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ARTICLE

Dyadic planning as a complementary process to individual planning: Physical activity in daily diaries of persons with pre-obesity or obesity

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Abstract

Objectives: Individual planning techniques are frequent intervention components in physical activity (PA) promotion, but it remains underdetermined whether interpersonal regulatory efforts such as dyadic planning contribute to their success. This study examines individual planning and dyadic planning as predictors of PA in persons with pre-obesity and obesity who seek outpatient treatment for intended weight loss.

Design: Intensive-longitudinal design with 8-day daily diaries.

Methods: One hundred and twenty-seven persons with pre-obesity or obesity who consulted an outpatient endocrinology clinic took part in a correlational 8-day daily diary study. This secondary analysis used multilevel models to explain daily self-reported PA. Planning categories (*no planning; dyadic planning only; both individual and dyadic planning*; reference category: individual planning only) were created and entered as same-day predictors.

Results: On days with *no planning*, participants reported being less physically active than on days with individual planning only. While *dyadic planning only* did not emerge as a unique predictor of daily PA, participants were more physically active than usual when they *planned both individually and dyadically* as compared to planning individually only. No significant planning–PA associations emerged at the between-person level.

Discussion: Consistent with scant previous research, we found dyadic planning to be mainly a complementary strategy to individual planning. Day-to-day individual planning together with dyadic planning was linked to more

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PA than individual planning alone. Our findings indicate that including planning partners in PA promotion for individuals with pre-obesity and obesity intending weight loss may be promising.

KEYWORDS
dyadic planning, health, individual planning, obesity, physical activity, pre-obesity

Statement of Contribution

What is already known on this subject?

- Individual planning is a powerful strategy to be more active in everyday life.
- Transactive goal dynamics theory posits that others can extend individual self-regulation resources.
- It is unclear whether planning one's behaviour with somebody else (e.g., dyadic planning) adds to individual planning.

What does this study add?

- Daily planning happens both individually and dyadically.
- Daily dyadic planning rarely occurs on its own without individual planning.
- Daily links to being active were strongest when both individual and dyadic planning were applied.

INTRODUCTION

Physical activity (PA) is a target behaviour in lifestyle interventions for people with overweight because it increases energy expenditure, which aids weight control and improves health (Bellicha et al., 2021; Pojednic et al., 2022). According to Wadden et al. (2020), PA only plays a minor role in short-term weight loss by increased energy expenditure. Its focus is rather on long-term maintenance of weight loss and health improvements, such as blood pressure reductions. Health improvements from PA could be particularly relevant for people with obesity (body mass index [BMI] $\geq 30\,kg/m^2$) who are, compared to people without obesity, at higher risk of cardiovascular disease (Hemmingsson et al., 2022), diabetes mellitus (Abdullah et al., 2010), certain cancers (Renehan et al., 2008) and depression (Pereira-Miranda et al., 2017). With a worldwide prevalence of obesity in adults of between 11% (men) and 15% (women; World Health Organization, 2022), trying to improve health and well-being through more PA is an important goal.

Planning as a potentially modifiable determinant of PA

Behaviour change towards regular PA is hard to achieve and maintain. One way to contribute to intervention development is to understand what processes determine PA, and thus identify potentially modifiable intervention targets. In addition to motivational factors that partially determine PA, theories

such as the Health Action Process Approach (HAPA; Schwarzer, 2008) assume that volitional factors such as self-regulation play a role. Individual planning (or sometimes used synonymously, implementation intentions; Gollwitzer, 1999; Hagger & Luszczynska, 2014) is a self-regulatory strategy facilitating the translation of intentions into actions. Planning generates a mental representation of a future situation and goal-directed action (Sniehotta et al., 2005) by specifying when, where and how to perform an action or how to cope with obstacles. Planning can happen naturally (or spontaneously) in daily life, but it can also be experimentally induced (Carraro & Gaudreau, 2013). Meta-analyses found evidence of an effect of planning on PA (Carraro & Gaudreau, 2013; Sheeran et al., 2024). Effect sizes of the link between planning and PA were stronger for spontaneously occurring planning ($\varphi = .38–.41$) compared to experimental intervention studies ($\varphi = .37$; Carraro & Gaudreau, 2013). A systematic review of studies with lifestyle interventions for people with obesity found the use of self-regulation skills (such as planning) as relevant mediators of successful PA promotion (Teixeira et al., 2015), especially in the short term; however, these mediating effects were observed in an analysis combining individual planning with other self-regulatory mediators (e.g., self-monitoring).

Planning dyadically: Social resources in day-to-day behaviour change

Involving planning partners in obesity treatment might be advantageous: An observational study with 537 adults with obesity found that higher social support from family and friends was related to more PA (Parschau et al., 2014). Moreover, evidence from a systematic review suggests that dyadic health behaviour change interventions (i.e., interventions involving two persons, such as couples) might be more beneficial than individual interventions (Arden-Close & McGrath, 2017), as additional resources and dyadic regulation could complement individual efforts to self-regulate. Transactive goal dynamics theory (Fitzsimons et al., 2015) posits that close relationships form a system that self-regulates as a unit. When there are numerous, strong and well-coordinated ties between goals, pursuits and outcomes, dyad partners can have transactive gain by drawing from a shared pool of resources.

One way in which interpersonal goal pursuit could manifest in social exchanges is dyadic planning. In dyadic planning, a target person and a planning partner create plans for the target person on where, when and how to perform a new behaviour (Burkert et al., 2011). It has been studied correlatively and as a dyadic behaviour change technique in interventions (Berli et al., 2025; Di Maio et al., 2024) with romantic partners (Buitenhuis et al., 2021; Katzenelenbogen et al., 2022; Keller, Wiedemann, et al., 2017; Knoll et al., 2017; Kulis et al., 2025) and parent–child dyads (Kulis et al., 2024; Szczuka et al., 2024). Dyadic planning's focus on one target person can be relevant for persons with chronic conditions who have to take up a new behaviour as part of the treatment plan (e.g., pelvic-floor exercise after prostatectomy; Burkert et al., 2011). Another joint planning procedure is collaborative planning where dyads plan joint engagement in an activity such as PA ('collaborative implementation intentions'; Kulis et al., 2022; Prestwich et al., 2012). Collaborative planning, however, is not part of the present research.

Plans created in dyads as compared to alone might be of higher quality, as planning partners could check feasibility of plans (Keller, Fleig, et al., 2017). Assumed mechanisms that underlie an effect of dyadic planning on health behaviours are social exchange processes such as social support, social control and intraindividual processes such as heightened action control (Burkert et al., 2011; Knoll et al., 2017) or self-efficacy beliefs (Keller, Wiedemann, et al., 2017). Evidence on dyadic planning interventions is heterogeneous: In an randomized controlled trial (RCT), Kulis et al. (2022) found a small effect of a dyadic planning intervention on target person's PA after 6 months, compared to an active control condition, whereas other planning conditions (planning alone, collaborative planning) tested in this trial did not differ from the active control condition in terms of PA. In contrast, 6-week and 1-year findings of an RCT with a dyadic planning condition tested against planning alone (henceforth referred to as 'individual planning', as opposed to dyadic planning, for clarity of exposition) and an active control condition (Keller et al., 2020; Knoll et al., 2017) did not demonstrate higher PA in target persons. The heterogeneous evidence might stem from the differences in intervention dosage and/or determination

of the role of target persons on the basis of health needs (Kulis et al., 2022) versus on the basis of randomization (Keller et al., 2020; Knoll et al., 2017). Dyadic planning has recently been examined as a daily time-varying predictor of individually chosen goal pursuits (e.g., improve academic performance, losing weight; Katzenelenbogen et al., 2022) in couples. In this two-study paper, the daily diary studies found that the combination of dyadic planning with individual planning was a stronger predictor of goal progress compared to individual planning alone. It also demonstrated that dyadic planning had mainly been used as a 'complementary strategy', in addition to individual planning. Dyadic planning as a predictor has yet to be explored as a naturally occurring, spontaneous phenomenon in daily lives of persons with pre-obesity or obesity and for the association with the target behaviour of daily PA.

Whereas some personal characteristics, dispositions, behaviour- and self-related cognitions determining health behaviour are stable, other determinants are time- and context-varying. Stable between-person differences in a determinant may differ in the direction or strength of association with the outcome, for example, health behaviour change, compared to time-varying differences within persons, for example, from 1 day to the next (Hamaker, 2025; Kievit et al., 2013). Intensive-longitudinal design studies (such as diary studies) enable researchers to understand and distinguish between-person-level from time-varying, within-person processes (Hamaker, 2025). Prior evidence exists for planning and social exchange processes as within-person processes linked with PA. Daily links between individual planning and daily PA have been found in couples with overweight and obesity (Berli, Lüscher, et al., 2018). Berli, Bolger, et al. (2018) confirmed high intrapersonal variability in daily social support, which is one assumed mechanism underlying dyadic planning. Higher-than-usual daily social support was found to be related to higher PA in couples with overweight and obesity (Berli, Bolger, et al., 2018). This was also found in a sample of patients with type 2 diabetes and their spouses (Khan et al., 2013). Based on this promising prior evidence from intensive-longitudinal design studies, our study investigated dyadic and individual planning as daily correlates of PA engagement of persons with pre-obesity or obesity.

Aims of the study

The aim of the present study was to describe spontaneous individual and dyadic planning in the daily lives of persons with pre-obesity or obesity who consulted an outpatient clinic of endocrinology for intended weight loss. Another aim was to examine whether there were within-person links between individual and dyadic planning and daily PA. Lastly, we examined whether dyadic planning would be a unique predictor of daily PA, in terms of predictive power. Specifically, and in line with analyses by the two-study paper by Katzenelenbogen et al. (2022), we investigated how not planning at all, planning only dyadically or planning both dyadically and individually compared with planning only individually. By design, we did not limit the focus on a fixed planning partner, such as the romantic partner, but any planning partner (e.g., friends, family members, etc.) being part of the daily life of the person. Our within-person hypotheses were:

H1. On days with no planning, individuals are less physically active than on days with individual planning.

H2. On days with dyadic planning, individuals are more physically active than on days with individual planning.

H3. On days with dyadic planning combined with individual planning, individuals are more physically active than on days with individual planning only.

Besides examining within-person level associations, we also explored respective between-person level associations, for which we expected the same patterns.

MATERIALS AND METHODS

Design and procedure

Data were collected as part of an observational, longitudinal study with outpatients seen for obesity diagnostics and weight loss management at the former Division of Clinical Endocrinology, Charité Universitätsmedizin Berlin, Germany, between May 2009 and September 2011. Data were correlational, without experimental manipulation. Trained research assistants approached patients after their consultation and invited them for participation in a prospective study across 6 months. From this larger study, we use only participants' baseline data, including medical information (BMI, comorbidities) from the consulting physician, and intensive-longitudinal data collected after study start for this secondary data analysis. Intensive-longitudinal study components were a daily diary for 8 days after the study start, and additional assessments of PA using the SenseWear™ PRO 3 armband (BodyMedia, Pittsburgh, USA) for 3 days (Sunday to Tuesday). Daily diaries were sent back by a prepaid return envelope after the 8 days. Participants did not receive compensation for participation. The institution's Research Ethics Board (Charité Universitätsmedizin Berlin, Protocol Number EA1/129/09) approved the study.

This is a secondary analysis of data previously published by Elbelt et al. (2015) that focused on reporting changes in PA, energy expenditure and eating habits across the 6-month follow-up period. In summary, only 19% of participants had achieved substantial weight loss of >5% body weight. Self-reported unhealthy food consumption had decreased, but objectively assessed PA and energy expenditure levels were not kept up across the study period.

Inclusion criteria for patients with pre-obesity and obesity at the outpatient clinic were written informed consent to participate in the study and a medical indication for an increase in daily PA. Exclusion criteria were insufficient German language skills for study participation, hypercortisolism, conditions prohibiting daily PA, for example, clinically relevant heart failure, severe osteoarthritis, limiting pulmonary diseases or amputations. Of $N = 169$ patients who were invited to take part, nine declined. A total of $N = 160$ participants gave informed consent, were included in the study and provided data at baseline. Of those, $n = 127$ participated in the daily diary part of the study. Descriptive statistics on differences between the diary and non-diary participants, who nevertheless participated in baseline assessments, are reported in Supporting Information S1. Participants who took part in the diary part of the study were older, had a lower BMI and had shorter relationship durations with their romantic partners.

Sample

Participants were on average M (SD) = 41.78 (14.10) years old and 78% were women. With an average of M (SD) = 42.76 (8.13) kg/m^2, their BMIs ranged between 28.12 and 64.27 kg/m^2. The obesity category of class III (≥40 kg/m^2; Centers for Disease Control and Prevention, 2022) was met by 58% of participants. Twenty-one percent of participants had type 2 diabetes. Forty-six percent of participants had a high school diploma. Sixty-nine percent were in a romantic relationship of on average M (SD) = 15.22 (13.54) years. For 86% of participants, this was the first consultation at the outpatient clinic. Five participants had already undergone bariatric surgery in the past (e.g., gastric bypass, sleeve resection), between 1 and 8 months prior to the diary phase. In the course of their routine treatment, all participants would receive individualized dietary and PA advice by a dietician and other, individually tailored weight loss treatments such as pharmacotherapy. At the time of the daily diary phase, participants had undergone no other treatment by the outpatient clinic.

Measures

Paper–pencil, end-of-day diaries in the German language were administered for 8 days after the consultation at the clinic in the context of the daily lives of participants.

Daily PA

Daily PA in metabolic equivalents of task (MET)-min/day was assessed via self-report. METs refer to an activity's energy expenditure in relation to body weight, with MET = 1 representing the energy expenditure during resting. Our measure of daily PA was adapted from the International Physical Activity Questionnaire (IPAQ) long version (Craig et al., 2003; Wanner et al., 2016). For walking, moderate activities and vigorous activities in four life domains (transport, work, home and garden, leisure), participants entered the minutes they spent in those activity categories on that day into a double-paged, 24-h timeline. A similar 'PA log book' daily diary was described in Hagströmer et al. (2006). Following the scoring protocol for the IPAQ (International Physical Activity Questionnaire team, 2005), we set any time span below 10 min to zero, and truncated records of total walking, total moderate and total vigorous activity minutes to 3 h a day each. Days with more than 16 h of activity were excluded as outliers. We then multiplied reported minutes per day with the respective MET-value of the activity (walking = 3.3 MET; moderate activities = 4.0 MET; vigorous activities = 8 MET; Ainsworth et al., 2011). A sum of MET-min for each day was computed. The outcome, daily PA, was winsorized to 5th/95th percentiles (Aguinis et al., 2013) to adjust for univariate outliers. To check for bias such as overestimation in our self-reported daily PA measure, we validated our measure with objective data. Energy expenditure indicators assessed by SenseWear armbands were used for partial validation of self-report-based daily PA through correlation coefficients. For details see Supporting Information S2, Supporting Box S2.

Individual planning and dyadic planning

Daily diaries assessed *individual planning* with two items, 'Today, I have planned concretely …', (a) '… when, where and how I want to be physically active', and (b) '… how I can be physically active despite possible difficulties and barriers' (adapted from Burkert et al., 2011; Sniehotta et al., 2005). The items were accompanied by the instruction to think of planning on one's own (i.e., alone, without a partner). Answers were given on a 6-point Likert scale from 1 (*not true*) to 6 (*exactly true*). The reliability of the average two-item responses across days was $R_{kF} = .96$, and of day-to-day changes it was $R_{change} = .81$ (Cranford et al., 2006).

Daily diaries also assessed *dyadic planning* by two items, 'Today, I have planned with my partner …', (a) '… when, where and how I want to be physically active', and (b) '… how I can be physically active despite possible difficulties and barriers' (adapted from Burkert et al., 2011; Sniehotta et al., 2005). 'My partner' referred to the respective planning partner on the specific day. The assessment allowed for varying planning partners and was not limited to romantic partners but any relationship type. Answers were given on a 6-point Likert scale from 1 (*not true*) to 6 (*exactly true*). The reliability of the average two-item responses across days was $R_{kF} = .96$, and of day-to-day changes it was $R_{change} = .85$ (Cranford et al., 2006). As additional descriptive information for each day, planning partners could be named as either 1 (*my [romantic] partner*), 2 (*a friend*), 3 (*another person*) or 0 (*I planned with nobody else*).

For hypothesis testing, individual planning and dyadic planning scales were dichotomized and combined into four planning categories for each day, as proposed by Katzenelenbogen et al. (2022) in their two-study investigation. This approach was chosen because, as in the Katzenelenbogen studies, daily dyadic planning was rarely reported in isolation, but rather in combination with daily individual planning. Consequently, variance of the continuous daily dyadic planning indicator was very limited. This also complicated the testing of a formal interaction effect between the two continuous planning indicators as models did not converge. As a remedy, we first dichotomized individual and dyadic planning scores, where the lowest response option, 1 (*not true*), was coded 'no planning' (0). Any answer above the lowest response option was scored as 'any planning' (1). These dichotomized scores for individual and dyadic planning were combined in four categories: *no planning* (i.e., no individual and no dyadic

planning), *individual planning only* (i.e., individual, but not dyadic planning), *dyadic planning only* (i.e., dyadic, but not individual planning) and *both individual and dyadic planning* (i.e., individual and dyadic planning). These categories were dummy-coded (0 = no; 1 = yes). In the following multilevel models, we used *individual planning only* as reference category.

Statistical analyses

All analyses were run in R (Version 4.3.1) and SPSS (Version 29). For descriptive statistics, between-person correlations were run as Pearson's correlations. Within-person correlations were analysed with the R-package *rmcorr* (Bakdash & Marusich, 2017), to allow for the nested structure of days in individuals. Handling missing data with listwise deletion meant that descriptive statistics were based on between 117 and 127 participants and between 824 and 926 observations. Reliabilities were computed with the R-package *psych* (Revelle, 2025). To understand change and variation in the variables, unconditional growth models were calculated for linear and quadratic time trends (Singer & Willett, 2003). If models did not converge, the random effect for the quadratic time trend was omitted from the models.

For validation of the self-reported primary outcome (i.e., daily PA) with the objective SenseWear data, we matched data by date. Agreement between the two sources of PA/energy expenditure data was determined by Spearman's rho for person-means, and repeated-measures correlations for daily PA.

We also investigated possible dropout mechanisms such as (a) characteristics differing between the diary and the non-diary sample (Supporting Information S1) and (b) characteristics differing between diary dropouts (i.e., partial diary reports with last diary entry on days 1–6) and diary non-dropouts (partial or complete diary reports with last diary entry on days 7 or 8) by *t*-tests or χ^2-tests.

The diary data were analysed using multilevel models with two levels (level 1: days; nested in level 2: persons) following recommendations by Bolger and Laurenceau (2013). Same-day, time-varying planning categories (*no planning*, *dyadic planning only*, *both individual and dyadic planning*) were separated into their within- and between-person components using group-mean centring of their grand-mean centred binary scores (Bolger & Laurenceau, 2013). Between-person predictors for each planning category indicated average planning deviations of a person across the diaries from the grand-mean. Within-person predictors for each planning category indicated the fluctuations of a daily score from a person's average. Among the fixed effects, we controlled for a linear time trend (centred at day 1) and person-level covariates (age, gender, BMI, type 2 diabetes, romantic relationship, mood/anxiety disorder, smoking, living alone, vocational training, without work). Covariates were partly derived from previous research and partly from covariate screening and dropout analyses. These additional covariates were grand-mean centred. We specified a maximal random effects structure (Barr et al., 2013) where this was possible, depending on model convergence. Priority was given to planning variables in random-effects estimation. Random effects for a linear time trend and *dyadic planning only* had to be omitted due to model non-convergence, however. We specified a first-order autoregressive covariance structure (AR1) for the within-person level and used restricted maximum likelihood. Equations can be found in Supporting Information S4, Supporting Box S4. We used listwise deletion to handle missing data: Days without complete data (both on level 1 and level 2) for the full model were excluded from the analyses (Graham, 2009). The multilevel model was based on data of 111 participants and 715 observations.

As sensitivity analyses, we re-ran the model excluding four participants whose BMI ranged below the obesity cut-off of 30 (108 participants, 698 observations). We also re-ran the model excluding observations for 19 days with conflicting information of dyadic planning and planning partner (110 participants, 700 observations). In an exploratory sensitivity analysis testing a temporal direction, we ran a lagged analysis adding previous-day within-person outcomes and previous-day within-person predictors to our model that already included same-day predictors (102 participants, 575 observations).

RESULTS

Dropout analyses

The compliance rate for 8 days of end-of-day diaries was 95%. Participants responded on average to *M* (*SD*) = 7.57(1.33) diaries, ranging from 2 to 8 diary days. Participants who did not participate in diary assessments were younger, had a higher BMI and were in shorter romantic relationships than participants who took part in diary assessments (Supporting Information S1, Table S1). Participants who dropped out in the course of diary assessments were more likely to have trained at a vocational school ($\chi^2(1) = 6.71$, $p = .010$), have a chronic respiratory/lung condition ($\chi^2(1) = 4.25$, $p = .039$) and were more likely to be currently without work ($\chi^2(1) = 3.97$, $p = .046$).

Validation of self-reported daily PA data by device-assessed energy expenditure

Correlations between person means for self-reported daily PA and three indicators of SenseWear-derived energy expenditure ranged between Spearman's $\rho = .33$–$.38$ ($p < .001$) for non-exercise-related activity thermogenesis, exercise-related activity thermogenesis and mean MET. Within-person correlations between daily PA and daily SenseWear-derived energy expenditure ranged from $r = .29$ ($p < .001$; exercise-related activity thermogenesis), across $r = .39$ ($p < .001$; non-exercise-related activity thermogenesis), to $r = .43$ ($p < .001$; mean MET; Supporting Information S2, Table S2).

Individual and dyadic planning: Descriptive results

Table 1 shows means, standard deviations and intraclass correlation coefficients for daily PA, individual planning and dyadic planning and the four planning categories. For daily PA, 48% of variability was due to between-person variation. For descriptive purposes, Supporting Information S3 shows two-level models estimating change in the continuous variables (Table S3) and figures displaying mean trajectories of continuous individual and dyadic planning (Figure S3A) and planning categories (Figure S3B). Daily PA or individual planning indicated no significant linear or quadratic time trend across the 8 days. There was a linear and a quadratic time trend for dyadic planning indicating a slight initial decrease,

TABLE 1 Means, standard deviations and intraclass correlations of daily physical activity (MET-min/day, winsorized 5th/95th percentile), dyadic planning and individual planning scales and planning categories used in multilevel modelling.

Variables	*n*	Range	*M*/ *n*	*SD*/ %	% missing	ICC
Daily physical activity	886	0–1,878	641.72	511.08	12.80	.48
Dyadic planning	825	1–6	1.93	1.60	18.80	.35
Individual planning	926	1–6	2.72	1.85	8.86	.39
Planning categories[a]						
No planning	824	0–1	314	31	18.90	.38
Dyadic planning only	824	0–1	13	1	18.90	–[b]
Individual planning only	824	0–1	254	25	18.90	.41
Individual and dyadic planning	824	0–1	243	24	18.90	.51

Note: Observations $824 \leq n \leq 926$, sample size $117 \leq n \leq 127$ due to missing values and dropouts. Percent missings from total observations of 127*8 = 1016.

Abbreviations: ICC, intraclass correlation coefficient; MET, metabolic equivalent of task.

[a]Planning categories were created from continuous dyadic planning and individual planning scales.

[b]Too few observations in category 'dyadic planning only' to calculate ICC.

which was compensated by a U-shaped increase in dyadic planning. Regarding between-person variation, there was substantial variation in starting points for daily PA, dyadic planning and individual planning, but no, or just a marginally significant random effect for time for individual planning's variation in slopes ($p = .056$).

Participants planned individually on 59% of days ($M = 4.32$ out of 8 days, total $n = 926$ days valid data), and dyadically on 31% of days ($M = 2.14$ days, total $n = 825$ days). Daily individual and dyadic planning were highly correlated, $r = .52$ ($p < .001$). Figure 1 displays frequencies of the four planning categories. The category of *dyadic planning only* held a mere 1% of observations which shows that dyadic planning was very rarely used as the only planning strategy (i.e., without individual planning).

Of all days with dyadic planning ($n = 257$), participants had planned with their romantic partner on 26%, with a friend on 4%, and with somebody else on 8% of days. The option 0 (*I have not planned with anybody else*) was selected in 7% ($n = 19$) of responses. A substantial number of responses for planning partner were missing (55%). The low number of valid observations for 'planning partner' limited further analysis options.

Hypotheses tests: Associations of daily PA (MET-min/day) with planning

We analysed links of daily individual planning and dyadic planning with daily PA with two-level models with planning categories (*no planning*, *dyadic planning only*, *both individual and dyadic planning*, reference category: *individual planning only*) in their within- and between-person components, as well as time as predictors (Table 2). At the *within-person level* we found that on days with *no planning* at all, participants

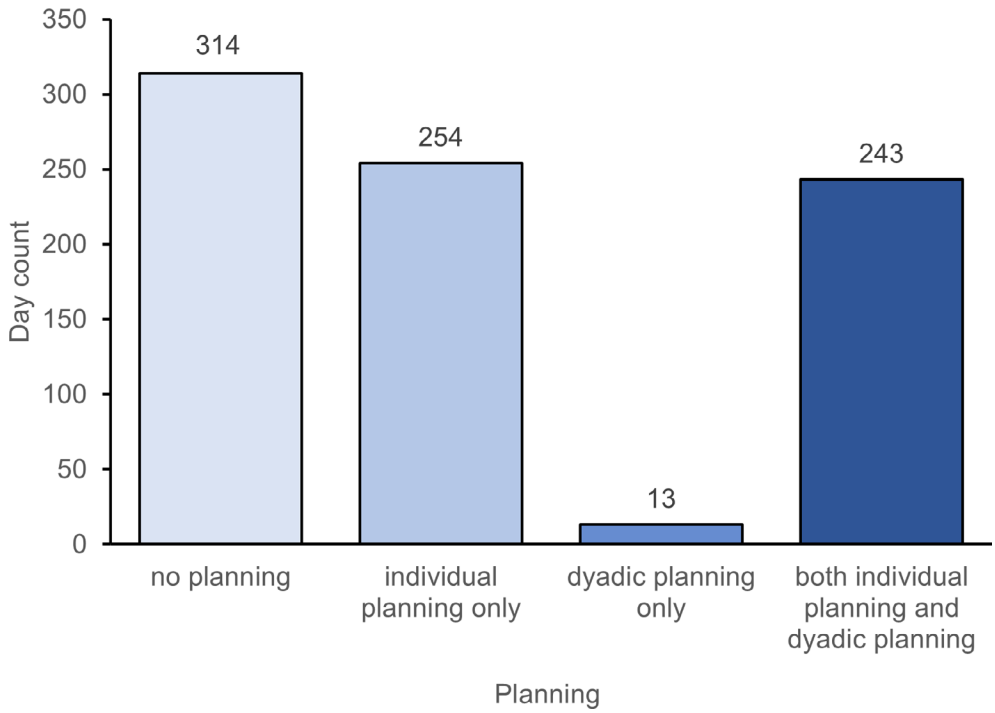

FIGURE 1 Frequency of physical activity-related planning in daily diary days. Frequency of four categories of spontaneous planning among daily diary entries (824 observations, 192 missing values). Combined categories from dichotomized scores for individual planning and dyadic planning are: *no planning* (i.e., no individual and no dyadic planning); *individual planning only* (i.e., individual, but not dyadic planning); *dyadic planning only* (i.e., dyadic, but not individual planning); and *both individual planning and dyadic planning* (i.e., individual and dyadic planning).

performed significantly less PA, b (SE) = −105.68 (43.30), p = .017, than on days with individual planning only, in agreement with H1. Within-person *dyadic planning only* was not significantly linked with PA, not supporting H2. Here, it is important to consider that this category only held n_{days} = 13 observations (Figure 1). On days with *both individual and dyadic planning*, however, participants were significantly more active, b (SE) = 161.88 (55.70), p = .005, than on days with individual planning only. Thus, H3 was supported. At the between-person level, we did not find any indication of *no planning, dyadic planning only* or *both individual and dyadic planning* being significantly linked to total PA. As for covariates, not having a mood/anxiety disorder, smoking and not living alone were significantly linked to more daily PA (Table 2).

Sensitivity analyses

To assess the robustness of our findings, we re-ran the analyses excluding pre-obese participants whose BMI was below the threshold for obesity (n = 4; BMI 28.12–29.57 kg/m^2). Results were comparable with those for the full sample reported above (Supporting Information S5, Table S5). In a few cases, conflicting responses (7%, 19 days) emerged in the descriptive information on 'planning partner' for days with dyadic planning: The dyadic planning items had indicated that the person had planned dyadically, but the planning partner item was responded to with 0 (*I have not planned with anybody else*). Another sensitivity analysis, excluding the 19 conflicting response days, showed comparable results to the full-sample analysis. The exploratory sensitivity analysis testing a temporal direction showed that when additionally controlling for previous-day within-person outcome, previous-day within-person *no planning at all* was significantly linked with less activity on the next day, b (SE) = −137.11 (45.92), p = .003. Previous-day *dyadic planning only* or *both individual and dyadic planning* were not significantly linked with daily PA. Same-day predictor results were comparable with those for the main analysis reported above (Supporting Information S6, Table S6). As for covariates, not living alone and smoking were consistently linked with more daily PA in all sensitivity analyses, while not having a mood/anxiety disorder and being in a committed relationship differed in their link to daily PA, with p-values ranging from .024 ≤ p ≤ .103.

DISCUSSION

Daily individual planning and dyadic planning were assessed as strategies by persons with pre-obesity and obesity intending weight loss who had a consultation at an outpatient clinic for endocrinology. As predicted, we found support for within-person individual planning to be linked to more daily PA (as indicated by significantly higher MET-min/day) compared to no planning at all. Dyadic planning was rarely used as a sole strategy and was not linked to more daily PA than individual planning, contrary to our hypotheses. However, we found that on days when individuals used dyadic planning in addition to individual planning, they were more physically active than on days when they only planned for themselves. None of the between-person planning predictors were significantly related to PA.

In line with theories of self-regulation such as the HAPA, and similar to empirical findings on between-person effects (Carraro & Gaudreau, 2013; Sheeran et al., 2024), our findings confirmed higher daily PA on days when participants had planned individually as compared to when they had not planned at all, supporting H1. Participants reported individual planning on 59% of days, indicating that this volitional, self-regulatory process was used on the majority of days. The same-day association finding is consistent with across-day associations reported by Berli, Lüscher, et al. (2018). They found previous-day individual planning, framed to refer to having planned how they would be active on the next day, to predict daily PA on the following day.

Dyadic planning was a less—but still fairly frequent feature on 31% of participants' diary days. It however mostly co-occurred with individual planning and, by itself, did not explain additional unique

TABLE 2 Parameter estimates from controlled mixed model testing daily planning and its link with daily physical activity (MET-min/day, winsorized 5th/95th percentile).

Fixed effects	*B* (*SE*)	*p*	95% CI
Intercept	**585.11 (38.52)**	**<.001**	509.18; 661.04
Linear time[a] (reference = day 1)	13.55 (7.15)	.060	−0.55; 27.65
Planning (reference = IP only) Within-person effects			
No planning at all	**−105.68 (43.30)**	**.017**	−192.17; −19.19
DP only	−91.53 (120.41)	.448	−328.83; 145.77
IP + DP	**161.88 (55.70)**	**.005**	50.67; 273.09
Planning (reference = IP only) Between-person effects			
No planning at all	−149.60 (126.09)	.238	−399.93; 100.73
DP only	−554.77 (532.83)	.300	−1,609.88; 500.33
IP + DP	94.22 (124.11)	.450	−152.31; 340.75
Age	0.81 (2.71)	.767	−4.58; 6.20
Gender (reference = woman)	26.33 (82.50)	.750	−137.57; 190.24
BMI	−0.60 (3.95)	.879	−8.46; 7.26
Type 2 diabetes[b]	250.52 (170.60)	.145	−88.33; 589.38
Mood/anxiety disorder[b]	**−157.38 (78.72)**	**.049**	−313.79; −0.98
Smoking[b]	**222.17 (77.59)**	**.005**	68.03; 376.32
In committed relationship[b]	−169.71 (85.70)	.051	−340.00; 0.58
Living alone[b]	**−222.78 (107.41)**	**.041**	−436.05; −9.52
Vocational training at university of applied sciences[b]	197.81 (110.89)	.078	−22.47; 418.09
Currently without work[b]	−122.14 (82.10)	.140	−285.23; 40.95
Random effects ([co-]variances)	***Var* (*SE*)**	***p***	**95% CI**
Level 2 (between-person)			
Intercept	**64,226.58 (15,380.95)**	**<.001**	40,167.00; 102,697.57
Linear time[a] (reference = day 1)	–	–	–
Planning (reference = IP only) Within-person effects			
No planning at all	12,386.34 (20,443.56)	.545	47.84; 314,662.28
DP only	–	–	–
IP + DP	50,942.91 (34,526.54)	.140	13,495.24; 192,302.76
Intercept and no planning at all	−9,178.30 (13,560.74)	.499	−35,756.87; 17,400.27
Intercept and IP + DP	16,270.01 (17,569.54)	.354	−18,165.65; 50,705.67
No planning at all and IP + DP	−8,263.64 (22,201.97)	.710	−51,778.40; 35,251.71
Level 1 (within-person)			
Residual	**135,195.44 (10,781.20)**	**<.001**	115,633.24; 158,067.06
Autocorrelation	**.22 (.06)**	**<.001**	.11; .33

Note: Seven hundred and fifteen observations; 111 individuals (due to missings). Unstandardized coefficients are displayed. Parameter estimates with significant *p*-values are printed in bold. Missing data were excluded listwise. Dyadic planning and individual planning refer to a daily and spontaneous formation of plans about physical activity.

Abbreviations: CI, confidence interval with lower level and upper level; DP, dyadic planning; IP, individual planning; MET, metabolic equivalent of task; reference, reference category; *SE*, standard error; Var, variance.

[a]Centred on day 1 (0 = day 1; 1 = day 2, …).

[b]Reference category = no.

variance in daily PA. Co-occurring dyadic and individual planning on a day, as compared to individual planning only, were linked to higher PA. Together, this is in contradiction with H2, but supports H3. Dyadic planning seems to have been used predominantly as a complementary strategy to individual planning (Katzenelenbogen et al., 2022). The similarity of our findings to those by Katzenelenbogen et al. (2022), who studied self-selected goal pursuits as outcomes in two studies with couples, strengthens the generalizability of our within-person level findings in a sample of persons with pre-obesity or obesity who planned dyadically with self-chosen planning partners. To the best of our knowledge, our results provide the first evidence of daily individual combined with dyadic planning of PA as a relevant combination of strategies for individual behaviour change in persons with pre-obesity or obesity.

Theoretically, dyadic planning would be especially helpful if it could compensate for low individual self-regulation capabilities (Keller et al., 2015), both stable as well as momentary. In the context of planning PA, low individual self-regulation may, for example, relate to the absence of individual planning, to low-quality or unrealistic plans or to not following through with plans. With our null findings of dyadic planning as a sole strategy, our findings cannot support the idea that dyadic planning takes over the regulatory function when individual planning is absent. However, the low number of days (1%) on which dyadic planning happened without individual planning limits the interpretability of our data regarding this hypothesis (H2).

One explanation of the finding of co-occurrence of dyadic and individual planning resulting in higher PA could be that participants also adapted their individual plans after planning together with a planning partner: Discussions during dyadic planning conversations with a romantic partner, a friend or a different partner, on what activity would be enjoyable, fit the schedule, weather and be overall feasible for today for the target person, could have produced re-evaluations and new ideas which could have been relevant for plans the individuals made for themselves. Individual planning might have been revised after dyadic planning. More ways in which dyadic planning may impact behaviour is through mechanisms (social support, social control, action control and self-efficacy beliefs) proposed by prior evidence (Burkert et al., 2011; Keller, Wiedemann, et al., 2017; Knoll et al., 2017). Another explanation for the finding of higher daily PA when planning dyadically and individually may be that both kinds of planning may have produced a greater number of plans, resulting in more frequent performance of health behaviour (Wiedemann et al., 2012). To date, prior evidence is conflicting on whether more plans are better (Keller, Fleig, et al., 2017) and more studies are needed (Sheeran et al., 2024). To determine any added effects in dyadic planning through more plans, the number of plans should be assessed in future research.

An additional explanation could come from the Systemic-Transactional Model (Bodenmann, 2005). Examining the temporal process of coping in couples, Bodenmann (2005) assumed that dyadic coping efforts would most frequently be used after the execution and failure of individual coping efforts. In a study across 8 months, Keller et al. (2015) found no conclusive evidence for a sequential use of individual and dyadic planning of rehabilitative exercises in patients following radical prostatectomy. At a much shorter timeframe of 8 days, our daily diary study found stable individual planning and fluctuating dyadic planning patterns. Future intensive-longitudinal studies should examine the sequential use of individual and dyadic planning by observing strategy use after the failure of individual self-regulation in an attempt to perform an intended behaviour.

To date, the daily occurrence of dyadic planning has only been studied among couples from the general population with regard to different goal pursuits (Katzenelenbogen et al., 2022). We studied daily dyadic planning for PA specifically in a sample of persons with pre-obesity or obesity who entered a health care setting and allowed our assessments to capture processes of planning with varying planning partners. Despite these differences, findings were similar to those for couples in the report by Katzenelenbogen et al. (2022). The finding for days when participants planned both individually and dyadically points towards synergistic processes of planning alone and with a planning partner. There was substantial variation due to within-person differences in planning. As described above, the dyadic planning addition could be especially helpful in times of need, represented by the within-person result for *both individual and dyadic planning*.

Between-person predictor variables were non-significant. Surprisingly, we did not find a between-person level link of PA with no planning versus individual planning only (i.e., persons who, in general, planned individually more often were not more active than those who did not plan at all). While this is not in line with prior evidence on the link between individual planning and PA (Carraro & Gaudreau, 2013; Sheeran et al., 2024), the special way of coding planning in our analyses does not permit a direct comparison with prior studies where planning is usually not assessed in different facets (e.g., individual and dyadic) and/or combinations thereof. Additionally, the interpretability of our findings on dyadic planning only is somewhat limited by its restricted use as the sole planning strategy, as discussed above. Moreover, planning levels, particularly for dyadic planning, were low, potentially posing a problem with restricted range to between-person level associations. Also, following the ideas on sequential execution of the planning strategies, it seems reasonable that people who often plan dyadically in addition to individually might also be more likely to encounter self-regulatory failure more often. In this case, between-person levels of *both individual and dyadic planning* would be unlikely to be predictors which could explain non-significant results.

As for covariates, better mental health and smoking were related to more daily PA. The rather unexpected positive smoking result can be explained by differential links for smoking and PA of different domains (Zhang et al., 2023). Living alone was related to less daily PA. This finding mirrors existing literature on the health-promoting aspects of social integration (Holt-Lunstad, 2024), and also prompts the notion of different opportunities for social exchange processes such as dyadic planning in daily life.

With an average 641.72 MET-min/day and 4492.03 MET-min/week of self-reported PA, our sample was quite active. While self-reported PA levels across 1 week were similar to total PA reports from a Swiss cohort sample with 4774 MET-min/week in the 7-day recall IPAQ (Wanner et al., 2016), daily diary assessments and samples with obesity often displayed lower amounts of PA in the literature (Bergh et al., 2017; Hagströmer et al., 2006). One possible explanation of our quite active sample is the timing of the assessment period, which started just after an appointment at the outpatient clinic. Motivation for health-promoting PA might have been particularly high. Also, high estimates can be expected from self-report PA questionnaires for 'total physical activity', including background activities such as work or housekeeping (Bauman et al., 2009). This could explain our high daily score.

Strengths and limitations

Whereas the present study had several strengths such as an intensive-longitudinal design, which limits recall bias, allows for the examination of within- and between-person links and has high external validity, there are also some limitations. One limitation is that analyses were conducted with self-reported PA as an outcome. Self-reports have been found to overestimate PA (Conway et al., 2002). Our approach to check for the impact of this bias was comparing the 3 days of SenseWear device energy expenditure assessment to the self-reported diary responses. We found them to be moderately correlated. This is in line with prior findings such as Wanner et al. (2016)'s of a moderate correlation for total PA assessed by the self-report IPAQ questionnaire and accelerometer data. This gave us some confidence in our self-report measure.

Also, our design did not allow us to explore other avenues of research that would complement the findings. Our observational data do not allow for causal conclusions on the effectiveness of planning alone versus with a planning partner. Also, we did not control for relationship quality with the planning partner, who could—due to the assessment format—change from day to day. Relationship quality had been found as a relevant moderator of the effect of dyadic planning in couples (Keller et al., 2020; Knoll et al., 2017). Future digital assessments may use filter questions to not only capture planning but also if plans were created alone or with a partner, the quality of the interaction, identity of and relationship quality with the planning partner and whether it involved joint behaviour. Assessments should also collect the dyadic perspective of the planning partner from

daily diaries to capture any spill-over effect from which a planning partner could benefit (Keller et al., 2020; Kulis et al., 2025).

Despite these limitations, our research provides a first view on daily planning processes, alone and with somebody else, for PA in persons with pre-obesity or obesity intending weight loss after a consultation at an outpatient clinic.

Practical implications

The findings have some implications for practice. Dyadic planning may be a time-varying, relevant complementary strategy to individual planning in a patient sample. As a within-person process, it could be a potentially modifiable target for future interventions to support individuals pursuing behaviour change. Dyadic planning could help to provide a clear format to promote solution-focused conversations and planning among two people wanting to help one person to achieve health-related behavioural goals.

CONCLUSION

The results of this research provide supporting evidence that planning is a relevant dynamic process in daily PA in persons with pre-obesity or obesity. The present study contributes to a growing body of evidence that dyadic planning may be a complementary strategy to individual planning.

AUTHOR CONTRIBUTIONS

Lea O. Wilhelm: Methodology; formal analysis; visualization; writing – original draft; writing – review and editing. **Nina Knoll:** Conceptualization; methodology; investigation; formal analysis; supervision; visualization; writing – original draft; writing – review and editing. **Aleksandra Luszczynska:** Methodology; visualization; writing – review and editing. **Eran Bar-Kalifa:** Methodology; visualization; writing – review and editing. **Ulf Elbelt:** Conceptualization; methodology; investigation; project administration; data curation; visualization; writing – review and editing; resources. **Silke Heuse:** Conceptualization; methodology; data curation; investigation; visualization; project administration; resources; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

None of the authors have a conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

Data analysis scripts can be obtained from the authors upon request. Data will not be shared due to confidentiality and informed consent agreements of the participants.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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