Received: 20 November 2019 | Revised: 10 February 2020 | Accepted: 24 February 2020

DOI: 10.1111/phn.12718

PHN PUBLIC HEALTH NURSING WILEY

POPULATIONS AT RISK ACROSS THE LIFESPAN–PROGRAM EVALUATIONS

Sociocognitive factors associated with lifestyle intervention attrition after successful weight loss among participants with prediabetes—The PREVIEW study

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Funding information
The work was support by EU 7th Framework Programme (FP7/2007-2013; grant agreement no. 312057); and The National Health and Medical Research Council—EU Collaborative Grant, AUS; and The New Zealand Health Research Council (14/191); and University of Auckland, New Zealand, Faculty Research Development Fund. The Cambridge Weight Plan kindly donated all products for the 8-week low-energy diet period.

Abstract

Introduction: Major risk factors for type 2 diabetes are lifestyle choices such as lack of physical activity (PA) and poor diet. Many individuals either do not take part or struggle to complete interventions supporting lifestyle changes. Demographic and theory-based sociocognitive factors associated with PREVIEW intervention attrition after successful weight loss were examined.

Methods: Participants (1,856) who started the weight maintenance phase after completion of low-energy diet were retrospectively divided into three clusters depending on the point they left the trial. Discriminant analysis examined which demographic and theory-based sociocognitive variables were associated with cluster membership.

Results: Most of the participants were women and well-educated. Two discriminant functions were calculated ($\chi^2(24) = 247.0$, $p \geq .05$, $d = 0.78$). The demographic variables, such as age and ethnicity, and the social cognitive variable outcome expectancies on the other side were associated with cluster membership. Older age,

Caucasian ethnicity, and fewer expected disadvantages of PA were associated with high success.

Discussion: The discriminant model gave insight into some factors associated with early attrition. For practitioners planning interventions it underlines the necessity to take extra attention to younger participants and to those being afraid that being physically active causes unpleasant ramifications.

KEYWORDS

attrition, completion, diabetes type 2, lifestyle, social-cognitive

1 | INTRODUCTION

Type 2 diabetes (T2D) is a major public health issue and risk factor for developing cardiovascular and renal diseases (World Health Organization, 2016). T2D is commonly triggered by a combination of reduced insulin secretion and increased resistance to insulin-mediated glucose disposal, which leads to hyperglycemia (Guariguata et al., 2014; Tamayo et al., 2014). Progress to T2D is often gradual with a transitional stage between normal glucose metabolism and T2D described as prediabetes (Wareham & Herman, 2016). While major risk factors for development of T2D are obesity and lack of physical activity (PA), changes in lifestyle leading to weight loss and increased PA can be effective in T2D prevention (Lindström et al., 2003), although challenging to achieve (Rockette-Wagner et al., 2017).

The PREVIEW (PREvention of diabetes through lifestyle Intervention and population studies in Europe and around the World—EU FP7 grant agreement no. 312057) was a two-phase, eight-center randomized controlled trial (RCT) aiming to identify an effective combination of diet and PA to decrease T2D risk among overweight participants with prediabetes (Fogelholm et al., 2017). In comparison to previous large-scale diabetes lifestyle intervention studies (Diabetes Prevention Program Research Group, 2002; Lindström et al., 2003), the PREVIEW included rapid weight loss and participants were supported by a theory-orientated and stage-based (Prochaska & DiClemente, 1992) group behavior modification program PREMIT (PREview behavior Modification Intervention Toolbox; Kahlert et al., 2016). PREMIT was inspired by a number of theoretical models including the Health Action Process Approach (Schwarzer, 2001), the Social Cognitive Theory (Bandura, 1996), and the Self-Determination Theory (Ryan & Deci, 2000) and aimed to influence critical behavioral determinants such as motivation, temptations, and self-efficacy (Bandura, 1996; Hausenblas et al., 2001; Ryan & Deci, 2000).

Community-based lifestyle interventions have attracted criticism due to their potential to increase health inequalities. Women and those with a more affluent life situation tend to be overrepresented, even though men, ethnic minorities, as well as those from lower social-economic background tend to have higher risk of developing, for example, T2D (Gavarkovs, Burke, & Petrella, 2016; Harreiter & Kautzky-Willer, 2018; Siegel et al., 2018; Sortsø, Lauridsen, Emneus, Green, & Jensen, 2018). Similarly, higher lifestyle intervention attrition has been associated with sociodemographic and cognitive factors such as lower educational achievement, ethnicity, younger age, higher BMI, unemployment, and lower self-efficacy (Burgess, Hassmén, & Pumpa, 2017; Goode et al., 2016; Haughton et al., 2018; Leung, Chan, Sea, & Woo, 2017).

Lifestyle interventions aim for healthy behaviors to become intrinsically regulated, that is, being rewarding in itself instead of being performed to avoid, for example, a guilty conscience (introjected regulation) or due to external demands (extrinsic motivation; Ryan & Deci, 2000). The formation of new lifestyle habits is also supported by strong self-efficacy, that is, beliefs about abilities (Bandura, 1996; Miller, Weinhold, & Nagaraja, 2016), and expected outcomes so that expected advantages increase the likelihood of a behavior being performed (Miller et al., 2016). Temptations, such as viewing television instead of exercising, describe commonly cited reasons for sedentary lifestyle, and appear to be especially important in impeding adherence to newly acquired behaviors (Hausenblas et al., 2001). While theory-based sociocognitive factors such as self-efficacy have been associated with achieving lifestyle change goals (Hansen et al., 2018; Huttunen-Lenz et al., 2018), evidence is less conclusive about which sociocognitive variables may predict attrition to a lifestyle change program after successful weight loss.

The primary aim of this study was to gain insight into a set of demographic and theory-based sociocognitive variables associated with intervention attrition after successful weight loss among participants with prediabetes. As it is well documented that higher weight is associated with increased intervention attrition (Goode et al., 2016), weight was not included in the analyses. The secondary objective of the study was to explore whether the intervention had a potential to increase health inequalities, which would be important if the program was to be translated into a community intervention.

It was hypothesized that younger age, lower educational achievement, non-Caucasian ethnicity, economic inactivity (not retirement), marital status (not married), living with children, and less-frequent attendance to the PREVIEW study weight-maintenance phase would be associated with early attrition once the weight-loss target was achieved. Furthermore, lower intrinsic motivation, lower self- and

coping self-efficacy, and higher self-reported temptations, as well as expected disadvantages caused by PA were hypothesized to be associated with early attrition.

2 | METHODS

2.1 | Study design

The PREVIEW RCT (trial registration number NCT01777893) was a two-phase intervention with an initial 8-week low-energy diet phase (LED, Cambridge Weight Plan™; phase II), followed by a 34-month weight maintenance phase (phase II) for those who achieved at least 8% loss of their initial body weight during the LED phase (Figure 1). At phase II participants were randomized into different intervention arms. The intervention was delivered as a 2 × 2 diet and exercise factorial design, where the intervention arms were comprised one of the two dietary programs (Higher Protein, Moderate Carbohydrate, Low Glycemic Index Diet vs. Moderate Protein, Higher Carbohydrate, Medium Glycemic Index Diet) and one of the two PA programs (High-Intensity PA; Moderate-Intensity PA; Fogelholm et al., 2017).

The group behavior modification program PREMIT was designed to support behavior change independent of the intervention arms. A range of behavior change techniques were deployed including knowledge, action planning, and setting behavioral goals (Kahlert et al., 2016). The PREMIT comprised of four different stages (Figure 1), which run concomitant with the PREVIEW RCT. Stage 1 ran parallel with the PREVIEW RCT Phase I and prepared participants for the PA and diet changes in Phase II. The stages 2 and 3 of the PREMIT supported formation of healthy habits, while the emphasis during the stage 4 was in maintaining the new habits (Kahlert et al., 2016). While the PREVIEW and PREMIT were conducted by local research personnel using local languages, PREMIT was not culturally or linguistically tailored to specific target populations.

2.2 | Participant recruitment

Overweight and obese (BMI ≥ 25 kg/m^2) men and women with confirmed prediabetes (increased fasting glucose and/or an impaired glucose tolerance in a 2-hr oral glucose tolerance test (American Diabetes Association, 2011), aged 25–70 years, were eligible for inclusion. Participant recruitment was completed in eight PREVIEW RCT intervention sites: Copenhagen, Denmark; Helsinki, Finland; Nottingham, United Kingdom; Maastricht, The Netherlands; Navarra, Spain; Sofia, Bulgaria; Auckland, New Zealand; and Sydney, Australia.

Participants were recruited through referrals from local primary and occupational health care providers and advertising both in print and visual media. Prospective participants were prescreened before being invited to full screening in a clinic. Recruitments strategies were not tailored to be country specific, although conducted in local language/s. Written informed consent was required before study enrollment. The Human Ethics Committees in each of the eight participating sites reviewed the study protocol (Fogelholm et al., 2017).

2.3 | Data collection and measurements

Data collection included anthropometric (e.g., body weight and height), physiological (e.g., HbA1c), demographic, and sociocognitive variables. The demographic and sociocognitive variables relevant to this study as well as weight were collected at the Week 8 of the intervention.

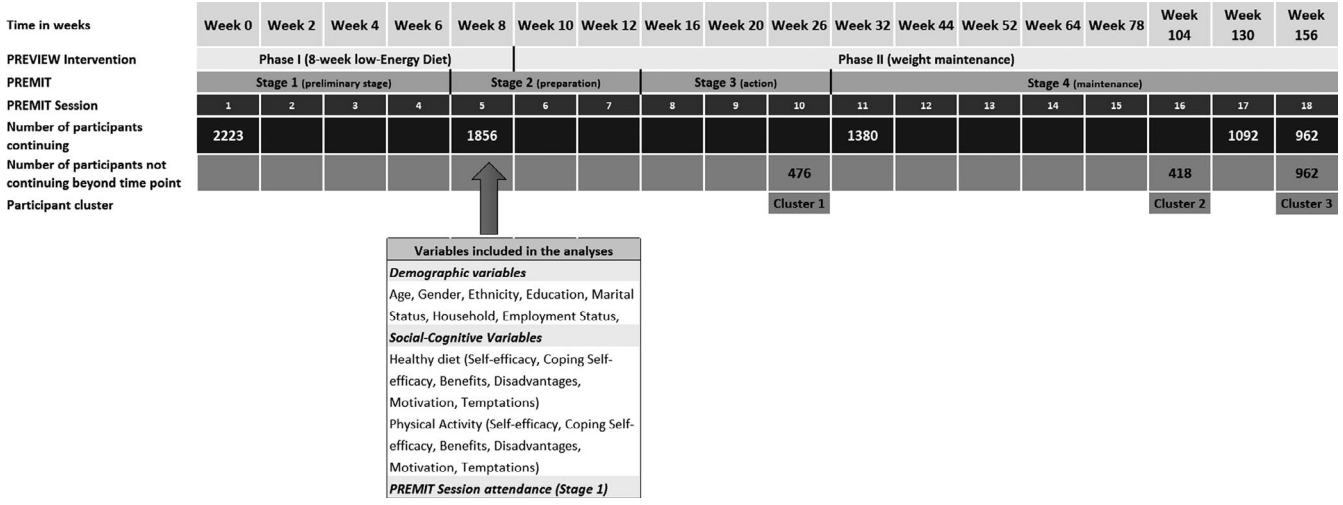

FIGURE 1 PREVIEW intervention and PREMIT behavior modification program structure. PREMIT, PREview behavior Modification Intervention Toolbox; PREVIEW, PREvention of diabetes through lifestyle Intervention and population studies in Europe and around the World

2.3.1 | PREMIT attendance and trial attrition

Participants' attendance to group-based PREMIT sessions was recorded on a centralized database (OpenClinica®). Drop out from intervention (attrition) was determined by the last recorded attendance to a Clinical Investigation Day (Figure 1). Reason for drop-out was collected using categories, such as personal reasons (known reason), continuation contraindicated, noncompliance, lost to follow-up (unknown reason).

2.3.2 | Sociodemographic characteristics

The European Social Survey and International Social Survey (ESS, 2015) was used to collect information about demographic variables such as age, gender, ethnicity, and education level.

2.3.3 | Sociocognitive variables

Sociocognitive variables were collected using questionnaires, which, for non-English speaking intervention sites, were translated into the local languages.

2.4 | Self-regulation of motivation

Self-regulatory style was measured using The Treatment Self-Regulation Questionnaire (Levesque et al., 2007) and included 15 items for both healthy diet and for PA. The scale provides measurements for four dimensions of self-regulatory style of motivation: autonomous regulatory style (six items), an introjected regulatory style (two items), an extrinsic regulatory style (four items), and a motivation (three items), which was not included in the analyses. Response options ranged from "1" (*not at all true*) to *"7"* (*very true*). For each dimension, an arithmetic mean of the dimension total score ranging from 1 to 7 was calculated, with higher scores indicating behavior being motivated by the particular self-regulatory style. Cronbach's alphas for the scales of autonomous, introjected, and external motivation for healthy diet were α = 0.92, 0.87, and 0.82, respectively. Cronbach's alphas for the scales of autonomous, introjected, and external motivation for PA were α = 0.92, 0.83, and 0.83, respectively (Levesque et al., 2007). Calculated α's corresponded to previously reported Cronbach's alphas for autonomous (α range 0.85–0.93), introjected (α range 0.74–0.93), and external (α range 0.73–0.91; Levesque et al., 2007) regulatory style.

2.5 | PA and healthy diet action self-efficacy

Self-efficacy for diet and PA was/were assessed separately by asking participants about how certain they are to overcome barriers for maintaining healthy diet (five items) and PA (five items; Schwarzer & Renner, 2005). Response options ranged from "1" (*very uncertain*) to "4" (*very certain*). For both dimensions, an arithmetic mean of the total dimension score ranging from 1 to 4 was calculated, with higher scores reflecting greater self-efficacy. Cronbach's alphas for the diet and PA scales were α = 0.89 and 0.91, respectively. Calculated α's corresponded to previously reported Cronbach's alphas for PA (α = 0.88) and diet (α = 0.87; Schwarzer & Renner, 2005).

2.6 | PA and healthy diet coping self-efficacy

Participants' confidence in staying physically active (11 items) and sticking to a healthy diet (three items) despite forthcoming barriers were measured using a questionnaire adapted from Schwarzer and Renner (2000, 2005). Response options ranged from "1" (*not at all true*) to "4" (*exactly true*). For both dimensions, an arithmetic mean of the dimension score was calculated ranging from "1" to "4", high scores indicating greater coping self-efficacy. Cronbach's alphas for the healthy diet and PA scales were α = 0.89 and 0.94, respectively. Calculated α's corresponded with previously reported Cronbach's alphas for diet (α = 0.85) and PA (α = 0.88) self-efficacies (Renner, Hankonen, Ghisletta, & Absetz, 2012; Schwarzer & Renner, 2000).

2.7 | Outcome expectancies

Participants were asked to rate expected benefits and disadvantages of behavior change for healthy diet (benefits six items/disadvantages six items) and PA (benefits 10 items/disadvantages three items; Renner & Schwarzer, 2005a; 2005b). Response options rated from "1" (not at all true) to "4" (exactly true). For each dimension, an arithmetic mean of the dimension total score was calculated ranging from "1" to "4". Low scores indicated fewer expected benefits or disadvantages from diet and PA changes. Cronbach's alphas for the scales of expected benefits and disadvantages of healthy diet were α = 0.75 and 0.66, respectively. Cronbach's alphas for the scales of expected benefits and disadvantages of PA were α = 0.86 and 0.63, respectively. Calculated α's corresponded to previously reported Cronbach's alphas for scales adapted from Renner and Schwarzer (2005a, 2005b) for healthy diet ($\alpha \geq 0.8$) and PA (α = 0.67; Heideman et al., 2012; Renner & Schwarzer, 2005).

2.8 | Physical inactivity and unhealthy diet temptations

Subscale "competing demands" of the Temptation to not Exercise Scale was used (five items; Hausenblas et al., 2001). A supplementary item ("How tempted are you not to exercise and be sedentary while being on a business trip") was added (total six items). Response options ranged from "1" (*not at all tempted*) to "5" (*extremely tempted*) not to exercise in certain situations. For measuring unhealthy food temptations, a new, seven-item scale was constructed based on the

temptation for physical inactivity Scale/scale subscale of competing demands (Hausenblas et al., 2001). On the response scale from "1" (*hard to do*) to "5" (*no problem at all*), participants were asked how easy it is for them to follow a healthy diet when…eating out at a restaurant or in a canteen/celebrating with family or friends/passing a fast-food restaurant/had a hard day and feeling restless or upset/others around me order or eat fatty or sweet food/looking in the shops at shelves filled with sweets or with fatty food/a lot of fatty and sweet food is available. Principal components analysis with varimax rotation was conducted to examine the factor structure of the scale. The results indicated one factor solution with all items loading in to one factor (Eigenvalue = 4.22) that explained 60.63% of the total variance. For both physical inactivity and unhealthy food temptations scales, an arithmetic mean was calculated ranging from "1" to "5", with low scores reflecting lower temptations. Cronbach's alphas for the scales of physical inactivity and unhealthy food temptations were α = 0.88 and 0.90, respectively. Calculated α's corresponded to previously reported Cronbach's alphas for PA competing demands (α = 0.86; Nigg et al., 2009).

2.8.1 | Statistical methods

Statistical analyses were performed with IBM SPSS® version 25 statistical program. Analyses were based on the 1,856 participants who were recorded as successfully completing the weight-loss phase of the PREVIEW intervention (phase I). Five sets of missing value data imputations for the sociocognitive variables of self-efficacy, outcome expectancies, motivation, and temptations using automatic method with maximum case draws set at 4,000 and maximum parameter draws at 4 were completed. For all analyses including variables with imputed data, sensitivity analyses without imputed data were performed. No values were removed as outliers. The following data transformations were completed: outcome expectancies benefits diet, coping self-efficacy diet, and autonomous motivation (LG10(K-X)); action self-efficacy diet, coping self-efficacy PA, and introjected motivation (SQRT(K-X)); outcome expectancies disadvantages diet, food temptations, and external motivation (SQRT(X)). Means and standard deviations in the tables are reported for untransformed data.

Descriptive statistical methods were used to analyze participant characteristics at baseline, and social-demographic variables at Week 8, and the recorded reason for leaving the trial. Participants were divided retrospectively into three clusters depending on the point they left the intervention (irrespective of the cause) or intervention completion. Those in the Cluster 1 (476) did not continue beyond Week 26 (action stage of the PREMIT) of the PREVIEW intervention. Those in Cluster 2 (418) did not continue beyond Week 104 (during maintenance stage of the PREMIT), whereas participants in Cluster 3 completed the PREVIEW intervention (962).

Chi-square ($p \leq .05$) test was used to examine whether attrition was associated with intervention arm allocation. Box's *M* test ($p \leq .01$) with inspection of Log-ranks was used to examine covariance matrices. While Multivariate Analysis of Variance can be used to explore association between a set of variables and a cluster membership, discriminant analysis with point of leaving the intervention (or completing) as a dependent variable was chosen. Analyses investigated whether a set of variables (predictors) were suitable to identify cluster membership and how adequate the classification was. Age, gender, ethnicity, marital status, educational achievement, living with others (adults, children), employment status, PREMIT attendance, self-efficacy (diet, PA), coping self-efficacy (diet, PA), motivation (autonomous, introjected, external—diet and PA), outcome expectations (advantages and disadvantages—diet and PA), temptations for physical inactivity, and unhealthy diet were included as predictor variables. For categorical variables, dummy variables were created. Stepwise method with Wilk's Lambda (entry value *F* 3.84; removal value *F* 2.71) was used for analysis to find best combination of predictors. Prior probabilities were calculated from group sizes. After determining the discriminant functions, only those predictor variables with absolute correlation (pearson) $r_{x,y} \geq .30$ with a discriminant function were interpreted. For the discriminant analysis, level of significance was determined as $p \leq .05$. Further sensitivity analyses without imputed data (n = 1,263) and participants diagnosed with T2D (n = 1,218) or unable to continue due to their general condition (total n = 1,202) were performed.

After determining the predictor variables in the model, further post hoc significance test was calculated for continuous variables by contrasting each of the participant cluster with the two other clusters, pooled, to determinate which predictor variables separated the groups reliably. For continuous variables, contrast function in ONEWAY ANOVA was used and Pearson χ^2 was calculated for categorical variables. Pooled correlations between the selected predictor variables were estimated using Pearson *r* for continuous variables and Point-Biserial (Pearson r_{pb}) for two-level categorical variables. Due to multiple testing, adjusted $p \leq .017$ was used for all post hoc tests. Effect sizes were calculated using Lenhard and Lenhard (2016).

3 | RESULTS

Analyses were based on the 1,856 participants with characteristics shown in Table 1. Participants were predominantly female. Mean age at the start of the trial was 52.3 (*SD* ± 11.2) years. The majority of participants had high level of educational achievement, were married (or in a civil partnership), lived in households without children, and were either employed or engaged in college or university studies. No significant differences were found in participant attrition between the intervention arms ($\chi^2(6) = 8.44$, $p \geq .05$). Most participants dropped out due to personal reasons (e.g., change in life situation or due to demands of participation, Cluster 1 n = 59.7%, Cluster 2 n = 41.6%) followed by those lost to follow-up (Cluster 1 n = 23.1%, Cluster 2 n = 34.2%). For the discriminant analysis, test of homogeneity of covariance matrices (Box's *M* test) suggested significant heterogeneity (F (156, 4,719,085.5) = 2.3, $p \leq .01$). Further inspection of log determinants, however, suggested that log determinants (Rank

TABLE 1 Demographic characteristics for the total participant population and separately depending on point of drop-out or completion of the PREVIEW intervention

	All (*N* = 1,856)	Cluster 1 Did not continue beyond Week 26 (*N* = 476)	Cluster 2 Did not continue beyond Week 104 (*N* = 418)	Cluster 3 Completed (*N* = 962)	Contrast analyses (variables included in the model)
Age (*M* ± *SD*)	52.3 ± 11.2	48.4 ± 12.1[a]	51.1 ± 11.2	54.8 ± 10.0[b]	Sig. younger[a] Sig. older[b]
BMI Week 8 (*M* ± *SD*)	31.2 ± 5.8	33.1 ± 6.4	32.7 ± 6.0	29.5 ± 4.8	—
Gender Female	1,233 (66.4%)	321 (67.4%)	293 (70.1%)	619 (64.3%)	—
Education					
Up to secondary	299 (16.1%)	79 (16.6%)	86[a] (20.6%)	134[b] (13.9%)	Sig. more[a] Sig. fewer[b]
Secondary vocational	328 (17.7%)	100 (21.0%)	64 (15.3%)	164 (17.0%)	
Higher vocational	328 (17.7%)	66 (13.9%)	69 (16.5%)	193 (20.1%)	
University	749 (40.4%)	181 (38.0%)	163 (39.0%)	405 (42.1%)	
Other	152 (8.2%)	50 (10.5%)	36 (8.6%)	66 (6.9%)	
Ethnicity Caucasian	1,663 (89.6%)	428 (89.9%)	344[a] (82.3%)	891[b] (92.6%)	Sig. fewer Caucasian[a] Sig. more Caucasian[b]
Marital status					
Married[a]	1,288 (69.4%)	308[a] (64.7%)	266[a] (63.6%)	714[b] (74.2%)	Sig. fewer married[a] Sig. more married[b]
Previous relationship[b]	281 (15.1%)	74 (15.5%)	73 (17.5%)	134 (13.9%)	
Single or other	287 (15.5%)	94 (19.7%)	79 (18.9%)	114 (11.9%)	
Household adults					—
Only 1	393 (21.2%)	112 (23.5%)	99 (23.7%)	182 (16.9%)	
2 adults	1,124 (60.6%)	271 (56.9%)	242 (57.9%)	611 (63.5%)	
3 or more adults	339 (18.3%)	93 (19.5%)	77 (18.4%)	169 (17.6%)	
Households without children	1,453 (78.3%)	355 (74.6%)	319 (76.3%)	779 (81.0%)	—
Employment status					
Employed or studying[c]	1,265 (68.2%)	328 (68.9%)	309[a] (73.9%)	628[b] (65.3%)	Sig. more[a] Sig. fewer[b]
Currently not economically active[d]	259 (14.0%)	85 (17.9%)	52 (12.4%)	122 (12.7%)	
Retired	332 (17.9%)	63 (13.5%)	57 (13.6%)	212 (22.0%)	
All PREMIT Session during preliminary stage attended	1,205 (64.9%)	320 (67.2%)	270 (64.6%)	615 (63.9%)	—

Abbreviation: PREVIEW, PREvention of diabetes through lifestyle Intervention and population studies in Europe and around the World.

[a]Includes those in civil partnerships.

[b]Widowed, Divorced, and Separated.

[c]Regardless of hours per week worked.

[d]Caring for home and/or family, Unemployed, Sickness, and missing values.

12) were relatively equal between the groups (Cluster 1 = −16.3; Cluster 2 = −16.2; Cluster 3 = −18.1).

Two discriminant functions were calculated with combined $\chi^2(24) = 247.0$ ($p \geq .05$, $d = 0.78$). After removing the first function, there continued to be a significant association between participant clusters and discriminant variables ($\chi^2(11) = 47.6$, $p \geq .05$, $d = 0.32$). Respectively, the two discriminant functions accounted for 75.4% and 24.6% of the between-participant cluster variation. The first discriminant function separated maximally between those who did not continue beyond Week 26 (Cluster 1) and those who completed the PREVIEW trial (Cluster 3—Week 156) with those not continuing beyond Week 104 (Cluster 2) falling in between. The second discriminant function appears to separate between those not continuing beyond Week 26 (Cluster 1) or Week 104 (Cluster 2), with those completing the PREVIEW intervention (Week 156—Cluster 3) falling in between. In Table 2 are shown means and standard deviations for sociocognitive variables.

Twelve predictor variables were included in the discriminant function model as significant predictors: age, marital status, employment,

TABLE 2 Means and standard deviations for the sociocognitive variables at the Week 8 (untransformed data) for all participants and separately for the participant clusters depending on the point of drop-out

Scale 1–4 **Self-efficacy (SE),** **Outcome expectancies (OE)** *Scale 1–7* **Motivation** *Scale 1–5* **Temptations**	**All** **(*N* = 1,856)** ***M* ± *SD***	**Cluster 1** **Did not continue beyond Week 26** **(*N* = 476)** ***M* ± *SD***	**Cluster 2** **Did not continue beyond Week 104** **(*N* = 418)** ***M* ± *SD***	**Cluster 3** **Completed** **(*N* = 962)** ***M* ± *SD***	**Contrast analyses (variables included in the model)**
SE healthy diet	3.2 ± 0.6	3.2 ± 0.6	3.2 ± 0.6	3.2 ± 0.6	—
SE physical activity	2.9 ± 0.7	2.8 ± 0.7	2.8 ± 0.7	2.9 ± 0.6	—
Coping SE physical activity	2.9 ± 0.7	2.8 ± 0.7	2.9 ± 0.7	2.9 ± 0.7	—
Coping SE healthy diet	3.3 ± 0.7	3.2 ± 0.7	3.3 ± 0.7	3.3 ± 0.7	—
Benefits—OE healthy diet	3.4 ± 0.5	3.4 ± 0.5	3.4 ± 0.5	3.4 ± 0.5	—
Disadvantages—OE healthy diet	2.0 ± 0.5	2.0 ± 0.6	2.0 ± 0.5	1.9 ± 0.5	—
Benefits—OE physical activity	3.3 ± 0.5	3.2 ± 0.5	3.3 ± 0.4	3.3 ± 0.5	—
Disadvantages—OE physical activity	2.2 ± 0.6	2.3 ± 0.7[a]	2.3 ± 0.6	2.2 ± 0.6[b]	Sig, more expected disadvantages[a] Sig. fewer expected disadvantages[b]
Autonomous motivation healthy diet	6.5 ± 0.8	6.4 ± 0.8	6.5 ± 0.8	6.5 ± 0.7	
Introjected motivation healthy diet	4.5 ± 1.8	4.7 ± 1.8	4.6 ± 1.9	4.4 ± 1.8	
External motivation healthy diet	3.3 ± 1.6	3.4 ± 1.7	3.5 ± 1.7	3.1 ± 1.5	
Autonomous motivation physical activity	6.3 ± 0.9	6.2 ± 1.0	6.3 ± 1.0	6.3 ± 0.9	
Introjected motivation exercising	4.3 ± 1.9	4.3 ± 1.9	4.45 ± 1.9	4.3 ± 1.8	
External motivation exercising	2.8 ± 1.6	2.9 ± 1.6	3.0 ± 1.6	2.7 ± 1.5	
Temptations for inactivity	3.0 ± 0.9	2.9 ± 0.9	3.0 ± 1.0	3.0 ± 0.9	
Temptations for unhealthy food	2.4 ± 0.8	2.4 ± 0.9	2.4 ± 0.8	2.4 ± 0.8	

Abbreviations: OE, outcome expectancies; SE, self-efficacy.

[a]Participants in Cluster 1 expected significantly more disadvantages than pooled other participants.

[b]Participants in Cluster 3 expected significantly fewer disadvantages than pooled other participants.

introjected motivation for diet, education, ethnicity, self-efficacy for diet, expected disadvantages of PA, autonomous motivation for PA, and temptations for physical inactivity. Standardized coefficients for the predictor variables and pooled within-cluster correlations between discriminating variables and standardized canonical discriminant functions are shown in Table 3. Also, univariate tests for the equality of group means are shown in Table 3.

Using a cutoff point of $r \geq .30$, predictor variables with lower correlation (i.e., $r < .30$) with the discriminant functions were not included in the further interpretation (Table 3, pooled correlations). After applying the cutoff point to predictor variables in the model, both functions were left with three predictor variables, function 1 with age ($r = .75$), marital status (married $r = .30$), and expected disadvantages of PA ($r = -.30$), and function 2 with ethnicity (non-Caucasian $r = -.71$), employment status (employed and studying $r = -.36$), and education (up to secondary school $r = -.37$).

Three contrasts were performed and each cluster was contrasted with the two other clusters pooled. Levene's test indicated heterogeneity of variance and thus contrasts were reported for unequal variances. Those in Cluster 1 was significantly younger than other participants (t (785) = 7.1, $p \leq .017$, $d_{Cohen} = 0.48$). Participants in Cluster 2 did not significantly differ in their age from others (t (709) = 0.8, $p \geq .017$), whereas those in Cluster 3 were significantly older than others (t (1,766) = −10.0, $p \leq .017$, $d_{Cohen} = 0.48$). Expected disadvantages of PA indicated similar pattern. Participants in Cluster 1 had significantly higher expectations of disadvantages from PA than others, although the effect size suggested only a small effect (t (852) = −2.6, $p \leq .017$, $d_{Cohen} = 0.14$). No significant differences were found between Cluster 2 and other participants (t (703) = −1.0, $p \geq .017$). In comparison with other participants, those in Cluster 3 had significantly lower expectations of disadvantages from PA than other participants (t (1,824) = 4.3, $p \leq .017$, $d_{Cohen} = 0.20$). Again, the effect size was small.

Binominal variables (married or civil partnership/other; up to secondary school/other; employed or studying/other; and Caucasian/non-Caucasian) were used in contrast analyses for categorical variables. No significant differences were observed in ethnicity between those in Cluster 1 and pooled other participants ($\chi^2(1) = 0.1$, $p \geq .017$). In contrast, those in Cluster 2 reported significantly more often non-Caucasian ethnicity when compared with pooled other participants ($\chi^2(1) = 30.9$, $p \leq .017$, $d = 0.26$). Participants in Cluster 3 reported significantly more often Caucasian ethnicity when compared with pooled other participants ($\chi^2(1) = 19.5$, $p \leq .017$, $d = 0.21$).

TABLE 3 Test for equality of group means, standardized coefficients, and pooled within-cluster correlations between discriminating variables and standardized canonical discriminant functions for the predictor variables included in the model

	Function 1 Standardized coefficients	Function 2 Standardized coefficients	Function 1 Within-cluster correlations (*r*)	Function 2 Within-cluster correlations (*r*)	Group means Univariate *F* (2, 1,853)
Age[a]	0.780	−0.50	0.75	−0.07	58.9*
Marital status (married)[a]	0.25	0.28	0.30	0.25	11.1*
Employment (employed or studying)[a]	0.03	−0.54	−0.18	−0.36	6.3**
Introjected motivation diet	0.26	−0.01	0.21	0.06	4.7
Education (up to secondary)[a]	−0.21	−0.31	−0.14	−0.34	4.8**
Education (secondary vocational)	−0.22	0.15	−0.09	0.27	2.8
Education (other)	−0.27	0.01	−0.16	0.05	2.9
Ethnicity (non-Caucasian)[a]	0.02	0.74	0.22	0.71	17.0*
Self-efficacy physical activity	0.23	0.17	0.24	0.03	6.0
Expected disadvantages physical activity[a]	−0.20	0.02	−0.30	−0.07	9.7*
Autonomous motivation physical activity	−0.23	0.16	−0.15	0.22	3.6
Temptations for physical inactivity	0.31	0.01	0.1	0.00	1.0

Note: Standardized coefficients with larger absolute values indicate variables with greater discriminating ability.

[a]Variables with loadings $r \geq .30$ included in the final model.

*Group mean significant at $p \leq .001$;

**Group mean significant at level $p \leq .01$.

Participants in Cluster 1 ($\chi^2(1) = 6.6$, $p \leq .017$, $d = 0.12$) and Cluster 2 ($\chi^2(1) = 8.4$, $p \leq .017$, $d = 0.13$) reported significantly less often being married when compared with pooled other participants, with small effect sizes. Those in Cluster 3 reported more often than other participants being married ($\chi^2(1) = 21.9$, $p \leq .017$, $d = 0.22$), with a small effect size. No significant differences were observed in being educated up to secondary school between those in Cluster 1 and pooled other participants ($\chi^2(1) = 0.1$, $p \geq .017$). In Cluster 2 ($\chi^2(1) = 8.0$, $p \leq .017$, $d = 0.13$), participants reported significantly more often, and in Cluster 3 ($\chi^2(1) = 7.0$, $p \leq .017$, $d = 0.12$) significantly less often than pooled other participants, being educated up to secondary school, with small effect sizes. For being employed or studying, no significant differences were observed between those in Cluster 1 and pooled other participants ($\chi^2(1) = 0.4$, $p \geq .017$). Participants reported in Cluster 2 ($\chi^2(1) = 9.5$, $p \leq .017$, $d = 0.14$) significantly more often and in Cluster 3 ($\chi^2(1) = 10.0$, $p \leq .017$, $d = 0.15$) significantly less often than pooled other participants being employed or studying, although with small effect sizes. Pooled within correlation among the two continuous predictor variables indicated that older age was significantly correlated with fewer expected disadvantages from PA ($r = -.13$, $p \leq .017$, small effect). Participant age and ethnicity as well as employment status were also significantly associated, so that younger age was associated with non-Caucasian ethnicity ($r_{pb} = -.25$, $p \leq .017$, small effect) and being employed or studying ($r_{pb} = -.42$, $p \leq .017$, medium effect). Other than Caucasian ethnicity was also associated with more expected disadvantages of PA ($r_{pb} = .13$, $p \leq .017$, small effect). Being married was associated with fewer expected disadvantages of PA ($r_{pb} = -.06$, $p \leq .017$, small effect).

The classification model, overall, did better than chance in separating participants between the different clusters with 56.4% of the original cases correctly classified. The model did this by disproportionally classifying participants as those who completed the PREVIEW intervention. Therefore, most of the participants were classified as completers (Week 26 = 64.1%, Week 104 = 72.7%, and Week 156 = 88.6%). Therefore, the classification procedure indicated that the model was suitable at identifying those participants who completed the trial, of whom 88.6% were correctly classified. Of those who did not continue beyond Week 26, 29.8% were correctly classified. The model was inadequate in classifying participants who did not continue beyond Week 104, with only 12.7% of the participants correctly classified.

Sensitivity analyses with the original dataset suggested fewer and slightly different potential discriminating variables in the model. Four discriminating variables emerged. One discriminating variable, namely, age, loaded significantly ($r \geq .30$) to discriminant function 1. Discriminating variables of ethnicity (non-Caucasian), employment (employed or studying), and external motivation for diet loaded in the discriminant function 2. Sensitivity analyses without imputed data or participants diagnosed with T2D suggested similarly four significant ($r \geq .30$) discriminating variables with age loading to discriminant function 1, and ethnicity, employment (employed or studying), and self-efficacy for PA loading to discriminant function 2. For the final set of sensitivity analyses participants who had developed T2D or whose participation was terminated due to their general condition were excluded. Results suggested likewise four ($r \geq .30$) significant predictor variables, with age loading to discriminant function 1 and ethnicity, employment (employed or studying), and external motivation for diet loading to discriminant function 2. For all the sensitivity analyses, the classification did overall better than chance in separating participants between different clusters, which was achieved

by allocating participants disproportionally to completers' category (Cluster 3).

4 | DISCUSSION

The principal aim of this study was to examine which variables from a set of demographic and theory-driven sociocognitive variables provided the best prediction for intervention attrition among participants with prediabetes after successful weight loss. Younger age, being non-Caucasian, and in employment or studying, expecting disadvantages of PA, educational achievement up to secondary school, and not married emerged as the most important predictors.

Second objective of the study was the examination of concerns that interventions have a potential to increase health inequalities (Gavarkovs et al., 2016; Wareham & Herman, 2016). Indeed, the intervention program, if translated into, for example, a community health program seems vulnerable to contribute increasing health inequalities, as participants were predominantly women with high educational achievement, and in employment or in study. Although the demographic profile of the participants may have been influenced by self-selection bias (Krauss, 2018), participant's characteristics appear similar to those observed in many health promotion interventions (Gavarkovs et al., 2016; Wareham & Herman, 2016), thus indicating that men and those with lower educational achievement were less likely to participate. In this trial, furthermore, attrition was associated with factors such as non-Caucasian ethnicity and lower educational achievement, factors which have been previously related with higher risk of developing T2D (Gavarkovs et al., 2016; Harreiter & Kautzky-Willer, 2018). The majority of the participants who did not complete the trial did so due to personal reasons such as finding the commitments too demanding.

Although the model was better than chance in predicting participants' cluster membership, this was achieved by allocating the majority of participants as completers. Furthermore, the model appeared inaccurate in allocating participants to those who dropped out during the maintenance stage of the behavior change (Cluster 2). Thus, the model offered limited information about identifying risk of early attrition. However, as hypothesized, participants who did not continue beyond action stage at Week 26 (Cluster 1) were significantly younger than other participants, expected more disadvantages from PA, and were not married, whereas those who completed were significantly older, married, and expected fewer disadvantages from PA.

As older age correlated with fewer expected disadvantages, these results could be tentatively interpreted that due to family (whether married or not) and work commitments younger adults may perceive increasing PA as a further demand on their resources and thus with more disadvantages. These results are in accordance with previous research (Bandura, 1996; Burgess et al., 2017; Goode et al., 2016; Miller et al., 2016), and suggest that even after successful weight loss, younger age and expected disadvantages of behavior change are associated with early attrition. Furthermore, as marriage is associated with higher social support (Burgess et al., 2017; Soulsby & Bennett, 2015), these results suggested that being older person in a marriage may potentially lead to higher social support for behavior change. In addition, being married was associated with fewer expected disadvantages from PA. These results are in accordance with social-cognitive theory (Bandura, 1996), which suggests that social support and fewer expected behavioral disadvantages are associated with increased success of health behavior change. However, due to rather small effect sizes, results for expected disadvantages and marital status should be interpreted with caution.

Non-Caucasian ethnicity, lower educational achievement (up to secondary school), and being employed or studying offered the best separation between participants in Clusters 1 and 2. It was hypothesized that non-Caucasian ethnicity and educational achievement would be associated with early attrition, but the results did not fully support this hypothesis, as participants in Cluster 2 continued until Week 104 (middle of behavior maintenance). Similarly with younger age, non-Caucasian ethnicity was also associated with higher expected disadvantages of PA. Previous research has suggested that while ethnic minorities are often underrepresented in lifestyle trials, this does not necessarily mean lower likelihood of completing (Haughton et al., 2018; Shrager, 2018). Our current results indicated that ethnicity was associated with attrition, but only during later stages of behavior change.

Although the model based on the selected sociocognitive variables was overall better than chance in predicting participants' attrition in a lifestyle trial after successful weight loss, the model was not accurate in differentiating between participants who completed the PREVIEW intervention or who left the trial earlier. For public health nurses and health care professionals more generally, being able to identify those participants who are at the highest risk of not continuing in an intervention, even after successful achievement of an initial goal, would help in targeting preventive actions. Better understanding of factors influencing lifestyle intervention attrition may enable public health nurses to recognize at risk populations more effectively and plan targeted measures to improve participation in general and reduce attrition more specifically among those who participate.

While the predictive value of the model presented in here can be questioned, the results provided nevertheless insights into factors of increasing the likelihood of a lifestyle intervention attrition. Generally, while women with higher educational achievement were overrepresented in the PREVIEW trial (Gavarkovs et al., 2016), after successful weight loss, gender was not associated with attrition. Both main and sensitivity analyses indicated demographic variables of younger age and non-Caucasian ethnicity as predictors of attrition after successful weight loss. To lesser extent, being married, not at work or studying, higher educational achievement, and expected benefits appeared to be associated with intervention completion after successful weight loss. However, here the effects were considerably weaker and dependent on the number of participants included in the analyses.

These results from PREVIEW indicate that those variables associated with completion of a successful 3-year intervention are similar to those predicting short-term weight loss (Burgess et al., 2017; Hansen et al., 2018). These analyses have, however, a number of limitations. Current analyses included imputed data for sociocognitive variables, and sensitivity analyses indicated subtly different results regarding sociocognitive variables. Thus, the results presented here should be interpreted cautiously especially regarding sociocognitive discriminating variables. Although participants' reasons for dropping out were recorded, further research would need to consider how more nuanced information about reasons of dropping out could be obtained. In addition, although demographic variables were considered, wider cultural and social factors influencing success of lifestyle interventions were not addressed in these analyses.

ACKNOWLEDGEMENTS

The corresponding author (MHL.) is the guarantor of this work and had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

CONFLICT OF INTEREST

No potential conflict of interest is reported.

AUTHOR CONTRIBUTION

Study concept and design

The PREVIEW project was designed by Anne Raben (University of Copenhagen, Denmark), Jennie Brand-Miller (University of Sydney, Australia), Margriet Westerterp-Plantenga (University of Maastricht, Netherlands), Mikael Fogelholm (University of Helsinki, Finland), Wolfgang Schlicht (University of Stuttgart, Germany), and Edith Feskens (Wageningen University, Netherlands). The PREVIEW intervention study (RCT) for the adult participants was designed by Anne Raben (University of Copenhagen, Denmark), Mikael Fogelholm (University of Helsinki, Finland), and Thomas Meinert-Larsen (University of Copenhagen, Denmark). The PREMIT behavior modification intervention was designed by Wolfgang Schlicht (University of Stuttgart, Germany), Daniela Kahlert (University of Stuttgart, Germany), and Annelie Unyi-Reicherz (University of Stuttgart, Germany).

Drafting of the manuscript

First author MHL.

Critical revision of the manuscript for important intellectual content

All authors.

Additional contributions

Lene Stevner assisted with advice on ethical issues, Good Clinical Practice, and approval of the study protocol. The following additional contributors listed below assisted in conduct of the trial during recruitment, intervention, and/or data collection: *University of Copenhagen, Denmark:* Ulla Skovbæch Pedersen, Marianne Juhl Hansen, Bettina Belmann Mirasola, Maria Roed Andersen, Anne Wengler, Jane Jørgensen, Sofie Skov Frost, Eivind Bjørås, Grith Møller, and Lone Vestergaard Nielsen. *University of Helsinki, Finland:* Saara Kettunen, Laura Korpipää, Tiia Kunnas, Heini Hyvärinen, Heikki Tikkanen, and Sanna Ritola. *University of Nottingham, United Kingdom:* Shelley Archer, Natalie Bailey-Flitter, Nicky Gilbert, Laura Helm, Sally Maitland, Melanie Marshall, Theresa Mellor, Grace Miller, Seodhna Murphy, Vicky Newman, Amy Postles, Jakki Pritchard, Maria Papageorgiou, Cheryl Percival, Clare Randall, Sue Smith, and Sarah Skirrow. *University of Navarra, Spain:* Blanca Martinez de Morentin Aldabe, María Hernández Ruiz de Eguilaz, Salomé Pérez Diez, Rodrigo San-Cristobal, Maria dels Angels Batlle, Laura Moreno-Galarraga, Alejandro Fernández-Montero, Marian Nuin, Javier Baquedano, Maria Eugenia Ursúa, Francisco Javier Martinez Jarauta, Pilar Buil, Lourdes Dorronsoro, Juana María Vizcay, Teodoro Durá-Travé, and all general practitioners and nurses from the Navarra Health Services who collaborated in the recruitment of the participants. *Medical University of Sofia, Bulgaria:* Nadka Boyadjieva, Pavlina Gateva-Andreeva, Georgi Bogdanov, and Galina Dobrevska. *University of Auckland, New Zealand:* Amy Liu, Lindsay Plank, Anne-Thea McGill, Madhavi Bollineni, Kelly Storey, Nicholas Gant, Jonathon Woodhead, Hannah Chisholm, Wonjoo Lee, Chelsea Cheah, Eric Hansen, Hacer Tekinkaya, and Nadia Harvey. *University of Sydney, Australia:* Kylie Simpson, Michele Whittle, and Kirstine Bell. We want to acknowledge all the additional people who have worked and are currently working for PREVIEW, including trainees, post-, and undergraduate students. Finally, a respectful thank you to all the study participants who participated in PREVIEW.

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How to cite this article: Huttunen-Lenz M, Raben A, Meinert-Larsen T, et al. Sociocognitive factors associated with lifestyle intervention attrition after successful weight loss among participants with prediabetes—The PREVIEW study. *Public Health Nurs*. 2020;00:1–12. https://doi.org/10.1111/phn.12718