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Immediate effects of a very brief planning intervention on fruit and vegetable consumption: A randomized controlled trial

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Abstract

Action planning interventions can effectively promote fruit and vegetable (FV) consumption, but not much is known about the day-to-day translation of intervention planning into action. In this randomized controlled trial, immediate intervention effects of a very brief planning intervention on FV consumption during the following 13 days were investigated. After a 13-day pre-intervention diary, $N = 206$ participants (aged 19–66 years) were randomly allocated to a waiting-list control condition or a planning condition, where they formed one FV plan. Participants from both conditions completed a 13-day post-intervention diary. Self-reported daily FV consumption, FV-specific self-efficacy, and action control were assessed. Segmented linear mixed models estimating a discrete change (i.e. "jump") between diary phases showed a positive "jump" of FV intake and self-efficacy in the planning condition when compared to the control condition. For action control, such effects were not observed. Changes in study variables throughout the post-intervention phase did not differ between both conditions. Present findings extend previous evidence on action planning interventions by showing that increases in self-regulatory (i.e. self-efficacy) and behavioral (i.e. FV intake) outcomes can occur very rapidly and already on the first day for which behavioral increases were planned.

KEYWORDS

action planning, ecological momentary assessment, fruit and vegetables, nutrition, randomized controlled trial

INTRODUCTION

Sufficient fruit and vegetable (FV) consumption decreases the risk for all-cause mortality and several diseases such as cardiovascular disease, cancer, and hypertension (Aune et al., 2017). International guidelines recommend the consumption of at least five servings of FV per day; however, globally, adherence to these recommendations remains comparatively low (Hall et al., 2009). Individuals frequently fail to translate their good intentions into action (Godin & Conner, 2008; Inauen et al., 2016), a phenomenon which is known as the "intention-behavior gap". As proposed by behavior change theories (e.g. Health Action Process Approach, HAPA; Schwarzer, 2008), volitional self-regulatory factors such as action planning, self-efficacy, and action control are important factors that might close the intention-behavior gap by helping to initiate behavior changes (Zhang et al., 2019).

Action planning is suggested to change health behavior by mediating the intention-behavior relationship (Gollwitzer, 1999; Schwarzer, 2008). That is, people with good intentions to eat healthily could form a plan on when, where, and how they perform a desired nutrition behavior such as "I will eat an apple for breakfast at 8 a.m. in the kitchen." With such an action plan, a mental link between situational cues (when and where) and the behavioral response (how) is created, which makes the behavioral performance more likely when individuals encounter the planned situation (Hagger & Luszczynska, 2014). Evidence from a meta-analysis on planning interventions on healthy nutrition revealed medium effect sizes for improvements in nutrition behavior (Adriaanse et al., 2011).

To evaluate the effectiveness of the intervention, many intervention studies use only a limited number of assessments, often relying on participants' retrospective reports on eating behavior over specified amounts of time, such as over the past seven days (cf. Adriaanse et al., 2011). However, day-to-day measurements of behavior change right after an action planning intervention would provide insights about the time point when the intervention unfolds its effects. In this context, Scholz (2019) emphasized the importance of investigating temporal dynamics in health behavior change and its processes, specifically taking a closer look at the starting point and the duration of intervention effects is highly relevant for a better understanding of the intervention. This also includes an investigation of day-to-day changes of self-regulatory factors, that is, self-efficacy and action control, that underlie behavior change following an action planning intervention (Sniehotta et al., 2005).

Self-efficacy and action control following action planning

Self-efficacy describes individuals' beliefs in their capabilities to master a specific task that is needed to achieve a desired goal (Bandura, 1997). In the context of nutrition, self-efficacy refers to beliefs in capabilities to stick to a healthy diet and is an essential factor enabling individuals to initiate and maintain their healthy nutrition. According to social cognitive theory (Bandura, 1997), mastery experiences, that is, the experience of having performed a desired behavior, are the strongest determinant of self-efficacy. The interrelation of self-efficacy and mastery experiences is proposed to be of reciprocal nature

(Bandura, 1997). A study by Warner et al. (2018) found that, during a smoking quit attempt, day-to-day mastery experiences and self-efficacy seemed to be reinforcing each other. In the context of pursuing an action plan, it can be assumed that a person who enacts an action plan perceives successful mastery of the planned behavior, which, in turn, increases the person's self-efficacy. When plans are supposed to be enacted daily, already the first enactment of the plan could lead to mastery experiences and, thus, to an enhancement of self-efficacy. For physical activity as the health behavior, results from meta-analyses revealed that self-efficacy increases after action planning interventions (e.g. Williams & French, 2011).

Action control is another self-regulatory factor that promotes behavioral adoption and maintenance (Sniehotta et al., 2005) and consists of three facets: *awareness of behavioral standards* (i.e. the constant awareness of one's behavioral plans), *self-monitoring* (i.e. observing actual behavior and comparing it with one's standards), and investing *self-regulatory effort* to reach the behavioral standard (i.e. reducing discrepancies between actual behavior and standards; Carver & Scheier, 1998; Sniehotta et al., 2006). While self-efficacy and action planning are prospective, action control operates at the situational level or even retrospectively (Sniehotta et al., 2005). Based on the HAPA, behavioral effects of action planning are proposed to be mediated by action control (Schwarzer, 2008; Sniehotta et al., 2005). The facets of action control are addressed through an action planning intervention by, for instance, setting the behavioral standard through forming an action plan and making self-monitoring more likely by specifying situational cues of future situations to facilitate the monitoring of behavioral enactment (Sniehotta et al., 2005). Planning interventions should therefore also have effects on action control as an underlying mechanism. Daily nutrition behaviors such as FV consumption might be particularly linked with action control as this behavioral context provides frequent opportunities for behavior change.

Immediate day-to-day effects of an action planning intervention

The effectiveness of action planning interventions on nutrition outcomes is mostly evaluated by aggregating behavioral measures over a certain time period (Adriaanse et al., 2011). As examining processes of behavior change at a high temporal resolution allows to gain a better understanding of such processes in daily life (Scholz, 2019), the present study focuses on day-to-day changes of FV consumption right before and after an action planning intervention. Nutrition-related ecological momentary assessment (EMA; Stone & Shiffman, 1994) studies with food diaries can be applied where participants monitor their nutrition behavior at a high temporal resolution (Inauen et al., 2017). For instance, Brookie et al. (2017) conducted a diary-based EMA study evaluating the effects of a 13-day text messaging intervention. After aggregating daily FV measures across 2 weeks, they found increases in FV consumption over time (Brookie et al., 2017). Daily diary EMAs following an action planning intervention were used in the studies by Gratton et al. (2007) and Verplanken and Faes (1999). Both studies found increases in healthy eating for outcome aggregations across different time periods: between the 1st and 5th day (Verplanken & Faes, 1999) and between the 8th and 14th day (Gratton et al., 2007) following the intervention. Thus, first evidence on immediate intervention effects of action planning interventions exists; however, due to outcome aggregations over certain time periods, it remains an open question when exactly (i.e. at which day) the behavior was taken up or changed.

Aims and hypotheses

The present study aims to investigate the day-to-day temporal development of FV consumption, self-efficacy, and action control in adults forming one FV action plan (planning condition) compared to adults from a waiting-list control condition. The present study design includes a 13-day pre-intervention and a 13-day post-intervention daily diary. Similar to analytical approaches reported by Berli et al. (2016) and Inauen et al. (2017), day-to-day effects on study outcomes prior to (pre-intervention phase) versus following (post-intervention phase) the action planning intervention as well as between both phases (i.e. immediate effect for the first day following the intervention) were examined.

Based on meta-analytic evidence on the effectiveness of planning interventions for FV intake (Adriaanse et al., 2011), we hypothesized that the action planning condition (vs. control condition) would be related (1) to higher FV intake by showing an adoption of FV intake immediately after the intervention (immediate intervention effect; Hypothesis 1a), which is maintained throughout the post-intervention phase (behavioral maintenance; Hypothesis 1b). Second, as action planning increases the likelihood of mastery experiences, a positive correlate of self-efficacy (Warner et al., 2018), we assumed for the action planning condition (vs. control condition) that (2) self-efficacy is immediately increasing following the intervention (immediate intervention effect; Hypothesis 2a) and this increase is maintained throughout the post-intervention phase (behavioral maintenance; Hypothesis 2b). Third, based on Sniehotta et al.'s (2005) suggestion that action planning is a determinant of action control, we hypothesized for the action planning condition (vs. control condition) that (3) action control is immediately increasing after the intervention (immediate intervention effect; Hypothesis 3a). This increase is assumed to be maintained throughout the post-intervention phase (behavioral maintenance; Hypothesis 3b).

METHODS

Design and procedure

The present study reports primary analyses from an intensive longitudinal two-condition randomized controlled trial (RCT) on the effects of a very brief planning intervention on adults' day-to-day FV consumption. Following informed consent, participants responded to the baseline questionnaire (14 days prior to the intervention; Day −14) and were handed a 13-day diary (henceforth called *pre-intervention diary*; Day −13 to Day −1) to complete at their homes. At Day 0, participants were asked to respond to a second questionnaire, followed by randomization procedures. For participants assigned to the planning condition only, the intervention was conducted after the second questionnaire at Day 0. Subsequently, all participants were asked to respond to another 13-day diary at their homes (henceforth called *post-intervention diary*; Day 1 to Day 13). Participants were instructed to respond to daily questionnaires each night before going to bed. No reminders were sent when participants did not respond to a daily questionnaire. Follow-up questionnaires were conducted at a 2- and 4-week follow-up but were not further considered in this report (the full study design can be found in Figure S1). All study materials were paper-pencil-based. Ethical approval was granted by the ethics committee of the German Psychological Society. The data sets generated during this study are not publicly available as we do not have permission from study participants. Group-level information about the data is available from the corresponding author on reasonable request.

Sample and recruitment

Eligible participants were at least 18 years old, had no self-reported medical conditions conflicting with health recommendations for dietary behavior, and did not participate in weight loss or nutrition programs. Individuals were recruited and surveyed in physical education classes (e.g. yoga, spinal exercises; no diet or weight loss programs) and university classes between August 2011 and November 2012. As incentives following complete study participation, participants had the choice to either enter a lottery for health-related products or to receive course credits. A total of *N* = 206 participants (out of a sample of 268 eligible participants; see Figure 1 for participant flow) were randomly assigned to the action planning condition (henceforth called *planning condition; n* = 106) or the waiting-list control condition (henceforth called *control condition*; *n* = 100) using a web-based randomization tool. Based on baseline self-reports, participants from the planning condition were on average 32.80 years old (*SD* = 12.25; range: 19–63), had a mean body mass index (BMI) of 22.72 (*SD* = 3.13; range: 18.00–32.77), 72% of them were employed (*n* = 76), and 78% of them were women (*n* = 83). Participants from the control condition were on average 30.59 years old (*SD* = 10.06; range: 20–66), had a mean BMI of 22.25 (*SD* = 3.23, range: 16.80–32.85), 58% of them were employed (*n* = 57), and 75% of them were women (*n* = 75). Detailed information on baseline sample characteristics is displayed in Table S1. A total of *n* = 186 participants (out of *N* = 206: 90%; *n* = 95 participants from the planning condition and *n* = 91 participants from the control condition) returned the post-intervention diary.

Experimental conditions

The intervention embedded in this study was a very brief FV-specific action planning intervention administered in the planning condition only. Participants randomly allocated to the planning condition were asked to generate an action plan for *one additional FV serving* that should be consumed daily from the next day on. Participants entered their action plan in three blank fields: *when*, *where*, and *what kind*. A sample FV action plan was provided to facilitate comprehension, that is, when? “in the evening, 8 p.m.”, where? “in front of the television”, and what kind? “one sliced apple”. Subsequently, participants were asked to memorize their plan and to visualize themselves with closed eyes consuming the planned serving of FV in the planned situation. Similar planning interventions have been proven effective for increasing FV consumption before (e.g. Wiedemann et al., 2012). In addition, participants from the planning condition had the possibility to adjust their FV plan throughout the following 13 days of the post-intervention diary. At the beginning of each daily questionnaire, participants were asked to report whether they had adjusted their plan by writing down either their original or their new plan (i.e. *when*, *where*, and *what kind*). In the intervention, the following behavior change techniques (BCTs; Michie et al., 2013) were applied: BCT 1.4 (“action planning”) and BCT 15.2 (“mental rehearsal of successful performance”).

Participants from the control condition did not receive a planning intervention.

Measures

Fruit and vegetable consumption

As the primary outcome of the present study, participants' daily FV consumption was measured by the pre- and post-intervention diaries using a 24-hr recall food frequency questionnaire (for an overview, see Pérez Rodrigo et al., 2015). The general question “At which occasions did you consume fruit or vegetables today?” was followed by the instruction: “Please be as precise as possible and use one row per serving.” Participants were then asked to enter their daily FV consumption, serving by serving, in a table with seven rows labeled “first serving”, “second serving”, …, and “seventh serving”. Other than in conventional food frequency questionnaires, additional columns on the FV opportunity were added. For each FV serving, participants entered information on “when?”, “where?”, and “how?” they

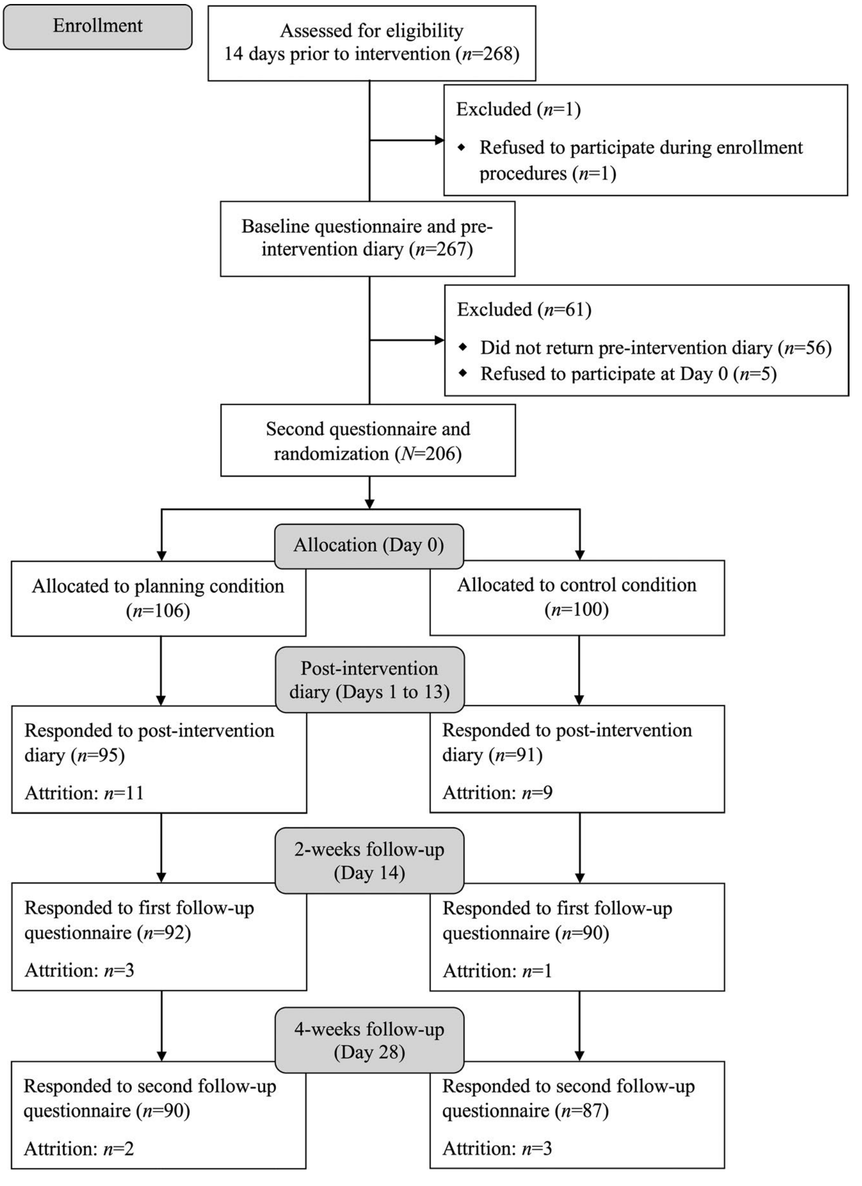

FIGURE 1 Flow diagram showing participant attrition

consumed the fruit or vegetable. An example for one FV serving was provided: when? “at lunch-time, 12.30 p.m.”, where? “cafeteria”, what kind? “carrots”, and how? “raw”. One serving was explained as a handful of FV, for example “a handful of grapes or salad”. Rice and potatoes did not count as FV.

Self-efficacy and action control

Adapting items from previous studies, daily FV-specific *self-efficacy* (Schwarzer et al., 2007) and *action control* (Sniehotta et al., 2005) were assessed by the pre- and post-intervention diaries using six-point scales ranging from *completely disagree* (1) to *completely agree* (6). Self-efficacy was measured by the item “Today, I was certain that I can manage to consume five servings of fruit or vegetables.” Action control was assessed by its three facets: awareness of standards (“Today, I have always made myself aware of my fruit and vegetable intake.”), self-monitoring (“Today, I have focused my attention on consuming five servings of fruit or vegetables.”), and self-regulatory effort (“Today, I have tried very hard to consume five servings of fruit or vegetables.”). Within- and between-person reliabilities for daily action control measures were calculated (Scott et al., 2018). The within-person reliability of 0.61 (planning condition) and 0.52 (control condition) indicates medium reliability to detect within-person fluctuations in action control across daily measurements. Between-person reliability was approximately 1 for both conditions.

Action planning

As a relevant measure for manipulation check analyses (see below), FV-specific *action planning* was assessed daily by using six-point scales ranging from *completely disagree* (1) to *completely agree* (6). Every item of the 3-item scale started with the item stem “For today, I have planned …”, and was complemented by “…when I will consume fruit and vegetables”, “…where I will consume fruit and vegetables”, and “…what kind of fruit and vegetables I will consume”. Within-person reliability of 0.85 (planning condition) and 0.80 (control condition) reflects high reliability to detect within-person fluctuations in action planning throughout daily measurements (Scott et al., 2018). Again, between-person reliability was approximately 1 for both conditions.

Covariates

Covariates included participants' baseline age, BMI (grand-mean centered, respectively), and sex (0 = *male*, 1 = *female*). Based on results from dropout analyses and randomization checks (see below), subsequent data analyses also included employment status (0 = *unemployed*; 1 = *employed*) as a covariate.

Data analysis

Dropout analyses and randomization checks

To examine attrition mechanisms in the full sample ($N = 206$ participants), chi-square and t-tests, followed up by logistic regressions, were performed for baseline variables. A dichotomous variable (0 = *noncompliers*; 1 = *compliers*) was coded; that is, participants who returned the post-intervention diary were coded as compliers ($n = 186$), and participants who did not return the post-intervention diary were coded as noncompliers ($n = 20$). For randomization checks, chi-square, t-tests, and logistic regressions were performed, using an experimental condition variable (0 = *control condition*; 1 = *planning condition*) as outcome.

Manipulation check

To examine whether the intervention was associated with increases in the active ingredient of the intervention, action planning, a manipulation check was performed applying analogous two-level models used for the analysis of intervention effects (described below).

Intervention effects

Intent-to-treat analyses used data from $N = 206$ randomly assigned participants (planning condition: $n = 106$; control condition: $n = 100$). Based on Shrout et al. (2018), first-day (Day −13) and second-day (Day −12) assessments of the pre-intervention diary were excluded from the present analyses as visual inspection indicated an initial elevation bias for study variables. Subsequently, a two-level structured dataset with time (level 1; within) nested in participants (level 2; between) was prepared. Three separate two-level models were used to test for intervention effects on the study outcomes FV consumption (Model 1a), self-efficacy (Model 2a), and action control (Model 3a) by applying the lmer function in the lme4 package (Bates et al., 2015) in RStudio, version 1.2.5042 (RStudio Team, 2020). To model different time slopes for the pre- and post-intervention phase (see Inauen et al., 2017) and to test for intervention effects in terms of a discrete change (i.e. "jump") for the first day of the post-intervention phase, segmented linear mixed models (i.e. spline models; Saeed et al., 2018) were fit. These models were defined by the following equation:

$$Y_{it} = b_0 + b_1 I + b_2 T_t + b_3 P + b_4 I T_t + b_5 I P + b_6 T_t P + b_7 I T_t P + u_{0t} + u_{2t} + u_{3t} + u_{6t} + e_{it} \quad (1)$$

Here, Y_{it} refers to person i's outcome on day t; I reflects the experimental condition variable (0 = *control condition*, 1 = *planning condition*); T_t represents the *linear day trend,* centered to the first day of the pre-intervention diary (0 = Day −11), that is, with 0–10 reflecting the pre-intervention diary days (Days −11 to −1), with a missing value for Day 0 when the intervention was conducted, and with 12–24 reflecting the post-intervention diary days (Days 1 to 13); and P reflects the intervention phase variable (0 = *pre-intervention diary*, 1 = *post-intervention diary*). The interpretation of regression coefficients as represented in the model (Equation) is as follows: b_0 represents the mean outcome level for the control condition at Day −11 (i.e. intercept); b_1 represents intercept differences between conditions at Day −11; b_2 represents the linear day trend of the outcome (i.e. slope) throughout the pre-intervention diary in the control condition; b_3 represents a discrete change in the outcome between pre- and post-intervention diary (i.e. "jump"; Saeed et al., 2018) in the control condition; b_4 represents slope differences between conditions in the pre-intervention diary; b_5 represents "jump" differences between conditions; b_6 represents the slope throughout the post-intervention diary in the control condition; b_7 represents slope differences between conditions in the post-intervention diary.

To identify the maximal random effects structure (Barr et al., 2013), the random effects of predictors were added stepwise and only maintained in the final model when models converged. Final models included random effects for the linear day trend (u_{2t}), the phase effect (u_{3t}), the linear day trend × phase effect interaction (u_{6t}), the intercept (u_{0t}), and residuals (e_{it}). For sensitivity analyses, covariates were added to the final two-level models.

RESULTS

Dropout analyses and randomization checks

Participants who did not return the post-intervention diary ($n = 20$ noncompliers) showed no differences in any baseline variables when compared with those who returned the post-intervention diary ($n = 186$ compliers). Randomization checks indicated no differences in baseline variables between the experimental conditions, except for employment status. Participants from the planning condition were more likely to be employed ($\chi^2(1) = 4.92$, $p = .027$); thus, employment status was added to the set of covariates.

Manipulation check

The manipulation check revealed no significant between-condition differences in action planning throughout the pre- and post-intervention phases (Table S2). Day-to-day temporal development of action planning across pre- and post-intervention diaries is displayed in Figure S2.

Descriptive results

In both intervention conditions, participants provided data on their daily FV consumption on most days (i.e. a mean response rate of 21.95 out of 24 days, $SD = 4.49$). Throughout the pre-intervention diary, participants consumed on average 3.51 ($SD = 1.19$) servings of FV per day. Across the post-intervention diary, participants from the planning condition had a mean FV consumption of 3.99 servings ($SD = 1.38$), whereas participants from the control condition reported a mean FV intake of 3.68 servings ($SD = 1.20$). The development of mean FV consumption over time including developments of randomly chosen $n = 10$ participants from each condition is depicted in Figure S3. Descriptive statistics on action planning, self-efficacy, and action control are displayed in Table 1.

Regarding intervention fidelity, $n = 95$ participants (out of $n = 106$; 90%) from the planning condition adhered to the instructions and formed a complete "when-where-what kind" action plan in the intervention session.

Intervention effects on FV intake, self-efficacy, and action control

Results of unstandardized coefficients derived from Model 1a, 2a, and 3a are displayed in Table 2 and Figure 2. Regarding Model 1a with *FV intake* as the outcome, results indicated that FV consumption in the control condition started at 3.62 servings at Day −11, which did not differ between conditions. Throughout the pre-intervention diary phase, the control condition showed a nonsignificant linear day trend, which was similar in the planning condition (i.e. nonsignificant between-condition effect of the pre-intervention day trend). FV consumption in the control condition did not show a "jump" between

TABLE 1 Descriptive statistics for mean levels of daily fruit and vegetable consumption, action planning, self-efficacy, and action control

	Pre-intervention diary						**Post-intervention diary**					
	Planning condition ($n = 106$)		**Control condition ($n = 99$)**		**All ($n = 205$)**		**Planning condition ($n = 95$)**		**Control condition ($n = 91$)**		**All ($n = 186$)**	
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
FV consumption	3.46	1.14	3.56	1.23	3.51	1.19	3.99	1.38	3.68	1.20	3.84	1.30
Action planning	2.76	0.94	2.72	0.95	2.74	0.95	2.96	1.06	2.69	1.01	2.82	1.04
Self-efficacy	2.78	1.13	2.88	1.16	2.83	1.14	3.24	1.25	2.97	1.24	3.11	1.25
Action control	2.76	0.92	2.76	0.98	2.76	0.95	2.98	0.99	2.75	0.98	2.86	0.99

Note: The number of participants listed for the pre-intervention diary ($n = 205$) differs from the number displayed in Figure 1 because one participant from the control condition did show missing values on all study outcomes.

Abbreviation: FV, fruit and vegetable.

TABLE 2 Multilevel model estimates predicting fruit and vegetable consumption, self-efficacy, and action control, using the control condition at day −11 as the reference

	Model 1a: FV consumption			Model 2a: Self-efficacy			Model 3a: Action control		
Fixed effects	**Est (*SE*)**	***p***	**95% CI**	**Est (*SE*)**	***p***	**95% CI**	**Est (*SE*)**	***p***	**95% CI**
Intercept	3.62 (.13)	**<.001**	3.36, 3.88	2.90 (.13)	**<.001**	2.64, 3.16	2.68 (.10)	**<.001**	2.48, 2.88
Interv. effect Day −11	−0.12 (.18)	.519	−0.48, 0.24	−0.18 (.18)	.314	−0.54, 0.17	0.08 (.14)	.585	−0.20, 0.36
Pre-interv. day trend CC	−0.01 (.01)	.479	−0.03, 0.02	−0.01 (.01)	.677	−0.03, 0.02	0.02 (.01)	.156	−0.01, 0.04
Pre-interv. day trend × PC	0.01 (.02)	.870	−0.03, 0.04	0.02 (.02)	.303	−0.02, 0.05	−0.02 (.02)	.294	−0.05, 0.01
Phase effect CC	−0.35 (.21)	.096	−0.76, 0.06	−0.16 (.19)	.419	−0.54, 0.21	0.14 (.15)	.366	−0.17, 0.43
Phase effect × PC	0.88 (.30)	**.003**	0.30, 1.46	0.57 (.27)	**.037**	0.05, 1.11	−0.06 (.21)	.769	−0.48, 0.36
Post-interv. day trend CC	0.04 (.02)	**.038**	0.01, 0.07	0.02 (.02)	.243	−0.01, 0.05	−0.02 (.01)	.182	−0.04, 0.01
Post-interv. day trend × PC	−0.03 (.02)	.168	−0.08, 0.01	−0.02 (.02)	.284	−0.07, 0.02	0.03 (.02)	.140	−0.01, 0.06
Random effects (variances)	**Estimate**		**95% CI**	**Estimate**		**95% CI**	**Estimate**		**95% CI**
Intercept	1.25		0.94, 1.62	1.45		1.14, 1.74	0.90		0.71, 1.12
Pre-interv. day trend CC	0.01		0.01, 0.01	0.01		0.01, 0.01	0.01		0.01, 0.01
Phase effect CC	0.56		0.08, 1.46	1.59		0.92, 2.37	1.02		0.62, 1.51
Post-interv. day trend CC	0.01		0.01, 0.01	0.01		0.01, 0.01	0.01		0.01, 0.01
Residual	1.54		1.48, 1.62	0.81		0.77, 0.85	0.48		0.46, 0.50

Note: Bold *p*-values indicate statistical significance at $p < .05$. Intercept indicates the mean of the control condition at Day −11. Models are based on data from $n = 205$ participants and $4450 \leq n \leq 4522$ observations due to missing values. Intraclass correlation (ICC) for FV intake (Model 1a): .43 ([0.39, 0.49]). ICC for self-efficacy (Model 2a): .55 ([0.50, 0.60)]. ICC for action control (Model 3a): .58 ([0.53, 0.63)]. Coefficients are unstandardized. Coefficients smaller than |.005| were rounded to .01 or −.01, respectively.

Abbreviations: CC, control condition; CI, confidence interval; Est, estimate; FV, fruit and vegetable; Interv., intervention; PC, planning condition.

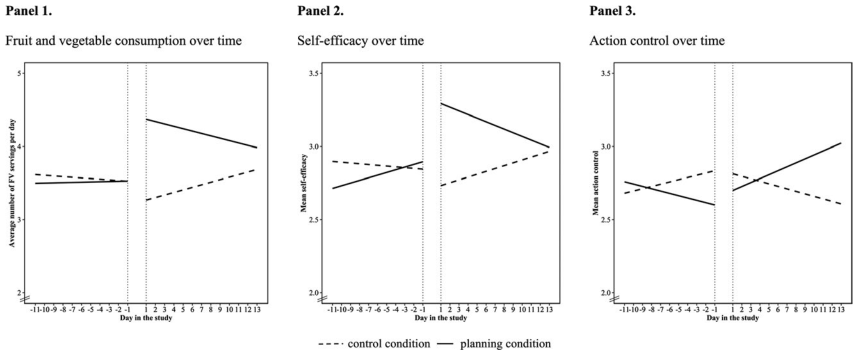

FIGURE 2 Day-to-day temporal development of fruit and vegetable consumption (panel 1), self-efficacy (panel 2), and action control (panel 3)

both diary phases (i.e. phase effect control condition in Table 2). However, significant between-condition differences of the phase effect were found, indicating that participants from the planning condition (vs. control condition) showed an enhanced FV consumption immediately following the intervention (i.e. a "jump"; see Figure 2). Regarding the day trend in the post-intervention diary, the control condition showed an increase over time. The nonsignificant post-intervention day trend × planning condition interaction indicated that there were no between-condition differences in FV consumption changes following the intervention. Post hoc analyses using an analogous model with a recoded condition variable (0 = *planning condition*, 1 = *control condition*) revealed that participants from the planning condition maintained their FV intake throughout the post-intervention diary ($B = .01$, $SE = .02$, $p = .877$).

Regarding *self-efficacy,* Model 2a revealed a similar pattern of results when compared to Model 1a (Table 2). Self-efficacy levels in the control condition at Day −11 started at 2.90, which did not differ from the planning condition. For the pre-intervention diary phase, there was a nonsignificant linear day trend in the control condition, which was similar in the planning condition. Moreover, the control condition did not show a "jump" in self-efficacy between pre- and post-intervention diary, but significant between-condition differences of the phase effect were found (i.e. a "jump" in the planning condition). For the post-intervention diary phase, analyses did not show any changes in self-efficacy in the control condition, which was similar in the planning condition.

Regarding *action control* (Model 3a), levels in the control condition at Day −11 started at 2.69, which did not differ between conditions. No significant effects were observed for control participants' changes throughout the pre- and post-intervention phase as well as between both phases (Table 2). Moreover, effects did not vary between conditions.

Sensitivity analyses across the three study outcomes revealed that the pattern of results found in Models 1a, 2a, and 3a remained the same when covariates were added as further predictors (results of Models 1b, 2b, and 3b are shown in Table S3). Further analyses of Models 1a, 2a, and 3a with the linear day trend centered on the last day of the post-intervention diary (Day 13) revealed no between-condition differences in FV consumption, self-efficacy, and action control at Day 13. Models 1c, 2c, and 3c with standardized coefficients can be derived from Table S4.

DISCUSSION

This intensive longitudinal two-condition RCT examined whether a very brief FV action planning intervention can lead to increased FV consumption, self-efficacy, and action control by particularly focusing on immediate intervention effects. The present results indicate that the planning condition, as opposed to the control condition, led to increases in FV intake and self-efficacy immediately following the intervention (supporting Hypotheses 1a and 2a). Enhanced levels of FV intake and self-efficacy were subsequently maintained throughout the 13-day post-intervention diary phase (supporting Hypotheses 1b and 2b). Regarding action control and not in line with present assumptions (Hypothesis 3a and 3b), effects did not reach significance at $p < .05$. Moreover, no differences between the planning condition and the control condition were found for FV intake, self-efficacy, and action control at the end of the diary phase (i.e. 13th day following the intervention).

Time proximity of effects from action planning interventions

Evidence from a meta-analysis revealed positive medium- and long-term effects of action planning interventions on FV consumption (Adriaanse et al., 2011). However, as the dynamics of short-term intervention effects have rarely been studied, this study provides insights into the question of *when exactly* an action planning intervention becomes beneficial for FV consumption (Scholz, 2019). Whereas previous studies on planning interventions reported the use of daily nutrition-related measures but aggregated respective outcomes across different time periods (e.g. Verplanken & Faes, 1999), the present study assessed and analyzed daily EMA data at this high temporal resolution. This facilitates the investigation of temporal dynamics in study outcomes following an intervention, that is, *when* does an intervention effect start and *how* does an effect evolve over time (Scholz, 2019). The analytical approach of modeling a discrete change following an intervention, that is, a "jump," has rarely been used in previous studies on health behavior change (see Berli et al., 2016 and Inauen et al., 2017 for exceptions). For instance, results from Inauen et al. (2017) yielded that a social support intervention led to a gradual increase in healthy eating, but no discrete change between study phases was found. The present study evaluating the effects of an action planning intervention revealed a different pattern: a discrete change in FV consumption (and self-efficacy) for the first post-intervention day and maintained levels for subsequent days. Possibly, different active ingredients of interventions might lead to different change dynamics in nutrition outcomes. The effects of social support seemed to need some time to unfold (Inauen et al., 2017), whereas effects of an action planning intervention (i.e. persons forming one plan for the next day) may occur very quickly but without leading to further FV increases in the longer run. Integrating evidence from Inauen et al. (2017) and the present study, nutrition-related interventions consisting of a combination of social support and action planning (cf. Prestwich et al., 2014) appear promising for intervention developers and should be followed up by future studies capturing immediate intervention effects as well as longer-term effects.

Effects on FV intake after forming one FV plan

After forming one plan in the planning condition, elevated levels of FV intake at post-intervention Day 1 remained unchanged (on average) throughout the following 13 days. Thus, intervention instructions on forming a plan for consuming one additional FV serving seemed to lead to an immediate increase but no subsequent increases in FV consumption. To increase one's FV consumption by one serving might therefore be a behavior that can be easily performed from one day to the next and embedded in one's daily routines. One-plan action planning might therefore be a promising active ingredient of interventions aiming at immediate effects. However, forming only one action plan might not be enough to achieve a further increase in FV levels. In the randomized controlled trial by Wiedemann et al. (2012), the number of FV plans was experimentally manipulated using six conditions (i.e. control condition, one plan, two plans, …, five plans). Their findings indicated that FV planning interventions consisting of at least four plans revealed at least small-sized intervention effects on FV intake at a one-week follow-up when compared to a waiting-list control condition (Wiedemann et al., 2012). The planning intervention condition consisting of only one plan was linked with overall increases in FV intake, but this effect did not differ from changes found in the control condition (Wiedemann et al., 2012), which was also observed in the present study. Hence, instructing participants to increase their FV behavior by more than one serving, for instance, by adding multiple action plans to the planning intervention, might increase the likelihood of further increases in FV intake levels. Based on meta-analytical findings on small-to-medium effect sizes across studies, where multiple plans were formed (Adriaanse et al., 2011), we believe that multiple plans might also be beneficial for higher immediate intervention effects on FV levels. However, it has to be considered that recruitment procedures in such studies often lead to the enrollment of motivated participants with higher FV baseline levels such as in the present study ($M = 3.51$ FV servings per day throughout the pre-intervention diary). Persons who start with lower FV levels may find it more difficult to form and enact multiple plans. Future research could examine for whom single versus multiple plans might be more effective.

Moreover, participants from the control condition showed post-intervention increases in FV consumption. This unexpected effect might be caused by daily measurements of FV intake as the measurements might, independent of intervention conditions, raise awareness about one's own FV consumption and increase the likelihood of performing the actual behavior, a phenomenon called *measurement reactivity* (for a review, see French & Sutton, 2010).

Effects on self-efficacy and action control

For self-efficacy, results support prior findings of self-efficacy enhancements after planning interventions in various health behavior change domains (Zhang et al., 2019). For instance, in the physical activity domain, the meta-analysis by Williams and French (2011) found larger effect sizes for longer-term follow-ups after action planning interventions than after interventions using other active ingredients. The present finding of effects for immediate self-efficacy increases provides insights into the role of action planning in the nutrition context. As a potential explanation for immediate self-efficacy increases, the mastery of a single and personalized FV plan seems more feasible than the mastery of a general intention toward FV and would thus support higher self-efficacy beliefs about one's FV intake (Keller et al., 2016). Moreover, once the behavior was successfully carried out, a personalized FV plan might facilitate internal attribution processes and result in further increases of self-efficacy (Bandura, 1997). However, as there were nonsignificant post-intervention day trends in both intervention conditions, the latter was not found in the present analyses. To facilitate subsequent mastery experiences and hence to elicit further increases in self-efficacy throughout the post-intervention diary, it might be beneficial to form multiple plans (as discussed above). Moreover, present findings extend the unidirectional link from self-efficacy to action planning, as proposed by the HAPA model, which was already shown for the physical activity domain (Keller et al., 2016). In this regard, a positive feedback loop might be initiated with higher levels of action planning leading to higher levels of self-efficacy, which, in turn, could further increase action planning and so forth. Temporal developments of self-efficacy-action planning links should be tested in future EMA studies.

Regarding action control, present results indicated no group-differential intervention effects, indicating that forming one FV plan had no short-term impact on action control in the present study design. Similar to the discussion above, forming multiple plans would potentially increase the likelihood to observe increases in action control (Adriaanse et al., 2011; Sniehotta et al., 2006). When comparing short-term intervention effects on action control with effects on FV intake and self-efficacy, our findings suggest that courses over time can differ between different factors of FV-related self-regulation (see also Figure 2).

Strengths and limitations

The present study has several strengths. The study design included an experimental manipulation within two intensive longitudinal assessment periods, which enabled the analysis of change in study outcomes before and after the manipulation. This procedure opens new insights into the temporal development of outcomes addressed by the intervention. Next to FV intake as the primary outcome, this study also focuses on two self-regulatory factors (i.e. self-efficacy and action control), which are important correlates of FV intake.

However, some limitations must be acknowledged. First, although participants from the planning condition reported more planning in the post-intervention phase, this difference was not significantly different from control condition participants' reports in full multilevel models. Thus, it may require more than one action plan to enhance self-reported action planning levels, which was shown in a study by Lhakhang et al. (2014) revealing increases in participants' action planning after forming two FV action plans. Moreover, the primary study outcome (i.e. FV consumption) was assessed using self-reports. Future studies could, additionally, use objective data such as meal photographs to validate the accuracy of self-reports. Moreover, this study was conducted using paper-pencil-based diaries, which goes along with lower controllability of study protocol adherence in terms of actual time points when the daily questionnaires are completed by participants. Applying mobile-based assessments would allow for better timing of the provision of study materials and provide time stamps of assessments (Villinger et al., 2019). Moreover, a digital reminder system could be used in future studies to improve study protocol adherence. As daily questionnaires were completed each evening, present findings underlie the assumption that participants can remember their present-day FV consumption. However, a potential recall bias cannot be ruled out. Possibly due to reactive recruitment strategies, which took place in physical education and university classes, present findings refer to a sample with higher education and higher levels of FV consumption, which may not generalize to the general German population (Mensink et al., 2013).

CONCLUSION

The present study showed that a brief action planning intervention can elicit immediate increases in self-regulatory (i.e. self-efficacy) as well as behavioral (i.e. FV intake) outcomes. Thus, this study extends the literature on nutrition-related action planning interventions by also examining the temporal proximity of short-term intervention effects. To not only facilitate immediate but also longer-term effects of planning interventions, future studies should focus on, for instance, forming multiple plans or adding other active ingredients to the intervention, such as social support.

CONFLICT OF INTEREST

None.

ETHICAL STATEMENTS

Ethical approval was granted by the ethics committee of the German Psychological Society.

DATA AVAILABILITY STATEMENT

The datasets generated during this study are not publicly available as we do not have permission from study participants. Group-level information about the data is available from the corresponding author on reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.
Supplementary Material

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