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Short- and long-term theory-based predictors of physical activity in previously overweight women

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Summary

Purpose: This study aimed at identifying psychosocial predictors of the Theory of Planned Behavior (TPB) and Self-Determination Theory (SDT), and evaluated their association with short- and long-term moderate plus vigorous physical activity (MVPA) and lifestyle physical activity (PA) outcomes in previously overweight women.

Methods: The 239 participants (age 37.6 ± 7.02 years) completed a 12-month self-determination based lifestyle intervention (71% retention), and were followed up for 36 additional months. Of these, 156 completed 36-month assessments. At 4 months as well as at 36 months, participants of the intervention group showed higher levels of MVPA (291.7 ± 224.8 min/wk and 197.2 ± 202.49 min/wk, respectively) and engaged more frequently in lifestyle PA. Validated instruments assessed psychosocial variables at 4 and 12 months. Data were analyzed using independent sample *t*-tests, and partial correlations. Multiple linear regression analyses were conducted to test associations between TPB and SDT psychosocial variables, and short- and long-term PA outcomes.

Results: Perceived competence, intrinsic motivation, perceived behavioral control (PBC), and intention constructs were strongly associated with short-term MVPA (p <0.001). Regarding short-term lifestyle PA, revitalization and enjoyment motives, intrinsic motivation, autonomous regulation and attitude were strongly related to PA outcomes (p <0.001). Perceived competence and intention were strongly associated with long-term MVPA and most SDT as well as TPB variables were associated with long-term lifestyle PA. Multiple regression analyses showed that control concepts (PBC, perceived competence) were significant and independent determinants of short-term and long-term MVPA, whereas affective, self-determined variables (perceived autonomy, enjoyment, intrinsic motivation, attitude) were strong predictors of short- and long-term lifestyle PA outcomes, with intrinsic motivation and enjoyment motives gaining of importance over the years. Regarding full short-term prediction models, TPB was stronger in predicting MVPA, whereas SDT was stronger in predicting lifestyle PA. At long-term, both forms of PA were better predicted by SDT in comparison to TPB.

Conclusion: Results highlight the importance of comparing and contrasting health behavior theories aiming at identifying the most critical mechanisms involved in the process of behavioral change and behavioral maintenance. Control concepts appear to be of great importance during early adoption of structured PA behaviors, whereas affective and intrinsic sources of motivation (enjoyment, affiliation, attitude) are more involved in natural, incidental types of PA especially regarding behavioral sustainment.

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1. Introduction

Overweight and obesity have been identified as common public health problem in industrialized countries (1). Globally it has reached epidemic proportions and constitutes a fifth of the leading risk for death. At least 2.8 million adults die each year as a result of excess weight (2). Overweight and obesity, defined as an abnormal or excessive fat accumulation that might impair health, are often the origin of the development of non-communicable diseases (2), such as type II diabetes, different types of cancers (3), cardiovascular diseases, hypertension, stroke and dyslipidemia (4) as well as premature mortality. Apart from that, co-morbidities and premature death are related to substantial health care costs (5). The prevalence of overweight and obesity among European adults is increasing. Twenty-five percent to 70% of the adult population is overweight and five percent to 30% are obese (2). Portugal is not an exception with an increasing overall overweight/obesity prevalence from 50% (in 1995-1998) to 54% (in 2003-2005) (6), with 62% of the male and 57% of the female adults classified as overweight, and 21% of the males and 26% of the females categorized as obese (2, 7).

Excessive weight is the result of an imbalance of energy intake and energy expenditure (2). Consequently, an unhealthy diet, defined as high intakes of unsaturated fats, sugar and salt and low intakes of fruits, vegetables and grain products (8), as well as physical inactivity are important causes responsible for weight gain (9). Research indicated that within Europe, Portugal reported the highest percentage (87.8%) of sedentary lifestyles (10) and the lowest prevalence (40.7%) of any physical activity (PA) during leisure time (11). Sedentary habits and total time spent sitting were directly associated with overweight and obesity in a dose-response relationship (12). A decline in energy expenditure requirements in many facets of daily life over the past 50 years, might be explained by reduced physical work due to increased laborsaving technology, greater reliance on motorized transport, as well as reductions in walking and cycling (12). To counteract this sedentary trend, PA guidelines have been developed to assist the public in understanding how much PA is required, in order to promote and maintain health. As such, it is recommended for all adults aged 18 to 65 years to accumulate 30 minutes or more of moderate-intensity aerobic PA on most, preferably all, days of the week (13), or to engage in vigorous-intensity aerobic activity for a minimum of 20 minutes on three days per week (13). Research has proven that even in the case of serious overweight and obesity, PA substantially reduces disease risk resulting in potential saving of lives and health care costs (12).

Although overweight and obesity have been identified as a national public health problem one decade ago, actions undertaken to reduce it have not been proven to be very effective to date (6). Usually, lifestyle interventions (focusing on PA promotion and/or diet) are the first step in the treatment of obesity. PA interventions in the last two

decades focused particularly on public education regarding the numerous benefits of regular exercising, such as improved quality of life, lower risk of obesity, hypertension and diabetes type II. Research has shown that home-, group-, and educational-based PA interventions resulted in increased PA levels (14). Although these lifestyle interventions seem to be initially effective, their effects and impacts on long-term behavioral maintenance are short-lived: as soon as the treatment period is over, the achieved PA levels are reduced dramatically (15). Unfortunately it still remains a major challenge to successfully integrate PA behaviors into daily life after cessation of the intervention. Focusing on the identification of determinants associated with behavioral maintenance should therefore be prioritized (16, 17).

Health behavior theories (HBTs) form the origin of systematically developed health promotion interventions. HBTs allow us to understand the social-psychological mechanisms that are involved in behavior change, and help in identifying what mediators of behavior an intervention should target (18). Numerous individual-level HBTs exist in the literature. However, there is no agreement upon which of the many theories is most precise in explaining and predicting health-related behavior, due to a lack of research focusing on identifying variables that are more influential or stronger in promoting health behavior change. Furthermore, many of the theories contain constructs that are very similar, but use different terminology, creating the illusion that they are all different (19).

More complex approaches in understanding health behavior have emerged, including ecological models (such as the PRECEDE-PROCEED model by Green & Kreuter (20)), in which both individual psychology and the broader environmental context are assumed to be influential in determining health behavior (18). Furthermore, theoretical integration seemed to be another promising solution, by taking the concepts with the most support from different theories and combining them into a single theory or research framework (21). However, integration of theories requires that theorists first agree upon common conceptualizations and names for similar concepts (19).

In summary, theory comparison might be the most promising approach that HBT research should focus on (19). Comparing theories has several benefits, not the least of which is that as soon as theories are not compared, health professionals might never truly know which theories are most accurate in predicting health behavior and behavior maintenance. Moreover, it helps to better understand the processes by which people change and maintain health behavior than relying on any single theory alone and thus results in better guidance in the development of interventions. Furthermore, by comparing theories, the best conceptualizations for similar constructs and how those could best be combined, will be uncovered, which will lead to greater consensus and a shared conceptual language. Despite afore mentioned benefits, few empirical theory comparisons exist in the literature. An updated state of empirical theory comparison revealed that the vast majority deals with just one theory (19). From an identified

sample of 2901 papers, 13 articles could be identified that truly compared or contrasted theories (19). The goal of theory comparison is not to end up with one unified theory of health behavior that discards all other theories developed to date (22). Instead, it is aiming at moving in the direction of models that truly integrate the lessons learned from previous research (19).

1.1 Theory of Planned Behavior and Self-Determination Theory

Health researchers have described the process of health behavior change as entailing the dual tasks of initiating and maintaining change (23). Two common HBTs are the Theory of Planned Behavior (TPB, (24)), a theory especially focusing on predicting behavioral initiation, and the Self-Determination Theory (SDT; (25),(26)), a theory tempting to explain behavioral maintenance.

The TPB is a belief-based, social-cognitive theory that was developed as a revision of the Theory of Reasoned Action by Ajzen and Fishbein (1991). The theory posits that people's expectations and values about engaging in a certain behavior form their behavioral, normative and control beliefs. Behavioral beliefs involve an individual's belief about consequences of a particular behavior and that engaging in that behavior will result into a given outcome. Normative beliefs are an individual's perception about the behavior in question, which is influenced by the judgment of significant others (e.g. parents, spouse, friends). Control beliefs are an individual's beliefs about the presence of factors that may facilitate/impede performance of the behavior. 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* (PBC; a person's overall judgment whether one has the ability and resources available to engage in the target behavior; this concept is related to self-efficacy) toward their *intention*, an indication of an individual's readiness to perform a given behavior. The concept of intention is assumed to be the most proximal antecedent of behavior (27, 28). Intention then predicts behavior, an individual's observable response in a given situation with respect to a given target. The TPB is regarded as a universal model of social behavior, and has been applied extensively in the domain of exercise (29) with a large number of reviews and meta-analysis that reported strong associations between TPB constructs and PA (30). Attitude, subjective norm and PBC were all significantly correlated with intention to exercise (rs = .51, .47, .48, respectively ps < 0.05), together accounting for 38% of the variance in behavior (31). Additionally, in predicting PA intention, a study revealed that 31% of the variance in intention was explained by the three TPB variables (32), which was in accordance with others (33), with PBC being the strongest and social norm the weakest predictors of the three (34). Despite this supporting evidence considering

the ability of the TPB to predict the initiation of behavior, very little research has investigated the factors important in maintaining behavior in the long-run (35).

The SDT, in contrast, a general motivation theory, particularly focuses on the process through which individuals acquire the motivation for initiating new health-related behaviors and maintain them over time (25). Most health-related behavior, such as PA, are not intrinsically motivated or inherently enjoyable and if such behavior is to be successfully maintained outside of controlled treatment settings, individuals have to value the desired behavior and personally endorse its importance. The theory states that motivation varies to the extent to which it is controlled or autonomous (self-determined). In order to understand long-term behavior change, one needs to understand the underlying internalization process; a process in which individuals transform and internalize external regulations, such as pressure, praise and rewards. Furthermore, SDT regards not only the quantity of motivation, but also and more importantly, the quality of motivation regulating behavior (25). These different types of motivation can be placed along a continuum, from the least autonomous form of motivation to the higher self-determined forms: *external regulation* involves acting merely to obtain external rewards, to avoid punishment or to comply with social pressure (e.g. 'Ok, I will exercise, if I really must'); *introjected regulation* reflects engagement in behavior to gain approval/praise, or to avoid feelings of guilt (e.g. 'I feel guilty if I do not exercise'); *identified regulation* involves the identification with the value or importance of the behavior (e.g. 'I want to exercise to get fit/lose weight'); *integrated regulation*, the most autonomic form of motivation, in which a person not only values a behavior, but also adjusts its central values and lifestyle, and acts because of its inherent satisfaction such as fun, enjoyment, and interest (e.g. 'I exercise because it is important to me and it symbolizes who and what I am') (25, 36). However, the behavior is still extrinsically motivated given that it might be an instrumental action, done to achieve personal goals rather than for pure joy of the action itself (37).

SDT additionally addresses the mechanisms that facilitate the development of motivation, by stating that even controlled regulations (external and introjected regulations) can be transformed into autonomous motivation, if the three basic psychological needs for autonomy, competence, and relatedness are met (25). The *need for autonomy* refers to volition and conscious choices about ones actions, and decisions in a sense of being entirely one's own and not someone else's (e.g. 'I am able to make choices about things that are important to me'). The *need for competence* involves experiences of confidence and striving to take control over outcomes (e.g. 'I have strengths and skills that are recognized to myself and others'). The *need for relatedness* describes a feeling of belongingness/connection to others and the social world more generally (e.g. ' I feel included, supported and encouraged by others'). If these needs are satisfied, it will result in internalization of behavior and thus behavioral maintenance

in the long-run (36). Investigating motivation within the field of health behavior change and maintenance becomes more and more important. Enjoyment, competence, intrinsic motivation and autonomous regulation have reliably been related to exercise participation (38). Furthermore, research on SDT indicated that the satisfaction of psychological needs as well as the feeling of enjoyment was predictive of greater adherence and attendance to one's chosen activities (36). As opposed to body-related motivations, which were conceptualized as largely an extrinsic focus, were not significantly associated with greater adherence (39).

Despite this evidence-based support for both theories in predicting exercise behavior, empirical and conceptual limitations still exist (35). Several trials demonstrated success in encouraging adoption of PA, however few studies examined the adherence to this behavior and the knowledge of effective intervention strategies to change and maintain PA behavior in free-living conditions is still at an early stage (40). On top of that, some methodological issues are worth bearing in mind. The vast majority of research is cross-sectional in type, which represents a significant limitation considering that motivational mechanisms need time to develop before they can fully be assessed. Even if prospective designs were applied, the time frame between initial assessment of the theory concepts and the subsequent measures of behavior has typically been short. Few studies exceeded assessment periods of more than one month (35). Longitudinal and more comprehensive studies are therefore required that allow more time for changes in motivational and behavioral processes to take place, which make it possible to assess whether those changes persist in the long-run (41).

In order to bridge these gaps in the literature, the present study aims at comparing the predictive ability of the TPB as well as the SDT for short- and long-term PA adherence (12 months and 36 months) in previously overweight/obese women. Based on theoretical assumptions and on previous investigations in exercise motivation and maintenance, the following hypotheses have been established: (1) it is expected that TPB is stronger in predicting short-term PA outcomes in comparison with SDT; (2) it is assumed that SDT is stronger in predicting long-term PA outcomes, in comparison to TPB*;* (3) furthermore, it is expected that more autonomously regulated individuals will better adhere to PA behavior.

2. Methods

A detailed description of the study protocol, the intervention and the applied behavior change strategies are described elsewhere (42) and will be briefly discussed in the following.

2.1 Study design and intervention

The study was set within the context of a large prospective, experimental, controlled trial, involving a 1-year behavior change intervention (called P.E.S.O II, Promotion of Exercise and Health in Obesity) aiming at weight control management and a 2-year follow-up period without any intervention.

The intervention was delivered in three successive cohorts of approximately 300 overweight and obese women. Around 100 participants per cohort were randomly assigned to experimental (n=50) and control groups (n=50), using the random number generator function for Microsoft Excel 2007 for Windows®. The controls received a general health education curriculum (29 sessions), developed for ethical reasons and for attrition prevention, which was based on health education topics such as healthy/preventive nutrition, stress management, self-care, and effective communication skills. These face-to-face contacts were similar to standard health care settings, with restricted feedback moments, reduced explanations and choice options, and no formation of specific behavioral goals. The experimental group was exposed to the main intervention program, which included 30 group meetings lasting 90-120 minutes, for ten months, with 23-25 women per class, targeting critical topics related to successful weight management (PA, nutrition and behavioral change). These topics as well as their delivery style were adapted to comply with SDT tenets, paying special attention on creating an autonomy supportive environment by presenting participants a range of options from which they could choose, in order to trigger their autonomous decisions, by encouraging them to identify their personal treatment motivations and by defining their own treatment goals. In contrast, external controls, such as rewards, and praise were eliminated.

2.2 Participants

To avoid large variation between the participants, the following inclusion criteria have been formulated: being female, having an age between 25 and 50 years, being premenopausal and not currently pregnant, having a BMI between 25 and 40 kg/m^2, be disposed to attend weekly meetings (for the period of 1 year), to be tested regularly (for the period of 3 years) and to be willing to not participate in any other formal or informal weight loss program during the first year of the study (for intervention group only). Furthermore, participants were excluded if they have taken (or took in the previous year to the intervention) any kind of medication known to interfere with body weight

regulation (e.g. antidepressants) or if they experienced some major diseases. Participants' flow in the study is shown in Figure 1 (Appendix 1). Participants were recruited from the community by means of media advertisements, including a website, newspapers, TV and radio advertisements, and flyers distributed in health care centers, local services, and schools, asking potential participants to enroll in a university-based behavioral (no medication involved) weight-loss program. All women who called to inquire about the study were invited to one of the several recruitment sessions in which the study was described in more detail. Prior to participation, all participants gave informed consent. The Ethics Committee of the Faculty of Human Kinetics in Lisbon approved the study.

The choice for the study population relies on the need for a homogenous sample and the great demand and interest observed in women for effective weight management. The lifespan under target (25-50 years) reflects important behavioral as well as physiological adaptations critical within this period, in which rapid weight gain is frequently observed (43).

2.3 Measurements

A large battery of psychometric instruments was used. All questionnaires were Portuguese validated versions of the most frequently used instruments for the constructs under investigation. Exercise related SDT variables were grouped into three broad categories, namely needs satisfaction for exercise, motives for exercise and regulations for exercise. Since the present study is merely interested in positive predictors of PA behavior only self-determined, intrinsic subscales of each psychological instrument were used. Participants were asked to attend several sessions to complete those at each evaluation point. Demographic variables were assessed at baseline; psychosocial variables derived from SDT and TPB were assessed both at 4 and 12 months. PA outcomes were measured at 12 months (regarded as short-term PA outcomes) and 36 months (regarded as long-term PA outcomes).

Needs satisfaction for exercise

The *locus of causality for exercise scale (LCE (44))* measured the perceived choice (or autonomy) of the participants regarding the performance of PA. The instrument aims at assessing the reasons for the initiation of behavior and includes three items (α = 0.81). Participants indicate the degree to which they feel that they choose by themselves to exercise rather than being forced to do it. An internal locus of causality is defined as a state in which an individual engages in a behavior freely, without any sense of coercion or external pressure. Response options are 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 more internal perceived locus of causality (or greater self-determination/autonomy).

The *intrinsic motivation inventory (IMI (45))* was used to measure the participants' subjective experience related to exercise in the dimension of perceived competence (e.g. 'I think I do pretty well at physical activities, compared to others'; α = 0.74), by means of four items. Response option ranged from 1 (strongly disagree) to 5 (strongly agree), on a 5-point Likert scale, resulting in a total score (range 4 – 20), with higher scores indicating a more internal, self-regulated type of motivation (greater control).

Motives for exercise

The *exercise motives inventory-2* (EMI-2,(46)) was used to assess motives for exercise participation. The total scale includes 51 items, which can be grouped into 14 different subscales (affiliation, appearance, challenge, competition, enjoyment, health pressure, ill-health avoidance, nimbleness, positive health, revitalization, social recognition, strength and endurance, stress management and weight management). One 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). From the 14 subscales only the motives of stress management (α = 0.87), revitalization (α = 0.83), enjoyment (α = 0.87), challenge (α = 0.75), affiliation (α = 0.84), ill-health avoidance (α = 0.76), nimbleness (α = 0.83), and positive health (α= 0.83) have been used, with ill-health avoidance, nimbleness and positive health combined to an additional subscale that reflected health/fitness motives (α = 0.90) for exercise, given that these represent intrinsic motives and thus positive predictors of PA. Each subscale is scored separately by summing up the responses to each of the subscale's items (ranging from 0 - 15 for stress management, revitalization, and challenge motives; from 0 - 20 for enjoyment and affiliation motives; and from 0 - 50 for health/fitness motives). Higher scores indicate respectively higher stress management, revitalization, enjoyment, challenge, affiliation and health/fitness motives. Higher scores on all or most of the subscales represent more intrinsic motives for exercise.

Exercise regulations

The *exercise self-regulation questionnaire* (SRQ-E (47)) measured domain-specific individual differences in motivation or regulation. These individual differences are regarded as types of motivation rather than 'trait' concepts, due to the fact that they are not general neither particularly stable. Eight items derived from the SRQ-E were used to assess the concept of autonomous regulation (α = 0.91), defined by identified regulation (e.g. 'Because it feels important to me personally to accomplish this goal'; α = 0.79) and

intrinsic motivation (e.g. 'Because it is a challenge to accomplish my goal', 'Because it is fun'; α = 0.83). Each subscale contains 4 items and participants have to indicate how they feel on a 7-point Likert scale, with response options ranging from 1 (not at all true) to 7 (very true). Each subscale is scored separately by summing up the responses to each of the subscale's items (range from 4-28). Higher scores indicate a more identified or intrinsic type of regulation, respectively.

The TPB exercise-related variables were assessed by means of 18 items, measuring *attitude* (7 items; α = 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; α = 0.86; e.g. 'People that are important to me, think that I should engage in regular physical activity within the next six month'; on a 7-point Likert scale, ranging from 1 (totally disagree) to 7 (totally agree)), *perceived behavioral control* (5 items; α = 0.86; e.g. 'For me personally, engaging in regular physical activity 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; α = 0.56; e.g. 'My personal goal is, to engage in regular physical activity within the next six months'; on a 7-point Likert scale, ranging from 1 (totally disagree) to 7 (totally agree)). Each scale is scored separately by summing up the responses to each of the subscales items (ranging from 7 - 49 for attitude, from 3 – 21 for social norm, from 5 – 35 for PBC, and from 3 – 21 for intention, respectively). Higher scores on each scale represent respectively higher attitudes, higher social norms, higher PBCs, and intentions.

Physical activity

To determine duration and intensity of PA, the 7-day physical activity recall (7 Day-PAR (48, 49)) 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, has been supported by previous studies (48). For the purpose of the present study, activity reports were converted into total minutes of moderate plus vigorous physical activity (MVPA) (metabolic equivalent (METs) (3.0) in a week).

The lifestyle physical activity index (LPAI) that has been specifically developed for the study of Silva et al. (42), was applied in this study as well. It is a self-administered instrument that assessed habitual lifestyle physical activities typical of the last month. Due to that, this variable is not typically available in existing PA questionnaires. A score is used based on seven questions (α = 0.83) to compute the index (choosing to use the stairs instead of the escalators; choosing to walk to reach nearby destinations instead of

using transportation; choosing to further park away from destination; choosing to use work breaks to be physically active; choosing to stand up instead of being seated; choosing hand work instead of mechanic/automatic; choosing to be physical active whenever possible). Participants have to indicate how many times they have chosen each of the activities described, within the last month. Response options ranged from 'never' (1) to 'always' (5) on a Likert-type scale. Higher scores indicate more engagement in lifestyle PA.

2.4 Statistical analysis

Analyses were carried out using IBM SPSS 20.0 software. Descriptive analyses were conducted, using baseline data, to get insight into key characteristics of the sample including age, marital status, educational level, weight, height, BMI and PA levels. Cronbach's Alpha (α) was calculated for all independent variables, using 4-month data. Independent sample *t*-tests were carried out to analyze differences in SDT and TPB psychosocial variables, and PA between intervention and control groups, at 4 and 12 months. These time points are justified by the absence of several SDT measurement constructs at baseline (e.g. perceived autonomy, motives for exercise, and exercise regulations) and missing TPB follow-up data. To identify potential correlations of the PA behaviors (MVPA and lifestyle PA) and psychosocial variables under investigation, partial correlations were computed. Pearson's *r* was calculated.

Multiple regression models were derived to evaluate multivariate estimates for the associations between psychosocial predictors (at 4, and 12 months) and PA changes (at 12, and 36 months). *A priori* hierarchical regression models were used, where variables were entered in successive blocks, either forced in or presented to the model in stepwise fashion, with each independent variable being assessed in terms of what it adds to the prediction of the dependent variable, after controlling for variables that remained in the regression equation in the previous step. Once all sets of variables are entered, the overall model was assessed in terms of its ability to predict the dependent measure (PA). The relative contribution of each block of variables is also assessed. TPB and SDT were presented separately to the multivariate models for 12 months and 36 months PA outcomes. After forced entry of demographic variables (age, educational level, group), needs for exercise, followed by motives, regulations and finally the full SDT model were presented separately to the model (stepwise) in step 2. TPB variables were presented to the model in the same way. Since intention is regarded as the most proximal predictor of behavior within the TPB, functioning like a mediator while capturing the influences of attitude, social norm, and PBC, two different models were established, one excluding intention and one including it.

For all analysis, a result was considered significant if the *p*-value was lower than 0.05.

3. Results

In the following section the results will be discussed.

3.1 Participants and dropout

Two hundred fifty-eight women completed baseline assessments and were randomized to either the intervention or the control group. Of those, 19 participants were excluded from further analysis due to medication/health issues (*n*= 14), entering menopause (*n*= 3), or pregnancy (*n*= 2). Thus, 239 women were available for the study and were regarded as valid sample. Follow-up data at 4 and 12 months were available for 220 and 208 women respectively, and for 156 women at 36 months. Reasons for dropout involved financial/time restrictions (*n*= 15), moving to another city (*n*= 4), and dissatisfaction with group assignment (*n*= 1). All other subjects did not indicate any reason. Overall retention rate was 71%.

3.2 Description of the sample

Table 1 represents the demographic characteristics of the sample. There was no significant difference between intervention and control groups for demographics (age, marital status, education), weight, BMI, and PA levels ($p > 0.05$) at baseline. The average age of the final sample was 37.6 (SD 7.02) years. Fifty-six percent of the women indicated to be married. Mean weight was 77.3 (SD 12.2) kg and 62% were obese. At baseline, women reported to engage on average 100 min/week (SD 136.0) in MVPA and scored on average 2.80 (SD 0.87) for lifestyle PA.

Table 1. Descriptive characteristics at baseline

Variables	Mean/SD (N= 239)
Age (years)	37.6 ± 7.02
Marital status	
Single	33%
Married	56%
Divorced/widow	11%
Weight (kg)	77.3 ± 12.2
Height (m)	1.61 ± 0.06
BMI (kg/m^2)	31.5 ± 4.12
BMI categories	
Normal weight	3%
Overweight (not obesity)	36%
Obesity	62%
Physical activity	
MVPA (min/week)	100.2 ± 136.0
LPAI	2.80 ± 0.87

Data are given in mean ± SD or %
MVPA = Moderate plus Vigorous Physical Activity; LPAI = Lifestyle Physical Activity Index

3.3 Results of independent sample t-tests

Independent sample *t*-tests were conducted to compare the psychosocial variables of the TPB and SDT for intervention groups and control groups at 4 and 12 months (Table 2) and for PA levels additionally at 36 months (not reported). At 4 months as well as at 12 months, significant differences in scores on psychosocial variables for intervention and control group were found for the great majority of the determinants (except for stress management and affiliation motives and social norm; $p > 0.05$). With respect to PA, intervention participants showed higher levels of PA at 4, 12, and 36 months, reflected in more minutes of MVPA per week (4 months: +117.32 min/wk; 12 months +139.67 min/wk; 36 months +86.00min/wk, respectively), compared to controls. Results for the LPAI indicated that participants were significantly more active at all three time points.

Table 2. Intervention group differences at 4 and 12 months

	4 months			12 months		
	Intervention	Control	*t (df)*	Intervention	Control	*t (df)*
Psychosocial variables	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Self-Determination Theory						
Needs satisfaction in exercise						
Perceived autonomy	14.9 ± 4.63	12.9 ± 5.17	-3.04** (216)	16.1 ± 4.43	13.0 ± 4.74	-4.78*** (200)
Perceived competence	14.6 ± 2.44	12.9 ± 2.91	-4.81*** (214)	15.0 ± 2.84	13.2 ± 2.92	-4.47*** (195)
Motives for exercise						
Stress management	11.6 ± 3.16	10.9 ± 3.53	-1.65 (216)	12.0 ± 3.10	11.3 ± 2.96	-1.48 (195)
Revitalization	12.6 ± 2.43	11.6 ± 3.08	-2.45* (217)	12.9 ± 2.19	11.9 ± 2.58	-3.00** (195)
Enjoyment	14.3 ± 4.43	12.4 ± 4.92	-3.00** (217)	15.6 ± 3.90	12.8 ± 4.43	-4.79*** (195)
Challenge	9.41 ± 3.62	7.10 ± 3.74	-4.61*** (216)	9.91 ± 3.18	8.00 ± 3.45	-4.02*** (195)
Affiliation	8.95 ± 4.76	8.48 ± 5.00	-0.72 (217)	10.3 ± 5.20	9.49 ± 4.71	-1.06 (195)
Health/fitness	12.8 ± 1.83	12.0 ± 2.32	-2.92** (217)	12.9 ± 1.76	12.1 ± 1.96	-2.98*** (195)
Exercise regulations						
Identification	25.8 ± 2.54	23.3 ± 3.90	-5.47*** (216)	26.1 ± 1.98	22.7 ± 4.48	-6.77*** (201)
Intrinsic	23.3 ± 4.10	19.0 ± 5.42	-6.50*** (216)	24.1 ± 3.87	18.9 ± 5.57	-7.57*** (201)
Autonomous	49.1 ± 6.07	42.3 ± 8.60	-6.61*** (216)	50.2 ± 5.34	41.6 ± 9.45	-7.76*** (201)
Theory of Planned Behavior						
Attitude	12.3 ± 3.76	15.9 ± 5.32	-5.49*** (212)	12.2 ± 4.10	14.9 ± 5.65	-3.85*** (198)
Social norm	18.5 ± 3.44	18.4 ± 3.31	-0.15 (217)	18.9 ± 3.97	17.9 ± 3.12	-0.02 (194)
Perceived behavioral control	26.8 ± 4.10	22.5 ± 6.55	-5.35*** (215)	28.4 ± 4.77	23.4 ± 6.71	-5.87*** (196)
Intention	17.1 ± 2.44	14.9 ± 2.82	-6.18*** (216)	16.7 ± 2.72	14.9 ± 3.56	-4.06*** (197)
Physical Activity						
MVPA	291.7±224.8	174.4±147.8	-4.49*** (203)	299.7±179.4	160.1±171.1	-5.41*** (188)
LPAI	3.57 ± 0.75	2.99 ± 0.90	-4.97*** (185)	3.84 ± 0.69	2.98 ± 0.81	-7.33*** (162)

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$ for *t*-test comparing intervention and control groups at 4 and 12 months
MVPA = Moderate plus Vigorous Physical Activity; LPAI = Lifestyle Physical Activity Index

3.4 Results of correlations and regression analyses

Correlations and multiple regression analyses were conducted to evaluate multivariate estimates for the associations between psychosocial predictors and PA outcomes. Short- (12 months) and long-term (36 months) PA outcomes were assessed by analyzing prospective (4 months psychosocial variables as independent variables and 12 months PA as dependent variable; and 12 months psychosocial variables as independent variables and 36 months PA as dependent variable) as well as cross-sectional (12 months psychosocial variables as independent variables and 12 months PA as dependent variable) associations.

3.4.1 Short-term physical activity outcomes

Bivariate analyses: Partial correlation was used to explore the relationship between psychosocial variables and short- and long-term PA outcomes, while adjusting for the experimental group (Table 3). Most of the SDT psychosocial variables were positively associated with short-term MVPA behavior. Perceived competence, as well as intrinsic motivation showed relatively strong partial correlations with short-term PA. Motives for exercise were the least correlated variables with MVPA. Regarding cross-sectional associations, perceived autonomy and autonomous motivation showed strong partial correlations with short-term MVPA behavior. All TPB variables showed positive and significant correlations with MVPA at short-term, except of social norm. PBC and intention showed the strongest partial correlations with short-term PA.

Positive and significant associations were found for most psychosocial variables regarding short-term lifestyle PA, with autonomous regulations, enjoyment and revitalization motives as well as perceived autonomy showing the strongest partial correlations. Regarding TPB psychosocial variables, attitude and intention showed strong partial correlations with lifestyle PA of similar magnitude.

Table 3. Correlation between psychosocial variables and short- and long-term physical activity outcomes

	Short-term prospective[1]		Short-term cross-sectional[2]		Long-term prospective[3]	
Psychosocial variables	MVPA	LPAI	MVPA	LPAI	MVPA	LPAI
Self-Determination Theory						
Needs satisfaction in exercise						
Perceived autonomy	0.17*	0.24**	0.27***	0.29***	0.16*	0.43***
Perceived competence	0.26***	0.14	0.27***	0.18*	0.24**	0.37***
Motives for exercise						
Stress management	0.01	0.25**	0.07	0.23**	0.07	0.33***
Revitalization	0.03	0.34***	0.12	0.27**	0.08	0.40***
Enjoyment	0.13**	0.28***	0.20**	0.28***	0.15	0.40***
Challenge	0.15*	0.27***	0.24**	0.22**	0.12	0.19
Affiliation	0.12*	0.21**	0.16*	0.21*	0.20*	0.40***
Health/fitness	-0.04	0.17*	-0.05	0.16*	0.02	0.28**
Exercise regulations						
Identification	0.15*	0.22**	0.15*	0.29***	-0.01	0.27**
Intrinsic	0.26***	0.31***	0.26***	0.30***	0.12	0.45***
Autonomous	0.23**	0.29***	0.23***	0.32***	0.07	0.40***
Theory of Planned Behavior						
Attitude	0.19**	0.22**	0.25**	0.30***	0.07	0.43***
Social norm	0.07	0.05	0.05	0.02	-0.01	0.06
Perceived behavioral control	0.37***	0.16*	0.33***	0.20*	0.17*	0.24**
Intention	0.30***	0.20*	0.36***	0.34***	0.23***	0.43***

[1] 4 months psychosocial variables and 12 months PA outcomes
[2] 12 months psychosocial variables and 12 months PA outcomes
[3] 12 months psychosocial variables and 36 months PA outcomes
MVPA = Moderate plus Vigorous Physical Activity; LPAI = Lifestyle Physical Activity Index
Partial correlation adjusted for group; *P < 0.05; ** P < 0.01; *** P < 0.001

Multivariate analyses: All multiple, linear regression models were corrected for the demographic variables age, education 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 theories. Detailed results of all conducted regression analyses can be found in the appendices 2-7 (Tables 6-11).

Results of multiple regression analyses for MVPA are presented in Table 4. In the prospective, hierarchical regression analyses on 12 months MVPA, perceived autonomy and intrinsic motivation explained a similar amount of the total variance in PA behavior. The full SDT model (R^2 22.8%; $p< 0.001$), presenting the strongest prediction model, showed that women who engaged in more MVPA perceived to have more competence and were more intrinsically motivated. Regarding cross-sectional regressions analyses, women who engaged in more MVPA perceived to have more autonomy and competence regarding the PA behavior, accounting for 25.8% ($p< 0.001$) in the total variation in MVPA behavior. Challenge motives and intrinsic motivation were significant independent predictors of the motives and regulations model. However, they did not remain in the full SDT model.

Regarding the TPB, prospective regression analyses indicated that both models, with and without intention, represented the strongest prediction model at 12 months (R^2 24.2%; $p< 0.001$), when comparing the predictive ability of both theories. Engagement in MVPA at 12 months was explained by more PBC towards exercising. In the cross-sectional regression analysis without intention on 12 months PA behavior, PBC explained 9% ($p< 0.001$) of the total variance in PA behavior. The inclusion of intention to the model increased the total amount of explained variance to 30% ($p <0.001$). Women who engaged regularly in MVPA experienced more behavioral control and had greater intentions to exercise.

Results for multiple regression analyses for lifestyle PA are shown in Table 5. All SDT models explained similar amounts of variance in lifestyle PA at 12 months (prospective and cross-sectional). Perceived autonomy, revitalization and affiliation motives, and intrinsic motivation were significant predictors of prospective assessments. The motives model represented the strongest prediction model (R^2 42.3%, $p< 0.001$). The full SDT model (R^2 39.8%; $p< 0.001$) showed that women, who engaged frequently in lifestyle PA, had higher revitalization motives. Regarding cross-sectional prediction models, perceived autonomy, enjoyment motives, and intrinsic regulation were significant predictors of short-term lifestyle PA. The full SDT model presented the strongest prediction model (R^2 41.4%, $p <0.001$), indicating that women, who perceived to have autonomy and affiliated with lifestyle PA, were more likely to engage in that type of PA.

With regard to the TPB, prospective analyses revealed that women, who engaged in lifestyle PA more often, had more positive attitudes towards exercising. Attitude

explained a similar amount of the total variance in short-term lifestyle PA regarding prospective and cross-sectional assessments. The inclusion of intention to the model, explained another 2% (p< 0.001) of the total variance in short-term lifestyle PA. Women, who had greater intentions to exercise, engaged more often in PA.

Table 4. Multiple regression analysis for MVPA – summary table

	MVPA								
	Prospective[1]			Cross-sectional[2]			Prospective[3]		
Psychosocial variables	ß	*P*	R^2	ß	*P*	R^2	ß	*P*	R^2
Self-Determination Theory									
Needs			0.215***			0.258***			0.134***
Autonomy	0.280	<0.001		0.195	0.014				
Competence				0.177	0.026		0.265	0.001	
Motives			0.163***			0.195***			0.100**
Enjoyment	0.136	0.048							
Challenge				0.228	0.001				
Affiliation							0.196	0.015	
Regulations			0.202***			0.207***			
Intrinsic motivation	0.267	<0.001		0.278	<0.001				
Full model			0.228***			0.259***			0.132***
Competence	0.183	0.026		0.197	0.015		0.271	0.001	
Autonomy				0.195	0.015				
Intrinsic motivation	0.180	0.033							
Theory of Planned Behavior									
Perceived behavioral control	0.352	<0.001	0.242***	0.325	<0.001	0.255***	0.182	0.038	0.093**
Full TPB						0.300***			0.112**
Perc. beh. control	0.352	<0.001	0.242***	0.249	0.001				
Intention				0.212	0.009		0.223	0.007	

[1] 4 months psychosocial variables and 12 months PA outcomes
[2] 12 months psychosocial variables and 12 months PA outcomes
[3] 12 months psychosocial variables and 36 months PA outcomes
MVPA = Moderate plus Vigorous Physical Activity
*** *P* <0.001 ** *P* <0.01 * *P* <0.05

Table 5. Multiple regression analysis for LPAI – summary table

	LPAI								
	Prospective[1]			Cross-sectional[2]			Prospective[3]		
Psychosocial variables	*ß*	*P*	R^2	*ß*	*P*	R^2	*ß*	*P*	R^2
Self-Determination Theory									
Needs			0.376***			0.401***			0.297***
Autonomy	0.243	<0.001		0.280	<0.001		0.469	<0.001	
Motives			0.423***			0.381***			0.318***
Enjoyment				0.262	<0.001		0.282	0.003	
Revitalization	0.267	<0.001							
Affiliation	0.125	0.048					0.249	0.005	
Regulations			0.386***			0.379***			0.285***
Intrinsic motivation	0.295	<0.001		0.280	<0.001		0.470	<0.001	
Full model			0.398***			0.414***			0.363***
Autonomy				0.235	<0.001		0.359	<0.001	
Revitalization	0.299	<0.001							
Affiliation				0.144	0.025		0.292	0.001	
Theory of Planned Behavior									
Attitude	0.233	0.001	0.356***	0.249	<0.001	0.379***	0.379	<0.001	0.224***
Full TPB						0.390***			0.288***
Attitude	0.233	0.001	0.356***				0.229	0.027	
Intention				0.286	<0.001		0.266	0.010	

[1] 4 months psychosocial variables and 12 months PA outcomes
[2] 12 months psychosocial variables and 12 months PA outcomes
[3] 12 months psychosocial variables and 36 months PA outcomes
LPAI = Lifestyle Physical Activity Index
*** *P* <0.001 ** *P* <0.01 * *P* <0.05

3.4.2 Long-term physical activity outcomes

Bivariate analyses: Results of bivariate analyses are presented in Table 3. Need satisfaction variables (perceived autonomy and perceived competence) and affiliation motives were the only variables that were positively and significantly associated with MVPA long-term outcomes. Considering TPB variables, PBC and intention showed positive and significant correlations with PA, with intention being strongly correlated with long-term MVPA. Partial correlations of psychosocial variables and long-term MVPA decreased over time. With respect to long-term lifestyle PA, strong positive correlations between autonomous regulations (especially intrinsic motivation), intrinsic motives (revitalization, enjoyment, affiliation) and long-term lifestyle PA were found. All TPB variables were positively and significantly correlated with long-term lifestyle PA with attitude and intention being correlated with PA of similar magnitudes. In general, partial correlations between psychosocial variables of both theories increased over time, showing strongest correlations with lifestyle PA at 36 months.

Multivariate analyses: As could be anticipated by the bivariate analysis, predictive power of the models regarding MVPA was generally lower in comparison to 12 months analyses (Table 4). The needs satisfaction model represented the strongest prediction model (R^2 13.4%; p< 0.001), with perceived competence being the strongest independent predictor, followed by the full SDT model (R^2 13.2%; p< 0.001). Perceived competence was the only variable that significantly added predictive power to both

models. Noticeably, autonomous regulations for exercise did not account for an additional amount of variance in MVPA behavior at 36 months.

The predictive power of TPB decreased with time regarding long-term MVPA outcomes. In the regression analysis without intention, PBC was the strongest independent predictor. The inclusion of intention to the model increased the total amount of explained variance to 11% (p = 0.002). Exercising more frequently was explained by greater intentions.

In the regression analyses on 36 months lifestyle PA (Table 5), enjoyment motives and intrinsic motivation explained independently 14% and 17% of the total variance in PA behavior (p<0.001). The full SDT model, being the strongest prediction model (R^2 36.3%; p<0.001), however showed that women who engaged more often in PA, perceived high autonomy and had affiliation motives. The predictive power of enjoyment motives and intrinsic motivation increased with time.

Attitude remained the strongest predictor of the TPB in the regression model on 36 months lifestyle PA. Including intention to the model revealed that attitude and intention were significant predictors of long-term lifestyle PA, accounting for 28.8% (p <0.001) in the total variance of behavior, indicating that women who had more positive attitudes and higher intentions towards performing PA, engaged more frequently in lifestyle PA.

4. Discussion

In recent years, increased scientific attention has been put on HBTs, aiming at better understanding the psychosocial mechanisms involved in behavioral change. Although these lifestyle interventions revealed effective short-term behavioral changes, their effects on long-term behavioral maintenance are limited (15). If interventions are supposed to effectively promote behavioral maintenance, it is necessary to identify those theories and those predictors that are most influential in promoting behavioral sustainment. Therefore, two behavioral theories, the SDT and the TPB, have been compared regarding their short- and long-term predictive ability of two kinds of PA in previously overweight/obese women.

Main results show that (i) perceived needs (especially the need for perceived competence), high levels of intrinsic motivation (to a lesser extent), as well as PBC, significantly and independently predict 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 towards exercising, explain some of the variance in short-term lifestyle PA, with SDT being the stronger predictive theory; (iii) SDT is stronger in predicting long-term behavioral sustainment (for both types of PA), partly explained by more perceived control concepts for MVPA, and by more intrinsic/affective concepts (perceived autonomy, enjoyment and affiliation motives, intrinsic motivation, and attitude) for lifestyle PA; (iv) more variance could be explained for lifestyle PA in comparison to MVPA at short- and long-term, regarding both theories.

In sum, the results suggest that engagement in structured and strenuous PA (like MVPA) relies on mastery experiences, control and organizational skills that people need to experience. In contrast, lifestyle PA reflects less involved commitment and effort, and requires therefore more affective drives like feelings of autonomy and volition, perceived joy, fun, and affiliation in order to be performed.

Although the present study incorporated several novel features in both its design and execution, it is nonetheless important to emphasize its consistency with prior research. In line with our hypothesis, the current study confirms that the TPB is stronger in predicting early behavioral adoption (short-term PA outcomes), which is consistent with previous research (35). In addition, the results clearly show that the TPB is stronger in predicting MVPA relatively to SDT. The TPB represents a deliberative processing model, in which individuals make behavioral decisions based on careful considerations of available information (50). Due to the incorporation of PBC, the framework is able to predict non-volitional, uncontrollable behavior (e.g. exercising, losing weight) that requires more complex goals and outcomes, which depend upon performances of complex series of

different behaviors. The control construct within the TPB is regarded as a continuum with easily executed behavior at one end, asking for little control, and behavioral goals demanding resources, opportunities, and specialized skills at the other (50). MVPA, reflecting structured and strenuous PA, represents such behavior that requires planning, commitment and organizational skills. Given that the TPB was originally designed to model planned, or goal directed behavior, it is thus not surprising that the framework explains strenuous, planned forms of PA rather well.

PBC presents one of the strongest predictors of short-term MVPA, which is in accordance with others (34). It is assumed that especially non-exercisers or individuals that just started to exercise (outside the treatment environment) might encounter and experience personal (e.g. lack of time, laziness) as well as environmental (destination to gym) obstacles while attempting to perform MVPA, which reflects a lack of complete volitional control over the performance of the behavior. As soon as individuals perceive any difficulties or barriers in performing exercises, their intentions to actually engage in it will be low and the likelihood that they exercise decreases (34). Ajzen (1991) stated that however strongly held, the implementation of an intention into action is at least partially determined and influenced by barriers, and that the inclusion of PBC into the TPB framework should become increasingly useful as volitional control over behavior decreases (34). This emphasizes the necessity of PBC in order to be able to initiate exercise. Increased feelings of control will enhance the extent to which individuals are willing to exert additional effort in order to successfully perform a particular behavior. The present findings show that regarding short-term MVPA outcomes, PBC clearly predicts behavior over and above the effects of intention. In contrast, the results indicate that over time the strong influence of PBC decreases, suggesting that people become more familiar with the behavior and experience a feeling of mastery and efficacy in overcoming perceived barriers, thus volitional control. As soon as behavior is perceived to be under volitional control, intentions accurately predict behavior, and control constructs become of less importance. Indeed, at 36 months, the influence of PBC decreases in favor of intentions (51). It is assumed that as soon as the behavior is relatively straightforward, exerting additional effort to engage in the behavior will not influence the actual performance of the behavior, over and above the effects of intention (34). In sum, it might be assumed that PBC and intention interact in their predictions of behavior, depending on the degree of control that is perceived. Interestingly, with respect to SDT and its ability to predict short-term MVPA, perceived competence turns out to be an influential factor. This is not surprising, since it extends results from TPB.

The finding that social norm was not a significant predictor of PA participation is consistent with previous research (52), suggesting that social norm only exerts a marginal influence on exercise levels. Furthermore, presumably people view the decision

to exercise as their own responsibility, rather than something that is influenced by opinions of others (53).

The literature provides good evidence for the value of SDT in understanding and exploring exercise behavior (41), and the present study does not make an exception. As hypothesized, SDT is stronger in predicting PA adherence in comparison to TPB with regard to MVPA as well as lifestyle PA. Even though less attention has been paid to investigating the extent to which satisfaction of psychological needs account for the variance in PA behavior, our results clearly underscore that the satisfaction of the needs for perceived competence and autonomy play a major role in PA maintenance over time. Noticeably, long-term MVPA outcomes are primarily explained by perceived competence, whereas lifestyle PA is explained by perceived autonomy, suggesting that feelings of competence, and efficacy are more related to structured exercise, in comparison to more natural, incidental PA that relies on self-regulated constructs. Regarding motives for exercise, consistent positive associations between more intrinsic motives (e.g. affiliation, challenge, and enjoyment) and exercise have been found, which has been confirmed by previous research (54). Motives, such as personal challenge and social affiliation are likely to be experienced as autonomous, which positively predicts intrinsic motivation (54), being simultaneously associated with progression and adherence of behavior (39). This causal relationship is supported in the present study. Since lifestyle PA is expected to require minimal cognitive involvement, it is not surprising that more affective rather than cognitive predictors determine the explanatory power of the prediction models.

Although the TPB is weaker in predicting exercise maintenance, the results emphasize that attitude appears to be an important predictor of lifestyle PA. This might be explained by the fact that the concept of attitude is composed of affective (enjoyable vs. un-enjoyable) and instrumental (beneficial vs. harmful) evaluations towards behavior (55, 56). Theoretically, this proposes that both instrumental evaluations of the benefits of exercise (appearance related reasons), as well as affective evaluations about the enjoyability of exercise, collectively affect intentions to exercise (38). The present results might suggest that the affective component of attitude is the one that explains behavioral maintenance, given that it reflects enjoyment, supporting the results from SDT; and being in line with previous research (38). However, since attitude was assessed as a summed scale including both concepts, this interpretation should be understood with caution. Additional research is required in order to support the current findings.

In general the predictive ability of the TPB considering long-term PA decreases over time (for MVPA more drastically than for lifestyle PA), which has been confirmed by others (57). It is not surprising that the TPB is less suitable to predict the maintenance of behavior, 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 (58). In contrast to TPB, SDT as a theory of human

motivation, pays special attention to goal pursuit, attainment and maintenance over time (25). According to SDT, a comprehensive understanding of goal-directed behavior cannot be reached without stressing the importance of the innate, psychological needs for autonomy, competence and relatedness and their satisfaction. As soon as people fulfill their psychological needs, they will be optimally motivated in pursuing their goals and sustain them in the long-run (59). Psychological needs do not only specialize the content of motivation, being controlled or autonomous, depending on different amounts of need satisfaction and degrees of internalization of extrinsic regulations (praise, pressure, reward), but also and more importantly form the energization and direction of enacting in a certain behavior (25). Research has shown consistently that fully internalized, hence more autonomous regulations, affect enjoyment outcomes, which in turn promotes persistence of behavior over time (25). Put differently, SDT focuses on motivating behavior change by stressing the support of patient's psychological needs for autonomy and competence within the process of change, fostering greater internalization, which results in maintenance of behavior in the long-run (59). As such SDT adds additional value over and above social-cognitive theories, which play a role during behavioral initiation and early adoption, by emphasizing and promoting health behavior maintenance.

The hypothesis that more autonomously regulated individuals will adhere better to PA behavior could only be confirmed for lifestyle PA. With respect to behavioral regulations and exercise, a positive relation between autonomous forms of regulations (identified regulations and intrinsic motivation) and lifestyle PA could be observed. Especially intrinsic motivation shows a strong association with lifestyle PA in the long-run, indicating that perception of fun and enjoyment resulting form engaging in the behavior are the driving forces that explain long-term sustained behavior. The motives of enjoyment, and the attitude concept from TPB emphasize, in conjunction with intrinsic motivation, that valuing the actual experience of the performed behavior is of undeniable importance in explaining behavioral maintenance.

Noticeably, for MVPA, autonomous regulations seemed to be of no influence for long-term adherence, suggesting that exercising purely for fun and enjoyment are by far not sufficient to adhere to long-term structured PA, due to all organization and commitments involved (60, 61). This again highlights that strenuous PA is highly dependent on control mechanisms (PBC, perceived competence).

This study is not without its limitations. Owing to the fact that only overweight/obese women were recruited, it is uncertain if the results can be generalized to the male population. Additionally, exercise behavior was assessed by means of self-reported questionnaires, proven to be valid and reliable assessments of the PA, however also being prone of recall bias and social desirable answers (62). MVPA was assessed by the

7-day PAR, the current gold standard of questionnaires (63), what needs to be considered when interpreting the results and moreover comparing them to the LPAI. Besides that, research has shown that people show better memory for vigorous intensity episodes, due to the greater effort required or a more stable behavioral context (e.g. gym, swimming pool). This is topped by the fact that MVPA was assessed by means of trained interviewers, indicating that more detailed prompting and stronger motivation to accurately recall PA (by the interviewer), may generate more accurate responses and elicit better recall than just simply filling in a self-administered questionnaire (64). To confirm the present results, it is suggested to apply more objective measurements of PA such as heart rate monitors or accelerometry. Besides that, it is important to mention that the intervention, where the data were extracted form, was based on SDT (and especially on creating a need-supportive environment), which might explain the higher amount of explained variance in PA behavior by SDT variables, since their development was targeted and fostered during the intervention period. Furthermore, the LPAI might be more representative of the sort of PA the participants were able to perform, due to lower effort involved and the fact that the sample was mostly sedentary at baseline. Regarding the assessment of psychosocial variables, the present study did not assess completely all constructs involved in SDT, given that merely positive predictors were analyzed. It would be interesting to see how external regulations would develop through the process of behavioral change, since research confirmed that they are more influential for short-term behavioral outcomes (65). The lack of baseline SDT psychosocial variables computes an additional limitation, since differences between intervention and control group regarding psychosocial variables at baseline cannot entirely be eliminated.

Nonetheless, the present study incorporates some strengths, first by investigating two different types of PA at the same time, given that most of the previous research does not clearly define or distinguish between different types of PA (intensity, frequency, duration). Second, since PA research focusing on determinants of long-term behavioral maintenance is primarily cross-sectional in type; this study is making a first step in providing longitudinal data, acknowledging time to motivational factors to fully develop. Finally, comparison of theories is a relatively new approach, but proven to be effective in identifying the most critical mechanisms involved in behavioral change while respecting different theoretical views and assumptions.

4.1 Practical implications and conclusion

The previous findings have crucial implications for practice. Considering the importance of regular exercising in successful prevention of chronic diseases such as type II diabetes, obesity and hypertension, understanding the mechanisms involved in the processes by which people change and maintain health behavior becomes more and more important. As such, the present findings uncovered the importance of attitude,

PBC, need satisfaction, motives and autonomous regulations as critical mechanisms involved in behavioral change and its sustainment over time, and are therefore claimed to promote and foster their development. This information is useful for health professionals in order to plan and develop more effective exercise promotion interventions that result in long-term behavioral maintenance.

In order to achieve the feeling of perceived control (PBC and perceived competence), persuasive techniques could be applied, aiming at convincing individuals that they are in possession of sufficient control over the target behavior. A second approach suggests personal mastery, trying to establish sub-goals, which result step by step in the desired behavior. Instead of trying to force a non-exerciser to attend the gym weekly, it is proposed to start with easier activities, such as walking to nearby destinations, rather than taking the car. As such, successful performance of the behavior will act like a motivator, which increases PBC or the need for competence. Modeling conceptualizes a third option, in which people learn by watching others and subsequently imitate their behavior (66). By encouraging participants to form behavioral goals, a sort of commitment to the target behavior is built, which might lead to greater competence and confidence. Besides that, research has proven (65) that an enjoyable exercise environment as well as staff that is perceived as need-supportive (by giving feedback, and providing choices to clients), are necessary to make exercising an enjoyable activity. Since PA consists of a great variety of activities, it is easy to provide participants with choices, which increases the chance that they find an activity they really like and can identify with, aiming at increased feelings of autonomy and ownership. Nonetheless, the focus should not exclusively be targeted on long-term adherence, but also on positive side effects prolonged exercise adherence brings about, like enhanced well-being and improved quality of life (67).

In conclusion, the present findings provide empirical support for the comparison of health behavior change theories in predicting short- and long-term PA outcomes, in order to identify the most critical factors involved in behavior change and its maintenance over time. Influencing individuals perception of efficacy and competence in the early phase of new behavior adoption, especially regarding behavior that requires organizational and control elements, as well as ensuring that individuals intrinsically enjoy, affiliate with and feel autonomous about the behavior, will positively contribute to their perceived sense of self-determination, which might present the key to successful initiation and subsequently integration of PA into daily life routines. Although the TPB and SDT are conceptually different, the present study confirms that their predictive directions are similar, even replenishing each other’s assumptions.

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Appendix 1 CONSORT diagram

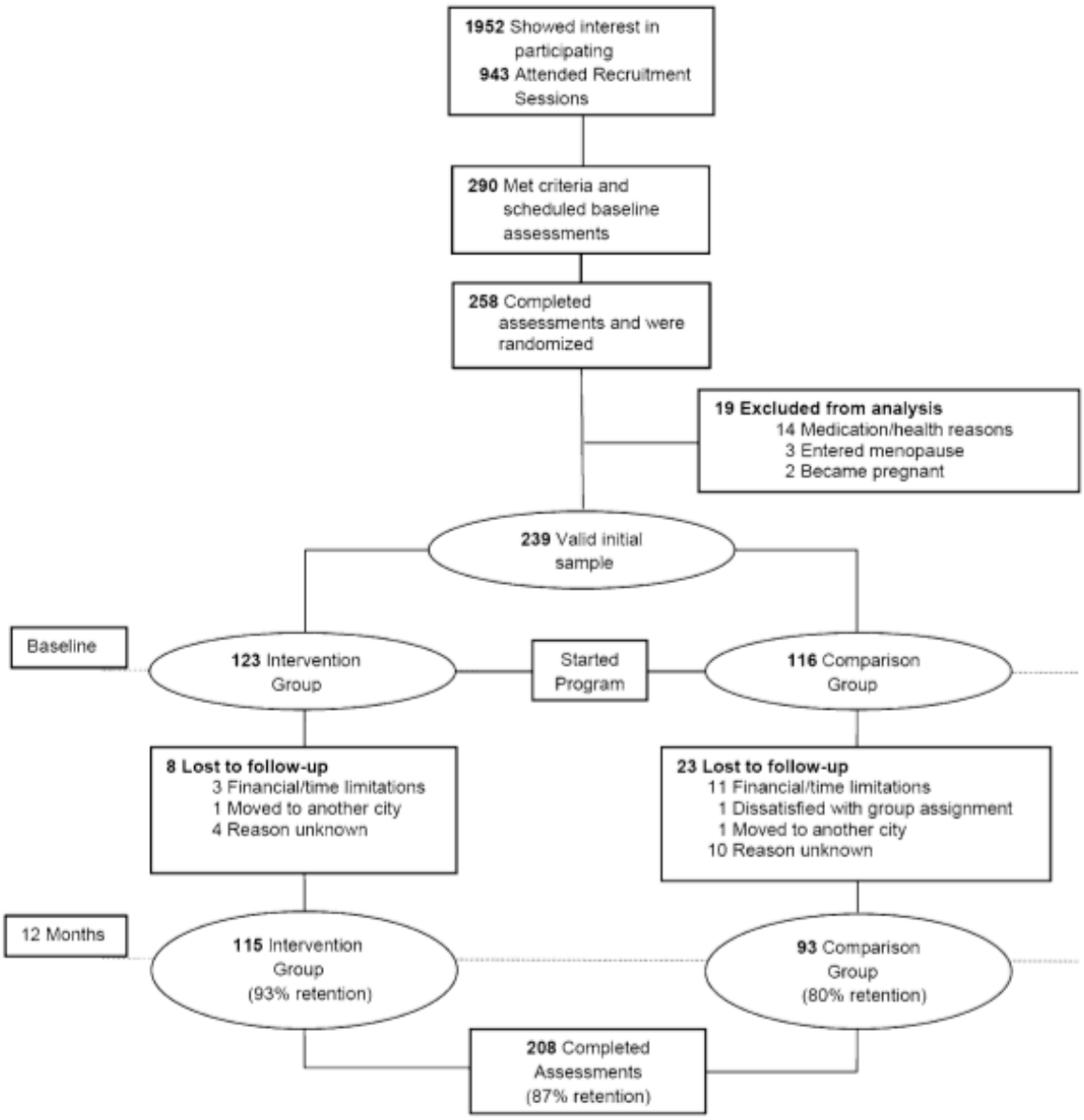

Figure 1. CONSORT diagram

Appendix 2 Table 6

Table 6. Multiple regression analysis for MVPA at 12 months from 4 month psychosocial variables*

Predictor variables	*ß*	*P*	R^2 change (*P*)	R^2 (*P*)
Self-Determination Theory				
Needs				0.215 (<0.001)
Age	0.099	0.142		
Education	-0.012	0.859		
Group	0.289	<0.001		
Perceived autonomy	0.280	<0.001	0.071 (<0.001)	
Motives				0.163 (<0.001)
Age	0.097	0.157		
Education	-0.043	0.527		
Group	0.335	<0.001		
Enjoyment	0.136	0.048	0.018 (0.048)	
Regulations				0.202 (<0.001)
Age	0.090	0.175		
Education	-0.031	0.641		
Group	0.255	<0.001		
Intrinsic motivation	0.267	<0.001	0.061 (<0.001)	
Full model				0.228 (<0.001)
Age	0.088	0.192		
Education	-0.001	0.992		
Group	0.246	0.001		
Competence	0.183	0.026	0.068 (<0.001)	
Intrinsic motivation	0.180	0.033	0.020 (0.033)	
Theory of Planned Behavior				0.242 (<0.001)
Age	0.066	0.319		
Education	-0.050	0.450		
Group	0.212	0.003		
Perceived beh. control	0.352	<0.001	0.107 (<0.001)	

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

Appendix 3 Table 7

Table 7. Multiple regression analysis for MVPA at 12 months from 12 month psychosocial variables*

Predictor variables	*ß*	*P*	R^2 change (*P*)	R^2 (*P*)
Self-Determination Theory				
Needs				0.258 (<0.001)
Age	0.130	0.047		
Education	-0.074	0.256		
Group	0.261	<0.001		
Perceived autonomy	0.195	0.014	0.075 (<0.001)	
Perceived competence	0.177	0.026	0.021 (<0.026)	
Motives				0.195 (<0.001)
Age	0.105	0.122		
Education	-0.028	0.675		
Group	0.297	<0.001		
Challenge	0.228	0.001	0.047 (0.001)	
Regulations				0.207 (<0.001)
Age	0.091	0.173		
Education	-0.041	0.533		
Group	0.229	0.002		
Intrinsic motivation	0.278	<0.001	0.060 (<0.001)	
Full model				0.259 (<0.001)
Age	0.138	0.037		
Education	-0.070	0.286		
Group	0.238	0.001		
Perceived competence	0.197	0.015	0.079 (<0.001)	
Perceived autonomy	0.195	0.015	0.025 (<0.015)	
Theory of Planned Behavior				
Age	0.108	0.096		0.255 (<0.001)
Education	-0.050	0.446		
Group	0.252	<0.001		
Perceived beh. control	0.325	<0.001	0.089 (<0.001)	
Age	0.109	0.088		0.300 (<0.001)
Education	-0.044	0.492		
Group	0.214	0.002		
Perceived beh. control	0.249	0.001	0.028 (0.009)	
Intention	0.212	0.009	0.114 (<0.001)	

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

Appendix 4 Table 8

Table 8. Multiple regression analysis for MVPA at 36 months from 12 month psychosocial variables*

	ß	*P*	R^2 Change (*P*)	R^2 (*P*)
Self-Determination Theory				
Needs				0.134 (<0.001)
Age	0.181	0.024		
Education	0.054	0.488		
Group	0.129	0.115		
Perceived competence	0.265	0.001	0.063 (0.001)	
Motives				0.100 (0.004)
Age	0.150	0.063		
Education	0.062	0.440		
Group	0.178	0.025		
Affiliation	0.196	0.015	0.038 (0.015)	
Regulations				0.068 (0.015)
Age	0.151	0.063		
Education	0.049	0.540		
Group	0.203	0.011		
Full model				0.132 (<0.001)
Age	0.189	0.020		
Education	0.050	0.527		
Group	0.113	0.177		
Perceived competence	0.271	0.001	0.065 (0.001)	
Theory of Planned Behavior				0.093 (0.007)
Age	0.147	0.068		
Education	0.046	0.564		
Group	0.128	0.142		
Perceived beh. control	0.182	0.038	0.027 (0.038)	
Age	0.127	0.117		0.112 (0.002)
Education	0.045	0.573		
Group	0.148	0.072		
Intention	0.223	0.007	0.046 (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

Appendix 5 Table 9

Table 9. Multiple regression analysis for LPAI at 12 months from 4 month psychosocial variables*

Predictor variables	*ß*	*P*	R^2 change (*P*)	R^2 (*P*)
Self-Determination Theory				
Needs				0.376 (<0.001)
Age	0.086	0.181		
Education	-0.244	<0.001		
Group	0.440	<0.001		
Perceived autonomy	0.243	<0.001	0.057 (<0.001)	
Motives				0.423 (<0.001)
Age	0.089	0.153		
Education	-0.212	0.001		
Group	0.456	<0.001		
Revitalization	0.267	<0.001	0.089 (<0.001)	
Affiliation	0.125	0.048	0.015 (0.048)	
Regulations				0.386 (<0.001)
Age	0.087	0.171		
Education	-0.213	0.001		
Group	0.376	<0.001		
Intrinsic motivation	0.295	<0.001	0.076 (<0.001)	
Full model				0.398 (<0.001)
Age	0.076	0.252		
Education	-0.174	0.010		
Group	0.428	<0.001		
Revitalization	0.213	0.002	0.063 (<0.001)	
Theory of Planned Behavior				0.356 (<0.001)
Age	0.094	0.159		
Education	-0.232	0.001		
Group	0.412	<0.001		
Attitude	0.223	<0.001	0.046 (0.001)	

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

Appendix 6 Table 10

Table 10. Multiple regression analysis for LPAI at 12 months from 12 month psychosocial variables*

	ß	*P*	R^2 Change (*P*)	R^2 (*P*)
Self-Determination Theory				
Needs				0.401 (<0.001)
Age	0.090	0.157		
Education	-0.229	<0.001		
Group	0.418	<0.001		
Perceived autonomy	0.280	<0.001	0.072 (<0.001)	
Motives				0.381 (<0.001)
Age	0.104	0.109		
Education	-0.241	<0.001		
Group	0.392	<0.001		
Enjoyment	0.262	<0.001	0.061 (<0.001)	
Regulations				0.379 (<0.001)
Age	0.087	0.172		
Education	-0.216	0.001		
Group	0.350	<0.001		
Intrinsic motivation	0.280	<0.001	0.061 (<0.001)	
Full model				0.414 (<0.001)
Age	0.068	0.289		
Education	-0.233	<0.001		
Group	0.424	<0.001		
Perceived autonomy	0.235	<0.001	0.063 (<0.001)	
Affiliation	0.144	0.025	0.020 (0.025)	
Theory of Planned Behavior				0.379 (<0.001)
Age	0.093	0.150		
Education	-0.239	<0.001		
Group	0.416	<0.001		
Attitude	0.249	<0.001	0.058 (<0.001)	
Age	0.080	0.222		0.390 (<0.001)
Education	-0.236	<0.001		
Group	0.399	<0.001		
Intention	0.286	<0.001	0.076 (<0.001)	

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

Appendix 7 Table 11

Table 11. Multiple regression analysis for LPAI at 36 months from 12 month psychosocial variables*

	ß	*P*	R^2 Change (*P*)	R^2 (*P*)
Self-Determination Theory				
Needs				0.297 (<0.001)
Age	0.110	0.173		
Education	-0.197	0.014		
Group	0.056	0.513		
Perceived autonomy	0.469	<0.001	0.190 (<0.001)	
Motives				0.318 (<0.001)
Age	0.088	0.275		
Education	-0.218	0.006		
Group	0.114	0.178		
Enjoyment	0.282	0.003	0.141 (<0.001)	
Affiliation	0.249	0.005	0.048 (0.005)	
Regulations				0.285 (<0.001)
Age	0.058	0.467		
Education	-0.184	0.022		
Group	0.011	0.905		
Intrinsic motivation	0.470	<0.001	0.173 (<0.001)	
Full model				0.363 (<0.001)
Age	0.098	0.211		
Education	-0.201	0.010		
Group	0.074	0.370		
Perceived autonomy	0.359	<0.001	0.162 (<0.001)	
Affiliation	0.292	<0.001	0.079 (0.001)	
Theory of Planned Behavior				
Age	0.059	0.480		0.244 (<0.001)
Education	-0.219	0.010		
Group	0.105	0.231		
Attitude	0.379	<0.001	0.129 (<0.001)	
Age	0.029	0.722		0.288 (<0.001)
Education	-0.215	0.009		
Group	0.083	0.335		
Intention	0.266	0.010	0.141(<0.001)	
Attitude	0.229	0.027	0.032 (0.027)	

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