A Pilot Study Evaluating the Feasibility, Utilization, and Estimated Functional Impact of EngAGE: A Voice-Activated Device Exercise and Social Engagement Program for Older Adult - Care Partner Dyads

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Table of Contents

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Abstract

Background: Maintaining exercise is essential for healthy aging but difficult to sustain. EngAGE is a socially motivated exercise program delivered over a voice-activated device that targets older adult (OA)-care partner (CP) dyads.

Objective: This 10-week pilot study aimed to assess EngAGE feasibility and utilization, obtain user experience feedback, and estimate potential impact on function.

Methods: Ten OAs ?65 years were recruited from an independent living residence together with their self-identified CPs. EngAGE delivered NIA Go4Life exercises to OAs daily, while CPs received progress reports and prompts to send encouraging messages which were read aloud by the device to the OA. OA utilization was tracked and physical function was assessed at baseline and follow-up. Follow-up focus group and interview data provided qualitative feedback.

Results: On average, participants completed 393.7 (median=431) individual exercises without injury and used EngAGE on 41 days (median: 51). Qualitative results revealed perceived benefits, favored program features, and areas for improvement. Mean grip strength increased by 1.3 kg (p=0.34) and 4/10 improved by a minimal clinically important difference (MCID). Five-repeated chair stands time reduced by 2.3 seconds (p=0.02) and 3/9 improved by a MCID.

Conclusions: We present the iterative, participatory design methodology for a new, voice-activated device application customized to older adult users which may serve as a guide to other technology development for older adults. In our final participatory design phase, our pilot study served to further refine the application and to inform a larger trial testing EngAGE's impact on functional outcomes, a necessary step for developing evidence-based technology tools. Clinical Trial: NA

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Objectives. This 10-week pilot study aimed to assess EngAGE feasibility and utilization, obtain user experience feedback, and estimate potential impact on function.

Methods. Ten OAs ≥65 years were recruited from an independent living residence together with their self-identified CPs. EngAGE delivered National Institute on Aging Go4Life exercises to OAs daily, while CPs received progress reports and prompts to send encouraging messages which were read aloud by the device to the OA. OA utilization was tracked and physical function was assessed at baseline and follow-up. Follow-up focus group data provided qualitative feedback.

Results. On average, participants completed 393.7 (median=431) individual exercises without injury and used EngAGE on 41 of 70 days (range 7-66 days; median: 51; IQR: 23, 56, average 4.1 days/week). OA participants cumulatively completed an average of 393.7 (range 48-492; median=431; IQR: 384, 481) individual exercises over the 10-week intervention period (average of 39.4 exercises/week). Mean grip strength increased non-significantly by 1.3 kg (p=0.34) and 4/10 improved by a minimal clinically important difference (MCID) of +2.5 kg. Five-repeated chair stands time reduced by 2.3 seconds (p=0.02) and 3/9 improved by a MCID of -2.3 seconds. Three-meter usual walk performance was brisk at baseline and decreased 0.1 seconds (p=0.13) though 5/9 improved by a MCID of +0.05 m/s. Qualitative results revealed perceived benefits, favored program features, and areas for improvement.

Conclusions. We present a pilot study of a new, voice-activated device application customized to OA users which may serve as a guide to other technology development for OAs.Our pilot study served to further refine the application and to inform a larger trial testing EngAGE's impact on functional outcomes, a necessary step for developing evidence-based technology tools.

Keywords: voice-activated device; frailty; technology; activity; caregiver

Introduction

Voice-activated devices offer the possibility of assisting the rising number of older adults (OAs) with maintaining physical and cognitive function, enhancing social connectivity, and accessing health and social resources from their home [1, 2]. Voice-activated devices reduce technology interface barriers by allowing users to simply talk to interact with a device [3, 4]. They have shown promising early acceptability, use and adoption among older adults, including low-income older adults. [5-7] Given the ease of use and early acceptability, commercial healthcare platforms incorporating a voice-activated element are on the rise [8, 9]. However, the development of evidence-based health content tailored to OAs for use with voice-activated devices is in its infancy. As a result, no examples of developing voice-activated device programs for OA users are in the literature to serve as a participatory design template.

EngAGE is a novel exercise program customized for OAs that is delivered over an Amazon Alexa Echo Show voice-activated device. The program has dual and interconnected aims to improve physical functioning and social engagement of OAs. EngAGE supports physical functioning by delivering daily exercise routines from the National Institute on Aging (NIA) Go4Life program [10] to OAs in their home. EngAGE supports social engagement by leveraging meaningful social relationships to: provide active social reinforcement that encourages behavior change [11], provide occasions for additional social contact, and provide passive safety oversight. EngAGE uniquely targets older adult-care-partner (OA-CP) dyads as paired users, providing a complementary resource that supports both roles. EngAGE was co-designed with OAs and their CPs through iterative, participatory design to ensure ease of adoption and meaningful content—a strategy recommended by experts in the field [12, 13]. First, the concept was informally discussed with >40 stakeholders in the field through 1:1 conversations for feedback. Second, static wire frames representing possible program features were presented to predominantly minority OAs and CPs residing in the community around the University of Chicago for feedback in co-design focus groups or 1:1 interviews for homebound participants for feedback. Finally, a prototype was presented to predominantly minority OAs and CPs residing in the community around the University of Chicago for feedback in focus groups. At the final set of co-design focus groups, participants were asked to interact with the prototype as well using a draft command tip sheet. At each stage, feedback was incorporated into the program.

As an extension of our participatory design process, we conducted a pilot study to: a) determine the feasibility of in-home administration of the EngAGE program to OA-CP dyads; b) quantify the utilization of EngAGE during a 10-week intervention phase; c) obtain qualitative feedback on the perceived program benefits, favored program features, and areas for improvement; and d) estimate the potential impact of the EngAGE program on functional outcomes. These findings have relevance to clinicians and researchers exploring the utility of voice-activated devices to deliver healthcare resources to OAs, and to technology developers seeking to contribute useful and usable voice-activated device tools for the delivery of OA healthcare resources. In an era of increasing reliance on telehealth and remote health care delivery and a shortage of geriatrics-trained healthcare workers [14],we anticipate a growing need for easy-to-use digital interventions for physical, social, and all other aspects of health for OAs and their CPs. Voice-activated devices are candidate technology vehicles for delivering healthcare programing that may be particularly suited for OA users; however, deploying participatory design and collecting user input in feasibility studies such as this one help ensure that interventions align with OAs' own preferences, lifestyle, and priorities to support adoption.

Methods

EngAGE.

EngAGE is a program that delivers socially motivated exercise routines tailored to OAs in their home on a voice-activated devices. The corresponding application was optimized for an Amazon Alexa Echo Show or Amazon Fire Tablet but can be used on any Amazon Alexa device. It is currently not adapted for use on any other platform (e.g., Google Nest). We contracted Orbita, Inc., which isa preferred Amazone Alexa programmer company, to program our EngAGE application; our partner was selected in part because they are a preferred Amazon Alexa programmer. EngAGE leverages a software platform created by our programming partner [16] which has three user portals: 1) a browser, 2) a mobile app, and 3) a voice-activated device. OA users primarily interface with the voice-activated device while CPs interface entirely with the browser and mobile application.

OA users activate EngAGE using voice on their screened Alexa device (e.g., “Alexa, start EngAGE”). Once started, EngAGE then reads aloud any new messages from their CP (e.g., “You have a new message from [NAME]. Great job doing your exercises! Can’t wait to see you this weekend!”). Following this communication, EngAGE delivers exercise routines that alternate daily. The exercises were selected from the NIA Go4Life program [10] that were designed to be done with equipment found in the home (**Supplemental Table 1**). The subset of exercises was selected in consultation with a physical therapist who specializes in aging; they target critical, major muscle groups needed for daily functioning. For each exercise, EngAGE provides audio and visual instructions (e.g., “Let’s start arm curls. Find some hand weights, water bottles or soup cans. Stand up. Hold the weights straight down at your sides, palms facing forward. Slowly bend your elbows and lift the weights toward your chest. Keep your elbows at your sides. Hold this position for one second. Slowly lower your arms. Do ten arm curls.”) and displays an image of a person completing the exercise. Each exercise is then accompanied by rhythmic music allowing the OA time to perform the exercise on their own. A total of 13 strength, flexibility, and balance exercises are divided into 2 routines of 6 and 7 exercises each. Each routine begins with a 3-minute warm-up of walking around one’s home or in place. Alternating routines target different muscles to avoid overuse if done daily. All OA users are started at a very low intensity with the lowest number of repetitions for each exercise. Users rate the exercise difficulty after completion of each unique exercise. EngAGE then auto-adjusts the number of repetitions for that exercise in subsequent sessions. For example, if an exercise was rated “too easy” three times in a row, the number of repetitions would subsequently increase. On the other hand, if an exercise was rated “too difficult” one time, the number of repetitions would subsequently decrease. This process both enables gentle increases in difficulty to promote muscle building and protects against injury that could come from too rapid of a progression.

CPs interface with the website or mobile app to view their paired OA’s daily, recommended exercise routines and to monitor exercise completion. They also receive a daily email with a summary of exercises completed, whether any exercise was rated “too difficult” by the OA (as a safety feature), and a prompt to send an encouraging message via the website or mobile application to be read by the OA’s voice-activated device.

Study Design

We conducted a 12-week pilot study between 5/13/2019 and 8/19/2019 to test the feasibility and to estimate utilization and potential functional impact of EngAGE among OA-CP dyads. The results from this pilot study were used to inform a randomized clinical controlled trial. Baseline survey and physical performance measures were assessed in-person and in the home of OA participants. The 12 week pilot was divided into two phases: a 2-week run-in phase and a 10-week intervention phase. In-home set-up of pre-programmed Alexa Echo Show devices and Alexa Fire tablets (e.g., using anonymous, study email and Amazon accounts and study phone numbers) was then conducted over 2 weeks. Research staff ensured connectivity, demonstrated how to use the program, and addressed privacy concerns, including demonstrating Alexa's muting function useful to protect private conversations. During the 2-week run-in phase, participants reported any connectivity or program glitches encountered while familiarizing themselves with EngAGE. All problems were addressed and resolved before participants were asked to use the EngAGE program ad lib over a 10-week intervention phase. Follow-up data collection, including physical performance measures and focus groups, occurred at the end of the intervention phase in the facility. Of note, one participant was wheelchair-bound with limited leg function, requiring lower extremity exercise adaptations that were provided in a paper supplement that was given to the participant during set-up. The study was approved by the University of Chicago Institutional Review Board (IRB #19-0130).

Study Sample

After obtaining Institutional Review Board approval, OAs and CPs were recruited together. *a) Older Adults.* OA participant recruitment activities occurred between 12/10/2018 and 5/7/2-19 at a single independent living facility in Chicago, IL: a facility already equipped with Alexa Dot devices in about 150 residential apartments. Alexa Dots are a voice-activated device without a screen. The residents who participated in this study were familiar with using the Alexa Dots. The EngAGE program was optimized for use on the Alexa Echo Show device, a screened voice-activated device. We selected this participant group because it helped us isolate the study of the EngAGE program experience from the more general experience using a voice-activated device. Adults 65 years and older with unlimited WiFi and data plans were eligible to participate. OAs were excluded only if they had known moderate to severe dementia or were unable to understand the consent form in a teach-back approach. Participants with early cognitive impairment who were still able to consent were allowed to participate. Functionally impaired adults were encouraged to apply, and use of walking devices or wheelchairs did not preclude participation. Recruitment of participants took place via in-person presentations and fliers at the independent living facility. Study participants meeting eligibility criteria were consented in-person. *b) Care partners.* OAs who consented to participate were asked to identify a trusted social contact to act as their CP. CPs were eligible if they were 18 years or older, had unlimited WiFi and data plans, and reported being comfortable using web browsers and mobile applications. If OAs did not have a CP in mind (n=2), the team worked with them to identify a staff member they knew and were comfortable with.

Older Adult Measures

Demographics. OAs self-reported their date-of-birth, race (White, Black/African-American, Asian or other race), Hispanic ethnicity (yes/no), gender (female/male), education (≤ high school / > high school), marital status (single, engaged or living with partner, married or civil union, separated, divorced, widowed, or other), number of household members, and monthly household income (≤ \$2000/>\$2000 per month). They also separately reported their 1) access to and 2) use of the Internet (yes/no) and any devices (check all that apply: computer, cell phone, smart phone, tablet, television, landline, other).

Physical Function Measures. We administered two functional assessments at baseline and follow-up. 1) *Adapted Physical Frailty Phenotype* [17]. The adapted frailty phenotype included five components: unintentional weight loss in the prior year (5% or 10 pounds), weakness (average of 3 dominant grip strength measures), exhaustion (2 self-reported questions from the Center for Epidemiologic Studies Depression Scale [18]), slowness (average of 3, 15-foot usual walks), and low physical activity level (6-item version of the Minnesota Leisure Time Physical Activities Questionnaire [19]) (**Supplemental Text 1**). 2) *Short Physical Performance Battery (SPPB)* [20]. The SPPB consisted of three assessments: 3 static balance poses (side-by-side, semi-tandem, and tandem stance); a 3-meter usual walk; and 5-repeated chair stands [20] **(Supplemental Text 1**).

Program Utilization. The software platform [16] that hosts the EngAGE program recorded every exercise completed by the participant and the corresponding level of difficulty ratings throughout the intervention and stored utilization data on a HIPAA-compliant server. Once the participant rated the level of difficulty following each exercise, the exercise was deemed “completed” regardless of the number of repetitions.

Care Partner Measures

CPs were asked to report their relationship to the OA participant (e.g., friend, family, spouse, staff).

Follow-Up Focus Groups

Three 1.5-hour focus groups of 2-4 OA participants were held after the completion of the 10-week intervention phase. The small focus group size accommodated participant availability. The study team's qualitative specialist (RN) acted as the moderator for each focus group and guided the discussion using the same semi-structured interview guide for each focus group to obtain feedback, with other research team members also contributing to focus group discussion. Prompts included the following topics: how EngAGE fit with pre-existing exercise habits; the role of EngAGE's social component; participants' current technology usage; perceptions of EngAGE's benefits; user interface feedback; and user experience, including favored program features and areas for improvement, barriers to use, and feature evaluation. CPs completed exploratory interviews or focus groups only and findings are not reported.

Analysis

Data collected from the mixed methods were analyzed using several steps.

Older Adult Sample Characteristics. OA and CP demographic characteristics were summarized for each group using number of participants and percent of the sample for demographic categories.

Implementation Experiences. The total number and type of the technology glitches reported during the 2-week run-in period were reported.

Program Utilization. Program utilization was quantified by summing the number of exercises each OA completed over the 10-week intervention phase, and then averaging across all participants.

Physical Performance. OAs' physical performance measures were summarized as means (continuous measures) or frequencies (categorical measures) plus standard errors and standard deviations for each of the five physical frailty phenotype and three SPPB components as well as the total scale scores at baseline and follow-up. Each continuous outcome variable was assessed for normality using the Shapiro-Wilk test. Normally distributed baseline and follow-up continuous measures (average 15-foot usual walk, self-reported physical activity energy expenditure, frailty phenotype score, the fastest of two 3-meter usual walks, 5-repeated chair stands, total SBBP score) were compared using unadjusted, paired, 2-tailed t-tests. Non-normally distributed baseline and follow-up continuous measures (average dominant grip strength) were compared using unadjusted Wilcoxon matched-pairs signed-rank test. Categorical variables demonstrated no change; therefore, no statistical tests were conducted. Statistical significance was set at *P* < 0.05. We additionally calculated the effect size of the change between pre- and post-measurements. For each measure, we also identified the minimal clinically important differences (MCIDs) based on the literature (as available) to assess the number of participants demonstrating clinical improvement. In many cases, the MCIDs reported in the literature were not well established; therefore, we chose informed but conservative cut-points. We reported the

number of participants meeting the following MCID criteria: grip strength change: +2.5kg [22]; frailty: -1 point [23]; 15-foot or 3-meter usual walk: +0.05mps [24]; 5- repeated chair stands: -2.3 seconds [25]; and SPPB score: +0.5 points [26]. The MCID is not established for exhaustion, self-reported physical activity on the 6-item Minnesota Leisure Time Physical Activity Questionnaire, side-by-side, semi-tandem and tandem balance performances. For these measures, we chose to report the number of participants meeting the following: a) physical activity: no longer meeting physical frailty 'low physical activity' criteria; b) exhaustion: no longer meeting physical frailty 'exhaustion' criteria; c) side-by-side stance: number able to hold for 10 seconds pre- and post-intervention; d) semi-tandem stance: number able to hold for 10 seconds pre- and post-intervention; and e) tandem stance: number able to hold for 10 seconds pre- and post-intervention. We did not report a clinically meaningful change in weight.

Qualitative Results for Perceived Benefits, Favored Program Features, and Areas for Improvement. **The qualitative data were analyzed to determine perceived benefits, favored program features, and areas for improvement. Audio recordings of the focus groups were transcribed and de-identified. They were analyzed using Dedoose software [21]. Two team members (RN, CS) independently read the transcripts to identify preliminary codes and major theme categories for qualitative analysis. Deductive themes were related to a priori topics of interest that were integrated into the focus group prompts, and inductive themes were based on topics/insights drawn from transcripts themselves. Themes and codes were then organized and compiled into an initial codebook created by the team's qualitative specialist (RN). The codebook was reviewed by the final coding team (RN, MHS). Adjustments were made the codes, themes and definitions based on discussion options to calibrate understanding of codes and ensure inter-coder agreement of all code definitions. Then, two members of the team (RN, MHS) independently reviewed the transcripts again, labeling appropriate excerpts with corresponding codes from the final codebook. Memos attached to ambiguous excerpts were discussed to reach consensus, and, where needed, adjustments to the codebook were made or re-coding was done. Upon completion of coding, any coding discrepancies between coders were discussed and resolved.**

Results

Older Adult Sample Characteristics (**Supplemental Table 2**). The OAs represented a broad range of ages (range = 65-84) with 7 of the 10 being 75 or older. A majority of the sample was female (7 of 10), Caucasian/White (9 of 10), college educated (10 of 10) and lived alone (8 of 10). Nine of 10 reported having access to and using a computer and smart phone.

Care Partner Sample Characteristics. Each OA identified an eligible CP; of the 10 CPs invited to participate, all consented. One discontinued immediately after consenting due to schedule conflicts. Of the 9 remaining CPs, 3 identified themselves as a "friend," 3 as a "child," 2 as "staff," and 1 as a "spouse."

Implementation Experiences. Having the necessary Orbita, Inc software pre-installed on the CP tablets and in-home set-up of the Alexa devices facilitated participation. The 2-week run-in phase with easy access to technology phone support enabled identification of 32 technical issues, most identified during the first 2 weeks. The majority were for programming glitches (20). Other issues addressed included requests to correct spelling errors (1), resolve clock inconsistency (1), increase the font size (1), address poor wireless connectivity (1), correct errors in exercise text instructions (2), clarify web app capabilities (2), remove a floor exercise (1), resolve a login error (1), resolve an EngAGE program set-up problem (1), and resend the EngAGE program invitation email (1).

Program Utilization (**Table 1**). User-level analytic data indicated that the OA participants cumulatively completed an average of 393.7 (range 48-492; median=431; IQR: 384, 481) individual exercises over the 10-week intervention period (average of 39.4 exercises/week). Since each routine included 6-7 exercises, OA participants completed an average of ~6 exercise routines per week. Participants opened the EngAGE program an average of 41 days of 70 possible days (range 7-66 days; median: 51; IQR: 23, 56) over the 10-week intervention period (average 4.1 days/week). Eight of the 10 OA participants completed at least 2 full strength, balance and flexibility exercise routines per week on average—the minimum recommended by the American College of Sports Medicine [27]—while 2 of the 10 did not meet this threshold.

Table 1. Cumulative 10-Week Utilization of EngAGE by Study Participant

Participant	Total # of Exercises Completed	Total # of Days Program Used
1	140	13
2	431	59
3	449	56
4	384	50
5	398	52
6	481	66
7	48	7
8	170	23
9	492	56
10	196	28

Physical Performance (**Table 2, Supplemental Table 3**).

Table 2 and Supplemental Table 3 summarize change in physical performance in specific domains and across the frailty phenotype and SPPB scales. Functional improvements were noted in hand grip strength (mean grip strength pre: 26.3 kg, post: 27.6kg, P = .34, effect size=0.32, 7/10 improved, 4/10 met MCID criteria); 5-repeated chair stands performance time (excluded wheelchair-bound participant, mean 5-repeated chair stand time pre: 12.0 s, post: 9.7 s, P = .02, effect size=-0.93 6/9 improved, 6/9 met MCID criteria); and in tandem balance (excludes wheelchair-bound participant, pre: 5.9 s, post: 6.5 s, *P* = .78, effect size=-0.10, 4 held stance for 10 seconds at baseline, 3 at follow-up), though only change in 5-repeated chair stands performance time was statistically significant in this small pilot sample. The group (excluding the wheelchair-bound participant) had an equally brisk 15-foot and 3-meter usual walk times at baseline and follow-up (15-foot walk *P* = .86, effect size=0.06; 3-meter walk *P* = .13, effect size=-0.57), but 5/9 had improved usual walk times in both tests, and 3 and 5 met MCID criteria in the 15-foot and 3-meter walks, respectively. Among those not wheelchair-bound (*n* = 9), all were capable of holding the side-by-side and semi-tandem balance stances for the full 10 seconds at baseline and

Table 2 Physical Function Performance Measures Before and After 10 Weeks of EngAGE Use Among Older Adults

	n	Pre	SE	SD	Post	SE	SD	*P-value*[c]	Any Improve-ment (#)	Met MCID Criteria (#)[b]
Functional Measures										
Frailty Phenotype										
Dominant handgrip strength (mean, kg)	10	26.3	3.5	11.0	27.6	3.7	11.6	0.33	7	4
Average 15-foot usual pace walk (mean, seconds)[a]	9	4.3	0.3	0.8	4.3	0.2	0.7	0.86	5	3
Self-reported physical activity energy expenditure (mean, kcal/week)	10	1304.3	407.0	1287.0	1687.7	615.9	1947.7	0.56	6	2
Exhaustion (#)	10	0	--	--	0	--	--	--	--	--
Self-reported weight (mean, pounds)	10	168.4	14.3	45.1	172.5	16.4	52.0	0.40	--	--
Frailty total score (mean, range 0-5)	10	0.7	0.2	0.7	0.0	0.0	0.0	**0.01**	6	6
Short Physical Performance Battery										
Usual pace 3-meter walk (mean, seconds)[a]	9	2.1	0.1	0.4	2.0	0.1	0.4	0.13	5	5
5 Repeated chair stands (mean, seconds)[a]	9	12.0	1.2	3.6	9.7	0.9	2.7	**0.02**	8	3
Side-by-side stance[a] (mean, seconds)	9	10	0	0	10	0	0	--	--	--
Side-by-side stance held 10 seconds[a] (#)	9	9	--	--	9	--	--	--	--	--
Semi-tandem stance[a] (mean, seconds)	9	10	0	0	10	0	0	--	--	--
Semi-tandem stance held 10 seconds[a] (#)	9	9	--	--	9	--	--	--	--	--
Tandem stance[a] (mean, seconds)	9	5.9	1.5	4.4	6.5	1.2	3.6	0.78	5	--
Tandem stance held 10 seconds[a] (#)	9	4	--	--	3	--	--	--	--	--
SPPB Total Score (mean, range 0-12)[a]	9	10.2	0.6	1.6	10.9	0.2	0.6	0.22	5	5

[a] Excludes wheelchair-bound participant.

[b] Minimal Clinically Important Difference: grip strength change: +2.5kg; 15-foot usual walk: +0.05mps; physical activity: no longer meeting physical frailty 'low physical activity' criteria; exhaustion: no longer meeting physical frailty 'exhaustion' criteria; Weight: NA; frailty: -1 point;

3-meter usual walk: +0.05mps; 5 repeated chair stands: -2.3 seconds; side-by-side stance: # able to hold for 10 seconds; semi-tandem stance: # able to hold for 10 seconds; tandem stance: # able to hold for 10 seconds; SPPB score: +0.5 points.

[c] Paired t-tests were used for normally distributed continuous variables, Wilcoxon signed rank was used for non-normally distributed continuous variables, chi-square was used for categorical

follow-up. The mean frailty score at baseline was 0.7 and 0.0 at follow-up (P = 0.01) with 6/10 showing improvement and meeting MCID criteria. The mean SPPB score at baseline was 10.2 and 10.9 at follow-up (P = 0.22) with 5/10 showing improvement and meeting MCID criteria.

Qualitative Results for Perceived Benefits, Favored Program Features, and Areas for Improvement

Perceived Benefits and Favored Program Features. Focus group participants described a number of positive outcomes resulting from their use of EngAGE, including improvement in upper and lower physical strength, balance/flexibility, knowledge gained, and social benefits (including adherence, interactions with other participants, and relationships with CPs).

Many of these comments provided “real world” examples that suggested clinically relevant strength improvements. For example, a participant attributed improvement in grip strength from EngAGE to their ability to open a pickle jar and bottle of wine that their companions were struggling with. Another participant described the benefits derived from sit-stand exercises when using low toilets without grab bars.

Overall, balance and flexibility were less frequently mentioned than strength gains in focus group discussions of program benefits. Both individuals who described flexibility improvements had not been previously doing this type of exercise, with one noting that

> *I am not sure I would have chosen [the hamstring stretch], if I had been asked to pick the exercises I wanted to do.*

That individual also reported balance improvements, and in both cases these exercises were among the most difficult for her at the start of the program.

The most dramatic of the physical health benefits was described by a wheelchair-bound participant who was provided adapted EngAGE exercises to accommodate his physical limitations. In focus groups he reported,

> *…one of the benefits to this program is that it had side benefits to me, it helped me lose weight, helped me stop eating so much, and helped me psychologically.*

He also reported being able to sleep through the night, due in part to elimination of nighttime muscle stiffness and spasms, which he attributed to the stretching exercises.

Another benefit participants noted was the knowledge gained through the program. One user praised EngAGE for providing greater knowledge about how to perform certain exercises, noting that in their prior experiences with exercise class settings,

> *…by the time I figured how I am supposed to do it we would be moving onto the next thing sometimes. So I like that and I could, sometimes I would pause between the first rep and the second [and] think, 'okay, now do I know what I am supposed to be doing?' So I like being able to do that.*

Another participant whose prior exercise regime focused on recumbent biking and walking praised the program for emphasizing the need for a comprehensive range of exercise, stating

> *It reminded me that I needed exercising for everything.*

This was echoed by another participant who praised the greater self-awareness of the need for comprehensive physical exercise that the program provided, saying,

> *I just realized I was getting lazy and at our age we can't afford to be lazy because I mean the muscles are going to go and they go quickly. So that's forced me to remember and to think about how I'm doing things, and I find myself taking the hard road sometimes simply because I know I can do it and I need to do it.*

Lastly, participants described positive outcomes related to the social component of EngAGE for motivating adherence, contributing to insight regarding the fitness benefits, and strengthening social relationships. Multiple participants reported that having a partner who could monitor their progress aided with their adherence to the program. One participant also described the questions that she received from her CP as “creating a dialogue, forcing you to think about it a little bit and that does help.” These interactions with CPs were occasions for reminding participants of the progress that they had made: “It was always something that would make you, really force you to think about, geez, yes, the sit-stand is really helping. I've really improved that.”

Participants also described benefits related to their relationships with their CPs and other participants. Some of this was related to the encouragement and social support that they received. Interestingly, two participants felt that this sort of “rah, rah, your chief cheerleader” support was better suited to the EngAGE messaging format, noting “it might seem a little bit corny if she said it to you in-person but in the email, in the message, it seems great.” Since all participants resided in the same building, participants also described their camaraderie with each other and reported interest in program features that would permit communication across exercisers, with one suggesting an interface “almost like a Facebook page.” One participant also described the benefits of EngAGE for individuals who prefer to exercise alone but still desire social reinforcement, noting,

> *That doesn't mean I don't like to talk about it. It doesn't mean I don't want to interact with somebody about it. I just don't want anybody there while I'm doing it.*

One participant whose CP was an adult child described the messaging functionality as an opportunity for increased communications on topics unrelated to exercise. Another participant whose CP was a friend noted that the program “certainly added to communication between us, although we still usually fairly often communicate.”

Areas for Improvement. The most common program criticism was the lack of exercise variety. Study participants wanted more than two alternating routines in a week and additional exercise types as skill level increased. Multiple participants reported the two daily alternating routines became “boring” or “tedious”.

Additionally, some participants felt the length of exercise instructions was longer than required, especially once familiar with the exercise, with one OA noting that “the full prompt every time, got to be a little bit much,” and others reporting they began the exercise while still listening to the instructions. In other cases, participants mentioned the length of the repeated exercise sets, with one noting,

> *…when I would hit the third one it was starting, I was starting to feel like, is this ever going to end?... And yeah, that was hard. And I'll be honest, I didn't always do the third set.*

Other feedback centered around the functionality of the EngAGE interface. Multiple participants, particularly the more experienced exercisers, requested more control over exercise difficulty rather than the automatic changes based on the exercise rating. Other sources of user frustration included difficulty pausing and returning to the same place when unexpectedly interrupted by a phone call or visitor, difficulty successfully skipping instructions, and exercises not registering as completed. One participant found the audio instructions more useful than the written instructions or pictures on the screen:

> *…I basically ignored the screen and listened to the verbal.*

Another theme emerged about care partners not meeting expectations. One participant emphasized that,

> *The quality of partner is an issue.*

Another mentioned that,

> *I was kind of hoping that she would get a little more into it, I guess, than she did.*

She further explained that,

> *I would have liked her to ask more questions about the exercises… I think you need more of a dialogue than just a pat on the back or their head.*

Discussion

This paper summarizes a participatory design approach for developing new voice-activated device programs with OA users, and it reports results from the final stage of participatory design, a pilot study. In this pilot study, we found the voice-activated device and EngAGE were feasible to set-up on site. The program was moderately utilized on average by study participants but with a wide range. User feedback provided targeted opportunities to improve the user experience. We estimated the potential impact on physical function to inform the sample size needed for a subsequent efficacy trial. We found participants were the most likely to experience improvement in chair stand time performance of all outcomes assessed. The results from this pilot study offered feasibility considerations for future aging technology studies, provided a reference range for voice-activated device program utilization among older users for future studies, recommended sensitive objective and patient-reported outcome targets for OA exercise trials and introduced a shift in targeted technology users from the OA to the OA-CP dyad.

This study provided several key feasibility implications for future voice-activated device intervention studies in OAs. First, the in-home device set-up and data collection provided for OAs greatly streamlined onboarding and facilitated completion of important objective functional measures but will be challenging for large-scale studies. Potential strategies to address home technology set-up needs for larger scale studies include: 1) leveraging the paired CP to assist the OA with device set-up, 2) utilizing set up-up instruction manuals that have undergone participatory design with OAs to ensure ease of use paired with telephone support, and 3) partnering with an organization that has existing on-the-ground technology support teams. Remote functional data collection may be done using video conferencing [28] or by leveraging wearable sensors in the future [29-33]. Second, our 2-week run-in phase helped address many technical issues prior to the intervention phase that could have interfered with a successful intervention adoption. Larger technology intervention studies should consider budgeting for phone and on-the-ground technology support, particularly in the first few weeks of technology use. Third, privacy concerns were not the participation barrier we anticipated they could be. We heavily addressed privacy issues during consent and provided strategies for maintaining privacy during device set-up, which may have alleviated concerns up front. Everyone in this group was an existing Alexa user, so future studies may encounter these concerns more frequently. Finally, we had to adapt the EngAGE exercises to accommodate a wheelchair-bound participant; future studies should anticipate functionally-limited users and prepare alternative exercises in advance.

In this study, the OAs who were familiar with Alexa at baseline used this program on more than half of the days per week on average, but the wide range of EngAGE program utilization was an important finding for future tech researchers. It is probable that adherence will be lower among users with less familiarity with Alexa at baseline or those who are more functionally impaired; therefore, a longer intervention period may be necessary to see significant functional gains in a trial targeting these subgroups. One option to boost voice-activated device program utilization among OAs would be to leverage regular visits from CPs such as a state-sponsored homemaker or paid CPs. The CPs could provide direct technology support and help the OA use the EngAGE program or other healthy aging programs in the home at each visit.

In our pilot sample of mostly current exercisers, chair stand times improved significantly, and we observed a non-significant improvement in dominant grip strength over the 10-week intervention phase. These findings inform the sample size needed for a larger EngAGE efficacy trial in OAs and may serve to inform similar technology-based exercise trials in OAs. The fact that a relatively high-functioning group of OAs exhibited improvement in some aspects of physical performance suggests EngAGE or similar programs may have even greater potential to improve outcomes for less robust OAs.

In addition to informing adjustments needed to the EngAGE program, results of our qualitative analyses provided insights regarding the potential subjective outcome targets for larger, technology-based exercise trials. A number of participants self-reported meaningful functional gains in activities requiring the hand (opening a jar) and proximal hip (improvement in standing up from low seat), suggesting these are sensitive patient-reported outcomes for a larger trial. A small number of individuals also noted subjective improvement in flexibility, weight loss, diet, mood and sleep which may be helpful outcomes to include in larger studies. Finally, while nearly all older participants in the pilot study were exercisers at baseline, participants described gaining knowledge from the comprehensiveness of the exercises—we did not measure knowledge gains directly but would be important for future studies.

OA dyadic relationships within their social network are important to healthy aging [36], but healthcare technology programs infrequently target both users as a unit. The EngAGE program uniquely leverages existing social relationships to motivate activity while allowing older users to exercise alone and at their own pace—both welcomed features in this pilot sample. This strategy aims to both improve OA physical independence and simultaneously increase opportunities for social engagement. Most OA exercisers reported that the CPs successfully provided accountability, promoted adherence, increased social communication, and even encouraged OAs to reflect on their progress. In technology interventions, this partnership could be leveraged even more to assist with things like device setup, addressing technical issues, monitoring safety, or even participating in a program like EngAGE *with* the older user. This pilot study also revealed that not all social relationships are equally effective. The most positive responses came from those who had CPs who were thoughtful, creative and engaging. One strategy for increasing the odds of receiving meaningful exercise motivation might be to increase the number of CPs paired with each OA or to allow the OA users to be connected to each other. For example, children, grandchildren and friends could be paired with a single OA—a feature that is available on the EngAGE platform. Another strategy might be to provide CPs with tips for motivating healthy behavior. A key message from this pilot is the critical nature of CPs in implementing and sustaining healthy aging behavior among OAs.

Study Limitations. By design, our pilot sample was small, the team and participants were unblinded and the participants' familiarity with Alexa devices enabled us to primarily test the EngAGE program including its utilization, experience, and potential impact. However, these restrictions limit the generalizability of our findings and could introduce bias. Many of those recruited were higher functioning and better resourced than frail OAs (our ultimate target users). Prior to this feasibility study, however, our participatory design process included less resourced, physically limited, less technology savvy, and predominantly minority OAs. The current sample was selected because they were existing Alexa users and could provide feedback on the EngAGE program experience and not the Alexa experience, allowing us to identify areas we could improve prior to testing in a more vulnerable group. It is crucial for future participatory design studies to include functionally impaired and less tech-savvy OAs during development so that their needs and concerns are addressed in the program design.

Conclusion. Voice-activated devices hold great promise for overcoming many technology use challenges for OAs, making them a potential vehicle for delivering healthy aging resources broadly to OAs [2, 38]. EngAGE is unique in that it targets OA-CP dyads and it underwent an iterative participatory design process throughout development with vulnerable users to improve likelihood of perceived ease of use, perceived usefulness, and technology adoption among all OAs. Our pilot study demonstrated that screened voice-activated devices are well-suited to remote delivery of exercise routines that do not require specialized equipment. Using the NIA Go4Life content, EngAGE appears capable of producing statistically and clinically significant improvements in objective and subjective physical function measures. The social component of EngAGE was, overall, viewed positively as an exercise motivator and as a means of strengthening bonds and increasing communication between dyad members. This study also has important feasibility implications for larger technology program trials, including the need for 1:1 device set-up infrastructure and technology support. These findings are relevant to all future aging technology studies but especially to voice-activated device studies.

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Conflict of Interest

MH-S and LH: The University of Chicago and NORC jointly own the intellectual property / copyright of the customized portions of the EngAGE Alexa skill. No funds have been received at the time of submission.

RN, CS, SS, MD, LF, YM: No conflicts of interest to declare.

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Data Availability Statement

The study data are available from the corresponding author (M.H.S.) upon reasonable request and after completion of a Data Use Agreement and Institutional Review Board assessment.

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Supplementary Files

Multimedia Appendixes

Supplemental Text 1.
URL: http://asset.jmir.pub/assets/5c6ceed4078ae6e2caf21a41c1d9d56e.docx

Supplemental Table 1.
URL: http://asset.jmir.pub/assets/0a7a94f485869ff177ef31f2ab9cf95d.docx

Supplemental Table 2.
URL: http://asset.jmir.pub/assets/760a8c108d325db51a6c15d1cd7dffb1.docx

Supplemental Table 3.
URL: http://asset.jmir.pub/assets/ba2608278a6e9bc9ae816588028e61f6.docx

CONSORT (or other) checklists

This document contains our responses to the online CONSORT survey.
URL: http://asset.jmir.pub/assets/9d66ea4c5ad1aae03d3404b1e305fb7f.pdf