial variables and short- and long-term PA outcomes*

	Short-term prospective[a]		Long-term prospective[b]	
Psychosocial variables	MVPA	LPAI	MVPA	LPAI
Self-Determination Theory				
Needs satisfaction in exercise				
Perceived autonomy	0.17*	0.24**	0.16*	0.43***
Perceived competence	0.26***	0.14	0.24**	0.37***
Motives for exercise				
Stress management	0.01	0.25**	0.07	0.33***
Revitalization	0.03	0.34***	0.08	0.40***
Enjoyment	0.13**	0.28***	0.15	0.40***
Challenge	0.15*	0.27***	0.12	0.19
Affiliation	0.12*	0.21**	0.20*	0.40***
Health/fitness	−0.04	0.17*	0.02	0.28**
Exercise regulations				
Identification	0.15*	0.22**	−0.01	0.27**
Intrinsic	0.26***	0.31***	0.12	0.45***
Autonomous	0.23**	0.29***	0.07	0.40***
Theory of Planned Behavior				
Attitude	0.19**	0.22**	0.07	0.43***
Social norm	0.07	0.05	−0.01	0.06
Perceived behavioral control	0.37***	0.16*	0.17*	0.24**
Intention	0.30***	0.20*	0.23***	0.43***

MVPA, Moderate plus Vigorous Physical Activity; LPAI, Lifestyle Physical Activity Index. [a]Four months psychosocial variables and 12 months PA outcomes. [b]12 months psychosocial variables and 36 months PA outcomes. Partial correlation adjusted for group; *$P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table II. *Multiple regression analysis for MVPA—summary table*

	MVPA					
	Prospective[a]			Prospective[b]		
Psychosocial variables	β	P	R^2	β	P	R^2
Self-Determination Theory						
Needs			0.215***			0.134***
Autonomy	0.280	<0.001				
Competence				0.265	0.001	
Motives			0.163***			0.100**
Enjoyment	0.136	0.048				
Affiliation				0.196	0.015	
Regulations			0.202***			
Intrinsic motivation	0.267	<0.001				
Full model			0.228***			0.132***
Competence	0.183	0.026		0.271	0.001	
Intrinsic motivation	0.180	0.033				
Theory of Planned Behavior						
Perceived behavioral control	0.352	<0.001	0.242***	0.182	0.038	0.093**
Full TPB						0.112**
Perceived behavior	0.352	<0.001	0.242***			
Control						
Intention				0.223	0.007	

In each model, age, education and group were forced in the model at Step 1, followed by separately entered needs, motives and regulations variables in Step 2 (stepwise). In the full model, all SDT variables were presented together to the model at Step 2 (stepwise). In the TPB models, after forced entry age, education, and group, attitude, social norm and perceived behavioral control were entered to the model at Step 2 (stepwise). In an additional model, intention was also added to the other TPB variables at Step 2. MVPA = Moderate plus Vigorous Physical Activity. [a]Four months psychosocial variables and 12 months PA outcomes. [b]12 months psychosocial variables and 36 months PA outcomes. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

perceived autonomy, revitalization, affiliation motives and intrinsic motivation being significant predictors of PA assessment. The full SDT model (R^2 39.8%; $P < 0.001$) showed that women who engaged in lifestyle PA frequently had higher revitalization motives. Considering TPB, analyses revealed that women who engaged in lifestyle PA more often had more positive attitudes toward exercising.

Long-term PA outcomes

Bivariate analyses

Partial correlations of psychosocial variables and long-term MVPA decreased over time (Table I). Only a few variables were positively and significantly associated with long-term MVPA, with perceived competence and intention showing slightly stronger associations than control constructs. Regarding long-term lifestyle PA, significant and positive correlations with need satisfaction, exercise regulations (especially intrinsic motivation), motives for exercise (revitalization, enjoyment, and affiliation), as well as most TPB, were found.

Multivariate analyses

Long-term MVPA was primarily explained by control and competence constructs. Perceived competence was the strongest predictor of long-term MVPA, being the only variable that significantly added predictive power to both the need satisfaction and full model (Table II). TPB models showed that in the model without intention, perceived behavioral control was the most influential predictor, however, the inclusion of intention in the model resulted in an increased total amount of explained variance to 11% ($P = 0.002$).

Table III. *Multiple regression analysis for LPAI—summary table*

	LPAI					
	Prospective[a]			Prospective[b]		
Psychosocial variables	*β*	*P*	R^2	*β*	*P*	R^2
Self-Determination Theory						
Needs			0.376***			0.297***
Autonomy	0.243	<0.001		0.469	<0.001	
Motives			0.423***			0.318***
Enjoyment				0.282	0.003	
Revitalization	0.267	<0.001				
Affiliation	0.125	0.048		0.249	0.005	
Regulations			0.386***			0.285***
Intrinsic motivation	0.295	<0.001		0.470	<0.001	
Full model			0.398***			0.363***
Autonomy				0.359	<0.001	
Revitalization	0.299	<0.001				
Affiliation				0.292	0.001	
Theory of Planned Behavior						
Attitude	0.233	0.001	0.356***	0.379	<0.001	0.224***
Full TPB						0.288***
Attitude	0.233	0.001	0.356***	0.229	0.027	
Intention				0.266	0.010	

In each model, age, education and group were forced in the model at Step 1, followed by separately entered needs, motives and regulations variables in Step 2 (stepwise). In the full model, all SDT variables were presented together to the model at Step 2 (stepwise). In the TPB models, after forced entry age, education, and group, attitude, social norm and perceived behavioral control were entered to the model at Step 2 (stepwise). In an additional model, intention was also added to the other TPB variables at Step 2. LPAI = Lifestyle Physical Activity Index. [a]Four months psychosocial variables and 12 months PA outcomes. [b]12 months psychosocial variables and 36 months PA outcomes. $*P < 0.05$; $**P < 0.01$; $***P < 0.001$.

Self-determination and affective constructs explained engagement in long-term lifestyle PA (Table III). Enjoyment motives and intrinsic motivation independently explained 14% and 17% of the total variance in PA ($P < 0.001$), respectively, with an increase in predictive power over time. The full SDT model (R^2 36.3%; $P < 0.001$) showed that women who engaged more often in PA perceived higher autonomy and had affiliation motives. Attitude remained the most influential predictor of the TPB in the regression model on 36 months lifestyle PA. Including intention in the model revealed that attitude and intention were significant predictors of long-term lifestyle PA.

Discussion

Two behavioral theories, SDT and TPB, were analyzed regarding their short- and long-term predictive ability for two types of PA in women who underwent a weight-management program.

Main results showed that (i) perceived need satisfaction (especially perceived competence), higher levels of intrinsic motivation (to a lesser extent), as well as perceived behavioral control, significantly and independently predicted short-term MVPA outcomes, with TPB being the theory with the stronger predictive ability; (ii) high levels of perceived autonomy, intrinsic motives, particularly feelings of enjoyment, affiliation and revitalization, greater intrinsic motivation, as well as more positive attitudes toward exercising, explained some of the variance in short-term lifestyle PA, with SDT explaining more variance in PA behavior than TPB; (iii) SDT was slightly more effective in predicting long-term behavioral engagement for both types of PA, but overall results are comparable between both theory-based models.

The current study confirmed that control constructs better predict early behavioral adoption of structured PA, showing that TPB is slightly more precise in predicting short-term MVPA outcomes, which is consistent with previous research [12]. TPB represents a deliberative processing model, in which individuals make behavioral decisions based on careful considerations of available information [31]. MVPA, reflecting structured and strenuous PA, represents behavior that requires planning, commitment and organizational skills. Given that TPB was designed to model planned, and goal-directed behavior, our results confirm that the framework is useful for explaining strenuous, planned forms of PA, especially in the short term.

Regarding short-term MVPA outcomes, findings showed that perceived behavioral control clearly predicts behavior over and above the effects of intention. Over time, the results indicated that the strong influence of perceived behavioral control decreases, suggesting that people became familiar with the behavior and experienced feelings of mastery and self-efficacy in overcoming perceived barriers, thus increasing feelings of volitional control. As soon as behavior was perceived to be under volitional control, intentions accurately predicted behavior, and control constructs became of less importance [32].

With regards to studies integrating SDT and TPB constructs, our findings of the importance of control/competence constructs in the initial phase of exercise behavior supported previous research showing that perception of self-efficacy is related to exercise adherence [19] and weight control [8], especially in early adoption stages. Collectively, these findings highlighted the importance of feelings of efficaciousness within the physical domain [12].

The literature provides good evidence for the value of SDT in understanding exercise behavior [21]. Results indicated that intrinsic sources of motivation and affective constructs explain long-term PA adherence, which confirmed our second hypothesis. Moreover, the results indicated that the satisfaction of the needs for perceived competence and autonomy plays an important role in PA maintenance over time. Notably, long-term MVPA outcomes were primarily explained by perceived competence, whereas lifestyle PA is explained by perceived autonomy and attitude, suggesting that feelings of competence and self-efficacy were more related to structured exercise, in comparison to more natural, incidental PA that appeared to rely especially on autonomous and affective forms of motivation.

Regarding motives for exercise, consistent positive associations between more intrinsic motives (e.g. affiliation and enjoyment) and exercise sustainment (MVPA and lifestyle PA) have been found, which supports previous research [33]. For instance, Ingledew *et al*. [33] reported that while weight and appearance management motives were present during early stages of behavioral change; motives like revitalization and enjoyment were more prominent regarding the progression to and sustainment of the activity. A recent systematic review concluded that having more intrinsic participation motives associated with PA, such as affiliation and social engagement, challenge and skill development, is clearly related to greater exercise participation [21].

With respect to behavioral regulations and exercise, positive correlations between autonomous forms of regulations and lifestyle PA were observed. Intrinsic motivation, in conjunction with the motives of enjoyment, affiliation and the attitude construct from TPB, showed strong associations with lifestyle PA in the long run. Indeed, research investigating the effects of behavioral regulations consistently emphasized that more fully internalized regulations were associated with higher quality of performance, greater behavioral persistence and better mental and physical health, explained by greater need satisfaction [9, 13, 34, 35].

In contrast to previous studies [17], this study confirmed the predictive ability of TPB constructs also regarding long-term PA; although the theory's predictive ability decreases slightly over time (for MVPA more drastically than for lifestyle PA). It is not surprising that TPB variables are less suitable to predict behavioral maintenance when one considers that the framework is primarily a model of intention formation and goal setting, rather than a model that

explains the translation of intention into action or goal pursuit [36]. In contrast to TPB, SDT does pay attention to goal pursuit, attainment and maintenance over time [16].

Limitations and strengths

This study is not without its limitations. Since only overweight/obese women were recruited, generalizability of results to the male population is limited. Additionally, exercise behavior was assessed through self-reported questionnaires, which are proven to be valid and reliable assessments of the PA, but can be prone to recall bias and socially desirable answers [37]. To increase precision, accuracy and counteracting issues of recall and response bias, it is suggested to apply more objective measurements of PA, such as heart rate monitors or accelerometry, additionally. It is noteworthy that the TPB measures (i.e. 'For me exercising regularly within the next 6 months . . .') and both PA measures (PA engagement in the previous 7 days) are not at the same level of specificity, which might have influenced the predictive ability of TPB. Additionally, it is important to mention that half of the sample was exposed to an intervention which was based on SDT (and especially on creating a need-supportive environment), which might partially explain the higher amount of explained variance in PA behavior by SDT variables. However, we tried to correct for this potential bias by including group allocation as a confounder in all analyses. The lack of baseline SDT psychosocial variables (justified in the 'Method' section) presents another limitation, as potential differences between the intervention and control groups regarding psychosocial variables at baseline cannot be eliminated entirely.

Strengths of the study include the unique analysis of two different types of PA at the same time, including a novel type of 'non-sedentary' daily PA behaviors. Secondly, in recognition that single-occasion reports of PA behavior are not optimal, this study provides prospective data, allowing time for motivational factors to fully develop. Finally, comparison of theories is a relatively new approach, but probably useful to identify multiple overlapping mechanisms involved in behavioral change, overcoming limitations of single-theory approaches [38]. Our results might be beneficial for extending findings from previous intervention research focusing on behavioral maintenance.

Conclusion

The present findings provide empirical support for the assertion that influencing an individual's perception of self-efficacy/competence in the behavioral adoption phase, while also ensuring intrinsic enjoyment, affiliation and autonomy, will positively contribute to PA behavior change. Feelings of self-determination might be the key to successful initiation 'and integration' of different types of PA into daily life routines for the long term. Although TPB and SDT are conceptually different, the present study suggests that their predictive ability is similar for two PA behaviors, in the context of weight control and in women, with some degree of specificity regarding type of behavior and time frame of behavior changes.

Acknowledgments

The authors wish to thank all of the women who participated in the trial for their commitment to this research project. Furthermore, they would like to thank Matthew J. Watson for professionally proofreading the English language of this manuscript prior to submission.

Funding

The Portuguese Science and Technology Foundation: [grant number FCT/POCI/DES/57705/2004] and the Calouste Gulbenkian Foundation: [grant number 65565/2004]. The authors are grateful to the Oeiras City Council, Nestlé Portugal and IBESA for their additional financial support.

Conflict of interest statement

None declared.

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