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Community and behavior maintenance: the association of community factors with behavior maintenance outcomes in people with type 2 diabetes participating in a group-based walking intervention

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ABSTRACT

Community factors may play a key role in facilitating effective diabetes self-management and sustained behavior change. We investigated whether community factors are related to behavior maintenance outcomes in people with type 2 diabetes participating in a group-based walking intervention. We examined if changes in walking behavior, diabetes self-management and health outcomes are related to perceived social support and diabetes self-efficacy, and if social support is related to behavior maintenance. A longitudinal study was conducted among 528 people with type 2 diabetes participating in a 20-week group-based walking intervention with measurements at baseline, post-intervention, and three months follow-up. Multilevel linear regression and multinomial logistic regression models showed that community factors and social support were positively associated with behavior maintenance outcomes, namely intervention engagement, intention to continue walking after the intervention, and maintenance of physical activity behavior three months following the intervention. Perceived social support and diabetes self-efficacy were positively associated with changes in diabetes self-management and emotional well-being, with those experiencing initial low social support and self-efficacy benefitting most from the intervention. The results emphasize the critical role of integrating community factors and social support components in behavior change interventions in order to promote sustained engagement and behavior maintenance after the intervention.

1. Introduction

Type 2 Diabetes is a chronic condition affecting hundreds of millions of individuals worldwide. The management of type 2 diabetes requires not only medical interventions but also implementation of comprehensive health behavior changes and psychosocial support. Previous studies highlight the direct and indirect effects of social factors on diabetes self-management and health outcomes (Azmiardi et al., 2022; Brinkhues et al., 2018; Feng and Astell-Burt, 2017; Koetsenruijter et al., 2015; Kwasnicka et al., 2016; Lindström, 2011; Mohebi et al., 2018; Obo et al., 2021; Parviniannasab et al., 2024; Qi et al., 2015; Song et al., 2017; Stopford et al., 2013; Strom and Egede, 2012; Sung and Lee, 2025). Notably, higher levels of social support provided by community members such as family, friends, and health care providers have been associated with increased engagement in diabetes self-management (Song et al., 2017). This encompasses favorable behavior changes in physical activity and nutrition behavior, medication adherence, and subsequently better health outcomes (Mohebi et al., 2018; Obo et al., 2021; Stopford et al., 2013; Strom and Egede, 2012; White et al., 2024).

Therefore, attention should be paid to the potential influence of social factors in preventing poorer health outcomes in people with type 2 diabetes. Evidence suggests that a recent type 2 diabetes diagnosis is associated with a reduction in social contacts and poorer quality of life (Feng and Astell-Burt, 2017). Additionally, a smaller social network size and less social support have been associated with higher type 2 diabetes incidence (Asif et al., 2025), a higher incidence of macro- and microvascular type 2 diabetes complications (Brinkhues et al., 2018), poor glycemic control (Sung and Lee, 2025) and increased risk of depression

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(Azmiardi et al., 2022; Feng and Astell-Burt, 2017). Conversely, social support is positively associated with quality of life, and social support has been found to partially mediate the relationship between depression and quality of life (Obo et al., 2021) and the relationship between diabetes distress and resilience (Parviniannasab et al., 2024) in people with type 2 diabetes. This underscores the significant role of social networks in improving well-being and buffering the negative impact of the disease in people with type 2 diabetes. Moreover, social support provided by community organizations (Koetsenruijter et al., 2015) and peer support interventions (Qi et al., 2015) have been associated with better health outcomes, including improved glycemic control. Furthermore, a supportive social network was found to be an essential determinant for sustained behavior change (Kwasnicka et al., 2016) and intervention adherence (Deslippe et al., 2023). These findings emphasize the significance of community factors in facilitating effective type 2 diabetes self-management behavior and underline the potential benefits of incorporating social support and community strategies to optimize diabetes care.

A community is defined by several elements: (1) membership, which encompasses a sense of identity and belonging; (2) the presence of common symbol systems, including shared languages and rituals; (3) shared values and norms; (4) the existence of mutual influence among its members; (5) a collective commitment to addressing shared needs; and (6) shared emotional connections, which involve a common history, shared experiences, and mutual support (Israel et al., 1994). Where social support usually refers to an individual's sense of available support from close others, community factors refer to a broader feeling of belonging and connectedness to a larger group. Community factors are positively associated with health behavior and health outcomes (Cohen et al., 2006; Gao et al., 2025; Hill-Briggs et al., 2020; Sung and Lee, 2025; Wood et al., 2010), and intervention engagement (Farrance et al., 2016; Heinrich et al., 2022). Furthermore, community factors seem to be associated with individual psychological and social factors, such as self-efficacy and social support, which also influence health and health behavioral outcomes (Bandura, 1997, 2000; Hill-Briggs et al., 2020; Lee et al., 2014). Therefore, it is valuable to incorporate community factors in health behavior interventions.

In earlier assessments, we were able to report positive effects of a group-based walking intervention known as the National Diabetes Challenge (NDC) on health outcomes and emotional well-being in people with type 2 diabetes (Regeer et al., 2020, 2021). This community intervention targets the enhancement of physical activity behavior, a cornerstone of diabetes self-management. One of the core-elements of this intervention is the local organization of walking communities by health care providers, wherein groups are working together to achieve a shared goal. Previous feasibility and qualitative studies (Regeer et al., 2020, 2025) showed that NDC participants with type 2 diabetes perceive the experienced social support from within the group as an important contributing factor in persevering with and completing the intervention, and maintaining physical activity behaviors after the intervention. This suggests that social support and specifically community factors might be important components of the working mechanisms of this intervention. However, the association of community factors with behavior maintenance has not previously been examined within the NDC population, or – to the best of our knowledge – within other type 2 diabetes populations participating in a physical activity intervention.

Therefore, the current study aims to investigate to what extent community factors are associated with behavior maintenance outcomes during and after a walking intervention. Specifically, this study explores whether a recurring community intervention such as the NDC can be of significant value in achieving sustained behavior change. Although community factors may comprise also of structural and environmental factors, we have specifically focused on the psychological and social dynamics within communities, looking at three commonly studied community factors – sense of community (Peterson et al., 2008), collective efficacy (Bandura, 1997), and social capital (Mackenbach et al., 2016).These community factors have been linked to better health outcomes and behavior, including higher levels of physical activity (Dlugonski et al., 2020; Gao et al., 2025; Legh-Jones and Moore, 2012; Lindström et al., 2001; Ross and Searle, 2019), lower likelihood for physical inactivity (Ueshima et al., 2010), healthier eating habits (Johnson et al., 2010; Poortinga, 2006), less smoking and alcohol consumption (Poortinga, 2006), lower BMI (Cohen et al., 2006), better quality of life and improved diabetes management (Sung and Lee, 2025). *Sense of community* is defined by feelings of belonging within a group, the significance that members feel towards one another and the group they belong to, and a collective belief that their needs will be fulfilled through their interactions (Peterson et al., 2008). *Collective efficacy* is defined by Bandura (Bandura, 1997, p. 477) as "a group's shared belief in its conjoint capabilities to organize and execute the courses of action required to produce given levels of attainments". Collective efficacy enables collective action and is hypothesized to mediate and reinforce individual self-efficacy (Band et al., 2019). *Social capital* is defined by the resources that are obtained through social connections, such as norms of reciprocity, trust, and the capacity for collective action (Mackenbach et al., 2016).

The primary goal of the current study was to investigate whether community factors are associated with behavior maintenance outcomes – such as intervention engagement, intention to continue walking after the intervention, and maintenance of walking behavior three months after the intervention – in people with type 2 diabetes that participated in the NDC. In addition, as perceived social support and self-efficacy have often been linked to positive behavior and health changes, we examined if changes in walking behavior, diabetes self-management and health outcomes are related to perceived social support and perceived diabetes self-efficacy, and if perceived social support is related to behavior maintenance outcomes.

2. Materials and methods

2.1. Design

The current study was a longitudinal study among people with type 2 diabetes, with measurements at baseline (T0; April 2019), at post-intervention (T1; September 2019), and at three months follow-up (T2; December 2019). This study was approved by the Medical Ethical committee of the Isala general hospital (Zwolle, the Netherlands; ref nr. 180341).

2.2. Participants and procedure

Data was collected among people with type 2 diabetes who participated during a group-based walking intervention organized by the Bas van de Goor Foundation (https://www.bvdgf.org/) in 2019 spread across 207 walking locations in the Netherlands. Participants were free to sign up for a walking group of their choice, typically one located near their home, and no selection or allocation was made by the organization. Study inclusion criteria were: type 2 diabetes, age $\geq$18 years, and written informed consent. At baseline (T0), all intervention participants received an information letter about the study by e-mail with a link to an online informed consent form and baseline questionnaire. Participants who gave informed consent and completed this baseline questionnaire (n = 528) received an invitation to also fill in the post-intervention questionnaire (T1) after 20 weeks and follow-up questionnaire (T2) three months after the intervention completion. Participants received a reminder twice if they had not completed their questionnaire after seven and fourteen days. The questionnaires included items on participant and intervention characteristics, emotional well-being, diabetes self-management behavior, physical activity behavior, perceived social support and diabetes self-efficacy. Community factors were only measured at post-intervention (T1). See Supplementary Table 1 for an overview of the data collection timepoints.

In addition, physical health outcomes (HbA1c and BMI) were assessed at baseline (T0), post-intervention (T1), and three months follow-up (T2) in a subgroup of 78 participants with type 2 diabetes from eight primary care practices involved in the NDC (out of a total of 207 NDC locations). Healthcare providers of these practices personally invited their patients to participate in the study during consultations and/or an information evening, and performed the health outcome assessments at fixed measurement times. If participants were unable to attend these measurement times, another appointment was made with them to obtain their physical health outcomes.

2.3. Intervention

The NDC is a group-based walking intervention during which people with and without diabetes participate in a weekly walk in their own neighborhood for 20 weeks. These walks were organized and attended by local community members such as general practitioners, physiotherapists, practice nurses, municipal employees, and former NDC participants. During the intervention, participants gradually worked towards achieving their personal goal, which was walking a distance of 5, 10, 15 or 20 km at the final NDC week. At the end of this week, all walking groups gathered at one central location in the country to walk the final kilometers of the challenge period as one group. A detailed description of the NDC can be found elsewhere (Regeer et al., 2020).

2.4. Measures

2.4.1. Participant and intervention characteristics

Participant characteristics included age, sex, comorbidity (no comorbid disease, one to two comorbid diseases, or three or more comorbid diseases), educational level (low, intermediate, high), former intervention participation (yes, no) and duration of diabetes in years.

2.4.2. Community factors

The community factors were measured by standardized questions adopted from the three questionnaires described below and modified to the specific intervention situation by replacing the word *neighborhood* with *walking group*. For each community factor we conducted separate exploratory factor analyses, which indicated good internal consistency and reliability of the three community factors (see Table 2 of the supplementary for results).

Sense of community was measured based on the validated Brief Sense of Community Scale (McMillan and Chavis, 1986; Peterson et al., 2008), and had a Cronbach's alpha of 0.93. Participants were asked to indicate on a 5-point Likert scale to what extend they agree with seven statements on needs fulfillment, group membership, emotional connections and influence, for example: "I feel connected to this walking group". A higher score indicates a greater sense of community.

Collective efficacy was measured with five statements adapted from the collective efficacy measure described by Lent, Schmidt, and Schmidt (Lent et al., 2006). Collective efficacy had a Cronbach's alpha of 0.94. Participants were asked to indicate on a 10-point Likert scale their confidence in the group's ability to perform successfully as a group rather than an individual group member, for example: "As a walking group, we help group members achieve their goals". A higher score indicates more collective efficacy.

Social capital was measured with a shortened version of the neighborhood social capital questionnaire of Mackenbach and colleagues (Mackenbach et al., 2016), and had a Cronbach's alpha of 0.92. Participants were asked to indicate on a 5-point Likert scale to what extend they agree with seven statements on trust, norms of reciprocity and social network, for example: "People in this walking group are willing to help each other". A higher score indicates higher social capital.

2.4.3. Physical activity behavior related outcomes

Four self-reported physical activity outcomes were measured. The first outcome was the number of minutes of (leisure time) walking per week as measured by the Dutch Short Questionnaire to Assess Health Enhancing Physical Activity (SQUASH) (Wendel-Vos et al., 2003) at baseline, post-intervention and follow-up.

Second, intervention engagement was measured by asking participants to indicate how often they attended the walking sessions, which was categorized into two groups (participated every week, did not participate every week).

The intention to continue walking after the intervention was assessed by asking participants whether or not they intended to continue walking after the intervention, either alone or with the walking group.

Finally, maintenance of walking behavior was measured by asking participants at three months follow-up whether they had continued walking after the intervention, and if so whether they continued with or without their walking group.

2.4.4. Emotional well-being

Emotional well-being was measured using the World Health Organization well-being index (WHO-5). The participants were asked to indicate on a 6-point Likert scale for five statements about their emotional well-being which answer best reflects how they felt the past two weeks. A higher WHO-5 score indicates better emotional well-being. A score equal or lower than 50 is considered an indication for impaired emotional well-being (Hajos et al., 2013).

Table 1
Baseline characteristics of total sample (n = 528).

Age (years), mean (SD)	63.6 (8.7)
Sex, male n (%)	204 (39.0)
Level of education, n (%)	
Low	261 (50.3)
Intermediate	120 (23.1)
High	138 (26.6)
Duration of diabetes (years), mean (SD)	9.9 (7.7)
Chronic comorbidity, n (%)[a]	
No comorbidity	53 (10.1)
1–2 comorbidities	291 (55.5)
>3 comorbidities	180 (34.4)
Meets fit norm at the start of the intervention, n (%)[b]	237 (45.1)
Previous participation in the walking intervention, n (%)	
Yes	179 (34.4)
No	342 (65.6)
Lower emotional well-being, n (%)	124 (23.9)
Obese (BMI ≥30 kg/m[b]), yes, n (%)[c]	34/62 (54.8)
Elevated blood glucose levels (HbA1c > 7 (%))[c]	50/78 (64.1)

[a] comorbidities pre-defined in the following groups: COPD, obesity, ischemic vascular disease, heart failure, asthma, dyslipidaemia, hypertension, rheumatic disease, arthrosis, kidney failure, polyneuropathy, diabetic ulcer, retinopathy, depression, 'other'. 'No comorbidity' refers to no morbidity other than type 2 diabetes.

[b] >150 min moderate – heavy physical exercise per week.

[c] As data on BMI and HbA1c was only available for a subsample, the n of these variables is noted after the forward (/).

Table 2
Descriptive statistics on behavior maintenance outcomes.

	N (%)
Intervention engagement	
Participated every week	215 (66.6)
Did not participate every week	108 (33.4)
Intention to continue walking after the intervention	
No, intention to continue walking	18 (6.7)
Yes, but not with the walking group	72 (27.0)
Yes, together with the walking group	177 (66.3)
Maintenance of walking behavior at follow-up	
Did not continue walking	54 (20.3)
Yes, but not with the walking group	124 (46.6)
Yes, together with the walking group	88 (33.1)

Notes. N, number of participants, %, percentage of participants.

2.4.5. Diabetes self-management

Overall diabetes self-management behavior was measured with the Diabetes Self-Management Questionnaire – Revised (DSMQ-R) (Schmitt et al., 2013, 2022). Participants were asked to indicate on a four-point scale to what extent statements on the following diabetes self-management behavior applied to them: eating behavior, taking medication, physical activity, glucose monitoring, and cooperation with their diabetes team. A higher total score indicates more effective diabetes self-management.

2.4.6. Diabetes self-efficacy

Diabetes self-efficacy was measured with the Diabetes Mellitus Self-Efficacy Scale (DMSES). This questionnaire consists of 20 items and measures the self-efficacy expectations someone has for performing several type 2 diabetes self-management activities such as blood glucose monitoring and physical exercise. A higher score indicates higher self-efficacy (Bijl et al., 1999).

2.4.7. Perceived social support

Perceived social support was measured with the Multidimensional Scale of Perceived Social Support (MSPSS). The MSPSS consists of 12 items on perceived support from family, friends and significant others, and a higher total score reflects a higher perceived social support (Pedersen et al., 2009; Zimet et al., 1990).

2.4.8. Physical health outcomes

HbA1c (mmol/mol), body weight (kg) and length (cm) were measured by health care providers at the intervention locations in a subsample of the study population. BMI was calculated based on length in meters and body weight in kg.

2.5. Statistical analyses

All statistical analyses were carried out using R (R Core Team, 2024). Participants were included in the analyses if they have outcome data regardless of their intervention adherence. Our data contained 51.4 % of missingness in the entire data set. To avoid potential bias due to drop-out across the multiple measurements we employed multiple imputation by chained equations (Van Buuren, 2018) to impute missing values in our data. Multiple imputation creates plausible values for missing data by analyzing multiple datasets with different values filled in for missing entries. Mean scores were calculated based on imputed item scores within each iteration. A total of 20 iterations were performed. Following the recommendations of White, Royston and Wood (White et al., 2011), we created 70 imputed data sets.

Separate multinomial logistic regression analyses were performed to examine if higher community factors (sense of community, collective efficacy, and social capital) and perceived social support at post-intervention (T1) (independent continuous variables) were related to intervention engagement and intention to continue walking at post-intervention (T1), and maintenance of behavior at follow-up (T2) (dependent categorical variables). The model included one of three community factors or social support to assess its influence on the likelihood of participants indicating that they had participated every week, intended to continuing walking after the intervention with, or without people from their group, and whether they actually did continue walking, relative to the reference category. The negative outcome category of the dependent variables was designated as the reference group for comparison (e.g. “I did not participate every week”, “No, I will not continue walking”, and “No, I did not continue walking”). Finally, multilevel linear regression models with a random intercept per participant were used to examine the association of perceived social support and diabetes self-efficacy (independent variables) with changes in physical activity behavior, diabetes self-management and physical health outcomes (dependent variables). Each model contained time as a categorical variable, with baseline as its reference category. Additionally, we included interaction terms to assess whether the relationships between dependent and independent variables were moderated by time. To account for the non-independence of repeated observations within individuals, a random intercept was included for each participant. For the sake of structure and readability of the article, only significant results have been reported. Non-significant or secondary results can be found in supplementary.

3. Results

3.1. Descriptive statistics

A total of 528 participants with type 2 diabetes (39 % male) were included. See Table 1 for baseline characteristics. The average age of the participants was 63.6 years, and the majority of the participants were lower educated (50.3 %). 34.4 % of the participants had participated in the walking intervention before. At the beginning of the intervention, 89.9 % of the participants had at least one or more comorbid disease in addition to type 2 diabetes. More than half of the participants (54.8 %) were obese and 64.1 % had an HbA1c higher than 53 mmol/mol 23.9 % of the participants reported a low emotional well-being at baseline. Furthermore, 54.9 % did not meet the Dutch fit norm of at least 150 min of moderate to heavy physical exercise per week, highlighting the potential for improving health and health behavioral outcomes. After 20 weeks of walking (T1), the majority of the participants (66.6 %) indicated that they had participated weekly during the intervention and 66.3 % of the participants intended to continue walking with their walking group after the intervention (see Table 2). At three months follow-up (T2), 79.7 % of the participants reported that they had continued walking after the intervention, of which 46.6 % without their original walking group and 33.1 % with their walking group.

3.2. Overall change in primary and secondary intervention outcomes

There was a significant increase in emotional well-being ($p < .001$), diabetes self-management ($p < .001$), and diabetes self-efficacy ($p < .001$) during the intervention, and these increases were maintained up to three months after the intervention with ($p < .001$) for emotional well-being, ($p < .01$) for diabetes self-efficacy, and ($p < .001$) for diabetes self-management. A significant decrease in BMI was found during the intervention ($p < .05$), but was not sustained at follow-up. No significant change in perceived social support was found during the intervention, however, a significant increase was found between baseline and follow-up perceived social support ($p < .05$). No significant change in minutes of walking per week was found during the intervention, but a significant decline in minutes of walking per week was found between baseline and follow-up ($p < .01$). No significant change over time was found in HbA1c. See Table 3 for detailed results.

3.3. Associations of community factors with behavior maintenance outcomes

Multinomial logistic regression analyses (see Table 4) showed that a higher sense of community at post-intervention, was associated with a higher likelihood of having attended the walking sessions every week (OR = 1.16, 95 % CI = 1.05, 1.28) and to have continued walking with the walking group up to three months after the intervention (OR = 1.16, 95 % CI = 1.02, 1.30), but not with the intention to continue walking after the intervention (OR = 1.18, 95 % CI = 0.99, 1.14). Higher scores on social capital and collective efficacy were also associated with a higher likelihood of having attended the walking sessions every week (subsequently (OR = 1.76, 95 % CI = 1.32, 2.35) and (OR = 1.50, 95 % CI = 1.09, 2.08)), to having the intention to continue walking with the walking group (subsequently (OR = 2.29, 95 % CI = 1.50, 3.49) and (OR = 2.11, 95 % CI = 1.32, 3.38)), and to have continued walking with the walking group up to three months after the intervention

Table 3
Overall changes in primary intervention outcomes on imputed data.

	Baseline (T0)[a]	Postintervention (T1)[a]	Follow-up (T2)[a]	t (df)[b]	p[b]	t (df)[c]	p[c]
Emotional well-being	63.52 (21.14)	66.67 (19.72)	66.89 (21.07)	3.15 (357.0)	<0.001	3.37 (295.8)	<0.001
Diabetes self-management	6.56 (1.21)	6.82 (1.16)	6.77 (1.15)	4.72 (356.4)	<0.001	3.76 (310.8)	<0.001
Minutes of walking per week	234.7 (235.9)	258.6 (274.2)	193.4 (187.0)	1.41 (257.4)	0.16	2.71 (268.3)	0.01
BMI (kg/m^2)	30.98 (5.00)	30.65 (5.10)	30.81 (4.94)	2.20 (171.5)	0.03	1.0560 (130.8)	0.12
HbA1c	57.91 (13.40)	58.48 (12.16)	60.05 (10.140)	0.37 (142.9)	0.71	1.43 (155.2)	0.15
Diabetes self-efficacy	3.50 (0.73)	3.69 (0.72)	3.60 (0.74)	4.96 (226.0)	<0.001	2.58 (232.7)	0.01
Perceived social support	5.32 (1.34)	5.41 (1.31)	5.47 (1.34)	1.47 (181.8)	0.14	2.54 (254.1)	0.01

Notes.
[a] Mean ± SD.
[b] comparison between baseline and post-intervention.
[c] comparison between baseline and follow-up.

Table 4
Multinomial logistic regression of community factors on intervention engagement, intention to continue walking after the intervention, and maintenance of behavior after the intervention on imputed data.

Dependent variables	Sense of community		Collective efficacy		Social capital		Social support	
	OR	**95 % CI**	**OR**	**95 % CI**	**OR**	**95 % CI**	**OR**	95 % CI
Intervention engagement								
Participated every week	1.16**	1.05–1.28	1.50*	1.09–2.08	1.76**	1.32–2.35	1.06	0.89–1.27
Did not participate every week	Ref		Ref		Ref		Ref	
Intention to continue walking								
Yes, together with the walking group	1.18	0.99–1.41	2.11**	1.32–3.38	2.29**	1.50–3.49	1.09	0.81–1.47
Yes, but not with the walking group	0.93	0.77–1.12	1.28	0.82–1.99	1.03	0.67–1.58	1.04	0.75–1.45
No intention to continue walking	Ref		Ref		Ref		Ref	
Maintenance of behavior								
Yes, together with the walking group	1.16*	1.02–1.30	1.46**	1.10–1.95	1.48**	1.12–1.97	1.23*	1.02–1.50
Yes, but not with the walking group	1.09	0.97–1.23	1.13	0.86–1.49	1.16	0.86–1.58	1.26*	1.01–1.56
No, did not continue walking	Ref		Ref		Ref		Ref	

Notes. CI, confidence interval; OR, adjusted odds ratio; Ref, reference category of the dependent variable.
*$P < .05$, **$P < .01$.

(subsequently (OR = 1.48, 95 % CI = 1.12, 1.97) and (OR = 1.46, 95 % CI = 1.10, 1.95)). See Supplementary Table 3 for mean scores on community factors per behavior maintenance outcomes.

3.4. Associations of perceived social support with behavior maintenance outcomes

Multinomial logistic regression analyses showed that higher perceived social support at post-intervention, was associated with a

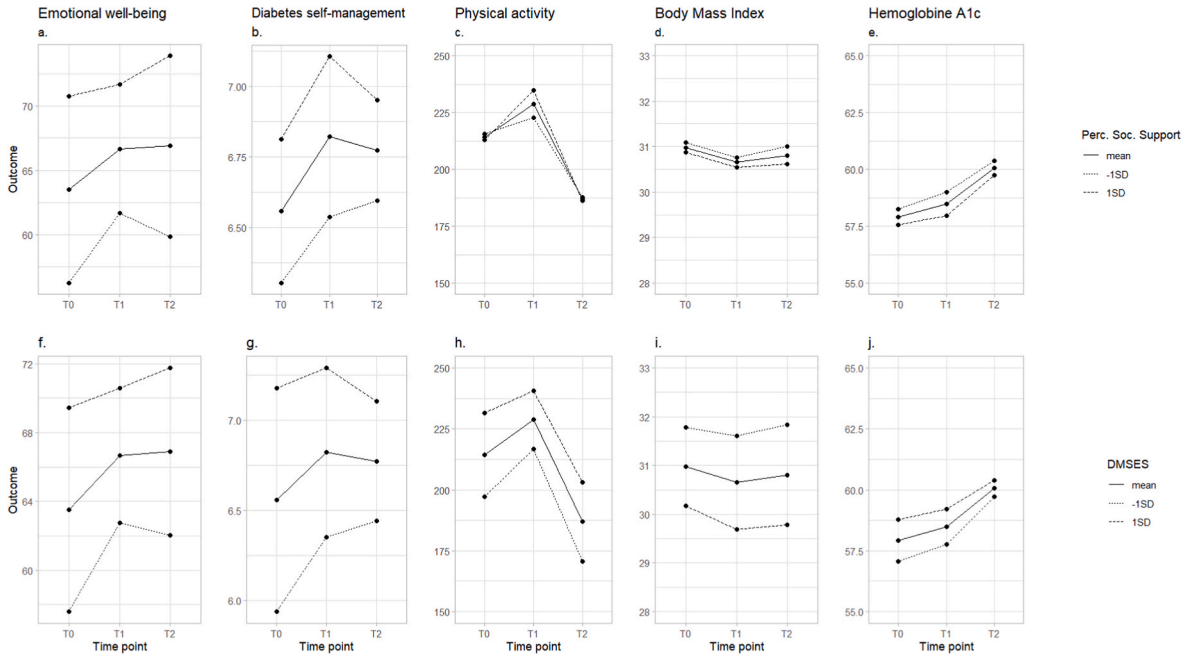

Fig. 1. Associations between baseline social support and perceived diabetes self-efficacy (DMSES) and changes in emotional well-being, diabetes self-management, physical activity behavior (number of minutes of walking per week), BMI, and HbA1c during a 20-week walking intervention and at 3-month follow-up.

higher likelihood of having continued walking either with (OR = 1.23, 95 % CI = 1.02, 1.50) or without the walking group (OR = 1.26, 95 % CI = 1.01, 1.56) up to three months after the intervention (see Table 4). No significant difference was found in intervention engagement or intention to continue walking after the intervention based on perceived social support.

3.5. Associations between baseline social support and diabetes self-efficacy and changes in primary outcomes

A multilevel linear regression analysis showed a main effect of perceived social support on emotional well-being at baseline and over time, and an interaction effect at post-intervention. People with higher perceived social support at baseline also reported higher scores in emotional well-being at baseline ($p < .01$). We found that this difference diminishes during the intervention ($p < .05$), indicating that people with lower levels of perceived social support at baseline improve on emotional well-being during the intervention regardless of how much social support they experience. This effect is, however, not sustained at follow-up: For those participants with low perceived social support, emotional well-being decreases after intervention from post-test to follow-up (see Fig. 1a). Similar results are found for the main and interaction effect between diabetes self-efficacy and emotional well-being (see Fig. 1f); the higher the score on diabetes self-efficacy the higher the scores on emotional well-being at baseline ($p < .01$), with the difference diminishing during the intervention ($p < .05$), indicating that people with lower levels of diabetes self-efficacy at baseline improve on emotional well-being during the intervention regardless of how much self-efficacy they experience. However, this is not sustained after the intervention. See Supplementary Table 4a for complete regression models.

A main effect of perceived social support and diabetes self-efficacy was found on diabetes self-management, meaning the higher the perceived social support ($p < .01$) and diabetes self-efficacy ($p < .01$) at baseline the higher the scores on diabetes self-management at baseline (see Fig. 1b and g). At post-intervention and follow-up, there is a significant interaction effect of diabetes self-efficacy on diabetes self-management (see Fig. 1g); the difference in diabetes self-management behavior based on diabetes self-efficacy diminishes during and up to three months after the intervention. This suggests, that diabetes self-management improves among those with lower self-efficacy, across time. No significant interaction effect of social support was found on diabetes self-management behavior. No significant main or interaction effects of social support and diabetes self-efficacy were found on change in the number of minutes of walking per week, HbA1c, or BMI (see Fig. 1c–j and Supplementary Table 4a and 4b for complete regression models).

4. Discussion

The current study investigated to what extent community factors are related to behavior maintenance outcomes among people with type 2 diabetes participating in a walking intervention. We found that favorable community factors and perceived social support were positively associated with intervention engagement, intention to continue walking after the intervention, and maintenance of physical activity behavior up to three months following the intervention. Furthermore, we found that perceived social support and diabetes self-efficacy were positively associated with changes in diabetes self-management and emotional well-being; people who score lower on social support and diabetes self-efficacy at baseline seem to benefit most from the intervention.

4.1. The association of community factors and social support with behavior maintenance outcomes

We found that participants with higher levels of sense of community, collective efficacy and social capital were more inclined to attend the intervention consistently throughout the 20-week period and, more interestingly, that they were more likely to have continued walking with their group three months after the intervention. Moreover, participants with a higher level of collective efficacy and social capital were more likely to indicate that they intend to continue walking within their respective groups after the intervention.

These results suggest that people might have difficulty persevering on their own after the intervention and that a sense of belonging to a group, feelings of connectedness, a shared belief in the capacity to take collective action, and shared values and norms helps in persevering with the intervention and to sustain the physical activity behavior at least up to three months after the intervention. This is consistent with previous studies that found an association between feeling connected to one another and social network with more engagement to a physical activity intervention (Deslippe et al., 2023; Farrance et al., 2016; Heinrich et al., 2022). Furthermore, community factors may play a role in shaping the intention to sustain the behavior afterwards as people are more inclined to sustain behavior that is approved by the group (Ajzen, 1991) which may be more pronounced in groups with a higher collective efficacy and social capital. Conversely, sense of community was not related to the intention to continue walking after the intervention (albeit a trend towards statistical significance), suggesting that feeling more effective as a group and sharing similar goals, values and norms seems of more importance in expressing the intention to continue walking than feeling connected to one another. Although the specific association of sense of community and collective efficacy with behavior change or maintenance has not been studied within the context of a physical activity intervention or in people with type 2 diabetes before, multiple studies found an association between other social and community factors such as social support, group membership, and social norms with behavior change and behavior maintenance (Bandura, 1997; Kwasnicka et al., 2016; Plotnikoff et al., 2008; Ryan and Deci, 2000). Sense of belonging and shared belief in the groups capacity to undertake collective action are concepts that align closely with the fundamental psychological needs of relatedness and competence. These needs are recognized as two of the primary drivers of intrinsic motivation according to the self-determination theory (SDT). Social contexts that meet these needs, such as a walking group as facilitated by the NDC, might contribute to engagement in health behavior, provide additional benefits of participating besides health, and foster sustained behavior change, and better health outcomes of individuals (Kwasnicka et al., 2016; Ryan and Deci, 2000).

Regarding perceived social support we found no significant difference in intervention engagement or intention to continue walking after the intervention based on perceived social support. This suggests that the extent to which one feels supported by one's environment (e.g., family and friends) is not related to how involved one was in the intervention or to forming the intention to continue walking with their walking group. Furthermore, the results showed that the higher the perceived social support at post-intervention, the more likely participants were to have continued walking either with or without their walking group up to three months after the intervention. This suggests that participants do persevere on their own after the intervention if they experience a higher perceived social support which might be independent from the level of community they have experienced within their walking group.

4.2. The association of perceived social support and diabetes self-efficacy with change in health outcomes

We showed that emotional well-being, diabetes self-management behavior and diabetes self-efficacy significantly improved during the intervention. These increases are maintained up to three months after the intervention, indicating a sustained change. Interestingly, particularly participants experiencing low social support and diabetes self-

efficacy at baseline seem to benefit most from the intervention, bringing them to a similar level in emotional well-being as those already experiencing higher levels of support. However, at follow-up, participants who initially had low social support do not maintain their gains in emotional well-being, indicating an apparent loss of support and self-efficacy as the intervention stops. A similar effect was found for diabetes self-efficacy in relation to change in diabetes self-management; at post-intervention and follow-up, participants who at baseline were less confident about being able to perform diabetes self-management behaviors became more alike to those who already experienced confidence in the actual engagement in diabetes self-management behavior. A possible explanation could be that the participants learned from each other with people with a higher diabetes self-efficacy and likely more engagement in diabetes self-management behavior becoming a role model for participants with low self-efficacy. Overall, the intervention appeared particularly beneficial for participants with initial low social support or diabetes self-efficacy, bringing their outcomes on emotional well-being and self-management behaviors closer to those with higher initial support or self-efficacy. Although the gain in emotional well-being subsided somewhat after the intervention, this is expected and the positive experience with engaging in the intervention and experiencing improvements may have a more lasting impact. It might potentially alter participants' outlook on managing a challenging condition like diabetes and increase their motivation to rejoin programs like the NDC to regain that positive experience.

4.3. Strengths and limitations

The current study contributes to previous literature on behavior change and maintenance by providing more insight on the relation between community factors and participation to a behavior change intervention and maintenance of behavior. To the best of our knowledge, there is no research on sense of community, social capital and collective efficacy, and their relation to behavior change and health outcomes in people with type 2 diabetes. Various health behavior interventions have shown to be effective in helping people change their behavior, but often this behavior is not maintained afterwards. It is therefore valuable to identify factors that help facilitate sustained behavior change, such as community factors, and integrate them in health behavior interventions. A limitation of the present study is that due to methodological issues we were not able to evaluate changes in the community factors as these were only measured at post-intervention, and hence we could not evaluate whether the NDC contributes to change in community factors and if this change mediates or moderates the intervention effects. An important methodological consideration is the extent to which our measures captured the theoretical concepts of interest. In particular, the construct community was operationalized through participants' reported sense of belonging, social capital, and collective efficacy within their walking group. While not covering all possible dimensions of community, this approach allowed us to meaningfully examine the role of group-based community dynamics in supporting engagement and behavior change. Another methodological consideration is that a third of the participants had participated in the intervention before, which could have influenced certain outcomes such as self-efficacy. However, it was not our aim to study the effectiveness of the intervention. Moreover, including all participants reflects the real-world setting of the program, where repeated participation is common, and thus supports the generalizability of our findings. Another limitation is the high amount of missing data. Even though multiple imputation is a robust way of imputing missing data (Van Buuren, 2018; White et al., 2011), when the missingness is high, the data can be imputed less accurately, potentially increasing estimation error and reducing the statistical power of our analyses. Furthermore, while a controlled design with a comparison group and a difference-in-differences analysis would have been methodologically preferable to assess causal effects, this was not feasible due to practical constraints. As a result, the current study does not allow for causal inference. Moreover, possibly the SQUASH is not reliable enough to measure change in physical activity, whereas an objective measure such as the activity tracker used in the former NDC study (Regeer et al., 2020) is. In contrast to results derived from this earlier study (Regeer et al., 2020), we found no significant increase in minutes of walking per week during the intervention as measured with the SQUASH in the current study. We did find a significant decline in minutes of walking per week between post-intervention and follow-up. This decline in physical activity is often observed after interventions and might be explained by the difficulty participants may experience in maintaining their behavior without support, or a seasonal effect. Another possible explanation is that participants overestimated their level of physical activity at baseline and became more aware of their actual level of physical activity during the intervention and accordingly made a more realistic estimate after the intervention and follow-up.

4.4. Conclusion

In conclusion, the key finding of this study is that community factors and social support seem to facilitate increased participation and maintenance of behavior. The study further indicates that participants with type 2 diabetes who previously experienced deficits in key determinants of positive health outcomes, such as low social support and low diabetes self-efficacy, showed significant improvement in emotional well-being and diabetes self-management behavior during the intervention. The results suggest that these previously limiting factors became less influential as participants progressed through the intervention. Our results contribute to the growing body of evidence emphasizing the importance of social and community factors in promoting sustained engagement in behavior change interventions and behavior maintenance after the intervention and therefore better health outcomes in people with type 2 diabetes. A recurring community intervention, such as the NDC, might be of significant value in achieving sustained behavior change through integration of social support and community strategies such as facilitating shared goals and identity, social comparison and modeling of desired behavior by peers. Our current results show a positive association between community factors and sustained behavior change, suggesting community as a potential mechanism of action for achieving sustained behavior change, and highlighting the power of a community approach, rather than an individual intervention approach. For future research, it would be interesting to measure change in community over the course of the intervention. Doing so could help reveal whether people whose sense of community changes during the intervention also benefit more from the intervention regarding the health and behavioral outcomes, and to identify through which elements the NDC contributes to change in community factors and important behavior maintenance outcomes. Investigating these pathways in greater depth would not only clarify how the intervention works but also inform the design of more effective and sustainable community-based programs.

CRediT authorship contribution statement

Hannah Regeer: Writing – original draft, Methodology, Data curation, Conceptualization. **Arjan Huizing:** Writing – review & editing, Visualization, Methodology, Formal analysis, Data curation. **Henk J.G. Bilo:** Writing – review & editing, Supervision, Conceptualization. **Eelco J.P. de Koning:** Writing – review & editing, Resources. **Sasja D. Huisman:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Pepijn van Empelen:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization.

Ethical statements

This study was approved by the Medical Ethical committee of the Isala general hospital (Zwolle, the Netherlands; ref nr. 180341).

Written informed consent was obtained from participants.

The authors declare that there is no conflict of interest.

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Declaration of generative AI in scientific writing

During the preparation of this work the first author has used Chatgpt in order to improve the readability of some parts of the manuscript. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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Declaration of competing interest

None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2025.118730.

Data availability

Data will be made available on request.

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