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Improving adherence to weight management strategies: information length and implementation intentions

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Abstract

Objective: Adherence to weight management strategies may be undermined where lengthy strategy explanations limit engagement and understanding, weakening intervention efficacy. By contrast, implementation intentions have been shown to promote adherence across various health behaviours. This study investigated the impact of explanation length and implementation intentions on adherence to brief weight management strategies. **Methods:** Participants (n=200) with a BMI above 25 and an interest in losing weight were recruited from a commercial weight management service provider. Participants received information about one of four weight management strategies on a smartphone application in either a brief or detailed format and were asked to plan their use of the strategy with implementation intentions or were given tips on strategy use. Participants received daily prompts over a 2-week period to report whether they used their assigned strategy. Proposed moderators (need for cognition and planning skills) were measured at baseline. **Results:** Strategy adherence was greater with brief information (M=74%, SD=23) compared to detailed information (M=69%, SD=23), however this small effect size (d = 0.24) was not statistically significant (p=.13). There was no moderation by need for cognition (p=.25). Adherence did not differ significantly between implementation intentions (M=71%, SD=27) and tips (M=72%, SD=21; p=.73), however there was moderation by planning skills (p=.04); as predicted, adherence was greater with implementation intentions compared to tips among those with poorer planning skills. **Conclusions:** Shorter explanation length and implementation intentions (in poorer planners) may enhance adherence to brief

weight management strategies; further investigation is required to confirm these effects.

Keywords: implementation intentions, weight management, behaviour change, adherence

Public significance statement

This study contributes to our understanding of methods that enhance adherence in digital health interventions. It describes an efficient method for identifying those with weaker planning skills who may benefit from being prompted to form implementation intentions. It also provides preliminary evidence for the benefits of imparting information more succinctly (in 70 to 100 words instead of 600 to 700 words) though further research is needed to confirm this.

Introduction

Successful weight loss and weight loss maintenance requires adjustments to food intake and physical activity; the key behaviours targeted by most weight management interventions (Chao et al., 2021). These interventions include a variety of behavioural and psychological strategies, ranging from calorie counting (Hartmann-Boyce et al., 2014) to mindful eating (Carrière et al., 2018) and intermittent fasting (Welton et al., 2020). While the efficacy of many of these interventions is well-established (Twells et al., 2021), their impact on weight management remains contingent upon individual adherence. However, evidence shows that adherence is often suboptimal and can be as low as 10%, undermining intervention effectiveness (Lemstra et al., 2016). There is also some evidence that adherence is lower in individuals with lower socioeconomic status (Birch et al., 2022), which may contribute to health inequalities. Therefore, it is crucial to explore methods by which adherence can be increased to maximise the potential benefits of interventions.

One important factor to consider is the way the information is presented. Communication in health promotion is crucial (Rimal & Lapinski, 2009), and

effective communication involves tailoring messages for the intended audience (Ngigi & Busolo, 2018). The Information-Motivation-Strategy (IMS) model (Martin & DiMatteo, 2014) states that one of the main reasons individuals do not adhere to behaviour change advice is because they are not given adequate, understandable information. One aspect that could influence understanding is the length of written information provided. Although longer more detailed information may enhance understanding, it is possible that longer material reduces engagement, which in turn limits understanding and implementation. By contrast, briefer information may enhance engagement, leading to increased understanding and implementation.

This idea is supported by research on attentional processes, which plays a critical role in how individuals process information (Cohen, 2014). In recent years there has been a decline in attention span, attributed in part to increased information overload due to the rapid rise of digital technology (Carr, 2020). Yeykelis et al. (2014) found that individuals tend to switch between different types of online content as frequently as every 19 seconds, and 75% of all content is typically viewed for less than one minute. This type of media multi-tasking is associated with worse performance on cognitive tasks requiring sustained attention (Uncapher & Wagner, 2018). This trend emphasises the importance of capturing and maintaining individuals' attention to enhance their engagement with the content of weight management strategies. Given the reduction in attention span, individuals may be more likely to engage with shorter, more focused content, while longer information may lead to cognitive overload and skim-reading or disengagement entirely.

Nevertheless, preference for longer versus shorter information may vary from person to person. For example, the Need for Cognition Scale (NCS; Cacioppo & Petty, 1982) assesses individuals' inclination to engage in and enjoy

cognitive activities. Therefore, those with higher need for cognition may be more willing to engage with lengthier written material and more interested in learning the rationale behind a particular weight management strategy. By contrast, those with low need for cognition may be put off by lengthier material, preferring information that is more succinct and to the point. This hypothesis has been partially supported by Williams-Piehota et al. (2003) who found that women who were high in need for cognition were more likely to follow more detailed (compared to more succinct) mammography advice. However, the format made no difference for those who were low in need for cognition.

Another key factor that may influence adherence is difficulty translating intentions into action, i.e., the intention-behaviour gap (Sheeran, 2002). Many individuals may understand, and be motivated to use, strategy information, yet still fail to implement it. The Rubicon Model of Action Phases (Heckhausen & Gollwitzer, 1987) posits two key phases of goal pursuit; a motivational (pre-decisional) phase when the individual forms the intention to perform the behaviour, and a volitional (post-decisional) phase when the behaviour is implemented. The theory suggests that behaviour change can be promoted by targeting motivation in the pre-decisional phase and implementation of the behaviour in the post-decisional phase (Gollwitzer, 2012). A powerful strategy for the latter phase is the formation of an implementation intention, which involves the development of a specific plan of action in the form of an if-then statement, for example, “If situation X is encountered, then I will initiate behaviour Y” (Gollwitzer, 1999). Systematic reviews have found implementation intentions to be effective in improving general goal attainment (Gollwitzer & Sheeran, 2006), and adherence to a range of health behaviours such as healthy eating (Adriaanse et al., 2011; Carrero et al., 2019), physical activity (Bélanger-Gravel et al., 2013; Silva et al., 2018; Kompf, 2020) and smoking cessation (Hagerman et al., 2021).

The use of implementation intentions in weight loss interventions have also been associated with greater weight loss (Luszczynska et al., 2007; Armitage et al., 2014). However, findings are mixed; Benyamini et al. (2013) and Hayes et al. (2021) found implementation intentions resulted in similar weight loss outcomes as simple goal intentions. Additionally, Knäuper et al. (2018) found that the addition of implementation intentions to the NIH-developed Diabetes Prevention Program did not result in greater weight loss.

This discrepancy may be due to the different ways implementation intentions are employed across studies. A range of variables may moderate the effects of implementation intentions, including the quantity (Verhoeven et al., 2013) and specificity of the intentions (de Vet et al., 2011). Individual differences in self-regulation may be another potential moderator; whether implementation intentions are helpful for an individual could be contingent upon their proficiency in planning skills. Allan et al. (2013) instructed participants to complete an online food diary to monitor their snack intake, and half were also instructed to generate an implementation intention to help them achieve this goal. The implementation intention intervention was significantly associated with higher completion rates in poorer planners, but not in skilled planners, suggesting that adherence can be enhanced by tailoring interventions to individuals' planning skill abilities.

In light of the above, the present study investigated whether adherence to brief weight management strategies over a 2-week period is influenced by length of strategy information and use of implementation intentions. The aims were to 1) explore the effect of information length on adherence, and whether this differs depending on need for cognition, and 2) examine the effect of implementation intentions on adherence, and whether this differs depending on planning skills. Given an absence of previous research, we did not formulate any confirmatory

hypotheses related to the first aim. However, for the second aim we predicted that use of implementation intentions would increase adherence, and that this increase would be larger for those with poorer planning skills.

The study also examined whether higher NCS scores were associated with a preference for longer information and whether use of implementation intentions was associated with increased strategy automaticity during the 2-week period. Additionally, the study investigated whether briefer, more lay friendly measures may be adequate substitutes for the longer, standardised measures of need for cognition and planning skills. This was considered important since although these measures may prove useful for increased personalisation of interventions, their length may make them too burdensome and impractical for digital interventions, especially where multiple characteristics are being assessed.

Additional exploratory aims related to the effects of participants' free time and priority of diet/weight on strategy adherence, and whether preferences for amount of time spent learning new things moderated effects of information length on adherence. Effects of information length on ease of understanding and remembering strategy content as well as memory of strategy rationale were also investigated. Additionally, differences in adherence to mental and physical strategies were explored, as well as differences in their helpfulness ratings. Finally, the research also aimed to gain qualitative insights into participants' views on the weight management strategies and their experiences during the study.

Method

Sample Size

A minimum sample size of 128 participants was calculated on G*Power based on a medium effect size, 80% power and 5% alpha for a 2x2 ANOVA. To account for participant attrition and exclusions, and the testing of exploratory hypotheses, the target sample size was set at 200 participants.

Participants

Participants were recruited from Oviva, a digital commercial weight management service provider. Individuals on the 9-month NHS Diabetes Prevention Programme, 12-week Tier 2 Weight Management and 12-week Diabetes Structured Education programmes were invited to take part in the study by email. To prevent the study interfering with programme engagement, participants were invited when they had completed the programme or were close to completion. Additional eligibility criteria were age 18 or over, access to a smartphone, BMI over 25, an interest in losing weight or avoiding weight gain and not on a meal replacement diet. Participants received Amazon vouchers worth up to £20 based on participation duration, with an extra £5 for completing the optional qualitative part of the study.

Two hundred participants enrolled onto the study. Participants' age ranged from 23 to 79 years, with a mean of 52 years (SD = 11.2). The sample consisted of 63.3% women. BMI ranged from 25.3 to 64.9kg/m^2 with a mean of 35.5kg/m^2 (SD = 7.3). Most participants (77.5%) were White, 11.7% were Asian or Asian British, 5.1% were Black, African, Caribbean or Black British, 3.6% were Mixed or multiple ethnic groups, and 1% were from other ethnic groups. Half of the sample (51%) had an undergraduate degree or higher, 21.5% were educated to GCSE level, 11% had a BTEC qualification, 10.5% had A-levels, 3.5% had no formal education and 2.5% had another form of qualification.

The study received ethical approval from the City, University of London Psychology Department Research Ethics Committee (ETH2223-2482). The

method and analysis strategy were pre-registered with the Open Science Framework (https://osf.io/nx3gj/).

Study design

The study employed a 2 x 2 x 4 between-groups experimental design. Participants were randomly assigned to one of 16 groups, which varied by information length (short or long), implementation intentions (present or absent) and strategy content (sensory eating, attending to fullness, eating vegetables first, or increasing physical activity). The dependent variable was the percentage of days participants adhered to their assigned strategy.

Experimental manipulation

Strategy content

Evidence-based written information was provided for one of four brief weight management strategies: paying attention to the sensory properties of food while eating (Segiuas & Tapper, 2018), paying attention to feelings of fullness while eating (Jordan et al., 2014), eating vegetables or salad before the rest of the meal (Nishino et al., 2018) and doing 5 minutes of physical activity following a meal (Buffey et al., 2022). The information provided the rationale behind the strategy as well as instructions on how to practice it. See Appendix 1 (in supplementary materials) for full strategy information.

Information length

The strategy information was either presented in a short format (approximately 70 – 100 words) with a focus on action (e.g., pay attention to the taste and texture of food in your mouth) or a long format (approximately 600 – 700 words) with a focus on outcome (e.g., how to slow down your eating) and additional detail on the strategy rationale.

Implementation intentions

Participants were either presented with planning prompts to help them form implementation intentions (present), or they received tips on strategy use (absent). The planning prompts involved first indicating when they would use the strategy (e.g. *If* I am eating breakfast / lunch / my evening meal / my daily snack), followed by how they would use it (e.g. *then* I will keep reminding myself to notice the taste, texture, and temperature of the food). The same content was presented in the tips condition in the form of tips on strategy use (e.g. When you're eating a meal or snack, keep reminding yourself to notice the taste, texture, and temperature of the food).

Materials

The study was delivered on the Avicenna Research (formerly Ethica Data) smartphone application (https://avicennaresearch.com). A baseline survey, a schedule of 14 daily surveys, and a follow up survey were triggered upon enrolment. Participants were notified to complete the surveys via phone notifications.

Measures

Baseline measures

Demographics. Participants indicated their age, gender, ethnicity, and education level.

Height and weight. Self-report measures were provided in kilograms / pounds and centimetres / feet and inches.

Weight loss intentions. Participants responded to *"Which of the following best describes you?"* with *'I'm trying to lose some weight' / 'I'm not trying to lose weight but I'm trying to avoid gaining weight' / 'I'm not currently trying to lose weight'.*

Priority of diet/weight. Participants were asked *"Thinking about all the things going on in your life right now, how much of a concern is your diet or*

weight?" with response options of '*It's the thing I'm most concerned about right now' / 'It's one of several important concerns I have right now' / 'There are other things I'm more concerned about right now'.*

Free time. Participants responded to *"Which of the following best describes you?"* with *'I'm very busy, and never seem to have enough time for everything I need to do' / 'I'm quite busy, but if something unexpected comes up, I can usually make time to deal with it' / 'I typically have plenty of free time to spend how I choose'.*

Planning skills. This was assessed using 10 items from the 'goal setting' subscale of the Short-form Self-Regulation Questionnaire (SSRQ; Neal & Carrey, 2005). Items were rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Total SSRQ score was computed by summing the 10 items; higher scores indicated greater planning skills.

Alternative measure of planning skills. Participants responded to *"Which of the following best describes you?"* with '*I'm good at making plans and sticking to them. If I set myself a goal, I'll spend time figuring out exactly how to reach it. If I'm not making good progress toward a goal, I'll go back to my plans and think again.' / 'I struggle to make plans and stick to them. I often find myself forgetting to do things I'd planned to do or getting distracted with other things'.*

Need for cognition. This was assessed using the short form of the Need for Cognition Scale (NCS; Lins de Holanda Coelho et al., 2020) which consisted of 6 items, each rated on a 5-point Likert scale ranging from 1 (*extremely uncharacteristic of me*) to 5 (*extremely characteristic of me*). A mean NCS score was computed from the 6 ratings, with higher scores indicating greater need for cognition.

Alternative measure of need for cognition. Participants responded to *"Which of the following best describes you?'* with *'If a doctor gives me advice, I*

like to understand the reasoning behind that advice. I'll ask questions or search the internet until I feel I really understand the issue.' / 'If a doctor gives me advice, I'm usually happy to simply take that advice. I don't feel the need for lengthy explanations and justifications'.

Preference for time spending learning new things. Participants were asked *"If you were part of a weight management programme, how much time would you prefer to spend learning new things?"* with response options '*No more than a few minutes a day or 30 minutes a week' / 'Up to 15 minutes a day or 1 to 2 hours a week' / 'Up to 30 minutes a day or 3 to 4 hours a week'.*

Daily measures

Adherence. Each day for 14 days participants were asked *"Did you use the strategy today?"* with response options '*Yes, I used it at least once' / 'No, I forgot to use it' / 'No, I didn't have time or didn't use it for another reason'.* Adherence was calculated as the percentage of days participants indicated they used the strategy out of the total number of daily surveys they completed.

Follow up measures

Ease of understanding / remembering strategy information. Participants responded to *"How easy was it to understand the instructions for the strategy?"* and *"How easy was it to remember the information you were given about the strategy over the 2-week period?"* on a 100cm visual analogue scale (VAS) anchored from 0 (*very difficult*) to 100 (*very easy*).

Views on length of strategy. Participants were asked *"When we gave you the strategy, we also explained why it might be helpful. Was this explanation..."* with response options '*too short?*' | '*about right?*' | '*too long?*'.

Helpfulness of strategy. Participants responded to *"How helpful did you find the strategy?"* on a 5-point scale ranging from 1 (*very unhelpful*) to 5 (*very helpful*).

Automaticity of strategy use. The 4-item Self-report Behavioural Automaticity Index (SRBAI; Gardner et al., 2012) assessed whether the assigned strategy became a habit over the 2-week period. Items were rated on a 7-point scale ranging from 1 (*strongly agree*) to 7 (*strongly disagree*). The 4 ratings were reverse-coded and summed to form a total score with higher scores indicating higher levels of automaticity.

Memory of strategy rationale. Four multiple choice questions, one relating to each of the strategies, were used to assess participants' knowledge of the rationale behind each strategy (see Appendix 2 in supplementary materials).

Qualitative questions. Four optional open-ended questions were administered to explore participants' experiences during the study. See Appendix 3 (in supplementary materials for details of the qualitative aspect of the study.

Procedure

Data collection took place between August and November 2023. Eligible Oviva patients were emailed the study advert, and interested participants first completed a screening survey on Qualtrics to confirm eligibility. Participants then completed the consent form and were given enrolment instructions. Once enrolled, participants completed the baseline measures and were randomised to one of the 16 possible groups where they were presented with their assigned strategy followed by planning prompts or tips on strategy use. It took approximately 30 minutes to complete baseline measures and read the strategy information. Participants then selected their preferred notification time (between 6pm and 11pm) for the daily surveys and were notified at their chosen time each day over the next 14 days to complete the surveys. To avoid participants mistakenly recording answers for the wrong day, each daily survey expired within 24 hours.

At 9am on the day following the last daily survey, participants were prompted to complete the follow up measures. This took approximately 30 minutes. Following this, participants were given the option to complete the qualitative survey, which took an additional 30 minutes. Participants were then provided with a written debrief and payment vouchers were issued via email.

Data Analysis

Data were analysed in the IBM SPSS statistical analysis package (version 28). All analyses were subject to bootstrapping at 5,000 resamples. Linear regression models were used to test the effects of information length and implementation intentions on strategy adherence. The moderating effects of NCS and SSRQ scores were examined using multiple regression models (Model 1) via the PROCESS macro (Hayes, 2017). The association between NCS score and participants' preference for information length was explored with an ordinal logistic regression model. An independent t-test examined the effect of implementation intentions on SRBAI scores.

Point-biserial correlation tests were used to test the association between the two need for cognition measures and the association between the two planning skills measures. The moderating effect of the alternative need for cognition measure on the association between information length and adherence was explored using analysis of variance (ANOVA), as was the moderating effect of the alternative planning skills measure on the association between implementation intentions and adherence.

Linear regression models tested the effects of participants' free time and priority of diet/weight on adherence. The moderating effect of information length in these analyses was explored using PROCESS Model 1. PROCESS Model 1 also assessed the moderating effect of preference for amount of time spending learning new things on the association between information length and

adherence. ANOVA models were used to explore the differences in adherence and helpfulness ratings across the four strategies.

The effect of information length on ease of understanding and remembering strategy information was explored using linear regression, and PROCESS Model 1 tested the moderating effect of NCS score. A logistic regression model evaluated the effect of information length on the likelihood that participants remember the rationale for the strategy they were assigned to, with NCS score entered as a moderator.

Results

Participant characteristics

Figure 1 presents the flow of participants through the study. As per the pre-registration, only participants with data for 7 or more daily surveys were included in the main analyses exploring the effects of information length and implementation intentions (n = 169). Analyses relating to follow-up measures were restricted to participants who completed the follow-up survey (n = 140). For all other analyses the full sample was used (n = 200). Participant characteristics of those included in the main analyses (n = 169) were well matched across conditions (Table 1).

FIGURE 1 ABOUT HERE

TABLE 1 ABOUT HERE

Main analyses

Effect of information length on adherence

Mean adherence to the strategy was 74% (SD = 25) in the short information group and 69% (SD = 23) in the long information group. This difference was not statistically significant (b = -5.70, SE = 3.74, 95% CI [-13.00, 1.77], p = .13), however, Cohen's d indicated a small effect size (0.24). There

was no significant moderation by need for cognition (b = 5.50, SE = 4.72, 95% CI [-3.82, 14.82], p = .25).

Effect of implementation intentions on adherence

Mean adherence to the strategy was 71% (SD = 27) in the implementation intentions group and 72% (SD = 21) in the group who received tips on strategy use. Contrary to predictions, there was no significant association between forming implementation intentions and strategy adherence (b = -1.34, SE = 3.71, 95% CI [-8.61, 5.84], p = .73) but as predicted, there was a significant interaction between implementation intentions and SSRQ (b = -1.21, SE = 0.58, 95% CI [-2.34, -0.07], p = .04). The Johnson-Neyman technique (Figure S1 in supplementary materials) revealed that implementation intentions (as opposed to tips) significantly increased adherence among those who scored below 13.01 on the SSRQ (poorer planners), however this only represented 0.6% of the sample, or 1 participant. Additional to our predictions, implementation intentions decreased adherence among those who scored above 48.88 (skilled planners) but again, this only represented 0.6% of the sample, or 1 participant. This was further explored with simple slopes analysis which revealed a similar pattern (Figure 2); implementation intentions increased adherence among participants with poor planning skills, and decreased adherence among participants with good planning skills. These results suggest that planning skills may moderate the effect of implementation intentions on adherence, but the effect may be small.

FIGURE 2 ABOUT HERE

Effect of need for cognition on preference for information length

Contrary to predictions, there was no significant association between NCS score and odds of preference for shorter information length, OR = 0.96, 95% CI [0.45, 2.05], p = .92.

Effect of implementation intentions on automaticity

Also contrary to predictions, there was no significant difference in SRBAI scores between participants who formed implementation intentions ($M = 17.0$, $SD = 7.1$) and those who were given tips ($M = 17.4$, $SD = 6.6$), $t(138) = 0.35$, $p = .73$.

Additional exploratory analyses

Alternative need for cognition measure

As expected, there was a significant positive correlation between the two need for cognition measures, $r_{pb}(198) = .19$, $p = .01$. Participants who reported they like to understand the reasoning behind doctors' advice ($n = 155$) had a greater NCS score ($M = 3.6$, $SD = 0.8$) than those who reported they are happy to simply take doctors' advice ($n = 45$, $M = 3.2$, $SD = 0.8$).

Contrary to the confirmatory analyses, the ANOVA exploring the moderating effect of the alternative need for cognition measure revealed a significant main effect of information length on adherence; adherence was greater in the short format group ($M = 74\%$, $SD = 25$) than the long format group ($M = 69\%$, $SD = 23$), $F(1, 165) = 4.97$, $p = .03$, $\eta_p^2 = .03$. For individuals with low need for cognition ($n = 37$), mean adherence was 83% ($SD = 16$) in the short format group and 66% ($SD = 29$) in the long format group. For individuals with high need for cognition ($n = 132$), mean adherence was 72% ($SD = 26$) in the short format group and 69% ($SD = 21$) in the long format group. These figures are in line with expectations, however, the interaction effect between information length and the alternative need for cognition measure was not significant, $F(1,165) = 2.61$, $p = .11$, $\eta_p^2 = .02$.

Alternative planning skills measure

Also as expected, there was a significant positive correlation between the two planning skills measures, $r_{pb}(198) = .58$, $p < .001$. Participants who reported they were '*good at making plans and sticking to them*' ($n = 84$) had a greater

SSRQ score (M = 38.8, SD = 5.4) than those who reported they '*struggle to make plans and stick to them*' (n = 116, M = 31.5, SD = 5.0).

Participants who reported being good at making plans also reported significantly greater adherence (M = 76%, SD = 25) than those who struggled to make plans (M = 68%, SD = 23), $F(1,165) = 3.97$, $p = .048$, $\eta_p^2 = .02$. For individuals with good planning skills (n = 74), mean adherence was 71% (SD = 30) in the implementation intentions group and 81% (SD = 17) in the tips group. For individuals with poor planning skills (n = 95), mean adherence was 71% (SD = 24) in the implementation intentions group and 66% (SD = 22) in the tips group. The interaction between implementation intentions and the alternative planning skills measure was significant, $F(1,165) = 4.66$, $p = .03$, $\eta_p^2 = .03$. However, independent samples t-tests revealed no significant effect of implementation intentions on adherence in individuals with good planning skills ($t(72) = 1.80$, $p = .09$) or individuals with poor planning skills ($t(93) = -1.19$, $p = .25$).

Effects of other variables on adherence

Mean strategy adherence was 67% (SD = 25) among participants who stated they were 'very busy' (n = 54), 73% (SD = 24) among those who were 'quite busy' (n = 86), and 77% (SD = 21) among those who stated they had 'plenty of free time' (n = 29). However, there was no significant main effect of free time on adherence (b = 4.99, SE = 2.64, 95% CI [-.29, 10.28], p = .06) and no moderation by information length (ps > .05). Mean adherence was 77% (SD = 19) in individuals whose diet/weight was of high priority (n = 48), 69% (SD = 26) in those with medium priority (n = 117) and 74% (SD = 9) in those with low priority (n = 4). The main effect of diet/weight priority on adherence approached significance (b = -6.20, SE = 3.15, 95% CI [-12.58, -0.11], p = .054). There was no significant moderation by information length (ps > .05). Additionally,

preference for time spending learning new things did not moderate the impact of information length on strategy adherence (*p*s > 0.05). See Appendix 4 for more details on the above analyses.

Mean strategy adherence was 72% (*SD* = 28) for sensory eating, 68% (*SD* = 25) for attending to fullness, 61% (*SD* = 30) for vegetables first and 70% (*SD* = 29) for physical activity. There was no significant difference between the 4 strategies, $F(3, 196) = 1.53$, $p = 0.21$. There were also no significant differences in helpfulness ratings across sensory eating (M = 3.8, *SD* = 1.0), attending to fullness (M = 3.9, *SD* = 0.9), vegetables first (M = 3.9, *SD* = 1.1) and physical activity (*M* = 4.1, *SD* = 0.9), $F(3, 139) = 0.44$, $p = .73$ ($n = 143$ as not all participants used the strategy). The pattern of results remained the same when participants with less than 7 days of data were excluded ($n = 169$).

Effect of information length on self-reported ease of understanding and remembering

There was no significant association between information length and self-reported ease of understanding the strategy information ($b = -2.62$, $SE = 2.01$, 95% CI [-6.77, 1.41], $p = .215$) and no significant interaction between information length and NCS score ($b = 0.72$, $SE = 2.80$, 95% CI [-4.81, 6.25], $p = .80$). However, ease of remembering was significantly higher among participants in the short format group (*M* = 83%, *SD* = 22) compared to those in the long format group (*M* = 74%, *SD* = 25), $b = -9.08$, $SE = 3.98$, 95% CI [-16.83, -1.14], $p = .02$. There was no evidence for a moderation effect of NCS score ($b = -0.84$, $SE = 5.33$, 95% CI [-11.39, 9.71], $p = .87$).

Effect of information length on memory for the strategy

Participants in the long format group were more likely to correctly remember the rationale for their assigned strategy than those in the short format group (OR = 3.08, 95% CI [1.18, 8.05], $p = .02$). There was no moderation by

NCS score (OR = 0.81, 95% CI [0.22, 2.94], $p = .75$). See Appendix 4 for details of additional exploratory analyses.

Sensitivity analyses

The analyses using the adherence variable were repeated using data from all 200 participants where adherence was calculated over the full 2-week period (missing data were replaced with 'non-adherent'). The pattern of results for all analyses remained unchanged apart from the ANOVA model exploring the moderating effect of the alternative need for cognition measure, where the main effect of information length became non-significant ($p = .47$).

Discussion

The novel key aim of this study was to explore whether adherence to brief weight management strategies over a 2-week period could be enhanced by manipulating information length, and whether this varied for individuals with different levels of need for cognition. The findings revealed no significant effect of information length on strategy adherence, however, the observed means were in the expected direction with adherence 5 percentage points higher among those who viewed the shorter information. This represented a small effect size which the study had not been powered to detect; whilst the planned regression analyses revealed a non-significant effect, an ANOVA, conducted as part of additional exploratory analyses, showed it as significant ($p = .048$). Because digital health interventions are often delivered to large numbers, an effect of this size may still be clinically significant. As such, these results warrant further exploration with an appropriately powered sample.

Contrary to Williams-Piehota et al.'s (2003) findings, the study failed to show that the effect of information length on adherence was influenced by need for cognition. Indeed, the overall pattern of results seem to suggest that even

those with high need for cognition may benefit from shorter information. In line with this finding, need for cognition also failed to predict preference for information length. Findings from the exploratory analyses provide some insights into why shorter information may lead to better adherence; although memory for strategy rationale was better among those given the longer information, those given the shorter information reported that it was easier to remember the strategy. Thus, it is possible that shorter information leads to greater adherence simply because it helps people remember the strategy. A key implication of these findings is that digital health interventions may enhance adherence by limiting information length to no more than 100 words of action-oriented text. Optional links to additional detail could then be provided for those who would prefer extra information.

In contrast to ease of remembering, ease of understanding was relatively high across both the short and long information groups (93% and 90% respectively). It was also not influenced by need for cognition, suggesting that need for cognition did not impact engagement with strategy content. It is possible that strategy understanding is better predicted by other participant characteristics such as health literacy and cognitive ability. Health literacy encompasses skills in understanding and applying information about health issues (Ishikawa & Kiuchi, 2010) and higher levels have been associated with better health behaviours (Šulinskaitė et al., 2022). Likewise, engagement in health promoting behaviours has been associated with greater cognitive ability as measured by general intelligence (Christopher Auld & Sidhu, 2005), processing speed (Anstey et al., 2009), and analytic reasoning (Junger & van Kampen, 2010). Given these correlations, it is possible that participants in this study had relatively high health literacy skills and cognitive abilities, which could have contributed to the high reported ease of understanding, regardless of

information length or need for cognition level. However, without direct measures of health literacy and cognitive ability, these interpretations remain speculative. Future studies may consider incorporating these measures in addition to need for cognition.

The study's second aim was to examine whether adherence could be enhanced with implementation intentions, and whether this varied for individuals with different levels of planning skills. In contrast to previous research (Adriaanse et al., 2011; Carrero et al., 2019; Bélanger-Gravel et al., 2013; Silva et al., 2018; Kompf, 2020), we found no evidence for benefits of implementation intentions over and above similar advice phrased as 'tips'. This discrepancy may be due to the use of different types of control groups in previous research. In Adriaanse et al.'s (2011) systematic review most studies employed a passive control group where participants received no instructions or considerably fewer instructions than the experimental group. Effects of implementation intentions were stronger across studies with these weaker control groups compared to studies with active control conditions which administered identical instructions to both control and experimental groups (apart from the manipulation). In these latter studies, the active control condition itself may promote goal achievement to some extent, thus reducing (but not entirely eliminating) the relative advantage of implementation intentions. It is therefore plausible that while implementation intentions may be effective in promoting goal achievement, other strategies, such as the provision of 'tips' (i.e. suggestions on how to implement a particular behaviour), may be just as effective.

Furthermore, contrary to predictions, the study failed to find evidence to support the notion that implementation intentions achieve their effect by increasing automaticity. Automaticity of the strategies over the 2-week period did not differ significantly between those who formed implementation intentions

and those who were given ‘tips’ with both groups reporting high automaticity (17.0 and 17.4 out of 20, respectively). Although it is plausible that the 2-week duration of the study was not sufficient to allow for any noticeable differences in automaticity to manifest, the high scores suggest that the ‘tips’ were just as effective as implementation intentions in promoting automaticity. Further research with an additional control group would be needed to confirm this.

Nevertheless, in line with our predictions and with previous research (Allan et al., 2013), we did find that individuals with poorer planning skills reported greater adherence when given implementation intentions instead of ‘tips’. Unexpectedly, we also found that those with better planning skills reported greater adherence when provided with ‘tips’ rather than implementation intentions. One possible explanation is that by asking good planners to form implementation intentions we prevented them from using their own well-rehearsed, more flexible implementation strategies. Nevertheless, the moderation effect size was relatively small. Given our sample comprised weight management programme patients who had volunteered to take part in our study, their motivation to try the strategies we provided them with may have been higher than the whole cohort of weight management programme patients. As such, larger effect sizes may emerge across the whole population or over longer timeframes during which motivation may wane. Testing this type of personalised content directly within a digital weight management programme would be the next most useful step for this line of research.

Another aim of the study was to explore whether simplified and more user-friendly versions of established measures of need for cognition and planning skills were effective substitutes. As expected, the short-form NCS was positively correlated with the alternative need for cognition measure ($r = .19$) and the SSRQ goal setting subscale was positively correlated with the alternative

planning skills measure (r = .58). Furthermore, the alternative measures produced similar results to the standardised measures when examining their moderating effects on the influence of information length and implementation intentions on adherence. These findings are key, as both the short-form NCS and SSRQ goal setting subscale consist of several questions (6 and 10 respectively) and are more burdensome to complete than our alternative measures, which consist of one question each, yet both measures yield similar results. The use of these brief alternative measures could facilitate personalised intervention by digital health companies since they make it more feasible to capture a range of different important psychological differences among patients.

A key strength of the present study is the sample, as participants were all patients who had been referred to a digital weight management programme. They are therefore representative of the types of participants who would typically be targeted by this type of intervention. However, a key limitation is that participants had already completed the weight management programme and thus may have been more motivated and had more practice at implementing behavioural advice. As participants were recruited at the end of the programme, the sample we obtained is likely to represent individuals with higher adherence rates since individuals with poor adherence may have dropped out before completing the programme. This is evident in the high adherence levels observed across both mental and physical strategies during the 2-week period, despite the different levels of effort and skill required for these two strategy types. As noted above, significant differences may have emerged with an alternative sample, such as patients at the start of a weight management programme, due to differences in motivation level and experience. It is therefore recommended to further investigate the effects of information length and implementation intentions within real-world digital weight management

programmes. These initiatives would enhance our understanding of what fosters adherence, enabling the development of more effective interventions.

References

Adriaanse, M. A., Vinkers, C. D., De Ridder, D. T., Hox, J. J., & De Wit, J. B. (2011). Do implementation intentions help to eat a healthy diet? A systematic review and meta-analysis of the empirical evidence. *Appetite*, *56*(1), 183-193.

Allan, J. L., Sniehotta, F. F., & Johnston, M. (2013). The best laid plans: Planning skill determines the effectiveness of action plans and implementation intentions. *Annals of Behavioral Medicine*, *46*(1), 114-120.

Anstey, K. J., Low, L. F., Christensen, H., & Sachdev, P. (2009). Level of cognitive performance as a correlate and predictor of health behaviors that protect against cognitive decline in late life: The path through life study. *Intelligence*, *37*(6), 600-606.

Armitage, C. J., Norman, P., Noor, M., Alganem, S., & Arden, M. A. (2014). Evidence that a very brief psychological intervention boosts weight loss in a weight loss program. *Behavior Therapy*, *45*(5), 700-707.

Bélanger-Gravel, A., Godin, G., & Amireault, S. (2013). A meta-analytic review of the effect of implementation intentions on physical activity. *Health psychology review*, *7*(1), 23-54.

Birch, J. M., Jones, R. A., Mueller, J., McDonald, M. D., Richards, R., Kelly, M. P., ... &

Ahern, A. L. (2022). A systematic review of inequalities in the uptake of, adherence to, and effectiveness of behavioral weight management interventions in adults. *Obesity Reviews*, *23*(6), e13438.

Buffey, A. J., Herring, M. P., Langley, C. K., Donnelly, A. E., & Carson, B. P. (2022). The acute effects of interrupting prolonged sitting time in adults with standing and light-intensity walking on biomarkers of cardiometabolic health in adults: a systematic review and meta-analysis. *Sports Medicine*, *52*(8), 1765-1787.

Carr, N. (2020). *The shallows: What the Internet is doing to our brains*. WW Norton & Company.

Carrero, I., Vilà, I., & Redondo, R. (2019). What makes implementation intention interventions effective for promoting healthy eating behaviours? A meta-regression. *Appetite*, *140*, 239-247.

Carrière, K., Khoury, B., Günak, M. M., & Knäuper, B. (2018). Mindfulness-based interventions for weight loss: a systematic review and meta-analysis. *Obesity Reviews*, *19*(2), 164-177.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of personality and social psychology*, *42*(1), 116.

Chao, A. M., Quigley, K. M., & Wadden, T. A. (2021). Dietary interventions for obesity: clinical and mechanistic findings. *The Journal of Clinical Investigation*, *131*(1).

Christopher Auld, M., & Sidhu, N. (2005). Schooling, cognitive ability and health. *Health economics*, *14*(10), 1019-1034.

Cohen, R.A. (2014). Focused and Sustained Attention. In: The Neuropsychology of Attention. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-72639-7_6

De Vet, E., Oenema, A., & Brug, J. (2011). More or better: Do the number and specificity of implementation intentions matter in increasing physical activity?. *Psychology of Sport and Exercise*, *12*(4), 471-477.

Gardner, B., Abraham, C., Lally, P., & de Bruijn, G. J. (2012). Towards parsimony in habit measurement: Testing the convergent and predictive validity of an automaticity subscale of the Self-Report Habit Index. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 1-12.

Gollwitzer, P. M. (1999). Implementation intentions: strong effects of simple plans. *American psychologist*, *54*(7), 493.

Gollwitzer, P. M. (2012). Mindset theory of action phases. *Handbook of theories of social psychology*, *1*, 526-545.

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in experimental social psychology*, *38*, 69-119.

Hagerman, C. J., Hoffman, R. K., Vaylay, S., & Dodge, T. (2021). Implementation intentions
to reduce smoking: a systematic review of the literature. *Nicotine and Tobacco*
Research, *23*(7), 1085-1093.

Hartmann-Boyce, J., Johns, D. J., Jebb, S. A., Aveyard, P., & Behavioural Weight
Management Review Group. (2014). Effect of behavioural techniques and delivery
mode on effectiveness of weight management: systematic review, meta-analysis and
meta-regression. *obesity reviews*, *15*(7), 598-609.

Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process*
analysis: A regression-based approach. Guilford publications.

Hayes, J. F., Balantekin, K. N., Graham, A. K., Strube, M. J., Bickel, W. K., & Wilfley, D. E.
(2021). Implementation intentions for weight loss in college students with overweight
and obesity: a proof-of-concept randomized controlled trial. *Translational behavioral*
medicine, *11*(2), 359-368.

Heckhausen, H., & Gollwitzer, P. M. (1987). Thought contents and cognitive functioning in
motivational versus volitional states of mind. *Motivation and emotion*, *11*, 101-120.

Ishikawa, H., & Kiuchi, T. (2010). Health literacy and health communication.
BioPsychoSocial medicine, *4*, 1-5.

Jordan, C.H., Wang, W., Donatoni, L. & Meier, B.P. (2014) Mindful eating: trait and state
mindfulness predict healthier eating behavior. *Personality and Individual Differences*,
68, 107–111.

Junger, M., & van Kampen, M. (2010). Cognitive ability and self-control in relation to dietary
habits, physical activity and bodyweight in adolescents. *International journal of
behavioral nutrition and physical activity*, *7*(1), 1-12.

Knäuper, B., Carriere, K., Frayn, M., Ivanova, E., Xu, Z., Ames-Bull, A., ... & McGill CHIP
Healthy Weight Program Investigators. (2018). The Effects of If-Then Plans on
Weight Loss: Results of the McGill CHIP Healthy Weight Program Randomized
Controlled Trial. *Obesity*, *26*(8), 1285-1295.

Kompf, J. (2020). Implementation intentions for exercise and physical activity: who do they
work for? A systematic review. *Journal of Physical Activity and Health*, *17*(3), 349-
359.

Lemstra, M., Bird, Y., Nwankwo, C., Rogers, M., & Moraros, J. (2016). Weight loss
intervention adherence and factors promoting adherence: a meta-analysis. *Patient
preference and adherence*, 1547-1559.

Lins de Holanda Coelho, G., HP Hanel, P., & J. Wolf, L. (2020). The very efficient

assessment of need for cognition: Developing a six-item version. *Assessment*, *27*(8), 1870-1885.

Luszczynska, A., Sobczyk, A., & Abraham, C. (2007). Planning to lose weight: randomized controlled trial of an implementation intention prompt to enhance weight reduction among overweight and obese women. *Health Psychology*, *26*(4), 507.

Martin, L. R., & DiMatteo, M. R. (Eds.). (2014). *The Oxford handbook of health communication, behavior change, and treatment adherence*. Oxford Library of Psychology.

Neal, D. J., & Carey, K. B. (2005). A follow-up psychometric analysis of the self-regulation questionnaire. *Psychology of addictive behaviors, 19*(4), 414.

Ngigi, S., & Busolo, D. N. (2018). Behaviour change communication in health promotion: Appropriate practices and promising approaches. *International Journal of Innovative Research and Development*, *7*(9), 84-93.

Nishino, K., Sakurai, M., Takeshita, Y., & Takamura, T. (2018). Consuming carbohydrates after meat or vegetables lowers postprandial excursions of glucose and insulin in nondiabetic subjects. *Journal of nutritional science and vitaminology*, *64*(5), 316-320.

Rimal, R. N., & Lapinski, M. K. (2009). Why health communication is important in public

health. *Bulletin of the World Health Organization*, *87*, 247-247a.

Seguias, L., & Tapper, K. (2018). The effect of mindful eating on subsequent intake of a high

calorie snack. *Appetite*, *121*, 93-100.

Sheeran, P. (2002). Intention—behavior relations: a conceptual and empirical

review. *European review of social psychology*, *12*(1), 1-36.

Silva, M. A. V. D., Sao-Joao, T. M., Brizon, V. C., Franco, D. H., & Mialhe, F. L. (2018).

Impact of implementation intentions on physical activity practice in adults: A

systematic review and meta-analysis of randomized clinical trials. *PLoS One*, *13*(11),

e0206294.

Šulinskaitė, K., Zagurskienė, D., & Blaževičienė, A. (2022). Patients' health literacy and

health behaviour assessment in primary health care: evidence from a cross-sectional

survey. *BMC Primary Care*, *23*(1), 1-7.

Twells, L. K., Harris Walsh, K., Blackmore, A., Adey, T., Donnan, J., Peddle, J., ... & Pace, D.

(2021). Nonsurgical weight loss interventions: A systematic review of systematic

reviews and meta-analyses. *Obesity Reviews*, *22*(11), e13320.

Uncapher, M. R., & Wagner, A. D. (2018). Minds and brains of media multitaskers: Current

findings and future directions. *Proceedings of the National Academy of Sciences*, *115*(40), 9889-9896.

Verhoeven, A. A., Adriaanse, M. A., De Ridder, D. T., De Vet, E., & Fennis, B. M. (2013).

Less is more: The effect of multiple implementation intentions targeting unhealthy

snacking habits. *European Journal of Social Psychology*, *43*(5), 344-354.

Welton, S., Minty, R., O'Driscoll, T., Willms, H., Poirier, D., Madden, S., & Kelly, L. (2020).

Intermittent fasting and weight loss: Systematic review. *Canadian Family Physician*, *66*(2), 117-125.

Williams-Piehota, P., Schneider, T. R., Pizarro, J., Mowad, L., & Salovey, P. (2003). Matching

health messages to information-processing styles: Need for cognition and

mammography utilization. *Health Communication*, *15*(4), 375-392.

Yeykelis, L., Cummings, J. J., & Reeves, B. (2014). Multitasking on a single device: Arousal

and the frequency, anticipation, and prediction of switching between media content

on a computer. *Journal of Communication*, *64*(1), 167-192.

Tables and figures

Figure 1

Flow chart of participants through the study

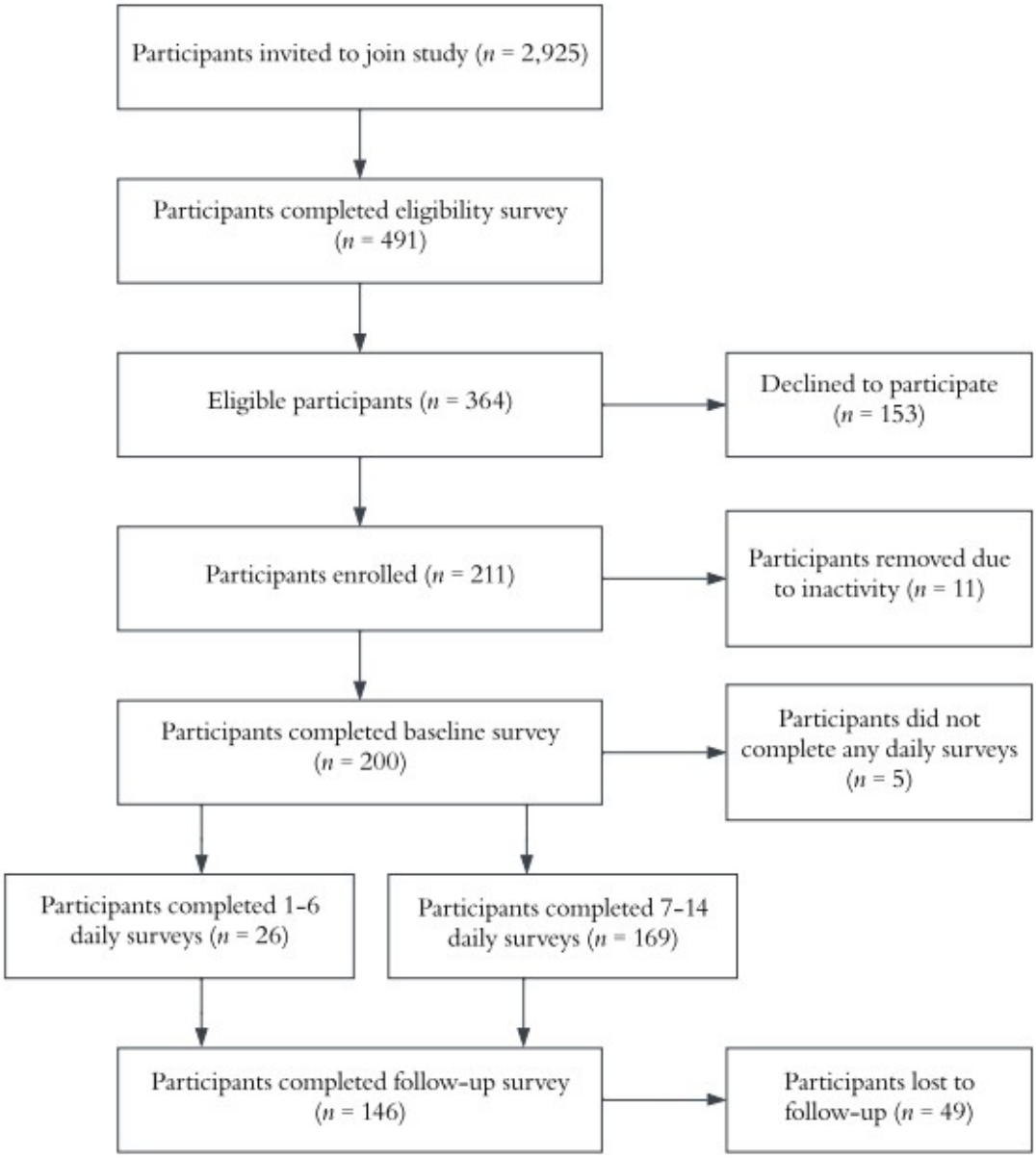


Table 1

Participant characteristics as a function of condition

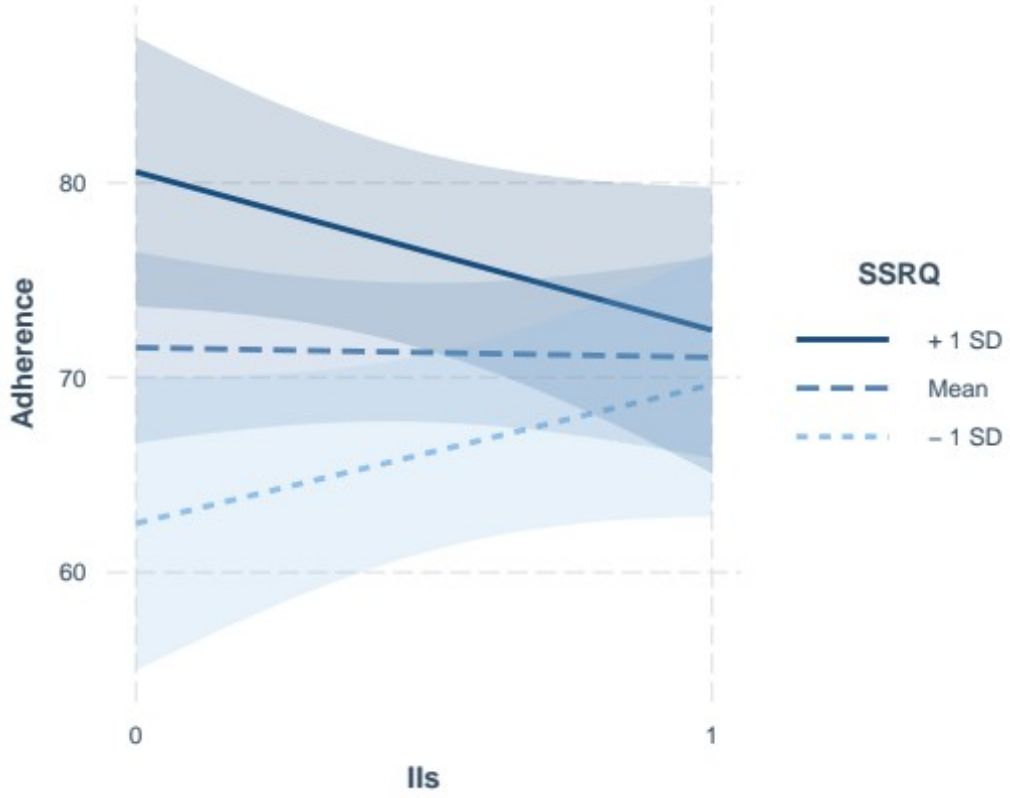
Characteristic	Implementation Intentions (*n*=80)	Tips (*n*=89)	Short Format (*n*=85)	Long Format (*n*=84)
Age (*M, SD*)	53 (12)	51 (10)	51 (11)	53 (11)
Gender (% women)	66%[a]	65%	63%[b]	68%
BMI (*M, SD)*	35.3 (6.5)	35.9 (8.3)	35.7 (7.2)	35.6 (7.8)
Education				
No formal education	3%	5%	2%	5%
GCSEs / O-levels or equivalent	23%	23%	20%	25%
A-levels or equivalent	9%	8%	7%	10%
BTEC or equivalent	13%	10%	11%	12%
Undergraduate degree or equivalent	29%	37%	33%	33%
Master's degree or equivalent	20%	17%	21%	16%
Doctoral degree or equivalent	1%	0%	1%	0%
Other	4%	1%	5%	0%
Ethnicity[c]				
Arab	0%	0%	0%	0%
Asian or Asian British	8%	13%	12%	8%
Black, Black British, Caribbean or African	4%	5%	6%	2%
Mixed or multiple ethnic groups	3%	2%	2%	2%
White	85%	81%	80%	86%
Other ethnic group	1%	0%	0%	1%
Percentage trying to lose weight	98%	94%	97%	95%
Percentage trying to avoid weight gain	3%	6%	4%	5%
Priority of diet/weight				
High	28%	29%	34%	23%
Medium	71%	67%	65%	74%
Low	1%	3%	1%	4%
Free time				
Very busy	26%	37%	27%	37%
Quite busy	53%	49%	53%	49%
Have plenty of free time	21%	14%	20%	14%
Preference for time spending learning new things in a weight management programme	26%	24%	19%	31%
Few minutes a day/30 mins a week	56%	57%	62%	51%
15 mins a day/1-2 hours a week	18%	19%	19%	18%
30 mins a day/3-4 hours a week				
SSRQ Score (*M, SD*)	34.3 (6.8)	35.3 (5.8)	35.3 (6.5)	34.3 (6.1)
NCS Score (*M, SD*)	3.4 (0.8)	3.6 (0.7)	3.6 (0.8)	3.5 (0.8)

[a] *n* = 79 due to missing data.

[b]n = 84 due to missing data
[c]*n* = 79, 87, 83 and 83 respectively due to missing data.

Figure 2

Simple slopes for the moderation effect of planning skills on the association between implementation intentions and adherence



IIs = implementation intentions (0 absent, 1 present), SSRQ = Short-form Self-regulation Questionnaire Score