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ORIGINAL ARTICLE

A novel approach to increase physical activity in older adults in the community using citizen science: a mixed-methods study

Anja Frei[1] · Kaba Dalla Lana[1] · Thomas Radtke[1] · Emily Stone[1] · Nevil Knöpfli[1] · Milo A. Puhan[1]

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Abstract

Objectives The aims of this study were to implement a novel, community-based physical activity (PA) intervention in a Swiss town with active participation of elderly participants and to evaluate its effectiveness, feasibility, acceptability and sustainability.

Methods The CAPACITY intervention combined important determinants of PA, used smartphone apps to provide feedback/facilitate interaction, and followed a citizen science approach to enable participants to organize walking groups. We targeted persons > 60 years from Wetzikon. Assessments took place at baseline and after 6 months, during this intervention period, and 11 months after step-wise withdrawal of the study team.

Results Twenty-nine persons were included in the study; 25 conducted 6-month follow-up. They had a significant increase in moderate-to-vigorous PA ($p = 0.046$) but not in daily steps ($p = 0.331$). After the intervention period, key participants took over organization, independently organized monthly get-togethers, added new walking routes and continuously recruit new participants. Eleven months after withdrawal of the study team, 61 people regularly walk in groups together.

Conclusions The novel CAPACITY intervention was successfully implemented, transferred to participants and is now self-sustainable for almost 1 year in the community.

Keywords Physical activity · Walking intervention · Elderly · Community · Citizen science · Long-term sustainability · CAPACITY

Introduction

Physical inactivity (PA) is the fourth leading risk factor for global mortality, accounting for 6% of deaths worldwide (World Health Organisation 2010), and a risk factor for the development and prognosis of chronic diseases (Lee et al. 2012). For older adults who often suffer from chronic conditions, PA is particularly important to stay independent, to maintain quality of life, and to cope with potential diseases (UK Government 2011; Physical Activity Guidelines Advisory Committee 2018).

The evidence about effectiveness of PA promotion interventions for elderly people and people with chronic diseases, ranging from simple advice from general practitioners to complex telehealth interventions, is heterogeneous. While some studies showed increases in PA through, for example, behavioral interventions or promoting walking in groups (Kassavou et al. 2013), others did not show any effects (Bravata et al. 2007; Orozco et al. 2008; Conn et al. 2011; Orrow et al. 2012; Fanning et al. 2012). One explanation for the lack of effectiveness of many PA promotion interventions is that these interventions focus only on individual factors that determine levels of PA such as personal motivation, preferences for specific activities or limitations due to existing diseases.

Research shows that determinants of PA go well beyond individual factors, as addressed in the medical context, and include interpersonal factors (e.g., family support, cultural norms), social environment (e.g., seeing others active),

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✉ Anja Frei
anja.frei@uzh.ch

[1] Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Hirschengraben 84, 8001 Zurich, Switzerland

built environment (i.e., cities, transport system) and natural environment (e.g., topography, recreational zones) as well as regional or national policy (e.g., PA plans, urban planning) (Bauman et al. 2012). Some factors are static or change slowly (e.g., built and natural environment), while others are more dynamic (e.g., interpersonal factors and social environment). When designing PA promotion interventions that take multiple determinants into consideration, it is important to face some realities (e.g., city infrastructure cannot be rebuilt overnight) and to benefit from existing opportunities (e.g., existing walking trails, modern communication tools, etc.) (Heath et al. 2012).

Against this background, we developed a novel, three-pronged, community-based approach to promote PA for elderly people: the CAPACITY intervention (Citizen-driven Approach to Increase PA in Older Adults Living in Urban Environments; official name of the intervention is "ZÄMEGOLAUFE", Swiss German for "walking together"). The intervention considered multiple determinants of PA [i.e., individual, interpersonal, environmental and local policy factors (Bauman et al. 2012)], used current technology to provide personal feedback and facilitate social interaction, and followed a dynamic citizen science approach in which participants could participate in the development of the intervention.

We aimed to implement the CAPACITY intervention sustainably into a typical Swiss town with active participation of the target population and to evaluate the intervention for effectiveness, feasibility, acceptability and sustainability.

Methods

Setting, participants and recruitment

Our target population was persons aged 60 years or older who lived within or < 5 km from Wetzikon (Swiss town in Zurich area with 24,640 inhabitants), who spoke and understood German, and who did not perform in the highest 25th percentile in the 1-min sit-to-stand (1-min STS) exercise capacity test compared to the Swiss general population [age and sex-specific reference values (Strassmann et al. 2013)]. Exclusion criteria were safety concerns (symptomatic/unstable cardiovascular disease, cardiac surgery within the last year).

To recruit the initial group of participants, we hosted an information event on May 4, 2016. This event was promoted through several channels: verbally by the project team at six different local events for elderly people, by a newspaper advertisement, by distribution of 1000 flyers (directly into mailboxes in elderly homes, provided at events, handed out to health care professionals and stakeholders), and by an advertisement displayed in the window of a centrally located pharmacy. 49 persons attended the information event.

After inclusion of the initial group of participants, we continued to recruit persons during 6 months. We informed participants that they could invite friends and peers who fulfilled the inclusion criteria to join the intervention. We also used additional recruitment channels (flyers, presentation at events, website http://www.zämegolaufe.ch/ and a newspaper article). Recruitment ended on December 1, 2016.

The study has been approved by the ethics commission Zurich (KEK Zurich, PB-2016-00885) and is registered in ClinicalTrials.gov (NCT02744924). Informed consent was obtained from all individual participants included in the study.

CAPACITY intervention

An interdisciplinary study team developed the intervention with the aim to tailor it to the needs of the target population and to embed it into the political and social context of the target town. To learn about the target population's needs, we conducted a focus group with four elderly persons from Wetzikon on August 26, 2015. Moreover, the study team contacted key persons from the local policy and service organizations for the elderly (senior citizens commission, Spitex, Pro Senectute, nursing homes, civic commission) as well as with the local police, and conducted individual interviews with eight representatives.

The overall aim of the intervention was to enable and encourage the participants to organize structured walking groups in their neighborhoods. The study team initially provided participants with six mapped walking trails of three different intensity levels, described in a participant handbook (Supplementary Fig. 1). Participants also received a study smartphone together with a belt to wear the smartphone. The smartphone provided access to a step-counter app to monitor one's own steps and the average steps of the group, to a calendar app (Google calendar) where time and meeting places of the group walks were displayed and to a messenger app (WhatsApp) to enable communication between participants, and between the participants and study team (WhatsApp group; Supplementary Fig. 2). Between baseline visit 1 and 2, the participants used the step-counter app for 1 week. During baseline visit 2, the study team discussed with them individual and specific benefit of being more physically active and agreed on short- and long-term step goals.

After baseline visit 2 of the initial group of 13 participants, the study team organized a kick-off event for the official start of the intervention where the participants met in small groups with persons with comparable fitness levels

and arranged the first walking groups on trails with appropriate intensity levels. After the initial support of the study team, the participants were encouraged to arrange regular walking groups themselves. They reported newly scheduled walks to the study team who entered them into Google calendar and sent reminders by WhatsApp messages. As new participants joined, the study team connected them to suitable groups and walking group leaders.

Monthly, the study team arranged informal group get-togethers where participants could meet for informal exchange with each other and the study team. The intervention period lasted from June 2016 until June 2017; for each participant 6 months. Table 1 outlines the elements of the CAPACITY intervention.

Transfer process of the intervention from the study team to the participants

Five months before the last participant completed the 6-month follow-up assessment, a study team member began to transfer responsibility for the walking groups to three key persons (i.e., participants who were enthusiastically involved and motivated to take an active role in this process). These three leaders were empowered to sustain the intervention in the long term. Support in the initial phase was provided for (1) transfer of organization skills, technical knowhow, user rights and new channels to publish scheduled walking groups to inform participants (use of Google calendar and WhatsApp messenger, linking of Google calendar with study homepage http://www.zämegolaufe.ch/, administrative process to register new participants, smartphone support etc.), (2) identifying new and appropriate recruitment strategies and (3) search for funding to finance a new flyer and ten smartphones to lend to future participants without their own smartphones.

Assessments

We evaluated the *effectiveness* of the intervention in a prospective pre-post design. Baseline assessments took place before the start of the intervention during two study visits (7 days apart); follow-up assessments were conducted after 6 months. PA was measured between the two baseline visits and 1 week before follow-up using a triaxial accelerometer (ActiGraph® wGT3X-BT, Pensacola, FL, USA). PA outcomes were average daily number of steps (primary outcome) and average number of minutes spent in moderate-to-vigorous intensity PA (MVPA; for details please see Supplementary Material) (Choi et al. 2012; Santos-Lozano et al. 2013; Aguilar-Farías et al. 2014).

Further assessments included exercise capacity [measured as number of repetitions in 1-min sit-to-stand test [1-min STS] (Strassmann et al. 2013)], health-related quality of life and health status [measured by EQ-5D-5L (Devlin and Krabbe 2013) and feeling thermometer (Puhan et al. 2005)], symptoms of anxiety and depression [measured by Hospital Anxiety and Depression Scale [HADS] (Snaith 2003)] and perceived social support [measured by the short version of the Social Support Questionnaire [F-SozU] (Fydrich et al. 2009)].

To evaluate *feasibility and acceptability of the intervention*, we conducted two structured interviews with the participants: at the participants' home (< 2 month after baseline assessments) and during the 6-month follow-up assessment visit. The aims of the interviews were to learn about recruitment channels/strategies, factors for participation, expectations and motivation (first interview) and about satisfaction with specific elements, perceived effectiveness, and ideas for optimizing the program and transfer of the intervention (second interview). The results provided information for the development of a guidance manual to implement the CAPACITY intervention in other Swiss cities. In addition, the participants filled-in a written satisfaction questionnaire during the 6-month follow-up visit.

To evaluate *use of the messaging app*, we focused on the intervention period of the initial group of participants (June–December 2016) and imported all WhatsApp messages sent during this period into a Microsoft® Excel file. The messages were coded according to the following categories: general characteristics (2 sub-categories), content (14 sub-categories) and social support [5 sub-categories (Cutrona and Suhr 1992)]. The categories and sub-categories were determined a priori and pre-tested by a first and a second encoder who categorized two random samples of 100 and 200 messages, discussed ambiguities and adapted category descriptions and sub-categories, if applicable. To assess interrater reliability, a third random sample of 100 messages was used and, again, independently coded by the two encoders.

To assess *sustainability*, we followed the project after the official study end from June 2017 until end of May 2018. We assessed the total number of participants and the main project-related changes (e.g., recruitment strategies) by contacting a key person by telephone and e-mail in May 2018. We further assessed the number of conducted walking trails by counting Google calendar entries and new walking trails that were established during this period.

Analyses and sample size

Baseline characteristics on participants' demographics and anthropometrics are presented as mean ± standard deviation (SD) and numbers and percentages. Outcome variables (not normally distributed) are summarized as median and interquartile range (IQR). We analyzed the changes before/after intervention of continuous outcome variables using

Table 1 Elements of the CAPACITY intervention categorized into the levels of determinants of physical activity proposed by Bauman (2012) [(Bauman et al. 2012) (CAPACITY study, Switzerland, 2015–2018)]

Level	Element	Detailed description
Individual	Step-counter app and agreement on short- and long-term step goals	At baseline visit 1, the participant received a smartphone with a step-counter app (specifically adapted "SRF bewegt" app) together with a belt bag. They were instructed to carry the smartphone when leaving the house. At baseline visit 2 (after 7 days), the study team fed back the average daily steps and discussed agreed together with the participant on a short-term (1 month) and a long-term (6 months) step goal (aspired: 10 and 30%, respectively, higher than the current average). The goals were reported in the participant handbook. During the intervention period, participants were encouraged to monitor their steps. Besides the individual steps, the app also provided the average number of steps of the whole group (totally and per day), and the participants were incentivized to reach their goals through a "gamification" approach, where they received "trophies" by the app when they attained a specific amount of steps
	Individual benefits	During baseline visit 2, the study team discussed with the participants based on motivational interviewing techniques their personal and specific benefits to increase physical activity and reported it in the participant handbook
	Estimation of fitness level	The participants' personal fitness level was roughly estimated by the study team by triangulation of the result in the 1-min sit-to-stand exercise capacity test (in relation to reference values from the Swiss population (Strassmann et al. 2013)) and the average daily steps walked during the first week. This information was fed back to the participants during baseline visit 2; the knowledge of the own personal fitness level was relevant to participants to find peers with similar levels to organize walking trails during the kick-off event
Interpersonal	Messaging app and calendar app	During baseline visit 2, the study team linked WhatsApp and Google calendar app on the participants' smartphones with the group's contacts (participants' phone numbers), so that all participants and a study team smartphone were linked together in a WhatsApp group chat and had access to the CAPACITY calendar. The study team used the WhatsApp chat to send reminders 24 h before group walks started, to communicate other events and for general information. The participants were encouraged to use the chat for communication between each other and to contact the study team in case of questions. In the calendar app, all planned walking groups were presented, including starting time and place and peer contact
	Monthly group get-togethers	The study team organized each month informal group get-togethers (regulars' table, "Stammtisch" in German) where participants could meet and exchange between each other and the study team, where help was provided in case of problems with the smartphone and where information was provided
	Recruitment of friends/peers	During the 6 months of recruitment, the participants were encouraged to invite people who fulfill the inclusion criteria to join the intervention
Environment	Walking trails	During the preparation process, the study team developed six walking trails in the urban and rural area of Wetzikon with different intensity levels. The walking trails were presented in the participant's handbook, illustrated by maps and described regarding distance in kilometers, by numbers of expected steps needed (assuming average step length of 60 cm), difference in altitude, accessibility of walking assistance like a walking frame, closed parking place, bus stop, specific attractions and restaurants as well as seating possibilities and public toilets on the trail. The six trails were two city circuits (0.9–1.6 km) and four mainly rural circuits (2.5–4.3 km) outside the city center. In addition to the walks, we recommend to perform strengthening exercises with own body weight 2–3 times per week
		During the kick-off event, the participants were helped to find peers with similar exercise capacity levels and to arrange together the first walking groups in trails with appropriate intensity levels and according to suitable times. Walks were usually led by peer group leaders, and at special events, study team members participated. Participants usually scheduled new walks after they walked one and informed the study team about new times, who included the new arrangements into the Google calendar and sent reminders by WhatsApp messages. Later included participants were introduced by the study team to suitable groups and connected with walking group leaders

Table 1 (continued)

Level	Element	Detailed description
Regional policy	Involvement of local politics and relevant stakeholders	During the early phase of the preparation process, the study team got in contact with key persons from the local policy and service providers for the elderly (senior citizens commission, Spitex, Pro Senectute, nursing homes, civic commission, national churches) and conducted personal interviews with eight persons. The aim was to embed it optimally into the political and social situation of the town. The project was presented at several events organized for elderly people in Wetzikon

The overall aim of the intervention was to connect, enable and encourage the participants to organize themselves for structured walking groups in their neighborhood

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Wilcoxon signed-rank tests. We summarized the interview answers and the sustainability results according to content, reported numbers and/or frequencies, and synthesized the content. Regarding messaging app use, we reported frequencies of the allocated codes and assessed interrater reliability by Cohen's Kappa statistics (0.41–0.60 = moderate, 0.61–0.80 = substantial, 0.81–1 = almost perfect agreement). Analyses were conducted using Stata (version 13.1; StataCorp, College Station, TX, USA).

Sample size calculation was based on the change of steps/day (primary outcome of PA evaluation part). In the absence of a minimal important difference, we assumed an effect size of 0.5 and a SD of 3000 (Tudor-Locke et al. 2011; Harris et al. 2015) resulting in a difference of 1500 steps/day which we aimed to detect. Assuming a power of 0.95 and a level of significance of $\alpha = 0.05$, a sample size of 54 participants is needed, with an estimated drop-out rate of 25% resulting in 70 participants (statistical software nQuery+nTerim 3.0).

Results

Participants

In total, 29 persons were included in the study: 16 right after the information event (initial group) and 13 during the following 6 months of recruitment. Three-quarters ($n = 22$) of the participants were female, with an age range from 61 to 91 years and a mean age of 75.4 years. Table 2 summarizes the baseline characteristics of the participants.

Follow-up assessments were conducted for 25 participants; for 22 persons according to protocol after 6 months and for 3 participants prematurely after 3–4 months. During the intervention period, 14 participants experienced a total number of 20 adverse events and six serious adverse events (not related to the intervention); four participants dropped out of the study due to these events (75% women; mean age 80.3 years). Seven participants experienced an adverse event during the week of PA follow-up assessment.

Table 2 Baseline characteristics (CAPACITY study, Switzerland, 2015–2018)

Characteristic	$N = 29$
Age, years	75.4 ± 7.8
Sex, female, *n* (%)	22 (75.9)
Marital status, *n* (%)	
Married or cohabiting	14 (48.3)
Widowed and living alone	10 (35.5)
Divorced or single and living alone	5 (17.2)
Working status, *n* (%)	
Retired (old-age pension)	27 (93.1)
Employed	1 (3.5)
Disability pension	1 (3.5)
Most recent job situation, *n* (%)	
Self-employed/CEO	8 (27.6)
Employed as qualified staff with leading position	3 (10.3)
Employed as qualified staff without leading position	14 (48.3)
Employed in unqualified position	4 (13.8)
Education (highest degree), *n* (%)	
Elementary school	8 (27.6)
High school or apprenticeship	15 (51.7)
University/university of applied sciences	6 (20.7)
Smoking, *n* (%)	
Current	2 (6.9)
Former	10 (34.5)
Never	17 (58.6)
BMI kg/m^2	27.8 ± 4.1
No. of diseases	3.8 ± 2.3
Category of disease groups, no. of diseases	
Cardiovascular disease group	11
Neurologic/cerebrovascular disease group	14
Metabolic/endocrine disease group	5
Musculoskeletal disease group	28
Pulmonary disease group	4
Psychiatric disease group	6
Other diseases	30

Data are presented as mean (SD), unless otherwise stated

BMI body mass index; *CAPACITY* citizen-driven approach to increase physical activity in older adults living in urban environments; *CEO* chief executive officer

Table 3 Median scores (interquartile ranges) for physical activity variables, exercise capacity tests and patient-reported outcomes, at baseline and follow-up and change after intervention (CAPACITY study, Switzerland, 2015–2018)

	Baseline $N = 29$[a]	Follow-up $N = 25$[a]	Change $N = 25$[a]	z[b]	p value[b]
Physical activity					
Steps per day	4802 (4004, 7939)	6022 (3818, 8015)	+ 285 (− 1047, + 2135)	− 0.97	0.331
Minutes in MVPA per day[c]	19.3 (12.8, 40.3)	29.0 (19.1, 54.0)	+ 7.9 (− 7.0, + 25.6)	− 2.00	**0.046**
Minutes in light PA per day[c]	314.9 (282.8, 363.4)	308.1 (258.8, 355.2)	+ 3.6 (− 52.56, + 16.0)	0.40	0.690
Minutes in sedentary time per day[d]	468.1 (418.2, 512.2)	478.4 (402.0, 531.3)	− 15.6 (− 43.0, + 46.2)	0.29	0.775
1-Minute sit-to-stand test (repetitions)	24 (22, 28)	28.5 (21.5, 28.5)	+ 0.5 (− 2.0, + 5.0)	− 1.08	0.283
EQ-5D-5L index value	0.887 (0.788, 0.999)	0.828 (0.810, 0.910)	0 (− 0.1, + 0.01)	0.70	0.487
Feeling thermometer	79 (70, 90)	79 (60, 89)	− 2 (− 10, + 5)	1.16	0.250
HADS depression	4 (2, 6)	4 (2, 7)	− 1 (− 1, 1)	0.86	0.393
HADS anxiety	5 (2, 6)	6 (4, 8)	0 (− 1, 1)	− 0.60	0.548
Perceived social support (S-SozU, short version)	4.6 (3.5, 4.8)	4.6 (4.1, 4.9)	+ 0.1 (− 0.1, + 0.1)	− 1.49	0.137

Data are presented as median scores (interquartile ranges), unless otherwise stated

CAPACITY citizen-driven approach to increase physical activity in older adults living in urban environments; *MVPA* moderate-to-vigorous physical activity; *PA* physical activity; *EQ-5D-5L* EuroQuol-5 dimensions-5 levels; *HADS* hospital anxiety and depression scale; *F-SozU* "Fragebogen zur sozialen Unterstützung" (questionnaire to assess perceived social support)

[a]Baseline: $n = 29$, except for physical activity scores and 1-min sit-to-stand repetitions ($n = 28$)/Follow-up and change: $n = 25$, except for physical activity scores and 1-min sit-to-stand repetitions ($n = 24$)

[b]Wilcoxon matched-pairs signed-ranks test

[c]MVPA: $\geq$ 2752 counts/minute and light PA: 201-2751 counts/minute [according to Santos-Lozano (2013)]

[d]Sedentary time: 0–200 counts/minute [according to Aguilar-Farías et al. (2014)]

During the intervention period, from June 2016 until June 2017, the participants walked a total of 252 trails (average 21.0/month) and proactively developed five additional walking trails including maps and illustrations for the participant handbook.

Pre-post comparison (effectiveness of the intervention)

Median steps per day at baseline for 28 participants (PA assessment was missing for 1 person) were 4802 (IQR = 4004, 7939) and for those 25 participants who completed follow-up 5082 (IQR = 4314, 8014). Median steps per day at follow-up were 6022 (IQR = 3818, 8015; $n = 25$), and median change in steps from baseline to follow-up + 285 (IQR = − 1047, + 2135; $n = 25$); this change was statistically not significant ($p = 0.331$). From all assessed outcomes, only minutes in MVPA per day significantly improved from baseline to follow-up with a median of 7.9 min (IQR = − 7.0 + 25.6; $p = 0.046$) (see Table 3).

Feasibility and acceptability of the intervention

Baseline interviews were conducted with 25 of the 29 participants. Regarding recruitment, participants reported most frequently that they were informed about the program verbally by project team members at events ($n = 8$), through the local newspaper (advertisement for information event [$n = 3$], article about program [$n = 4$]), by other participants [$n = 6$], by distributed flyer ($n = 5$) and by their general practitioner ($n = 2$) (multiple answers possible). Nineteen (76%) participants reported that they tried to recruit peers for the intervention.

Participants reported "social aspects, meeting people" most frequently as the reason for participation ($n = 15$), followed by "health reasons, being more physically active" ($n = 14$), "I like to walk, enjoying nature" ($n = 5$), "finding motivation in the group" ($n = 4$), "become better acquainted with Wetzikon" ($n = 3$), "commitment to walk, organized walking" ($n = 2$) and "being interested in the study" ($n = 1$).

Follow-up interviews were conducted with 25 participants. All participants gave a positive overall feedback on the intervention. Most frequently, they reported that they liked the social aspects best (without mentioning walking) and least liked challenges regarding smartphone use (e.g., due to automatic updates). Subjectively, 10 persons estimated that they walked more, 9 somewhat more, 4 similar, and 2 that they walked less than before intervention onset. On a scale from 1 (lowest value) to 10 (highest value), participants estimated their motivation to continue with the

intervention after withdrawal of the study team with a mean of 8.1 ± 1.7.

Participants indicated in the satisfaction questionnaire that they enjoyed the intervention. On a 4-point Likert-type scale, with higher values representing greater enjoyment, all participants either replied "3" (n = 8) or "4" (n = 16). 86% reported, that the program supported them very much (n = 15) or somewhat (n = 7) to walk more in daily life. On a scale from 0 (not useful at all) to 10 (very useful), participants rated the following program elements as most useful: "knowledge of regular walks in groups" (mean = 8.9), contact with other participants (mean = 8.5), contact with study team (mean = 8.4) and monthly get-togethers (mean = 7.7). Few participants reported that the apps were too complicated for them to use (n = 2–3).

Use of the messaging app

Out of the 21 categories, the interrater reliability was moderate or substantial in four categories; all other categories reached almost perfect agreement (> 0.8). For eight categories, Kappa could not be calculated.

In total, 1211 messages were sent during the intervention period in the WhatsApp chat, 62.4% (n = 756) by participants. All participants sent at least one message, ranging from 1 to 359 messages per participant (median = 7, mean = 26.0 ± 66.1). Table 4 shows the exchanged messages categorized according to general characteristics, content and social support. The most frequent themes were organization of walks (n = 159, 21.0%), other talk about study (n = 159, 21.0%), out of topic chat (n = 127, 16.8%) and photos/pictures (n = 103, 13.6%).

Table 4 Overview of 1211 exchanged messages in the WhatsApp chat from June to December 2016; categorized according to general characteristics, content and social support (CAPACITY study, Switzerland, 2015–2018)

Categories	Sent by participants (n = 756)	Sent by study team (n = 455)
General characteristics[a]		
Self-initiated message	270 (35.7)	187 (41.1)
Response	419 (55.4)	268 (58.9)
Content		
Messages used for organization of walks	159 (21.0)	n.c.
Walk reminders	0	100 (22.0)
Responses on walk reminders	21 (2.8)	n.c.
Responses without specific context	30 (4.0)	n.c.
Technical questions	38 (5.0)	n.c.
Non-technical questions	19 (2.5)	n.c.
Technical help provided	8 (1.1)	40 (8.8)
Non-technical help provided	4 (0.5)	13 (2.9)
Connecting messages	96 (12.7)	n.c.
Negative communication	2 (0.3)	0
Other talk about the study	159 (21.0)	n.c.
Out of topic chat	127 (16.8)	n.c.
Erroneous messages	67 (8.9)	0
Pictures/photos	103 (13.6)	5 (1.1)
Social support[b]		
Informational support	9 (1.2)	n.c.
Emotional support	5 (0.7)	n.c.
Esteem support	11 (1.5)	n.c.
Network support	0	n.c.
Tangible assistance	7 (0.9)	n.c.

Data are presented as numbers and percentages n (%). None-coding of messages was allowed; multiple coding of messages was allowed for content categories. "n.c.": category explicitly not coded for this group (coding instruction)

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[a] n = 67 (8.9%) messages sent by participants were erroneous messages ("f.e. S6 8jy") and were not coded as self-initiated/as a response

[b] See Cutrona and Suhr (1992)

Non-technical questions (n = 4, 0.5%) and social support (n = 32, 4.2%) were less frequent content.

Sustainability

At the end of May 2018, 38 new participants were registered and two participants from the original group dropped out, resulting in a total number of 61 participants.

The first five new participants were recruited by word of mouth recommendation. In autumn 2017, the group started recruitment predominantly by publication of the planned walking trails in two local newspapers. This recruitment strategy (free of charge publication) was initiated by a key person. In addition, the group successfully acquired funding of CHF 3000 from a non-profit organization.

During the 11 months after withdrawal of the study team, a total of 210 walking trails (average 19.2/month) and monthly get-togethers were organized. Several of the eleven existing walking trails were extended and modified. One active person enhanced the attractiveness of six walking trails in the participant handbook by including pictures and geographical and historical information (http://www.zämegolaufe.ch/).

Discussion

We developed a novel approach to promote PA for elderly people that considered multiple determinants of PA, used current technology and followed a dynamic citizen science approach. We implemented the intervention in the Swiss town of Wetzikon. Participants were successfully involved in the transfer of the intervention to a self-sustained program. Eleven month after withdrawal of the study team, the number of elderly people who regularly walk in groups together has more than doubled.

Interestingly, after 6 months of intervention, the participants significantly increased time in health-relevant MVPA, but not in daily steps. The sample was underpowered for the first part of CAPACITY, and it remains unclear whether the effect on daily steps would have been statistically significant with a larger sample size. However, it is promising that the intervention showed an effect on the intensity of PA, which is particularly relevant for health (World Health Organisation 2010; UK Government 2011). No effect was shown for any of the assessed patient-reported outcomes (quality of life, symptoms of depression and anxiety or perceived social support). One possible reason is that the intervention integrated multiple approaches and was not tailored to address specific constructs such as symptoms or quality of life.

The novel community-based PA intervention consisted of multiple approaches to promote PA. On the one hand, it considered several determinants of PA. Notably, participants rated interpersonal elements like contact with others as more useful compared to individualized elements such as feedback on daily steps and agreement on personal step goals, which have been shown to be effective in other studies (Harris et al. 2015; Demeyer et al. 2017). However, they felt motivated by getting feedback on their PA and attempted to reach their individual step goals. The consideration of environmental elements, i.e., the possibility to conduct the walking groups in the participants' neighborhoods, facilitated accessibility and increased participation in the walking groups. A similar approach to provide easily accessible walking trails in the natural environment of the target population to increase PA has recently been presented as urban training to patients with chronic obstructive pulmonary disease by a group in Barcelona, Spain (Arbillaga-Etxarri et al. 2016).

Although our participants were elderly and many were not experienced using smartphones and apps, the majority succeeded in using the apps. Besides the purpose to inform participants on scheduled walking trails, we introduced the messenger app to promote social interaction. Interestingly, the participants used WhatsApp chat predominantly to organize walks and to talk about intervention concerns. They used the messenger less for social support and even less frequently for (non-)technical questions. Thus, the apps were particularly important for organizing and informing about walking groups.

Based on the citizen science approach of the intervention, we involved participants from the beginning of the development of the intervention, particularly in organizing walking groups and determining topics for the monthly get-togethers. This approach fostered the feeling of participant involvement and allowed the intervention to be tailored according to the participants' needs. The fact that the participants contributed proactively with five additional walking trails including cards for the participant handbook underlines their involvement. The process of supporting the three key persons to take over the lead and organization of the intervention was successful. After withdrawal of the study team, the participants continued to walk in groups and to hold monthly get-togethers. Moreover, they developed new recruitment strategies, acquired external funding, and extended and modified walking trails. The number of participants more than doubled and the program is now sustained by the participants.

Strengths of our study are that we were able to put effort and time in the development, planning and piloting of the intervention. Based on the focus group, we learned how to tailor the intervention to the needs of the elderly people (e.g., use of apps and smartphones, location and planning of walking trails) and how to optimize recruitment strategies (e.g., we originally planned to specifically address

elderly persons with chronic disease conditions but then realized that the mention of chronic diseases could provoke a feeling of stigmatization). Through the interviews with the stakeholders, we established contacts with key persons from the local policy and service organizations who provided us access to recruitment channels and facilitated organizational and administrative aspects such as use of rooms for study visits. The fact that the study team was multidisciplinary (physiotherapist, epidemiologist, psychologist, exercise scientist and public health specialist) facilitated the multiple approaches we considered for the construct of the intervention. Strengths regarding assessment aspects are that we measured PA objectively, that we considered different assessment strategies (patient-reported outcomes, personal interviews, content analysis of sent messages) and that we assessed sustainability follow-up data after withdrawal of the study team.

One limitation of the study is that despite extensive recruitment efforts we were only able to recruit 29 instead of the targeted 70 participants for the first 6 months of the intervention during which we performed the PA assessments. After the planned recruitment period (6 months), we decided against prolonging recruitment for the pre-post assessment study part and instead to focus on the transfer of the intervention to participant leaders. Further participants were included only for the intervention but not for detailed assessments. Consequently, the sample is underpowered for effectiveness analyses and the primary outcome PA. In addition, we used a simple pre-post test to analyze changes and could not control for confounders, especially for season (Demeyer et al. 2014). However, we recruited across 6 months; baseline assessments of the initial group were in summer and those of the participants included later spread until winter, so we expect that the seasonal effect is approximately equally distributed.

The fact that we could not include the targeted sample size means that fewer participants were available to inform the direction of the intervention and to assist with the transfer to the participant leaders. A larger number of participants could have led to other organizational challenges and different social dynamics. However, the transfer process succeeded, the number of participants more than doubled, and the intervention is running well with participant leaders.

Based on the results and our experiences, we developed a guidance manual to implement the CAPACITY intervention in other communities in Switzerland and abroad. Currently, the CAPACITY intervention has been replicated in two cities in the Canton of Zurich, led by the Epidemiology, Biostatistics and Prevention Institute (EBPI) division of Prevention and Health Promotion Canton of Zurich and supported by a study team member, and the guidance book is piloted by two voluntary work leaders in the communities. Our vision is to further expand the intervention to other cities and, therefore, to motivate elderly people in their communities to walk together, to strengthen their social networks and, consequently, to positively impact their health.

Conclusions

The novel CAPACITY intervention was successfully implemented, transferred to participants and has now been self-sustained in the community for almost 1 year. Our study showed that it is possible to combine different approaches to promote PA in the community using technology and a dynamic citizen science approach. Based on the evaluation and experiences, we developed a guidance manual to implement the CAPACITY intervention in other communities in Switzerland and abroad.

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Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest The authors declare that they have no conflict of interest.

References

Aguilar-Farías N, Brown WJ, Peeters GMEE (2014) ActiGraph GT3X+ cut-points for identifying sedentary behaviour in older adults in free-living environments. J Sci Med Sport 17:293–299. https://doi.org/10.1016/j.jsams.2013.07.002

Arbillaga-Etxarri A, Torrent-Pallicer J, Gimeno-Santos E et al (2016) Validation of walking trails for the urban training TM of chronic obstructive pulmonary disease patients. PLoS ONE 11:e0146705. https://doi.org/10.1371/journal.pone.0146705

Bauman AE, Reis RS, Sallis JF et al (2012) Correlates of physical activity: Why are some people physically active and others not? Lancet 380:258–271. https://doi.org/10.1016/S0140-6736(12)60735-1

Bravata DM, Smith-Spangler C, Sundaram V et al (2007) Using pedometers to increase physical activity and improve health: a systematic review. JAMA 298:2296–2304. https://doi.org/10.1001/jama.298.19.2296

Choi L, Ward SC, Schnelle JF, Buchowski MS (2012) Assessment of wear/nonwear time classification algorithms for triaxial

accelerometer. Med Sci Sports Exerc 44:2009–2016. https://doi.org/10.1249/MSS.0b013e318258cb36
Conn VS, Hafdahl AR, Mehr DR (2011) Interventions to increase physical activity among healthy adults: meta-analysis of outcomes. Am J Public Health 101:751–758. https://doi.org/10.2105/AJPH.2010.194381
Cutrona CE, Suhr JA (1992) Controllability of stressful events and satisfaction with spouse support behaviors. Commun Res 19:154–174. https://doi.org/10.1177/009365092019002002
Demeyer H, Burtin C, Van Remoortel H et al (2014) Standardizing the analysis of physical activity in patients with COPD following a pulmonary rehabilitation program. Chest 146:318–327. https://doi.org/10.1378/chest.13-1968
Demeyer H, Louvaris Z, Frei A et al (2017) Physical activity is increased by a 12-week semiautomated telecoaching programme in patients with COPD: a multicentre randomised controlled trial. Thorax 72:415–423. https://doi.org/10.1136/thoraxjnl-2016-209026
Devlin NJ, Krabbe PFM (2013) The development of new research methods for the valuation of EQ-5D-5L. Eur J Heal Econ HEPAC Heal Econ Prev Care 14(Suppl 1):S1–S3. https://doi.org/10.1007/s10198-013-0502-3
Fanning J, Mullen SP, McAuley E (2012) Increasing physical activity with mobile devices: a meta-analysis. J Med Internet Res 14:e161. https://doi.org/10.2196/jmir.2171
Fydrich T, Sommer G, Tydecks S, Brähler E (2009) Fragebogen zur sozialen Unterstützung (F-SozU): normierung der Kurzform (K-14)Social Support Questionnaire (F-SozU): Standardization of short form (K-14). Zeitschrift für Medizinische Psychol 18:43–48. https://doi.org/10.1026/1616-3443.37.1.72
Harris T, Kerry SM, Victor CR et al (2015) A primary care nurse-delivered walking intervention in older adults: PACE (pedometer accelerometer consultation evaluation)-lift cluster randomised controlled trial. PLoS Med 12:e1001783. https://doi.org/10.1371/journal.pmed.1001783
Heath GW, Parra DC, Sarmiento OL et al (2012) Evidence-based intervention in physical activity: lessons from around the world. Lancet (London, England) 380:272–281. https://doi.org/10.1016/S0140-6736(12)60816-2
Kassavou A, Turner A, French DP (2013) Do interventions to promote walking in groups increase physical activity? A meta-analysis. Int J Behav Nutr Phys Act 10:18. https://doi.org/10.1186/1479-5868-10-18
Lee I-M, Shiroma EJ, Lobelo F et al (2012) Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 380:219–229. https://doi.org/10.1016/S0140-6736(12)61031-9
Orozco LJ, Buchleitner AM, Gimenez-Perez G et al (2008) Exercise or exercise and diet for preventing type 2 diabetes mellitus. Cochrane Database Syst Rev. https://doi.org/10.1002/14651858.cd003054.pub3
Orrow G, Kinmonth A-L, Sanderson S, Sutton S (2012) Effectiveness of physical activity promotion based in primary care: systematic review and meta-analysis of randomised controlled trials. BMJ 344:e1389
Physical Activity Guidelines Advisory Committee (2018) 2018 Physical Activity Guidelines Advisory Committee Scientific Report, Washington, DC
Puhan MA, Guyatt GH, Montori VM et al (2005) The standard gamble demonstrated lower reliability than the feeling thermometer. J Clin Epidemiol 58:458–465. https://doi.org/10.1016/j.jclinepi.2004.07.010
Santos-Lozano A, Santín-Medeiros F, Cardon G et al (2013) Actigraph GT3X: validation and determination of physical activity intensity cut points. Int J Sports Med 34:975–982. https://doi.org/10.1055/s-0033-1337945
Snaith RP (2003) The hospital anxiety and depression scale. Heal Qual Life Outcomes 1:29. https://doi.org/10.1186/1477-7525-1-29
Strassmann A, Steurer-Stey C, Lana KD et al (2013) Population-based reference values for the 1-min sit-to-stand test. Int J Public Health 58:949–953. https://doi.org/10.1007/s00038-013-0504-z
Tudor-Locke C, Craig CL, Aoyagi Y et al (2011) How many steps/day are enough? For older adults and special populations. Int J Behav Nutr Phys Act 8:80. https://doi.org/10.1186/1479-5868-8-80
UK Government (2011) Start active, stay active: a report on physical activity from the four home countries' chief medical officers, London
World Health Organisation (2010) Global recommendations on physical activity for health, Geneva