Using Smartphone-Based Support Groups to Promote Healthy Eating in Daily Life: A Randomized Trial

Abstract

Background: Although many people intend to eat healthily, they often fail to do so. We report the first randomized trial testing if smartphone-based support groups can enhance healthy eating. **Methods:** Adults (*N*=203) were randomized to the support or control condition (information), and to one of two eating goals (increasing fruit and vegetable / decreasing unhealthy snack consumption). After baseline, participants received information on their assigned eating goal, and completed a 13-day electronic diary. During Days 4-10, support participants were asked to support each other in achieving their eating goal in smartphone-based groups. The primary outcome was daily servings of fruits/vegetables or unhealthy snacks. Maintenance of intervention effects was assessed on Days 11-13, and at 1-month and 2-month follow-ups. **Results:** Support participants showed a gradual increase in healthy eating over time, and ate 1.4 fruits and vegetables more, 95% CI [0.3, 2.6], or 0.8 unhealthy snacks less, 95% CI [-1.4, -0.2] than controls on Day 10. Most effects were not maintained at follow-ups. **Conclusions:** Smartphone-based groups can promote fruit and vegetable consumption and decrease unhealthy snack intake. This study extends previous findings of the benefits of support groups, and sheds light on the temporal dynamics of behavior change.

Keywords: Eating behavior; Fruits and vegetables; Unhealthy snacks; Social support groups; Intensive longitudinal methods

What we eat influences our health. To prevent chronic disease, current dietary guidelines include increasing fruit and vegetable consumption, and reducing fat and sugar intake (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). Higher fruit and vegetable consumption has been found to reduce risks of cancer (Turati, Rossi, Pelucchi, Levi, & La Vecchia, 2015) and coronary artery disease (Brunzell, 2007), and is associated with delayed mortality (Wang et al., 2014). Unhealthy snack consumption, which is the consumption of energy dense foods between main meals, has been linked to increased energy intake (Graaf, 2006), and increased risk of being overweight and obese (Murakami & Livingstone, 2016). Although people are often motivated to eat healthily, they frequently fail to do so in their daily lives. This so-called intention-behavior gap may be due to self-regulation failures during certain times of day when temptation is high or in circumstances when persons can rationalize setting aside their healthy eating goals (Inauen, Shrout, Bolger, Stadler, & Scholz, 2016).

One important influence on self-regulation success is social support. Social support has been defined as "a set of processes through which another person helps individuals engage in effective self-regulation" (Fitzsimons & Finkel, 2010, p. 103) to accomplish a particular goal. The association of social support with physical health is well documented (Uchino, Bowen, Carlisle, & Birmingham, 2012), and an increasing body of research indicates that social support may promote health behavior change. In correlational studies, social support is associated with healthy eating (McKinley, 2009), such as eating a low-fat diet (Scholz, Ochsner, Hornung, & Knoll, 2013). Yet, intervention studies of social support have not shown strong effects. One partner-based intervention found small and marginally significant effects (Prestwich et al., 2014), and others found no effects on eating behavior (Anderson Steeves, Jones-Smith, Hopkins, & Gittelsohn, 2016; Kwan & Gordon, 2016) or eating-related behavioral intentions (McKinley & Wright, 2014).

One reason that some support interventions are not shown to be effective is that the quality of support provided by a partner, family member or peer is not uniformly high (Kiernan et al., 2012). A promising alternative to spontaneous support is the formation of specially constructed support groups. Helgeson and Gottlieb (2000) define support groups to be a group of peers with a common goal or experience that includes a moderator or coordinator, exist for a fixed period and do not engage in advocacy. These features distinguish support groups from self-help groups. Support groups with moderators have been shown to be more effective than unmoderated groups (Mohr, Burns, Schueller, Clarke, & Klinkman, 2013).

Because group members share a common goal, they often promote empathy and acceptance. They can also reinforce self-efficacy and provide new information, such as ways to achieve the common goal. Such support groups are increasingly being administered online and on smartphones, harnessing the popularity of social media, such as WhatsApp, Twitter, and Facebook (Rains, Peterson, & Wright, 2015). They are low cost and promising for eating behavior change, which happens in response to many environmental cues in daily life (Papies & Hamstra, 2010) where offline interventions may not be readily accessible. Particular times of day are especially prone to self-regulation failure (Inauen et al., 2016). Therefore, support through a smartphone-based support group (i.e., ecological momentary interventions; Heron & Smyth, 2010) seems especially promising to help regulate eating.

Ecological momentary interventions for weight regulation are increasingly being used and scientifically investigated (Bardus, Smith, Samaha, & Abraham, 2015; Williams, Hamm, Shulhan, Vandermeer, & Hartling, 2014). They have successfully promoted healthy eating using text messaging (Joo & Kim, 2007) or self-monitoring applications, such as diaries where participants keep track of their food consumption (Atienza, King, Oliveira, Ahn, & Gardner, 2008). Commercial dieting programs have also started harnessing the availability of social media on mobile phones and the possibility to deliver group support to regulate eating

in people's daily lives (e.g., Weight Watchers®, Ballantine & Stephenson, 2011). Yet, the experimental evidence on their ability to promote health behavior is scarce. To the best of our knowledge, the effects of smartphone-based support groups on healthy eating have not been experimentally tested.

Smartphone-Based Support Groups to Promote Healthy Eating

In this article, we report results of a randomized trial to test a smartphone-based support group intervention to promote healthy eating. Participants who were randomly allocated to the intervention condition were assigned to a small group that included a trained member who provided frequent support. Group members communicated with each other via WhatsApp, a popular smartphone application that allows for the private exchange of multimedia content via the phone's internet connection, and further internet-connected devices. Such support groups should effectively promote healthy eating because, first, social support provided by a group of persons sharing the same eating goals should provide beneficial effects by meeting participants' needs in terms of timing and content. Second, it can promote self-efficacy by allowing group members to provide support in addition to receiving it. Third, the messages exchanged within the group should serve as reminders of the shared eating goals. Fourth, the group can provide informational support by sharing healthy recipes and information about purveyors of healthy food and ingredients.

The moderator in each group was not identified as a leader, but was rather introduced as another peer participant. We used this design to create a safe space where members with similar behavioral goals could share their experiences and interact as peers. The trained support moderator provided timely supportive responses to every post in the group, and served as a role model of support provision for other group members. We hypothesized that participants in the social support group compared to a control group would eat a healthier diet (with more servings of fruit/vegetables or less unhealthy snacking) by the end of the intervention period.

Besides the overall effectiveness of this approach to promote healthy eating, we are interested in gaining understanding of the temporal development of behavior change in daily life. For this purpose, this study uses an intensive longitudinal design that provides a rare opportunity to investigate how the effects of the social support condition on healthy eating may develop over time. To the best of our knowledge, no temporal theory of behavior change exists to date. The opportunity to look at temporal dynamics of intervention effects is also often missed, even when temporal data is being collected (Brookie, Mainvil, Carr, Vissers, & Conner, 2017). To make a first contribution to understanding the temporal dynamics of the effects of social support on eating behavior change, we will explore two temporal effects. First, it is possible that groups of strangers first have to get to know each other before gradually increasing their support behavior. Second, the invitation to join a smartphone-based support group might have an immediate impact on eating.

Finally, we seek to determine whether this form of social support can promote persistent health behavior change or whether the effects fade after the group support ends. The previous literature on social support suggests such maintenance effects (Kwasnicka, Dombrowski, White, & Sniehotta, 2016; White & Dorman, 2001). However, this has mostly been shown for romantic couples, where support is usually ongoing. The present study, in contrast, provides the rare opportunity to investigate what happens when support ends.

Methods

We conducted a randomized factorial trial of a social support vs. a control condition by two eating goals: eating more fruits and vegetables or eating fewer unhealthy snacks. Participants were randomly allocated to the support or control condition. Furthermore, they were randomly assigned to one of two eating goals: Eating more fruits and vegetables or eating fewer unhealthy snacks. Data was collected using an intensive longitudinal assessment: 3 days prior to the intervention (Days 1-3), 7 days during (Days 4-10), and 3 days after the intervention (Days 11-13). Three panel surveys additionally served to assess participants'

baseline characteristics (T1), and to determine the maintenance of behavior change at 1-month (T2) and 2-month follow-ups (T3). This trial was approved by the Internal Review Board of the University of Zurich. Also, the data analyses of the trial was registered on the Open Science Framework available here: osf.io/9v73s).

Participants and Procedures

Adult staff and student members of the University of Zurich were recruited in September 2014 via flyers, email notifications, and social networks. The recruitment materials aimed at attracting persons with an intention-behavior gap regarding eating, using the heading "Do you intend to eat healthily but find that difficult sometimes?". Participants were included if they were at least 18 years old, currently not dieting nor participating in a weight loss program, had a Body Mass Index (BMI) of at least 18, owned a smartphone with internet access, and were fluent in German.

The sample size was a priori determined to detect a small to medium effect (d=0.35) of social support on healthy eating using an independent samples t-test with 80% power. Using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) we determined that a total sample size of 204 participants was needed, assuming a two-tailed Type I error probability of .05. Because our pilot study suggested up to 15% dropout, we aimed at recruiting a total of 236 participants to obtain an effective sample of 204 persons.

Prior to participants' individual appointments at the University, a research assistant randomized them to the conditions by entering their names in the sequence that they signed up for the study into a list of block-randomized cells (with block size 8) that was created by random number generation. As shown in Figure 1, 232 participants were randomly allocated to the conditions.

>>>>> ADD FIGURE 1 HERE <<<<<

Participants and the interventionists were blind to condition until the participant's appointment at the lab, where written informed consent was first obtained from all individual

participants included in the study. Using scale and meter, members of the research team subsequently measured participants' weight and height before they answered the baseline survey. Then, all participants received the informational intervention. Support condition participants additionally received instructions on the social support intervention (details see below). Participants were further instructed to keep a 13-day diary, starting the next day. One month and two months after the diary phase, in December 2014 and January 2015 respectively, participants were asked to fill in the two online follow-up surveys. After the last follow-up survey, participants were fully debriefed (including information on the experimental confederate, see below), and entered a lottery to win a $1000.- prize (helicopter flight or wellness weekend), or one of eight shopping vouchers. Students were offered the choice of receiving study credit for their participation instead of entering the lottery.

Intervention

Information on healthy eating and the social support intervention were delivered individually by trained psychology master's students. Participants in the control condition only received the information on healthy eating, whereas participants in the support condition additionally partook in the social support intervention. All intervention materials and protocols can be found in the Electronic Supplementary Material.

Information on healthy eating. Information on healthy eating was presented at participants' individual lab appointments, after baseline assessment. It included behavior change techniques (BCTs) 5.1 "Information about health consequences", and 1.1 "Goal setting" (Michie et al., 2013). The information about healthy eating that was tailored to the participant's randomly assigned eating goal (increasing fruit and vegetable consumption or decreasing unhealthy snack consumption). After the presentation, participants received a fact sheet with identical information as presented by the interventionist: a definition of [fruit and vegetable consumption / unhealthy snacks], health effects of [fruit and vegetable consumption / unhealthy snack consumption], and current recommendations for consumption. Also, the

interventionist reinforced participants' assigned eating goal by saying: "Therefore, it is very important that you [eat more fruits and vegetables / avoid unhealthy snacks]". This was also printed on the factsheet.

Social support intervention. The social support intervention included BCT 3.1 "Social support (unspecified)" (Michie et al., 2013). After receiving the informational intervention, social support participants were informed that they would be invited by the group administrator (a male Master's student of the research team) to join a WhatsApp chat group starting Day 4 of the diary for seven days. Participants who did not have WhatsApp were assisted in installing the app. Participants were asked to support each other to reach their assigned eating goal. They were assured that their identity and exchanged content would be kept confidential.

We randomly assigned social support participants to small chat groups, plus one female confederate moderator (n=32 groups with Md=3 participants; Min=2, and Max=5 participants). The purpose of the moderator was to ensure that a minimum of social support was delivered to the chat group. She ostensibly participated in the group like a regular participant, but was trained to provide a standardized support message on each of the seven intervention days (e.g. "Hey guys, how's it going for you on the second day? Wishing you lots of success with consuming fewer unhealthy snacks! And just reach out if things get rough. I will do the same :)"). Furthermore, moderators were instructed to respond with a supportive message to any message posted. If suitable, moderators followed a list of supportive responses to common support demands; otherwise, they wrote unstandardized supportive responses.

On the evening of the seventh day of the intervention, participants were informed that the chat group would be deleted by the administrator the next morning. At 8 AM on the eighth day, the administrator downloaded the chat content and then deleted the chat.

Measures

Primary outcome: Healthy eating.

Self-reported healthy eating was assessed using an electronic daily evening diary. Participants were asked, "How many servings of fruits and vegetables did you eat today?", and "How many unhealthy snacks did you eat today?". Following the conceptualization by Kelly, Smith, King, Flood, & Bauman (2007), an unhealthy snack is as any food consumed between main meals that belongs to the non-core categories (e.g. cake, candy, fast food). The servings of fruits and vegetables represented the outcome for the fruit and vegetable goal group, whereas the servings of unhealthy snacks served as the outcome for the unhealthy snack goal group. Because the reports were based on a single question each day, reliability on each day could not be estimated, but we assessed the consistency of responses of each item over the 10 days. Cronbach's alpha for fruit/vegetable consumption was .92 and for unhealthy snacks it was .78, indicating systematic responses. Because we made identical predictions for each outcome in its respective goal group, we constructed a single harmonized index as the pre-registered outcome variable. First, for the fruit and vegetable goal group, the group's mean fruit and vegetable consumption was subtracted from each participant's fruit and vegetable servings on a particular day, and divided by the group's standard deviation of fruit and vegetable consumption. Second, for the snack goal group, the group's mean snack consumption was subtracted from each participant's snacks on a particular day, divided by the group's standard deviation of snack consumption, and reverse coded. In both goal groups, the relevant eating outcome therefore had a mean of zero and a standard deviation of one, which harmonized them for a combined analysis while eliminating any differences between goal groups. Across both goal groups, positive values indicate healthier eating than the typical person, and negative values indicate unhealthier eating than the typical person.

To investigate the maintenance of behavior change, self-reported daily healthy eating was also assessed at 1-month and 2-month follow-up. The same items were used as in the

diary, the only difference being that they referred to "yesterday" rather than "today" in order to assure a full daily consumption was reported.

Covariates.

At study registration, several covariates were pre-specified. Besides gender and age, being vegetarians, vegans, or having diabetes, BMI was calculated from participants' objectively measured weight and height, and active participation in the chat groups was coded (0=no message sent, 1=at least one message sent). Further assessed were restrained eating (Dutch Eating Behavior Questionnaire; Grunert, 1989; van Strien, Frijters, Jan E. R., Bergers, Gerard P. A., & Defares, 1986, α=0.88), stress (Kuhl & Fuhrmann, 1998, α=0.87), and social desirability (Balanced Inventory of Desirable Responding; Paulhus, 1991; Winkler, Kroh, & Spiess, 2006, α=0.61).

Data Analysis

Analysis of intervention effects on healthy eating. As specified in the study registration, we conducted independent samples t-tests to test for differences in fruit and vegetable consumption, unhealthy snack consumption, and healthy eating between the social support and the control condition during the last three days of the intervention. We computed the average of each outcome over Day 8 to 10 for each participant: average scores for fruit and vegetable consumption (for the fruits and vegetable goal group), unhealthy snack consumption (for the snack goal group), and healthy eating (for the total sample).

Analysis of temporal dynamics of intervention effects. To investigate the day-to-day intervention effects, we constructed a segmented linear mixed model (i.e., a spline model, Fitzmaurice, Laird, & Ware, 2012). This allowed for separate time slopes for the three days prior to the intervention and for the intervention period (see also Figure S-2 in the Electronic Supplementary Material):

$$Y_{igt} = b_0 + b_1 I_g + b_2 T_t + b_3 I_g T_t + b_4 I_g preT_t + u_g + u_{i(g)} + w_{i(g)} T_t + e_{igt} \quad \text{Eq. 1}$$

Y_{igt} is the health behavioral outcome of person i in chat group g at day t. The interpretation of the regression coefficients (b) are determined from the scoring of the independent variables, I, T, and $preT$. I is a dummy code for intervention condition (0: control; 1: social support); T_t is day in the study, centered on Day 10 (last intervention day); $preT_t$ is a time variable that is coded -2, -1, and 0 for the first three days and zero for the remaining seven days. With this coding and the model represented in Eq. 1, b_0 reflects average healthy eating for the control condition at Day 10. b_1 represents the intervention effect at Day 10, i.e., the difference in healthy eating between the control condition and the social support condition. b_2 is the time trend (slope) over the diary period in the control condition. Furthermore, b_3 represents the difference in the slope for healthy eating between the support condition and control condition from one day to the next during the intervention period. b_4 represents the possibility of a difference between the support and the control condition during the pre-intervention time.

The model accounted with random effects for the fact that the daily observations were nested in individuals and chat groups, and allowed for the possibility that the intervention effect might vary across the 32 chat groups (u_g), and across individuals (at Day 10: $u_{i(g)}$; over time: $w_{i(g)}T_t$). We also estimated the residual variance (e_{igt}), and fit an AR(1) covariance structure of the repeated measure residuals. The models were fitted using the PROC MIXED procedure in SAS. The code is provided in the Electronic Supplementary Material.

We further conducted several additional analyses. First, we investigated the possibility of a discrete change in healthy eating at the onset of the intervention. For this purpose, we added an interaction term of a dummy coded variable for intervention phase (-1: pre intervention; 0: intervention phase) with the intervention condition. Furthermore, we conducted sensitivity analyses. Models were computed again adding the pre-registered

covariates[1]. Also, in line with recommendations (White, Horton, Carpenter, & Pocock, 2011), we conducted a series of missing analyses, to investigate whether the intervention effects depended on dropout. Our main model used all available data, and treated missing values as missing at random. A second model replaced missing values of participants who dropped out during the diary with their first diary day (baseline value carried forward). This can be considered the most conservative model as null intervention effects are assumed for dropouts. Similarly, a third model used the third diary day to replace missing values, as first diary day was missing for some persons. Finally, a fourth model replaced missing values of dropouts with the last observed value (last observation carried forward).

Analysis of maintenance of intervention effects. To investigate the maintenance of intervention effects on eating outcomes, we conducted independent samples t-tests for the immediate follow-up (averaged Day 11 to 13 per person) as well as the 1-month and 2-month follow-ups.

Results

Preliminary Analyses

Of the 232 participants, 203 participants (87.5%) had at least one diary entry and were included in the main analyses. See Figure 1 for sample sizes of the four experimental conditions (support vs. control condition by assigned eating goal). The analyzed participants had filled in on average 10.0 out of 13 diary days (*SD*=4.3). They were on average 27.5 years old (*SD*=8.6), and had a mean BMI of 23.5 (*SD*=4.0). Most participants were female (75.5%), 24.5% were male, and enrolled as students (58.7%; 41.3% staff members and other adults). The 29 persons who were randomized but did not fill out a single diary did not significantly differ from compliers in age, gender, and student/work status. There were also no significant baseline differences between the social support condition and the control condition (see Table S-4 in the Electronic Supplementary Material).

[1] Diabetes was not included, because none of the participants reported having diabetes.

In total, 1249 messages were exchanged during the 7-day intervention period. Of these, 666 messages were sent by the participants (53.3%), whereas 478 messages were written by the confederate (38.3%) and 105 were written by the group administrator (8.4 %). Per group, 14 to 95 messages were exchanged (M= 41.4, SD= 4.3). On average, participants wrote 7.1 messages (SD = 0.7, range: 0-29). There were 10 silent participants who attended the group, but never wrote a message, and nine participants left the group after invitation.

Regarding intervention fidelity, 95% of the standardized support messages to be sent by the confederate were actually posted into the chat groups, whereas 5% were not sent. Eighty percent of the standardized messages were sent at the pre-specified time, and 20% of the messages were sent between 13 to 108 minutes later than scheduled. Sixty-one percent of the sent messages were correct in terms of contents, whereas 39% of the sent messages were modified in minor ways, e.g. to fit it more naturally into an ongoing conversation or to adapt it to the audience (e.g., also addressing workers instead of students only).

Immediate Intervention Effects on Healthy Eating

At the last three days of the intervention, social support participants ate almost one and a half fruits and vegetables more (M_{diff}=1.31; 95% CI [0.17, 2.45], t[76*]*=2.28, p=0.025), or about two thirds of an unhealthy snack less than controls (M_{diff}=-0.59; 95% CI [-1.11, -0.06], t[79]=2.23, p=.028). The combined healthy eating outcome indicated that social support participants ate two fifths of a standard deviation more healthily than controls (M_{diff}=0.39; 95% CI [0.15, 0.62], t[157*]*=3.27, p=.001).

Temporal Dynamics of Intervention Effects

>>>>> ADD FIGURE 2 HERE <<<<<

The temporal model displayed in Figure 2 and Table 1 provides a detailed account of the primary results (see also Figure S-2 in the Electronic Supplementary Material). There was a significant gradual increase in healthy eating over the course of the intervention. On Day 10, social support participants in the fruit and vegetable goal subgroup ate more than five fruits

and vegetables – almost one and a half fruits and vegetables more than controls (*B*=1.43, *SE*=0.55, *p*=.020). In the snack goal group, they ate four fifths of an unhealthy snack less than controls (*B*=-0.80, *SE*=0.27, *p*=.010). The analysis for the total sample indicated that social support participants ate about half of a standard deviation more healthily than controls on Day 10 (*B*=0.48, *SE*=0.12, *p*<.001).

Social support participants increased their fruit and vegetable consumption by almost a sixth of a serving on each day of the intervention (*B*=0.15, *SE*=0.07, *p*=.031). In the unhealthy snack goal group, they reduced their unhealthy snack consumption by about a seventh more than controls from day to day (*B*=-0.14, *SE*=0.05, *p*=.007). Correspondingly, the combined healthy eating outcome in the total sample indicated a small day to day increase in healthy eating compared to controls (*B*=0.06, *SE*=0.02, *p*<.001). Control group participants seemed to decrease in terms of healthy eating over the study period, although this was not significant (*B*=-0.01, *SE*=0.01, *p*=.162).

>>>>> ADD TABLE 1 HERE <<<<<

To rule out the possibility that eating already started changing in the social support condition before the beginning of the chat groups, we further compared the intervention and control conditions during the 3-day pre-intervention phase. We found no indication of pre-intervention differences in fruit and vegetable consumption for the fruit and vegetable goal group (*B*=-0.27, *SE*=0.24, *p*=.259), unhealthy snack consumption for the snack goal group (*B*=0.24, *SE*=0.15, *p*=.120), or healthy eating in the total sample respectively (*B*=-0.09, *SE*=0.05, *p*=.100).

The random effect estimate for the chat groups shows that fruit and vegetable consumption on Day 10 varied significantly across chat groups in the intervention condition (see Table 1, lower half). Expressed in standard deviations, the results indicate that fruit and vegetable consumption on Day 10 varied by $\sqrt{0.77} = 0.88$ between the chat groups.

Assuming normal distribution, this means that 95% of social support participants consumed between 3.5 to 7.0 fruits and vegetables on the last day of the intervention.

Additionally, there was variation in the outcomes at Level 2, meaning that participants significantly differed in their fruit and vegetable consumption, and unhealthy snack consumption at the last day of the intervention. Level 1 results indicated the presence of autocorrelation, which attained significance for the healthy eating outcome. Finally, there was a significant proportion of residual variance in healthy eating, fruit and vegetable, and unhealthy snack consumption that was unaccounted for by the models.

The additional analyses indicated no instantaneous effects on healthy eating at the beginning of the intervention. Also, the inclusion of the covariates did not substantively change the model results. Finally, all missing analyses confirmed the intervention effects. See Table S-5 in the Electronic Supplementary Material.

>>>>> ADD FIGURE 3 HERE <<<<<

Maintenance of Intervention Effects

To determine whether the intervention effects held in the days after the intervention and 1-month and 2-month follow-ups, we compared the effects at each of those time points. The results are displayed in Figure 3. The intervention effect remained significant immediately after the intervention for unhealthy snack consumption (M_{diff}=-0.68; 95% CI [-1.32, -0.05], t=-2.14, df=53.160, p=.043, d=0.59), and healthy eating in the total sample (M_{diff}=0.34; 95% CI [0.07, 0.62], t=2.46, df=150, p=.015, d=0.40), but not for fruit and vegetable consumption (M_{diff}=0.58; 95% CI [-0.40, 1.55], t=1.18, df=72, p=.242, d=0.28). There was no indication of the intervention effect at 1-month follow-up for fruit and vegetable consumption (M_{diff}=0.32; 95% CI [-.47, 1.10], t=-0.81, df=71, p=.423, d=0.19), unhealthy snack consumption (M_{diff}=0.08; 95% CI [-0.73, 0.89], t=0.21, df=68.377, p=.838, d=0.05), or for healthy eating in the total sample (M_{diff}=0.07; 95% CI [-0.26, 0.40], t=0.43, df=143, p=.671, d=0.07). Neither was there an intervention effect at 2-month follow-up for fruit and

vegetable consumption (M_{diff}=0.52; 95% CI [-0.46, 1.49], t=1.05, df=69, p=.296, d=0.25), unhealthy snack consumption (M_{diff}=-0.23; 95% CI [-0.88, 0.43], t=-0.68, df=57.856, p=.501, d=0.18), or for healthy eating in the total sample (M_{diff}=0.21; 95% CI [-0.12, 0.54], t=1.24, df=136.237, p=.0.217, d=0.21). Adding gender, age, BMI, restrained eating, stress, and social desirability did not substantively change the results.

Discussion

The results provide first experimental evidence for the hypothesis that smartphone-based support groups can promote healthy eating in daily life. The intervention successfully increased fruit and vegetable consumption, and decreased unhealthy snack consumption, suggesting generalizability to both eating behaviors. By the last day of the intervention, social support participants ate almost one and a half more servings of fruits and vegetables or almost one unhealthy snack less than control participants did. These are sizeable effects considering the short intervention period of seven days.

The intensive longitudinal assessment allowed for interesting new insights into the temporal effects of the intervention. The data supported a gradual increase in healthy eating due to the intervention rather than an immediate discrete increase after the support groups were formed. Likely, participants of chat groups first have to be acquainted and possibly gain trust before social support processes begin to take place.

There was variance in healthy eating between the different chat groups at the end of the intervention, which was significant for the fruit and vegetable goal group. This suggests that in some groups, the social support processes worked better than in others. Future research might investigate factors that contribute to the success of social support groups, such as group climate (Bakali, Wilberg, Klungsøyr, & Lorentzen, 2013), or normative processes (Robinson, Fleming, & Higgs, 2014).

Contrary to expectations, the intervention effects, for the most part, did not last beyond the end of the social support groups. The effects would have persisted if the participants had

created healthy eating habits that became more automatic or had enabled self-efficacy (Rackow, Scholz, & Hornung, 2015), but our 7-day intervention period appeared to have been too short to foster such effects. As such, previous studies have used longer intervention periods of typically four weeks or longer (Prestwich et al., 2014; Wing & Jeffery, 1999). Another possible explanation for the lack of persistent effects is the timing of our intervention. The intervention period took place during the month of November and early December, and the 1-month follow-up survey was conducted around Christmas and New Year's Eve. This is a period when participants may have found it particularly difficult to adhere to their eating goals. Hence, the effects may have been lost. The negative tendencies towards unhealthier eating in the control condition lends some support to this explanation. Future studies that replicate and extend this intervention at a more favorable time for changing eating may therefore expect larger effects and greater maintenance.

Strengths and Limitations

The present study has several strengths. First, the study provides first experimental evidence that smartphone-based peer support groups can promote healthy eating. We successfully created a scenario where persons sharing the same eating goal were able to share their experiences related to achieving their goals. This finding encourages the practical application of the intervention for eating regulation, by training an expert to provide emotional, informational, and instrumental social support to group members. From our results, this supportive effect is expected while the support is ongoing. Further research is needed to investigate how the effects can be sustained after the chat groups end. Alternatively, a possible low-cost intervention could be to encourage chat group participants to continue the peer support after the trained expert exits the chat group. Second, the experimental and intensive longitudinal study design allowed for rare new insights into the temporal development of intervention effects. Even when researchers collect intensive longitudinal data in randomized trials, the opportunity to investigate temporal intervention effects is often

missed, and the data are analyzed on aggregate level only (e.g. Brookie et al., 2017). Third, the intensive longitudinal design allowed for assessing the heterogeneity of the intervention effects at the individual and group level, rather than the average effects of the intervention alone. For example, our analysis revealed that not all individuals equally benefitted from the intervention, which can inspire further research on moderators of the effects of support groups. A fourth strength is the investigation of the intervention for two different eating goals.

This randomized trial also had some limitations that offer opportunities for future research. First, the primary outcome measure of the study was self-reported. Retrospective bias was minimized by daily diary, but social desirability effects may have biased the reports. The sensitivity analysis adjusting for social desirability lends confidence to the conclusion that the differences between the control condition and the social support condition were not due to social desirability. Furthermore, studies using objective biomarkers of eating have indicated good validity of self-reports (Brookie et al., 2017). Second, the effects were shown with a sample of participants who had a healthy baseline diet but who reported having difficulty in maintaining the diet. The intervention might not necessarily work with participants who had weak motivation to eat healthily, but we predict that it would generalize to motivated persons with lower fruit and vegetable consumption or higher snack consumption at baseline. Studies in other populations, including those who are overweight or obese, are needed to assess the generalizability of the findings. Third, our effects were obtained by treating the trained moderator as a confederate peer group member. The presence of an unidentified peer moderator rather than an identified moderator labeled as coach or staff member or no moderator may have altered the effects of this support group intervention. The effects might be larger due to having a trained professional in the group, but they might also have been diminished due to possible reactance of participants suspecting deception. This may be an additional reason for the between-person variability in intervention effects. We included the covert expert in this study, because we wanted to prompt peer support in this

study, and ensure minimal support in each group. Future research is needed to address the question if moderator presence and type in support groups contributes to their effect.

Conclusions

This study extends literature on the benefits of social support for health behavior change to smartphone-based support groups. The results are encouraging as the integration of social support groups via personal smartphones provides a low-cost way to promote healthy eating among persons motivated to change their eating behavior. The maintenance of behavior change remains a challenge that will need to be addressed in the future.

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Table 1. *Linear Mixed Model Predicting Intervention Effects on Healthy Eating.*

	Fruits and Vegetables (servings per day) F&V Goal Group (n = 97)		Unhealthy Snacks (servings per day) Snack Goal Group (n = 106)		Healthy Eating (z standardized) Total Sample (N = 203)	
Fixed effects (intercept, slopes)	Estimate (*SE*)	95% CI	Estimate (*SE*)	95% CI	Estimate (*SE*)	95% CI
Intercept (mean control condition Day 10)	3.85 (0.34)***	[3.13, 4.57]	1.61 (0.18)***	[1.22, 2.00]	-0.17 (0.08)*	[-0.34, <-0.01]
Intervention effect Day 10	1.43 (0.55)*	[0.26, 2.59]	-0.80 (0.27)**	[-1.38, -0.23]	0.48 (0.12)***	[0.23, 0.73]
Time (slope control condition)	-0.02 (0.04)	[-0.10, 0.06]	<0.01 (0.03)	[-0.05, 0.07]	-0.01 (0.01)	[-0.04, 0.01]
Intervention by time	0.15 (0.07)*	[0.01, 0.29]	-0.14 (0.05)**	[-0.24, -0.04]	0.06 (0.02)***	[0.03, 0.10]
Intervention by pre-intervention time	-0.27 (0.24)	[-0.74, 0.20]	0.24 (0.15)	[-0.06, 0.55]	-0.09 (0.05)†	[-0.20, 0.02]
Random effects ([co-]variances)	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Level 3 (chat groups): Intercept[a]	0.77*	[0.25, 10.39]	0.07	[0.01, 25514]	0.04	[0.01, 1.79]
Level 2 (between-person)						
Intercept[a]	2.79***	[1.76, 5.09]	0.38***	[0.14, 2.87]	0.32***	[0.21, 0.52]
Time	0.11**	[0.02, 0.21]	-0.02	[-0.09, 0.06]	0.01	[-0.01, 0.02]
Intercept-time covariance	[b]	[b]	0.01†	[<0.01, 0.11]	<0.01	[<0.01, 0.03]
Level 1 (within-person)						
Autocorrelation	0.03	[-0.05, 0.11]	0.01	[-0.09, 0.11]	0.12**	[0.05, 0.19]
Residual	5.00***	[4.50, 5.59]	2.44***	[2.88, 2.76]	0.53***	[0.48, 0.58]

Note. Time: Linear trend from pre-intervention Day 1 (=-10) to the last day of the intervention (=0), Pre-intervention time = 3 days prior to intervention. Intervention: 1 = social support, 0 = control. F&V = fruit and vegetable.

[a] Estimate of variance of healthy eating at the last day of the intervention.

[b] Was not estimable.

* $p < .05$, ** $p < .01$, *** $p < .001$, † $p < .10$.

Figure 1. Participant flow through the trial. BMI = Body Mass Index, F&V = Fruit and Vegetable.

Figure 2. Model predicted intervention effects on self-reported healthy eating over time. F&V: Fruit and Vegetable.

Figure 3. Intervention effects on healthy eating during the intervention (averaged diary days 4-10), immediately post intervention (averaged diary days 11-13), and at 1-month and 2-month follow-up. Solid lines represent the social support condition, dashed lines represent the control condition. Error bars: +/- 2 times the standard error. F&V: Fruit and Vegetable.

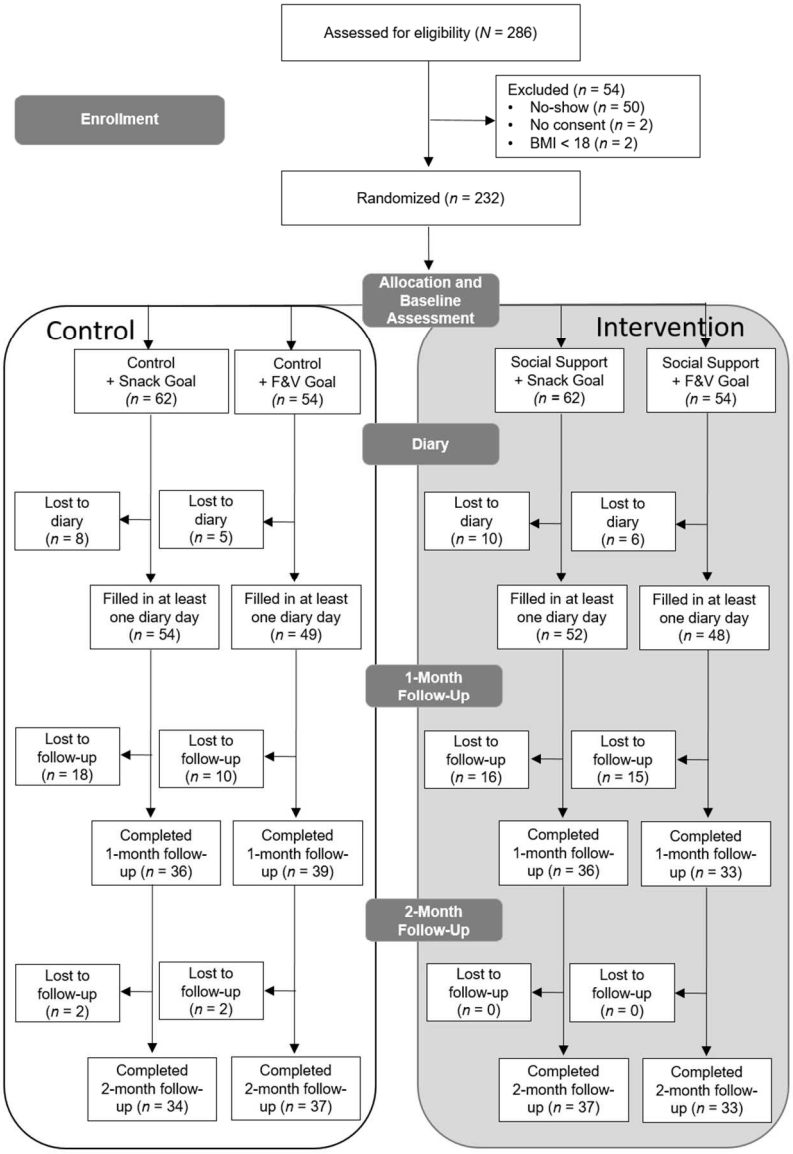

Figure 1. Participant flow through the trial. BMI = Body Mass Index, F&V = Fruit and Vegetable

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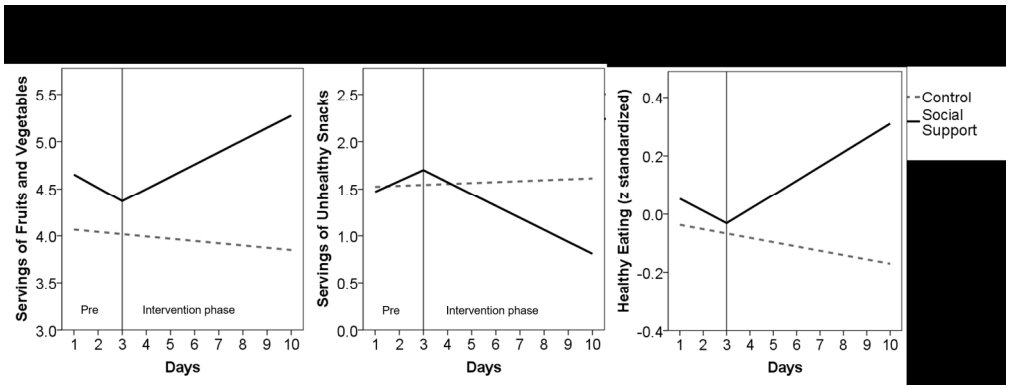

Figure 2. Model predicted intervention effects on self-reported healthy eating over time. F&V: Fruit and Vegetable.

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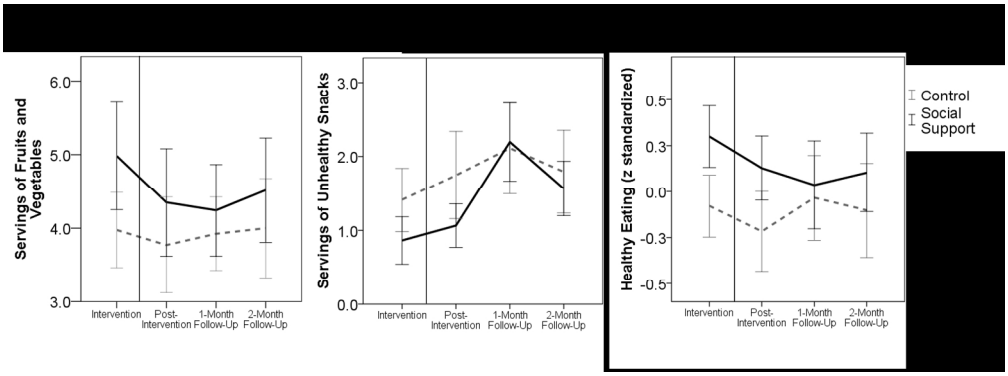

Figure 3. Intervention effects on healthy eating during the intervention (averaged diary days 4-10), immediately post intervention (averaged diary days 11-13), and at 1-month and 2-month follow-up. Solid lines represent the social support condition, dashed lines represent the control condition. Error bars: +/- 2 times the standard error. F&V: Fruit and Vegetable.

368x134mm (150 x 150 DPI)