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Original Article

The PREVIEW Study

Supporting Behavior Change in an International Intervention Study Among Participants With Pre-Diabetes

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Abstract: Individuals at risk of Type 2 Diabetes are advised to change health habits. This study investigated how the PREMIT behavior modification intervention and its association with socio-economic variables influenced weight maintenance and habit strength in the PREVIEW study. Overweight adults with pre-diabetes were enrolled (n = 2,224) in a multi-center RCT including a 2-month weight-loss phase and a 34-month weight-maintenance phase for those who lost ≥ 8% body weight. Initial stages of the PREMIT covered the end of weight-loss and the beginning of weight-maintenance phase (18 weeks). Cross-sectional and longitudinal data were explored. Frequent PREMIT sessions attendance, being female, and lower habit strength for poor diet were associated with lower weight re-gain. Being older and not in employment were associated with lower habit strength for physical inactivity. The PREMIT appeared to support weight loss maintenance. Younger participants, males, and those in employment appeared to struggle more with inactivity habit change and weight maintenance.

Keywords: habits, behavior therapy, prevention, type 2 diabetes mellitus, weight loss

The most common form of diabetes is type 2 diabetes (T2D) (Guariguata et al., 2014; Tamayo et al., 2014). Typically, development of T2D is a gradual process over a number of years. The intermediate stage between normal glucose metabolism and T2D is described as pre-diabetes, characterized by impaired fasting glucose (IFG), impaired glucose tolerance (IGT), or both. The study here gives insight into a part of the PREVention of diabetes through lifestyle Intervention and population studies in Europe and around the World (PREVIEW) lifestyle (diet and exercise) intervention (EU FP7 grant agreement no. 312057). PREVIEW was an 8-center randomized controlled trial (RCT) whose aim was to identify an effective combination of diet and physical activity to decrease T2D risk in overweight participants with pre-diabetics (Fogelholm et al., 2017).

As a part of the PREVIEW RCT, participants' efforts to change diet and physical activity habits were supported by a theory- and evidence-based behavior modification intervention PREview behavior Modification Intervention Toolbox (PREMIT; Kahlert et al., 2016). The PREMIT provided a stage-based approach (see Figure 1) to change health risk behaviors (e.g., Prochaska & DiClemente, 1992). Habit change was supported by modifying behavioral determinants such as motivation, volition (i.e., commitment to a particular action), knowledge, skills, and social support (Fishbein et al., 2001; Michie, Johnston, Francis, Hardeman, & Eccles, 2008) during preliminary

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Time in months	Month 1			Month 2		Month 3		Month 4	Month 5	Months 6/7
Data collection Clinical Investigation Day (CID)	CID1				CID2					CID3
PREVIEW RCT	Phase I (8-week low-Calory Diet)					Phase II (weight maintenance)				
PREMIT program	Stage 1 (preliminary)				Stage 2 (preparation)			Stage 3 (action)		
Timing of counselling sessions	Week 0	Week 2	Week 4	Week 6	Week 8	Week 10	Week 12	Week 16	Week 20	Week 26
PREMIT group counselling session	1	2	3	4	5	6	7	8	9	10
PREMIT session (primary) objectives	Enable to follow the low-Calory Diet	Sensitise for habit change, promote self-efficacy	Promote self-efficacy	Promote self-efficacy, positive outcome expectancies, prepare for physical activity	Prepare for habit change, set goals, define plans	Prepare for habit change, promote self-regulation, self-efficacy, positive outcome expectancies	Maintaining behaviour change, social support, overcoming barriers	Promote self-efficacy and self-regulation, overcoming barriers	Support self-regulation and motivation, social support	Support self-regulation and motivation

Figure 1. Timeline of the PREVIEW RCT, PREMIT program and its objectives by session up to the end of Stage 3.

(Stage 1), preparation (Stage 2), and action (Stage 3) stages. While the PREMIT behavior modification intervention was influenced by different theoretical models such as the Health Action Process Approach (Schwarzer, 2001), the Social Cognitive Theory (Bandura, 1996), and the Self-Determination Theory (Ryan & Deci, 2000), the focus in here, however, was not in testing the assumptions of those theoretical models explaining habit formation. Several studies have shown that social-cognitive variables such as attitudes, risk perception, outcome expectancies, self-efficacy, action planning, and motivation have been associated with habit formation (e.g., Bandura, 1996; Renner & Schwarzer, 2005; Ryan, Patrick, Deci, & Williams, 2008). The focus here was to initially explore associations between the PREMIT, weight-maintenance, and socio-economic variables, then examine self-reported changes in habit strength (e.g., Gardner, Lally, & Wardle, 2012), and its association with weight-maintenance and the PREMIT participation.

Habits describe strong, situational, and unconsciously triggered predictors of automated behavior (Gardner, Corbridge, & McGowan, 2015; de Vries, Eggers, Lechner, Van Osch, & Van Stralen, 2014). Habits are formed through repeated performance of an action, and at the core of a habit is a cue-dependent automaticity, which is separate of its cause, that is, context-dependent repetition of habit (Gardner, 2012). Therefore, habit can be understood as the automaticity of a behavior rather than frequency of a behavior, which once formed does not need to be frequently performed (Gardner, 2012). Habit strength, on the other hand, refers to the strength of a process where an impulse to behave in a certain way is instigated upon encountering a setting in which the behavior has been performed in the past, that is, frequency of a behavior in a context (e.g., time, place, circumstance; Gardner et al., 2015; Labrecque & Wood, 2015; de Vries et al., 2014). Strong habit strength describes frequent performance of behaviors in stable contexts, while weak habit strength describes performance of behaviors infrequently or in unstable contexts (Labrecque & Wood, 2015). Strong habit strength may reduce the impact of intentions on behaviors, and thus habit strength may predict future behaviors (Ji & Wood, 2007; Williams, Wood, Collins, & Callister, 2015; Wood, Tam, & Guerrero Witt, 2005).

In the context of health behavior change, research has indicated that introducing small habit changes in daily routines show promise in implementing long-term behavior changes. In this way, after an initial learning stage, behavior becomes an automation (i.e., habit) requiring little cognitive effort to be performed (Gardner et al., 2012; Lally & Gardner, 2013). Further, research has suggested that habit strength is a strong predictor of health-related behaviors, including unhealthy snacking (Verhoeven, Adriaanse, Evers, & De Ridder, 2012) and physical activity (Phillips & Gardner, 2016).

Previously, higher levels of physical activity have been associated with factors such as greater educational achievement, perceived behavioral control, and better knowledge of the advantages of physical activity. Lower levels of physical activity, on the other hand, have been associated with factors such as older age, a higher body weight, and being in paid employment (Marques-Vidal et al., 2015; Mesters, Wahl, & Van Keulen, 2014). Factors such as younger age,

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higher body weight, and lower educational achievement have been associated with less frequent attendance at group sessions supporting habit changes (Goode et al., 2016). Influence of gender on physical activity habits, however, is less well understood (Duclos, Dejager, Postel-vinay, Nicola, & Quéré, 2015; Mesters et al., 2014).

The purpose of the analyses presented here was two-fold. The first set of analyses examined whether patterns of associations between socio-economic characteristic and weight maintenance and participation in the PREMIT sessions during the preparation (Stage 2) and action (Stage 3) stages were similar to those reported in previous studies (e.g., Marques-Vidal et al., 2015; Mesters et al., 2014) despite the support offered by the PREMIT. It was hypothesized that weight regain after weight loss would be associated with less frequent PREMIT attendance and with higher habit strength for physical inactivity and poor diet. Also, it was hypothesized that socio-economic variables of younger age, being employed, and living in a household with children were associated with higher weight-regain and not attending the PREMIT sessions. The second set of analyses examined changes in habit strength for poor diet and physical inactivity during the preparation (Stage 2) and action stages (Stage 3) of the PREMIT and whether any changes were associated with weight maintenance. It was hypothesized that from the preparation to the action stage, habit strength for inactivity and poor diet would decrease. Finally, for physical inactivity habit strength only, as physical activity was emphasized during the PREMIT sessions, it was hypothesized that more frequent PREMIT attendance would be associated with lower habit strength after controlling for socio-economic factors of age, gender, employment, and living with children.

Methods

Study Design

The PREVIEW RCT was a 36-month intervention, which comprised two phases. Phase I comprised an initial 8-week low-energy diet (LED – Cambridge Weight Plan Ltd., Corby, UK) weight-loss phase for all participants, which was followed by a 34-month weight maintenance phase (Phase II) for those who had lost at least 8% of their initial body weight during Phase I. Weight-loss during the Phase I was achieved using meal replacement products providing approximately 800 kcal/day. Participants were not expected to change their physical activity habits during the Phase I weight-loss period. Prior to the start of the Phase II, eligible participants were randomized into different intervention arms, using a 2 × 2 diet and exercise factorial design. The intervention arms were comprised from two dietary programs (high protein with lower dietary Glycemic Index (GI) diet or moderate protein with medium dietary GI diet) and two physical activity programs (high-intensity physical activity or moderate-intensity physical activity). The full study protocol is published elsewhere (Fogelholm et al., 2017).

The PREMIT (behavior modification intervention) ran concomitantly with the PREVIEW RCT and contained four different stages (Figure 1). Stage 1 (preliminary) covered mostly the PREVIEW RCT Phase I (weight-loss). Stage 2 (preparation) started at the end of the PREVIEW RCT Phase I, and Stage 3 (action) covered the first 4 months of the PREVIEW RCT Phase II (weight maintenance). Stage 4 (maintenance) of the PREMIT covered the remaining 2.5 years of the PREVIEW RCT Phase II. Participants were expected to acquire new diet and physical activity habits during Phase II of the PREVIEW RCT to prevent weight regain. Development of new diet and physical activity habits was supported during Stages 2 and 3 of the PREMIT, while habit maintenance was supported during Stage 4 of the PREMIT. The PREMIT was not tailored for the different PREVIEW RCT arms; it offered the same support for each participant irrespective of their group allocation.

This paper reports on the PREMIT preparation and action stages for behavior change. During Stage 2 (preparation for behavior, i.e., habit change), behavioral determinants of intention (behavioral goals), outcome expectancies (beliefs about consequences of behavior change), and self-efficacy (perceived ability to change habits) were influenced. Participants' self-efficacy to perform new dietary and exercise behaviors was promoted and positive outcome expectancies following a behavior change were reinforced. In Stage 3 (action-habit change), capabilities to act in long-term self-interest (self-regulation) were emphasized and self-regulation to perform the intended behaviors was endorsed. A number of behavior change techniques, such as improving knowledge of lifestyle choice consequences, action planning, setting behavioral goals, reinforcing successful behaviors, and planning solutions for behavioral barriers were employed (for further details, see Kahlert et al. 2016).

The PREMIT behavior modification intervention was delivered within group sessions by trained instructors with approximately 10–20 participants per group. Participants were generally allocated to group sessions according to the four PREVIEW intervention arms. Nevertheless, there was variability between the study sites. However, as support offered by the PREMIT was not tailored to match the PREVIEW RCT allocation, but to support weight maintenance and health behavior change in general, participants were considered as a single group independent of their PREVIEW RCT allocation.

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Participant Recruitment

Participants were recruited to the PREVIEW RCT between August 2013 and March 2015 from the study sites in University of Copenhagen (UCPH), Denmark; University of Helsinki (HEL), Finland; University of Nottingham (UNOTT), United Kingdom; University of Maastricht (UM), The Netherlands; University of Navarra (UNAV), Spain; Medical University of Sofia (MU), Bulgaria; University of Auckland (UOA), New Zealand; and University of Sydney (UNSYD), Australia. Overweight and obese (Body Mass Index (BMI) $\geq$ 25 kg/m^2) men and women aged 25–70 years with confirmed pre-diabetes and willing to be randomized into a weight-loss intervention were eligible for inclusion. Pre-diabetes was confirmed by an oral glucose tolerance test (OGTT) using the American Diabetes Association criteria (American Diabetes Association, 2011). Participant recruitment was undertaken by advertising in print and visual media, and by contacting primary and occupational health care providers for referrals. Before full screening, potential participants were pre-screened either by telephone or using an e-mail questionnaire. The Human Ethics Committees in each of the participating countries approved the study protocol, and all participants enrolled in the study provided written informed consent (Fogelholm et al., 2017).

Data Collection

As shown in Figure 1, outcome measures were collected at the beginning of the PREMIT Stage 2 (at Clinical Investigation Day 2–Week 8) and at the end of Stage 3 (at Week 26), covering a period of 18 weeks. Data collection included both anthropometric (e.g., body weight and height), metabolic (e.g., HbA1c), and psychological variables. All psychological measurements were collected using standardized questionnaires. For non-English speaking countries questionnaires were translated into local languages. Accuracy of the translations were checked by back-translating the local versions into English and comparing them with the original English version.

Outcome Measurements

Body Weight

Body weight was measured while lightly clad at Week 8 (beginning of the PREMIT Stage 2) and Week 26 (end of the PREMIT Stage 3) and values were used to calculate percentage weight change.

Socio-Demographic Characteristics

The European Social Survey and International Social Survey (ESS, 2015) was used to collect information about gender, age, educational achievement, marital status, people living in the household, and employment status.

PREMIT Attendance

Attendance to the PREMIT behavior modification intervention was recorded separately for each session on a centralized database (OpenClinica open source software, version 3.1., OpenClinica LLC & Co., Waltham, MA, USA).

Habit Strength of Physical Inactivity and Poor Diet

The habit strength questionnaire asked about physical inactivity (6 items – 3 for each sitting and inactive commuting habits) and unhealthy dietary (6 items – 3 for each high fat and snacking habits) behaviors (based on Ji & Wood, 2007; Wood, Tam, & Guerrero Witt, 2005). Questions inquired about both frequency (how often) and stability (context – time and either location or purpose) of behaviors. Frequency of behaviors was evaluated on a scale from 1 (= *never/almost never*) to 7 (= *very often/almost every day*). Stability of the context regarding the time and either location or the purpose of behaviors was evaluated on a scale from 1 (= *never/almost never*) to 7 (= *almost always at the same time/location/purpose*). Habit strength was estimated by multiplying score for behavior frequency by score for stability of circumstances (time and either location or the purpose, i.e., max 7 $\times$ 7 $\times$ 7). Mean values for habit strength of inactivity (encompassing sitting and inactive commuting habits) and poor diet (encompassing high fat and snacking habits) were computed. Hence habit strength can range from 1–343. Lower scores reflect either infrequent performance or variable circumstances and higher scores reflect frequent performance in stable circumstances. Scale reliability was satisfactory. Cronbach's alphas for habit strength at Week 8 were α = .74 for physical inactivity and α = .83 for poor diet. At Week 26 Cronbach's alphas were α = .74 for habit strength of physical inactivity and α = .79 for poor diet.

Statistical Methods

The analyses are based on the 1,569 participants who were eligible for participation in the PREVIEW RCT (Phase II) and for whom body weight data were available at Week 26. Participants were analyzed as one group without adjustments for study sites or the PREVIEW RCT treatment arms. All analyses were conducted using IBM® SPSS Statistics Program version 23.

A number of participants were unsure of the level of educational achievement and used the "other" option with description, for example, "PhD". Where possible, data were recoded within the correct level of achievement. Missing values were estimated for the constructs of habit strength of inactivity and poor diet. Missing values imputation

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method was specified as automatic with maximum of 50 case draws and 5 sets of imputations were done. For the imputation model, age, gender, attendance to the group counseling sessions, and weight change percentage were included as predictor variables.

Outlying values were identified for weight change and habit strength as those $\geq$ 3.29 standard deviations above the mean value and removed, leaving 1,521 participants for the analyses. Before statistical significance-testing data, transformations were employed to improve data normality for habit strength of physical inactivity (SQRT; Howell, 1997; Tabachnick & Fidell, 2001). Habit strength for poor diet could not be successfully transformed and a non-parametric statistical test was used instead. Sensitivity analyses were conducted with the transformed, but not imputed, dataset and reported if discrepancies existed.

Descriptive statistical methods were employed to analyze participant characteristics. Bonferroni adjusted ($p \leq .01$) chi-square tests analyzed the PREMIT group counseling session attendance by different participant characteristics. Percentage of weight change was calculated as "weight Week 26 minus weight Week 8" and expressed as percentage (±). Weight change was not adjusted for the PREVIEW RCT treatment arm. Independent samples *t*-tests were used to compare percentage change in body weight between participant characteristics. Analysis of variance (ANOVA; Welch's *F*) was used to examine association between weight change and number of group counseling sessions attended using *p*-value $\leq$ .025. Post hoc tests after significant Welch's *F* were performed with Games-Howell correction using significance level of $\leq$ .01 with those who had attended all the available sessions forming the comparison group (Field, 2013).

For habit strength of poor diet non-parametric sign-test and for habit strength of inactivity dependent samples *t*-tests were used to evaluate changes from the beginning of the PREMIT Stage 2 until the end of Stage 3. Spearman's and Pearson's bivariate correlations were conducted to evaluate associations between weight change and habit strength at the end of Stage 3. Sequential regression with 2 steps was used to estimate whether frequency of attending group counseling sessions increased variance explained in habit strength (inactivity-outcome variable) at the end of Stage 3 (step 1 age, gender, employment, living with children; step 2 the PREMIT attendance; categorical variables were dummy coded).

Bonferroni corrected *p*-value of $\leq$ .007 was used for all analyses that included habit strength for inactivity. Analyses with habit strength for poor diet used Bonferroni corrected *p*-value of $\leq$ .025. Effect sizes were calculated using Lenhard and Lenhard (2016) apart for the non-parametric sign-test for which the effect was calculated as *r* (Field, 2013). While statistical analyses were completed with transformed data, for the ease of interpretation, means and standard deviations are presented for the non-transformed data.

Results

Participant Characteristics

Across all sites, 15,611 individuals were prescreened, 5,472 individuals were screened in clinic, and 2,326 were found eligible to participate in the study. Of these, 2,224 individuals began the LED phase, with a dropout rate of 9.2% between Week 0 (baseline) and Week 8. At Week 8, 1,857 participants were eligible to continue into the PREVIEW RCT Phase II (weight maintenance). Dropout rate between Week 8 and Week 26 was calculated as 15.5%. Characteristics at baseline for the 1,521 participants included in this study are shown in Table 1. Most participants were female, married or in a civil partnership, of Caucasian ethnicity, and with high educational achievement. Body weight change from the beginning of Stage 2 to the end of Stage 3 ranged from −13.3 kg (−16%) to +17.0 kg (+20%), with mean change of +0.3 kg (*SD* = 4.0 kg), with over half (55%) of the participants having regained some body weight.

PREMIT Attendance, Socio-Economic Variables, and Weight Maintenance

No consistent pattern between participant characteristics and the PREMIT attendance was found (Table 2). Overall, participation in the group sessions declined from 6th to 9th session, but recovered for the 10th session, which coincided with the end of Stage 3 of the PREMIT program and Week 26 attendance. This pattern, however, was not observed among participants from the non-Caucasian backgrounds. Consequently, participants from the non-Caucasian backgrounds were less likely to have attended the last group counseling session during Stage 3 ($\chi^2(1) = 29.90$, $p \leq .01$).

ANOVA (Welch's *F*) indicated that there was a statistically significant association between the number of the PREMIT group counseling sessions attended during the preparation and action stages, and weight change (% body weight); Welch's $F(5, 191) = 15.95$, $p \leq .001$, est. $\omega^2 = .05$. The number of participants attending 0, 1, 2, 3, 4, or 5 times in the group sessions and $M \pm SD$ percentage of weight change are shown in Table 3. Post hoc comparisons using Games-Howell adjustment indicated significant difference in weight change (%) between those who attended all 5 sessions and those who attended 0–3 of the sessions. Examination of the mean values indicated that those who attended

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Table 1. Participant characteristics

Participant characteristics (n = 1,521)	
Age* (years) ($M \pm SD$)	53.4 ± 10.8
BMI (kg/m^2) ($M \pm SD$)	
Week 8	30.5 ± 5.2
Week 26	30.6 ± 5.4
Female	1,004 (66%)
Married or in civil partnership*	1,080 (71%)
Living in a household with at least 2 adults*	1,208 (79%)
Living in a household with at least 1 child*	309 (20%)
Ethnicity – Caucasian	1,380 (91%)
In paid employment (regardless of hours worked per week)*	925 (61%)
Level of educational achievement*	
Up to secondary education	237 (16%)
Secondary vocational education	269 (18%)
Higher vocational education	301 (20%)
University	592 (39%)
Other (including those with missing data)	122 (8%)

Note. BMI = Body Mass Index; M = Mean; SD = Standard Deviation. *As given at the start of the trial.

0–3 of the sessions regained body weight, whereas those who attended 4 or 5 of the sessions lost weight.

Pairwise comparisons with weight change percentage during Stages 2 and 3 of the PREMIT as dependent variable, showed that males regained significantly more weight than females, $t(1{,}519) = -4.36$, $p \leq .025$, $d_{\text{Cohen, unequal group size}} = .24$. Those not married or in a civil partnership, $t(1{,}519) = -2.67$, $p \leq .025$, $d_{\text{Cohen, unequal group size}} = .15$, living in one adult households, $t(1{,}519) = -2.37$, $p \leq .025$, $d_{\text{Cohen, unequal group size}} = .15$, and not Caucasian ethnicity, $t(1{,}519) = 2.27$, $p \leq .025$, $d_{\text{Cohen, unequal group size}} = .20$, also had a significantly higher percentage of body weight regain. Effect sizes for all comparisons, however, were small. Employment status, $t(1{,}336) = .29$, $p > .025$, or living in a household with children, $t(1{,}519) = 1.95$, $p > .025$, were not associated with body weight change.

Habit Strength and PREMIT Attendance

Means and standard deviations (SD) for habit strength (poor diet and physical inactivity) are shown in Table 4. Habit strength for physical inactivity had not significantly changed at the end of Stage 3, $t(1{,}520) = -2.17$, $p \geq .007$. Sign-test indicated that habit strength for poor diet had increased between the beginning of Stage 2 and the end of Stage 3 ($Z = -32.04$, $p \leq .025$, $r = -.58$), indicating a large effect size. The score for habit strength on average increased from a low (7.70) at Week 8 to significantly higher level at Week 26 (45.56). The low score observed at Week 8 was likely due to the recent completion of the low-energy diet (Phase I). While habit strength for physical inactivity at the end of Stage 3 was not significantly associated with weight change percentage, $r_{x,y}(1{,}521) = .10$, $p \geq .007$, habit strength for poor diet at the end of Stage 3 was associated with percentage weight change, $\rho(1{,}521) = .25$, $p \leq .025$, though the effect size was weak. This suggested that increasing habit strength for poor diet was associated with higher weight regain percentage.

Sequential regression was used to examine whether attending the PREMIT group counseling sessions during the preparation and action stages predicted habit strength for inactivity at the end of the action stage, after effects for socio-demographic variables of age, gender, employment status, and living with children were controlled. After all the variables were entered into the model, overall $R = .302$ [$F(9, 1{,}511) = 16.84$, $p \leq .007$] was significant, with adjusted $R^2 = .09$ indicating that the model explained 9.0% of the variance in the habit strength for inactivity at the end of Stage 3. At step one, age, gender, employment status, and living with children were entered in the equation resulting in a significant $R = .295$ [$F(4, 1{,}516) = 36.09$, adjusted $R^2 = .09$, $p \leq .007$]. At step two, five categorical variables created for frequency of attending the group counseling sessions were included. Results indicated no significant change in the overall model; $R = .295$ [Change $F(5, 1{,}511) = 1.40$, $R^2 = .004$, $p \geq .007$]. Both unstandardized (B) and standardized (β) regression coefficients and intercept are shown in Table 5. Inspection of the coefficients indicated age and employment status were individually significant predictors of habit strength at Week 26, such that older age and not being in employment were associated with lower habit strength for inactivity.

Discussion

Although healthy diet and physical activity are effective means to reduce the risk of developing T2D (Alouki, Delisle, Bermúdez-Tamayo, & Johri, 2016), many of those at risk struggle to achieve permanent habit changes and participate in interventions offering support with habit changes (Følling, Solbjør, & Helvik, 2015; Goode et al., 2016). Results from this study showed that, on average, participants had regained some weight during the PREMIT Stages 2 and 3. Higher weight regain percentage, however, was associated with being male, not married or in a civil partnership, living in one adult household, and of non-Caucasian ethnicity. In addition, more frequent attendance at the PREMIT sessions and lower habit strength for poor diet at the end of Stage 3 were associated with lower body weight regain. But habit strength for physical inactivity was not associated with body weight regain. Furthermore,

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Table 2. Attendance to individual PREMIT sessions according to participant characteristics during preparation and action stages

		Gender		Marital status		Living in a household with								
						Other adults		Children		Ethnicity		Employment status		
Session	All	Female	Male	Married/Civil partnership	Other	At least two adults	One adults	At least one child	None	Caucasian	Other	Paid employment	Other
6th	1,117 (74%)	753 (75%)	364 (70%)	776 (72%)	341 (77%)	**869 (72%)**	**248 (79%)**	211 (68%)	906 (75%)	1,016 (74%)	101 (72%)	689 (74%)	428 (72%)
7th	1,051 (69%)	720 (72%)	332 (64%)	739 (68%)	312 (71%)	829 (69%)	222 (71%)	202 (65%)	849 (70%)	949 (69%)	102 (72%)	618 (67%)	433 (73%)
8th	994 (65%)	671 (67%)	323 (62%)	696 (64%)	297 (67%)	788 (65%)	205 (66%)	191 (62%)	802 (66%)	911 (66%)	82 (58%)	597 (65%)	396 (67%)
9th	902 (59%)	595 (59%)	308 (60%)	634 (59%)	268 (61%)	717 (59%)	185 (59%)	160 (52%)	742 (61%)	821 (60%)	81 (57%)	541 (58%)	361 (61%)
10th (CID3)	1,175 (77%)	770 (77%)	405 (78%)	840 (78%)	335 (76%)	925 (77%)	250 (80%)	230 (74%)	945 (78%)	1,092 (79%)	83 (59%)	688 (74%)	487 (82%)

Notes. Participant characteristics as given at baseline. Participants with no data have been included in these categories. Significant differences between the groups at the level of $p \leq .01$ are shown in bold.

frequency of attending the PREMIT was not predicting habit strength for physical inactivity at the end of action Stage 3 over and above socio-economic variables, especially of age and employment status.

Overall, the majority of participants attended the PREMIT sessions during Stages 2 and 3, with over one quarter of the participants (28%) recorded as attending all the five sessions. Previously, attendance in weight-loss trials has been associated with characteristics such as age and level of educational achievement (Goode et al., 2016). However, in PREVIEW, no consistent pattern was observed between participant characteristics and attendance at group sessions. Apart from participants of non-Caucasian ethnicity, participation in the group counseling sessions declined between the data collection points, but recovered for the final session of Stage 3, coinciding with Week 26. This was very likely due to attendance at clinic for blood tests and associated study measurements at this time point. Consequently, non-Caucasian participants were not only less likely to have attended the last group counseling session during Stage 3, but also potentially more likely to miss the clinic attendance for data measurements.

Habit strength for physical inactivity, measured here as a combination of behavioral frequency and context, was not significantly associated with weight change. Although not significantly different, the mean value for habit strength for physical inactivity at the end of Stage 3 was lower than at the beginning of Stage 2. As even small changes in the daily routines may enable long-term habit modification (Gardner et al., 2012; Lally & Gardner, 2013), small changes observed in habit strength for inactivity may indicate successful habit changes in future. Further research, however, should explore whether habit strength for inactivity continues to weaken.

Habit strength has been shown to be a strong predictor of behavior such as unhealthy snacking (Verhoeven et al., 2012). As expected, increasing habit strength for poor diet, that is, frequency and context of snacking and eating high fat food, was associated with higher weight gain. Contrary to expectations, habit strength for poor diet was significantly higher by the end of Stage 3 than at the beginning of Stage 2, indicating, on average, poorer diet habits. In retrospect, this result may not be surprising as at the start of Stage 2 participants had just finished an 8-week LED with meal replacement products. How the habit strength for unhealthy diet develops during the maintenance period of the PREMIT intervention needs to be explored to understand whether the results reported here mirror differences in participants' eating habits during the LED and after, or whether there is a tendency toward poorer diet habits as the intervention progresses.

Previous research has indicated that variables such as age and being in paid employment are associated with level

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Table 3. Weight change during the 18-week follow-up period (preparation and action stages) and means, standard deviations, and results for pairwise comparisons between participants attending different amount of the PREMIT group counseling sessions

				Pairwise comparisons with attending all the sessions (5)					
								Cohen's *d* 95% CI	
Number of PREMIT sessions attended	*N*	Weight change % (*M*)	*SD*	*M* Diff.	*SE*	*p*-value	Cohen's *d*	Lower	Upper
None (0)	21	3.13	3.42	−3.39	0.78	≤ .01	−0.82	−1.27	−0.38
One (1)	158	1.43	3.84	−2.23	0.38	≤ .01	−0.49	−0.68	−0.31
Two (2)	201	1.71	4.33	−2.51	0.38	≤ .01	0.54	−0.71	−0.37
Three (3)	312	0.70	4.41	−1.49	0.34	≤ .01	−0.32	−0.47	−0.17
Four (4)	403	−0.29	4.42	0.50	0.32	≥ .01	–	–	–
Five (5)	426	−0.79	4.81						

Note. *M* = Mean; *SD* = Standard Deviation; *SE* = Standard Error; CI = Confidence Interval.

Table 4. Means (*M*) and standard deviations (*SD*) for habit strength for poor diet and physical inactivity

Time point	Week 8 (*M* ± *SD*)	Week 26 (*M* ± *SD*)
Variable	*n* = 1,521	*n* = 1,521
Habit strength (Scale: 1 = Low to 343 = High)		
Physical inactivity	139.44 ± 86.24	134.67 ± 83.58
Poor diet	7.70 ± 14.65	45.56 ± 43.56

Note. All data before data transformations.

Table 5. Unstandardized and standardized regression coefficients for socio-economic variables and attendance for the PREMIT sessions with habit strength for physical inactivity as dependent variable at Week 26

	Unstandardized coefficients	Standardized Coefficients	
Model	*B*	β	*p*-value
Constant	**13.559**		**≤ .007**
Gender: male	0.266	0.032	≥ .007
Age	**−0.033**	**−0.091**	**≤ .007**
Household with children	−0.238	−0.025	≥ .007
Employment other	**−1.907**	**−0.239**	**≤ .007**
PREMIT attending 4 sessions	0.145	0.016	≥ .007
PREMIT attending 3 sessions	0.137	0.014	≥ .007
PREMIT attending 2 sessions	−0.253	−0.022	≥ .007
PREMIT attending 1 sessions	−0.648	−0.051	≥ .007
PREMIT attending 0 sessions	0.510	0.015	≥ .007

Note. Statistically significant results at the level of $p \leq .007$ are in bold.

of physical activity as well as with success in attending interventions promoting healthy habit changes (Goode et al., 2016; Marques-Vidal et al., 2015; Mesters et al., 2014). Here, predictors for habit strength for physical inactivity at the end of the action stage of the PREMIT were examined. Results indicated that after controlling for social economic variables of age, gender, living with children, and employment, frequency of attending in the PREMIT did not significantly add to the prediction.

Furthermore, of individual predictors, only age and employment were significant predictors for habit strength for physical inactivity so that younger age and being in employment were associated with higher habit strength for inactivity. While the association between employment and physical activity is in line with previous literature (e.g., Marques-Vidal et al., 2015; Mesters et al., 2014), association between younger age and physical activity was unexpected. In addition, neither gender nor living with children was associated with habit strength as expected. While it could be hypothesized that pressures of combining work and family life are particularly acute for younger participants, leaving limited capacity to concentrate on physical habit changes, living with children was not found to be associated with inactivity habit strength. Alternatively, younger adults might be less concerned about the future consequences of the T2D and perceive that it will affect them only in middle/old age. Thus, younger adults may be less motivated to change their habits and may require additional support in weight maintenance from the PREVIEW instructors.

While frequency of attending the PREMIT group counseling sessions was not an independent predictor of habit strength for inactivity, it should be emphasized that this result is not an indication that the PREMIT intervention does not influence habit strength for physical inactivity. As participants had been preparing for behavior change during Stage 1 (weight-loss phase of the PREVIEW RCT, Figure 1), it is possible that attending these sessions may have had more influence on physical inactivity habit strength than attending the sessions during active physical activity changes (Stages 2 and 3). Stage 1, however, was not included in this report as analysis here was focused on understanding changes in social-cognitive variables during preparation and action stages of active behavior change. Moreover, frequent attendance to the PREMIT group counseling sessions appeared to be associated with lower weight

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regain. Although it was not possible to show a causal relationship between attending the group counseling sessions and weight change, results indicated that having the support offered during the PREMIT sessions may be useful in guiding and sustaining participants through successful behavior change. Results, however, suggested that especially younger participants and those in employment may struggle with weight-maintenance and physical activity habit changes, and may require special emphasis during the PREMIT session to ensure adequate support for successful behavior change.

The present study had a number of limitations. The multiple interactions with the PREVIEW RCT and the PREMIT made evaluation challenging. However, as the PREMIT intervention was also theory- and evidence-based, it was possible to evaluate whether social-cognitive variables developed as expected from the previous evidence base, correlated with group session attendance, or were associated with changes in objective physiological measurements such as weight. Effects of the different PREVIEW intervention arms were not controlled in this study. However, as the purpose of the PREMIT program was to support weight maintenance regardless of the intervention condition, results still provided insight into how a program such as the PREMIT can be utilized in supporting participants. The results of the analyses are also only indicative, as they were based on causal relations between the PREMIT program and changes in the social-cognitive variables. In addition, habit strength was assessed as combination of frequency and stability (context) of behavior, which meant that the automaticity facet of the habit was not considered. Current analyses also did not consider a range of other cognitive variables, such as self-efficacy and motivation, and their interactions with habit strength. Therefore, it is important that future research examines how habit strength interacts with other social-cognitive and environmental variables.

Conclusions

Results did not indicate any clear pattern of socio-economic variables associated with the PREMIT attendance. Weight regain was found to be associated with less frequent PREMIT attendance, male gender, not being married or in a civil partnership, living in one adult household, and non-Caucasian ethnicity. Results also suggested mixed success in modifying poor diet and physical inactivity habits during the preparation and action stages of the PREMIT program. Changes in body weight were not reflected in changes in habit strength for physical inactivity, but weight regain was associated with higher poor diet habit strength. Socio-economic variables of younger age and being in employment were found to be significant predictors of higher habit strength for physical inactivity. Changes in habit strength for inactivity were not associated with frequency of attending the PREMIT program. Taken together, the results indicated that while attending the PREMIT appeared to support participants in weight-loss maintenance, PREMIT instructors may need to ensure that in particular younger participants, those who are from non-Caucasian ethnic background, are male, and who are in employment receive adequate support for habit change and weight maintenance.

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History
Received August 16, 2018
Revision received March 26, 2019
Accepted April 2, 2019
Published online June 3, 2019

Acknowledgments
The corresponding author (Maija Huttunen-Lenz) 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.
Lene Stevner assisted with advice on ethical issues, Good Clinical Practice and approval of the study protocol.
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University of Nottingham, United Kingdom: Elizabeth Simpson, 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, Sarah Skirrow.
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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, 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, Nadia Harvey.
University of Sydney, Australia: Kylie Simpson, Michele Whittle, 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 that participated in PREVIEW.

Publication Ethics

The study has been approved by the following ethics committees: University of Copenhagen (UCPH): The Secretariat of Research Ethics Committees for the Capital Region of Denmark. University of Helsinki (HEL): The Coordinating Ethics Committee of the Helsinki and Uusimaa Hospital district, Finland. University of Maastricht (UM): The Medical Ethics Committee for azM og Maastricht University (METC azM/UM), Netherlands. University of Nottingham (UNOTT): East Midlands – Leicester Central Research Ethics Committee, United Kingdom. University of Navarra (UNAV): Clinical Research Ethics Committee of Navarra, Spain. Medical University of Sofia (MU): Commission on Ethics in Scientific Research with the Medical University – Sofia (KENIMUS), Bulgaria. University of Sydney (UNSYD): Ethics Review Committee at the Sydney Health Local District, Australia. University of Auckland (UOA): Northern B Health and Disability Ethics Committee, New Zealand.

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It was Maija Huttunen-Lenz's idea to examine changes in habits during Stages 2 and 3 of the PREMIT program.
All authors were engaged in the analysis and interpretation of data and the critical revision of the manuscript for important intellectual content. Finally, Maija Huttunen-Lenz drafted the manuscript.

Funding

EU 7th Framework Programme (FP7/2007-2013) under grant agreement no. 312057, The National Health and Medical Research Council – EU Collaborative Grant, AUS, The NZ Health Research Council (14/191) and UoA Faculty Research Development Fund, The Cambridge Weight Plan kindly donated all products for the 8-week Low-Calorie Diet period.

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