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POPULATION HEALTH INTERVENTION RESEARCH

The Victoria Assistive Devices and Coach (VADAC) study

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Abstract

Intervention A 90-day intervention employed peer coaching, with and without home-based electronic devices connected to an app, to assess effectiveness in enhancing self-reported health outcomes of older adults.

Research question Does peer coaching aid older adults to better manage their chronic health conditions, and is the coaching further enhanced by home-based electronic devices?

Methods The study employed a pre-post intervention randomized controlled trial design with three groups: control (no coach, no devices), coach only, and coach + devices. Participants were 163 adults living in British Columbia, Canada, aged 65 to 98 years, with one or more chronic health conditions and access to a computer and Wi-Fi. Responses on five questionnaires assessed health outcomes pre- and post-intervention: Self-Efficacy Scale, PHQ-9, Medical Care, Patient Activation Measure and the RAND 36-Item Health Survey 1.0 Questionnaire.

Results Compared with the control group (no coach, no devices), participants with a coach reported decreased depression, higher activation levels and energy levels, and better handling of role limitations due to physical health, social functioning, and communication with their physician. Participants with coaches and devices showed similar improvements on these measures with further decreases in depression severity as well as improved self-efficacy, better handling of role limitations due to emotional problems, higher level of emotional well-being and general health ratings, and lower pain.

Conclusion Peer coaches alone and in combination with assistive devices demonstrated several positive outcomes for older persons with chronic conditions that lasted at least 90 days. The program can enhance effectiveness of care provided by general practitioners.

Résumé

Intervention Une intervention de 90 jours a employé l'encadrement des pairs, avec et sans appareils électroniques à la maison connectés à une application, pour évaluer l'efficacité de l'amélioration des résultats cliniques autodéclarés d'adultes d'âge mûr.

Question de recherche L'encadrement des pairs aide-t-il les adultes d'âge mûr à mieux prendre en charge leurs affections chroniques, et cet encadrement est-il renforcé par l'utilisation d'appareils électroniques à la maison?

Méthode L'étude a employé un plan d'essai comparatif randomisé avant et après l'intervention avec trois groupes : un groupe témoin (sans pair aidant, sans appareils), un groupe avec pair aidant seulement et un groupe avec pair aidant et appareils. Les participants étaient 163 adultes de 65 à 98 ans vivant en Colombie-Britannique, au Canada, présentant une ou plusieurs affections chroniques et ayant accès à un ordinateur et au Wi-Fi. Les résultats cliniques avant et après l'intervention ont été analysés d'après les réponses à cinq questionnaires : échelle d'auto-efficacité, Patient Health Questionnaire (PHQ-9), questionnaire Medical Care, Patient Activation Measure et Questionnaire Rand de 36 questions sur l'état de santé (version 1.0).

Résultats Comparativement au groupe témoin (sans pair aidant, sans appareils), les participants encadrés par un pair aidant ont déclaré une dépression réduite, des niveaux d'activation et d'énergie plus élevés et une meilleure gestion de leurs limites fonctionnelles dues à leur santé physique, à leur fonctionnement social et à leurs communications avec leurs médecins. Les participants ayant un pair aidant et

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des appareils ont présenté des améliorations semblables de ces indicateurs, avec des réductions plus poussées de la sévérité de la dépression, ainsi qu'une auto-efficacité améliorée, une meilleure gestion de leurs limites fonctionnelles dues aux troubles affectifs, de plus hauts niveaux de bien-être émotionnel et de santé générale, et moins de douleur.

Conclusion Les pairs aidants à eux seuls et en combinaison avec des accessoires fonctionnels sont à l'origine de plusieurs résultats positifs pour les personnes d'âge mûr atteintes d'affections chroniques ayant duré au moins 90 jours. Le programme peut améliorer l'efficacité des soins offerts par les omnipraticiens.

Keywords Elderly · Chronic disease · Coaching · Assistive devices · Randomized controlled trial · Patient-reported outcome measures

Mots-clés Personne âgée · maladie chronique · encadrement · appareils fonctionnels · essai contrôlé randomisé · indicateurs de résultats déclarés par les patients

Introduction

Chronic pain, restricted mobility, and depressive feelings and emotions all take a toll on patients' quality of life and health outcomes as well as the broader health care system in terms of possibly reducing hospitalization rates and associated costs. Increased ability to manage these problems, therefore, clearly has many broad benefits for individuals and society. During the past decade, research studies have consistently found that individual management and outcomes of chronic disease are enhanced through the use of peer and professionally-led self-management education (Cheng et al., 2017; Chrvala et al., 2016; Brady et al., 2013). Using another model, telephone peer coaching, clinicians, and peers have also demonstrated effectiveness in bringing about improved outcomes (Gagliardino et al., 2013; McGowan et al., 2019; Thom et al., 2013; Walker et al., 2011; Wolever et al., 2010). Peer coaching has been shown to be effective with several health conditions. A review (Elstad et al., 2010) of 47 papers from eight countries that looked at pre/post-natal care, diabetes, asthma, cardiovascular disease, HIV, smoking cessation, mental health, and drug use reported that 83% of the studies reported significant between-group or pre-post changes showing benefits of peer support, across different age demographics.

Recently, with the advent of smart technology, the use of home-based electronic devices is becoming popular; however, digital medicine is a young field, and little of the research focuses on older adults with chronic illnesses (Denton & Spencer, 2010). The present study was conducted as part of a larger initiative of expanding digital medicine and bridging peer coaching programs with the electronic assistance aimed to assess the impacts of peer coaching, with and without the additional use of electronic devices, on a number of outcome measures in older adults experiencing chronic health conditions. A randomized controlled trial design was used to evaluate whether integrated electronic home monitoring improved health outcomes and self-management over and above only using the Self-Management Telephone Health Coach Program. This program is a free, individualized telephone program comprised of weekly 30-min calls between a participant and a trained peer self-management coach. Coaches telephone their assigned participants once a week for 12 consecutive weeks and inquire how they are managing their chronic conditions, medications, and other general life challenges. When participants identify a problem, coaches assist them in following problem-solving steps to select an action to take to resolve it. Coaches then encourage and assist participants to develop an "action plan" to complete the activity during the following week. A summary of the Self-Management BC Health Coach Program can be found at http://www.selfmanagementbc.ca/healthcoachprogram. Ethical approval to conduct the research was acquired from the Joint Island Health and University Research Ethics Board.

Methods

Participants

The target population of the research was older adults with one or more chronic conditions, living in their own homes and having access to the internet and Wi-Fi. Government Health data was used to estimate that 125,805 older persons lived in this geographic area.

Several methods were used to recruit participants from this target population, including newspaper ads, posters, and flyers; radio and internet; in-person and virtual presentations to older person groups and health professionals; and collaborations with community organizations that provided coordination and assistance to older people. Persons who met the inclusion criteria (e.g., hearing, comprehension, etc.) completed a Study Consent Form and a questionnaire which served as the baseline assessment for data analyses. When the consent form and questionnaire were returned, persons were randomized to one of three study groups.

One hundred ninety-three participants were recruited to the study and assigned to one of three groups, a control group and

two treatment groups (coach only and coach + devices), using a blocked randomization technique (Efird, 2011). This randomization method maximizes the similarity of the three groups with regard to known and unknown factors while keeping the group sizes equal at baseline. Furthermore, in longitudinal studies, randomly assigning participants across the different treatment groups as they enter the study is also desirable as this controls for external factors such as seasons/weather and historical factors (e.g., changes in government policies) that may potentially and inadvertently impact the key outcome measures. In our case, this was particularly fortuitous because the COVID-19 pandemic hit about halfway through recruitment into our study. Furthermore, we chose larger blocks of participants (blocks of 15) and pseudo-randomized the orders of assignment to always assign participants to the two treatment groups that use trained peer coaches first, to maximize the coaches' availability and maintain their interest in the study.

Persons randomized to the control group received a participant book entitled *Living a Healthy Life with Chronic Conditions* (Lorig et al., 2020) or *Living a Healthy Life with Chronic Pain* (LeFort et al., 2015) and were placed on a 3-month waitlist to receive a coach. Members of this group completed the questionnaire again 3 months later and received a $25 honorarium each time they completed the questionnaire.

Participants randomized to the coach-only group also received a participant book and were paired with a coach. Participants and coaches were matched based on background collected for eligibility. In this group, coaches telephoned participants and conversed for approximately 30 min weekly for a period of 3 months. Participants in this group also completed the questionnaire again 3 months after baseline, and received a $25 honorarium.

Participants randomized to the coach + devices group received the participant book and were matched with a coach, similar to the process used in the coach-only group. Each person also received three assistive devices, namely (a) a steel wrist-worn watch which collects physical activity and sleep data; (b) Body+ Scale, a scale which tracks weight, heart rate, body composition (such as bone density), and environmental data (such as weather and air quality); and (c) Nokia Sleep, a sleep-tracking pad that is installed underneath the participant's mattress that tracks sleep cycles (deep, light, REM), sleep onset and duration, and sonority quality and provides an overall sleep quality score. Data collected by the devices is sent via Bluetooth Low Energy to a Health Mate app downloaded onto a smartphone or tablet computer.

Before the COVID interruption (prior to March 2020), the devices were installed by the devices coordinator who visited participants in their homes. After August 2020, when the study resumed following a 5-month recruitment stoppage due to the COVID-19 pandemic, devices were installed in participants' homes through telephone and online communication between the devices coordinator and participant. Participants in this coach + devices group also completed the questionnaire again 3 months after their baseline assessment, and received a $25 honorarium.

Health coaches

Coach recruitment included advertising in newsletters, websites and community newspapers, posters, and brochures. Interested candidates were registered into a 2-day coach-training workshop. Each trainee received a copy of the Self-Management Health Coach Program Coach Manual (Self-Management BC, 2020). In the training, coaching role, expectation, commitment, and core functions were explained and trainees practiced key self-management strategies, namely problem solving and action planning. Basic and complex scenarios were used to generate resolution of difficult situations. The training concluded with a review of self-compassion; effective communication techniques; a review of information in participants' books; key community resources; potential coaching challenges; personal safety; a Coach Code of Conduct; and Key Points for Self-Management Health Coaching.

Twelve in-person workshops were delivered prior to March 2020 which trained 82 coaches. Because of COVID, participant recruitment discontinued for approximately 5 months mainly because the devices coordinator was unable to enter participants' homes. Following the re-start in August, three additional sessions which trained 14 new coaches were delivered through virtual 2-day webinars. In total, 96 persons completed the coach training.

Coach-participant pairing

After completing the training, coaches and participants were paired on the basis of gender, age, and interests. The first regularly scheduled coach-participant phone call was scheduled by the coach coordinator. Weekly phone calls lasted a minimum of 30 min. During the 3-month intervention, either the coach coordinator or project lead called coaches three times to provide support, problem solve, and ensure program fidelity. These calls addressed difficulties coaches had getting their participants to describe problems managing their condition(s) and their medications, in their home and family environment, and in making weekly action plans describing the steps they would take to solve the problem. Coaches received an honorarium of $72 at the end of the 3 months of the study.

Outcome measures

These measures were chosen because they have been used in our prior studies, have been validated, and assess the specific outcomes of interest. Our prior experience with these measures also indicates that participants are comfortable with the

length of the battery, and as noted above, participants were compensated each time they complete the battery.

Self-efficacy scale (Lorig et al., 1996)

This is a 6-item scale, with responses ranging from 1 (not at all confident) to 10 (totally confident). Responses are added to produce a total score for each participant. Scores can range from 6 to 60, with higher scores indicating higher self-efficacy.

Depression Severity Measure (PHQ-9) (Kroenke et al., 2001)

A 9-item scale, asking respondents to rate how often they experience a number of negative feelings in the past 2 weeks (e.g., little interest or pleasure in doing things; feeling down, depressed, or hopeless; trouble falling/staying asleep; etc.). Responses range from not at all (0) to nearly every day (3). Responses are added, and total score can range from 0 to 27, with higher scores indicating more frequent negative feelings. One additional overall item is also asked at the end, where the respondent is asked to indicate, on a 4-point response scale, how difficult the negative feelings make it for them to work, take care of things at home, or get along with other people, ranging from not difficult at all (0) to extremely difficult (4).

Medical care (Lorig et al., 1996)

Three items ask about communicating with their doctor. These ask about preparing a list of questions; asking about things the respondent wants to know about or does not understand about their treatment; and discussing any personal problems related to their illness. Responses range from never (0) to always (5). The three responses are summed to give an overall score, ranging from 0 to 15.

Three questions ask about health care services utilization in the past 6 months (Thom et al., 2013): the number of visits with a physician; number of visits to an emergency room; and number of nights spent in hospital. These are treated as individual outcome measures.

Health literacy (Chew et al., 2008)

Three follow-up questions ask about communication and visits: how often does someone help you read hospital materials; how often do you have problems learning about your medical condition; and how confident are you in filling out forms by yourself. Responses range from always (1) to never (5). These are treated as separate outcome measures.

Patient Activation Measure (PAM) (Hibbard et al., 2004)

This 13-item questionnaire asks about self-reported role in caring for their own health. Items ask about their responsibility for managing their condition and their ability to maintain lifestyle changes. Items ask about (1) their confidence in taking care of their health (e.g., actively minimizing symptoms, telling their provider about concerns), following medical treatment at home, and (2) their knowledge and understanding of their condition (e.g., the nature and causes of the condition, medication(s), medical treatment options).

Responses range from strongly disagree (1) to strongly agree (4) with no neutral/middle points, but a "not applicable" (N/A) response option is also available. All items are phrased positively. Each person's responses are added to obtain a total, excluding items with N/A responses, and the sum is divided by the number of items answered (excluding N/A items) and multiplied by 13. These raw PAM scores are then converted to a PAM activation scale score, ranging from 0 to 100, with higher scores indicating higher activation level, as suggested by Moljord et al. (2015).

The RAND 36-Item Health Survey 1.0 Questionnaire (SF-36) (RAND Corporation, 1992a)

The 36 items are recoded and summarized into eight scale scores, each ranging from 0 to 100. The subscales assess self-reports regarding physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, emotional well-being, social functioning, pain, and general health. Scale scores represent the average scores of items that the respondent answered (i.e., excluding items not responded to). The individual items were recoded and subscales were scored according to the instructions (RAND Corporation, 1992b). Higher scores indicate more favourable health states.

Analyses

Four sets of analyses were conducted. First, to ensure that the randomization worked and the three groups were equivalent at baseline, a one-way analysis of variance (ANOVA) was conducted on all demographic variables and baseline outcome measures.

Second, to assess whether the device installation may have had an impact on the outcome measures, participants in the coach + devices group were split into groups based on when they enrolled in the study, either prior to the COVID shutdown (prior to March 2020) or after (August to December 2020). A set of 2 × 2 mixed-factorial ANOVAs was conducted on all outcome measures, with each pre/post outcome measure as the repeated-measures factor and the two subgroups of this group as the between-subjects factor. Although not planned for, the overall potential impact of the COVID shutdown on the outcome measures was also examined in the whole baseline sample.

The third set of analyses looked at the pre- versus post-treatment scores on each outcome measure across the three

groups. A 2 × 3 mixed-factorial ANOVA was conducted to test for a statistically significant interaction effect with larger pre- to post-test changes expected in the coach-only and coach + devices groups. Because the outcome measures intend to assess different aspects of the participants' experience, and to retain statistical power to detect group differences and reduce type II error, the ANOVA *F* test for each outcome measure was conducted at the 0.05 level of statistical significance. Significant interactions were followed up with post hoc *t* tests to compare the two treatment groups with the control group and to each other, using Bonferroni correction for type I error for two-sided familywise error at .05.

The final set of analyses examined the potential influences of four covariates on the outcome measures. Sex was included as a factor in a 3-way ANOVA, with study group and sex as between-subjects factors. Age (in years), number of health conditions, and years of education were included in repeated-measures general linear models as continuous predictors (analyses of covariance). All analyses were conducted using SPSS version 22.

Results

Randomization: group differences at baseline

Table 1 shows the demographic characteristics of the whole sample and each of the three study groups. No statistically significant differences were seen among the three groups, except a slightly higher proportion of men in the coach-only group and correspondingly smaller proportion of men in the coach + devices group.

Tables 2 and 3 show a description of the three groups, at baseline, on all the outcome measures. Both tables also give the scale reliability, using Cronbach's alpha, as applicable. Table 2 provides information on all outcome measures except the SF-36 Health Survey, which is shown in Table 3. There were no differences in the frequencies of the various chronic conditions among the three groups. The most frequently reported chronic conditions were arthritis (50.3% of all participants) and cardiovascular disease (45.6%). About one in five reported chronic pain (21.8%) and/or a neurological disorder (22.8%). Some (14.5%) reported respiratory disease, and about 11% reported cancer.

Dropouts

Thirty participants (15.5%) dropped out of the study. Proportionally, the dropout rate was not impacted by the COVID interruption ($\chi^2(1, N = 193) = 0.182, p = 0.670$), with 20 of the 135 (14.8%) who enrolled pre-COVID dropping out and 10 of the 58 (17.2%) who enrolled post-COVID shutdown dropping out.

The dropouts did not differ from those who remained in the study in terms of sex ($\chi^2(1, N = 193) = 2.035, p = 0.154$); age ($t(191) = 1.126, p = 0.262$); years of education ($t(189) = 0.462, p = 0.645$); and whether they lived alone or with someone ($\chi^2(1, N = 193) = 0.003, p = 0.954$). They did differ on language, with a higher proportion (7, 35.0%) of non-English participants compared with (23, 13.3%) English speakers ($\chi^2(1, N = 193) = 6.434, p = 0.011$), and the total number of chronic conditions ($t(191) = 2.429, p = 0.016$), with participants who dropped out reporting fewer ($M = 2.43, SD = 1.30$) compared with those who stayed in the study ($M = 3.55, SD = 2.44$).

Table 1 Demographic description of study participants at baseline (excluding dropouts)

	All participants at baseline ($N = 163$)	Control group ($N = 55$)	Coach only ($N = 56$)	Coach + devices ($N = 52$)	Test statistic for group differences[a]	*p* value
Sex: *N (%)* men	41 (25.2%)	14 (25.5%)	19 (33.9%)	8 (15.49%)	$\chi^2(2) = 4.929$	0.085
Age[b]: *M (SD)*	76.0 (6.5)	77.4 (7.5)	75.3 (5.0)	75.2 (6.6)	$F(2, 160) = 2.133$	0.122
Education: *M (SD)* years	15.5 (3.0)	15.5 (3.0)	15.6 (2.7)	15.5 (3.4)	$F(2, 160) = 0.029$	0.971
Education level: *N (%)*						
Less than high school (6–11 years)	8 (4.9%)	2 (3.6%)	1 (1.8%)	5 (9.6%)	$\chi^2(6) = 6.592$	0.360
High school graduate (12 years)	26 (16.0%)	9 (16.4%)	11 (19.6%)	6 (11.5%)		
College/university (13–16 years)	85 (52.1%)	32 (58.2%)	26 (46.4%)	27 (51.9%)		
Graduate school (17–22 years)	44 (27.0%)	12 (21.8%)	18 (32.1%)	14 (26.9%)		
Language: *N (%)* English	150 (92.0%)	51 (92.7%)	53 (94.6%)	46 (88.5%)	$\chi^2(2) = 1.460$	0.482
Living situation: *N (%)* live alone	77 (47.2%)	23 (41.8%)	25 (44.6%)	29 (55.8%)	$\chi^2(2) = 2.318$	0.314
Total number of chronic conditions: *M (SD)*	3.55 (2.89)	3.13 (1.82)	3.82 (2.52)	3.69 (2.89)	$F(2, 160) = 1.262$	0.286

[a] *F* value from one-way analysis of variance for testing *M (SD)* equal across three study groups; χ^2 test of independence for *N (%)* equal across three study groups

[b] Age was computed as the difference between 2020 and the year of birth

Table 2 Baseline means *(M)* and standard deviations *(SD)* on outcome measures (excluding dropouts)

Outcome measure at baseline	# of items	Possible range[a]	Cronbach's α[b]	Whole sample ($N = 163$)	Control group ($N = 55$)	Coach only ($N = 56$)	Coach + devices ($N = 52$)	F value[c]	p value[c]
Self-efficacy scale score	6	6 to 60*	.91	39.84 (11.39)	41.05 (10.27)	40.27 (11.09)	38.12 (12.76)	< 1.0	0.390
Depression severity	9	0* to 27	.85	7.30 (5.38)	6.35 (4.94)	7.46 (4.96)	8.14 (6.15)	1.494	0.228
If problems with feelings, how difficult?	1	1 to 4	–	1.87 (0.77)	1.76 (0.72)	1.91 (0.77)	1.92 (0.81)	< 1.0	0.484
Communication with doctor	3	0 to 15*	.77	9.01 (3.79)	8.85 (4.09)	9.18 (3.64)	8.98 (3.69)	< 1.0	0.902
Number of visits to doctor in past 3 months	1	0* to 90	–	2.65 (2.89)	2.76 (2.61)	2.38 (2.39)	2.85 (3.61)	< 1.0	0.665
Number of visits to ER in past 3 months	1	0* to 90	–	0.25 (0.57)	0.18 (0.48)	0.20 (0.40)	0.38 (0.77)	2.117	0.124
Number of nights spent in hospital in past 3 months	1	0* to 90	–	0.48 (1.80)	0.25 (1.38)	0.64 (2.09)	0.56 (1.87)	< 1.0	0.496
Help reading hospital material	1	1 to 5*	–	4.62 (0.94)	4.60 (1.01)	4.57 (0.97)	4.69 (0.83)	< 1.0	0.787
Problems learning about treatment	1	1 to 5*	–	4.54 (0.81)	4.51 (0.90)	4.61 (0.82)	4.50 (0.70)	< 1.0	0.747
Confidence in filling out forms	1	1* to 5	–	1.53 (1.11)	1.51 (1.15)	1.45 (0.99)	1.63 (1.21)	< 1.0	0.695
Patient Activation Measure	13	0 to 100*	.88[d]	59.8 (14.2)	60.3 (14.0)	59.0 (15.1)	60.1 (13.6)	< 1.0	0.870

[a] Asterisks in this column indicate the best/most favourable score on the scale [b] Based on all participants ($N = 193$, including dropouts) and baseline scores [c] F and p values are from one-way analyses of variance with (2, 160) degrees of freedom for testing the null hypothesis that the means of the three study groups are equal [d] Based on $N = 164$, and raw responses to 13 individual items with responses ranging from 1 to 4

Participants who dropped out did not differ on any of the outcome measures (all $p > 0.123$), except the SF36-Social subscale ($t(190) = 3.597$, $p < 0.001$), and marginally on the three items about health literacy ($0.017 < p < 0.063$).

There was a difference in the dropout rate across the three study groups ($\chi^2(2, N = 193) = 6.763$, $p = 0.034$), with a higher proportion of participants in the coach + devices (16) compared with 4 in the control group and 10 in the coach-only group. Reasons for dropping out included dissatisfaction being randomized to the control group ($N = 1$); discomfort receiving weekly telephone calls from their coach ($N = 5$ in coach only, $N = 2$ in coach + devices); falling ill ($N = 4$ in coach only; $N = 4$ in coach + devices); unable to use devices ($N = 1$) or found them too difficult ($N = 7$); moving out of

Table 3 Baseline means *(M)* and standard deviations *(SD)* on subscales of the 36-item short form (SF-36) of the Health Survey (excluding dropouts)

Health survey subscale scores at baseline[a]	# of items	Cronbach's α[b]	Whole sample *M (SD)*	Control ($N = 55$) *M (SD)*	Coach only ($N = 56$) *M (SD)*	Coach + devices ($N = 52$) *M (SD)*	Group differences? F value[c]	p value[c]
Physical functioning	10	.907	52.8 (26.4)	52.0 (25.3)	53.7 (29.3)	52.60 (24.6)	< 1.0	0.948
Role limitations due to physical health	4	.792	25.8 (33.5)	28.6 (31.3)	22.8 (34.8)	26.0 (34.6)	< 1.0	0.655
Role limitations due to emotional problems	3	.796	60.5 (40.4)	68.5 (39.2)	58.9 (41.2)	53.8 (40.2)	1.837	0.163
Energy/fatigue	4	.833	42.4 (23.7)	46.7 (22.6)	38.0 (23.8)	42.4 (24.4)	1.885	0.155
Emotional well-being	5	.769	72.0 (15.7)	72.7 (16.2)	72.4 (16.1)	70.9 (14.9)	< 1.0	0.817
Social functioning	2	.817	63.0 (26.5)	70.5 (22.6)	59.4 (28.2)	58.9 (27.3)	3.415	0.035
Pain	2	.881	50.8 (25.6)	50.4 (24.5)	50.3 (25.8)	51.7 (26.9)	< 1.0	0.951
General health	5	.776	50.4 (21.7)	51.9 (20.1)	49.6 (23.5)	49.6 (21.7)	< 1.0	0.820

[a] The possible range of scores on all subscales is 0 to 100, with higher scores indicating more favourable outcomes [b] Based on all participants ($N = 193$) and baseline scores [c] F and p values are from one-way analyses of variance with (2, 160) degrees of freedom for testing the null hypothesis that the means of the three study groups are equal

the area ($N = 1$); coach became ill ($N = 1$ in coach only, $N = 1$ in coach + devices); and the post-questionnaire was not returned for unknown reasons ($N = 3$ in control).

Impact of device installation and the COVID-19 shutdown

Table 4 shows the results comparing study participants at baseline grouped into pre-COVID shutdown (N = 134) and post-COVID shutdown (N = 58) enrolled between August and December 2020. The COVID shutdown did result in slight differences on six of the 19 baseline outcome measures, at the 0.05 level of significance (bolded p values). Two measures of health services utilization in the past 3 months decreased and four of the eight health survey subscales showed higher baseline ratings by the post-COVID enrollees.

Table 5 shows the average pre-test/post-test mean differences for the coach + devices group, divided into pre- and post-COVID shutdown, to assess any potential impacts of the difference in device installation. None of the mean differences in the outcome measures reached statistical significance, suggesting that the method of device installation does not impact participants' changes in the outcome measures; however, the statistical power for this unanticipated 2 × 2 repeated-measures ANOVA was relatively low.

Impact of coaches, with and without devices, on outcome measures

Table 6 shows the mean differences for the three groups for each of the 19 outcome measures. Group mean differences statistically different from 0 are shown in bold, and also shown graphically in Figs. 1, 2, and 3. For the statistically significant interactions, post hoc tests of pairwise comparisons of the mean differences obtained by the three study groups, using Bonferroni type I error correction, revealed several group differences.

As shown in Fig. 1, the coach + devices group increased their self-efficacy relative to both the control ($p = 0.002$) and coach-only groups ($p = 0.080$), and the latter two did not differ from each other ($p = 0.604$). The depression severity scores of the coach + devices group became less negative relative to those of the control group ($p = 0.003$) but did not differ from those of the coach-only group ($p = 0.547$) which did not statistically differ from those of the control group ($p = 0.120$). For the PAM activation scores, the interaction was not

Table 4 Baseline outcome measure *(M, SD)* comparisons of participants recruited pre- versus post-COVID shutdown (including dropouts)

Outcome measure (at baseline)	Recruited pre-COVID ($N = 134$)	Recruited post-COVID ($N = 58$)	t value[a]	p value[a]
Self-efficacy scale score	38.34 (11.34)	41.60 (10.42)	− 1.878	0.062
Depression severity	7.94 (5.60)	6.57 (5.17)	1.573	0.117
If had problems, how difficult? (single item)	1.92 (0.79)	1.74 (0.70)	1.507	0.134
Communication with doctor (3-item scale score)	8.76 (3.69)	9.57 (3.92)	− 1.353	0.178
Number of visits to doctor in past 3 months	3.10 (2.82)	1.60 (2.89)	3.338	**0.001**
Number of visits to ER in past 3 months	0.30 (0.65)	0.14 (0.40)	2.174	**0.031**
Number of nights spent in hospital in past 3 months	0.55 (1.86)	0.41 (1.66)	0.475	0.635
Help reading hospital material (single item)	4.55 (1.04)	4.52 (1.06)	0.189	0.851
Problems learning about treatment (single item)	4.49 (0.85)	4.45 (0.88)	− 0.300	0.765
Confidence in filling out forms (single item)	1.64 (1.17)	1.48 (1.11)	0.894	0.372
Patient Activation Measure (PAM Activation scale score)	59.21 (13.83)	59.54 (15.22)	− 0.147	0.884
SF-36: Physical functioning	48.89 (26.62)	60.93 (24.16)	− 2.961	**0.003**
SF-36: Role limitations due to physical health	22.41 (32.79)	33.62 (35.22)	− 2.1304	**0.034**
SF-36: Role limitations due to emotional problems	58.52 (41.42)	62.07 (39.71)	− 0.553	0.581
SF-36: Energy/fatigue	40.15 (23.25)	46.03 (24.23)	− 1.592	0.113
SF-36: Emotional well-being	71.30 (16.17)	72.46 (14.74)	− 0.345	0.730
SF-36: Social functioning	57.46 (26.86)	66.16 (26.59)	− 2.067	**0.040**
SF-36: Pain	48.50 (25.52)	55.43 (25.37)	− 1.733	0.085
SF-36: General health	48.59 (21.92)	55.26 (19.94)	− 1.989	**0.048**

[a] t and p values are from independent-samples t tests with 190 degrees of freedom; p value is two tailed

Table 5 Pre- to post-intervention mean differences on outcome measures for participants in the coach + devices group based on COVID-19 recruitment into the study (pre- versus post-COVID shutdown)

Outcome measure (at baseline)	Recruited pre-COVID ($N = 34$)	Recruited post-COVID ($N = 18$)	F value[a]	p value[a]
Self-efficacy scale score	8.56*** (10.55)	3.00 (10.46)	3.286	0.076
Depression severity	− 2.50** (4.46)	− 1.75 (4.89)	< 1.0	0.593
If had problems, how difficult? (single item)	− 0.21 (0.64)	− .018 (0.64)	< 1.0	0.878
Communication with doctor (3-item scale score)	0.85* (2.27)	0.71 (3.55)	< 1.0	0.858
Number of visits to doctor in past 3 months	− 0.85 (3.00)	− 0.11 (3.92)	< 1.0	0.450
Number of visits to ER in past 3 months	− 0.24 (1.13)	0.06 (0.42)	1.105	0.298
Number of nights spent in hospital in past 3 months	0.71 (4.36)	− 0.50 (1.89)	1.245	0.270
Help reading hospital material (single item)	− 0.06 (0.60)	− 0.50 (1.04)	3.770	0.058
Problems learning about treatment (single item)	− 0.03 (0.67)	0.28 (0.67)	2.459	0.123
Confidence in filling out forms (single item)	0.03 (0.76)	− 0.28 (1.07)	1.439	0.236
Patient Activation Measure (PAM activation scale score)	2.83 (10.45)	8.03* (14.25)	2.260	0.139
SF-36: Physical functioning	2.21 (10.09)	4.03 (11.22)	< 1.0	0.554
SF-36: Role limitations due to physical health	13.24* (37.56)	2.78 (18.96)	1.222	0.274
SF-36: Role limitations due to emotional problems	13.73 (45.78)	19.61* (35.47)	< 1.0	0.645
SF-36: Energy/fatigue	9.56* (21.58)	8.61* (13.78)	< 1.0	0.867
SF-36: Emotional well-being	1.88 (12.58)	7.94* (11.91)	2.832	0.054
SF-36: Social functioning	13.24** (27.34)	11.81** (15.74)	< 1.0	0.839
SF-36: Pain	5.66 (17.13)	6.94 (15.59)	< 1.0	0.792
SF-36: General health	3.82 (13.77)	5.28 (11.04)	< 1.0	0.701

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ two tailed, for paired-samples t tests of the null hypothesis that the mean difference (post- minus pre-intervention) is statistically different from zero (excluding dropouts) [a] F and p values are for the (1, 50) degrees of freedom interaction effect of pre-/post-intervention and 2 subgroups in 2 × 2 repeated-measures ANOVAs

statistically significant due to the large variability in the scores, but participants in the two coach groups did increase their PAM scores by almost the same amount.

There was quite a lot of variability in the scores on the eight subscales of the SF-36 (see Fig. 2), but several group differences were statistically or marginally statistically ($p < 0.10$) significant. Specifically, for ratings of role limitations due to emotional problems, whereas the ratings of the control group decreased over time, ratings of both coach-only and coach + devices groups increased, with the coach + devices group differing from control ($p = 0.011$) but not from the coach-only group ($p = 0.584$), and the coach-only group average, while in the positive direction, not differing from the control group ($p = 0.272$). For the energy/fatigue subscale, while the coach-only group did not differ from the control group ($p = 0.136$) and the two coach groups did not differ from each other ($p = 1.000$), the coach + devices group did differ from the control group ($p = 0.067$), but marginally significant differences were also seen for emotional well-being, where only the coach + devices group differed from control ($p = 0.062$). Finally, with regard to social functioning, the coach-only group increased their ratings relative to the control group ($p = 0.031$) as did the coach + devices group ($p = 0.001$), but the two coach groups did not differ from each other ($p = 0.779$). Group differences in ratings on the SF-36 subscales for physical functioning, role limitations due to physical health, pain, and general health did not reach statistical significance.

No statistically significant differences were found for communication with physician; the average number of visits to the ER; and the three items about health literacy.

Influence of sex, age, education, and number of chronic conditions

Table 7 shows that the influences of sex, age, years of education, and the number of chronic conditions did not impact the outcomes. There were only two statistically significant effects at the 0.05 level. There was a potential effect of gender on the number of visits to a physician, with men in the coach + devices group decreasing the number of visits to the doctor ($M = 5.13$ visits on average prior to the study and $M = 2.38$ visits at the conclusion of the study; all other sex-study groups had a mean difference less than 0.72 visits). This is likely due to one participant (a man in the coach + devices study who reported 20 visits, the remaining participants reported 13 or fewer visits). The second covariate was age and it seemed to influence social functioning; there was no correlation of age

Table 6 Post- minus pre-intervention mean differences on each outcome measure for participants across the three study groups

Outcome measure	Control ($N = 55$)	Coach only ($N = 56$)	Coach + devices ($N = 51$)	F value[a]	p value[a]
Self-efficacy scale score	− 0.09	2.34	**6.63*** **	6.205	**0.003**
Depression severity	0.38	− **1.21***	− **2.26*** **	5.667	**0.004**
If had problems, how difficult? (single item)	− 0.04	− 0.18	− 0.20*	< 1.0	0.408
Communication with doctor (3-item scale score)	0.37	**0.77***	**0.80***	< 1.0	0.686
Number of visits to doctor in past 3 months	− 0.64	− 0.48	− 0.60	< 1.0	0.948
Number of visits to ER in past 3 months	0.24	− 0.11	− 0.14	3.677	**0.027**
Number of nights spent in hospital in past 3 months	0.15	− 0.34	0.29	< 1.0	0.418
Help read hospital material (single item)	0.00	− 0.18	− 0.21	< 1.0	0.441
Problems learning about treatment (single item)	0.07	− 0.18	0.08	1.503	0.226
Confidence in filling out forms (single item)	0.24	0.09	− 0.08	< 1.0	0.394
Patient Activation Measure (PAM activation scale score)	1.71	**4.40** **	**4.63** **	1.034	0.358
SF-36: Physical functioning	2.33	0.45	2.84	< 1.0	0.637
SF-36: Role limitations due to physical health	7.27	**16.52** **	**9.62***	1.044	0.354
SF-36: Role limitations due to emotional problems	− 7.88	5.36	**15.69***	4.417	**0.014**
SF-36: Energy/fatigue	0.12	**7.95** **	**9.23*** **	3.164	**0.045**
SF-36: Emotional well-being	− 1.60	0.64	**3.98***	2.759	0.066
SF-36: Social functioning	− 4.77	**7.37***	**12.74*** **	7.129	**0.001**
SF-36: Pain	0.77	1.79	**6.11** **	1.03.7	0.357
SF-36: General health	2.00	3.48	**4.33***	< 1.0	0.697

[a] F and p values are for the interaction effect of 2 × 3 repeated-measures ANOVAs, with pre-/post-intervention and three study groups. Degrees of freedom for F values are (2, 160). Data exclude dropouts

*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$ two-tailed, for paired-samples t tests of the null hypothesis that the mean difference (post- minus pre-intervention) is statistically different from zero (within each group)

with social functioning at baseline ($b = -.069$, $p = 0.831$), but there did appear to be a positive weak relationship of social functioning with age at the conclusion of the study ($b = .635$, $p = 0.063$), such that older participants across all three groups were more likely to be engaged socially at the end of the study (could also be a type I error).

Discussion

The study's participant randomization process was effective in that there were no statistically significant differences in demographic characteristics among the groups and there was only one difference in the social functioning subscale score of the Rand 36-item Health Survey Questionnaire at baseline. Furthermore, within the control group, participants' scores on the outcome measures did not change statistically significantly during the intervention time interval on any of the outcome measures, indicating that any observed changes in outcomes for the two intervention groups are unlikely due to confounding variables due to time. Despite our best efforts in conducting this randomized control pre-post-test study, its limitations include differential dropout rates across the three intervention groups and the sudden appearance of the COVID-19 pandemic midway through.

Thirty persons withdrew from the study with an equal proportion withdrawing before and during COVID. Subjects who withdrew differed from those who stayed with respect to their language being non-English, having fewer chronic health conditions, and scoring lower on the SF-36 Social subscale, and marginally lower on health literacy, ability to read hospital materials, having problems learning about their medical condition and in their confidence filling out forms (likely due to the language issue). A majority of dropouts were from the coach + devices group, with almost half of these reporting they found the devices difficult to use. This differential dropout rate for the group with the devices was a study limitation that future research can take into account, and perhaps explore individual difference factors, such as familiarity and comfort with new devices, which likely play a role in using the devices for enhancing health outcomes effectively.

The impact of the COVID shutdown was seen on six of the outcome measures. Participants who enrolled after the shutdown reported fewer doctor visits and fewer trips to the emergency department in the prior 3 months, not surprising as this was mandated by the health officials at the start of the pandemic. This group also had higher baseline

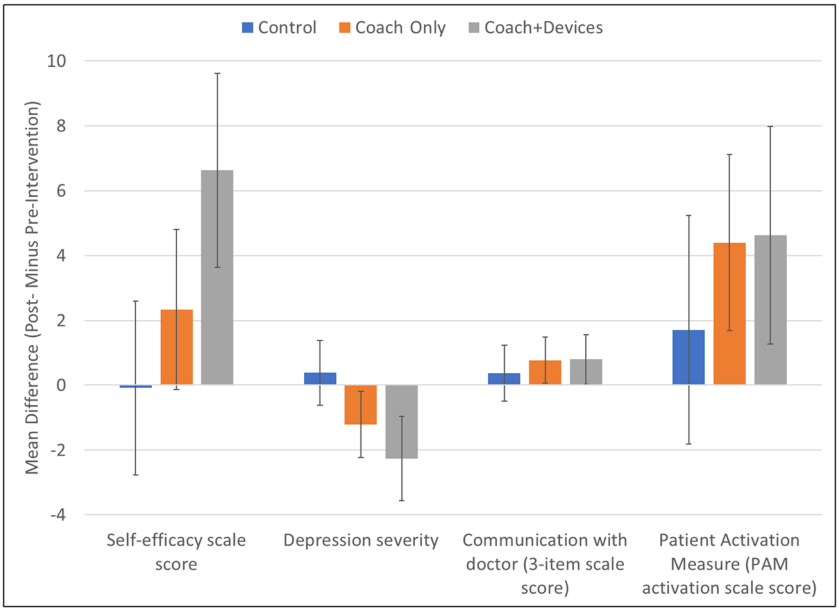

Fig. 1 Changes in participants' ratings on self-efficacy, depression severity, communication with physician, and patient activation measure (PAM) across the three study groups (error bars are 95% confidence intervals of the mean post- minus pre-intervention differences)

scores on four of the eight Health Survey subscales, namely physical functioning; role limitation due to physical health; social functioning; and general health. It is interesting that older adults who felt stronger physically, but did not differ in terms of the more emotional subscales (role limitation due to emotional problems, emotional well-being, energy/fatigue, and pain), were more likely to be recruited during the pandemic. Exploring this observation, however, is beyond the scope of this study. Finally, and luckily, the method of device installation (i.e., in person by study personnel vs. by telephone instructions) that was required by the COVID shutdown did not impact the outcome scores and changes in the outcome measures for participants in the coach + devices group.

In terms of the main hypotheses of the study, several results stand out. Compared with the control group, participants who worked with a coach (only) reported decreased depression, higher activation levels, better handling of role limitations due to physical health, higher energy levels, better social functioning, and better communication with their physician. Participants who had devices along with a coach showed similar improvements on all of these

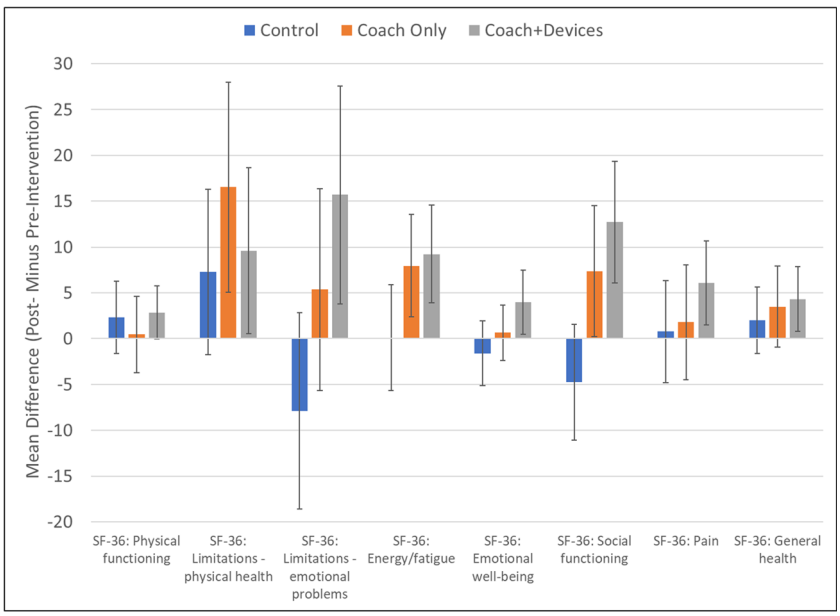

Fig. 2 Changes in participants' ratings on SF-36 subscales across the three study groups (error bars are 95% confidence intervals of the mean post- minus pre-intervention differences)

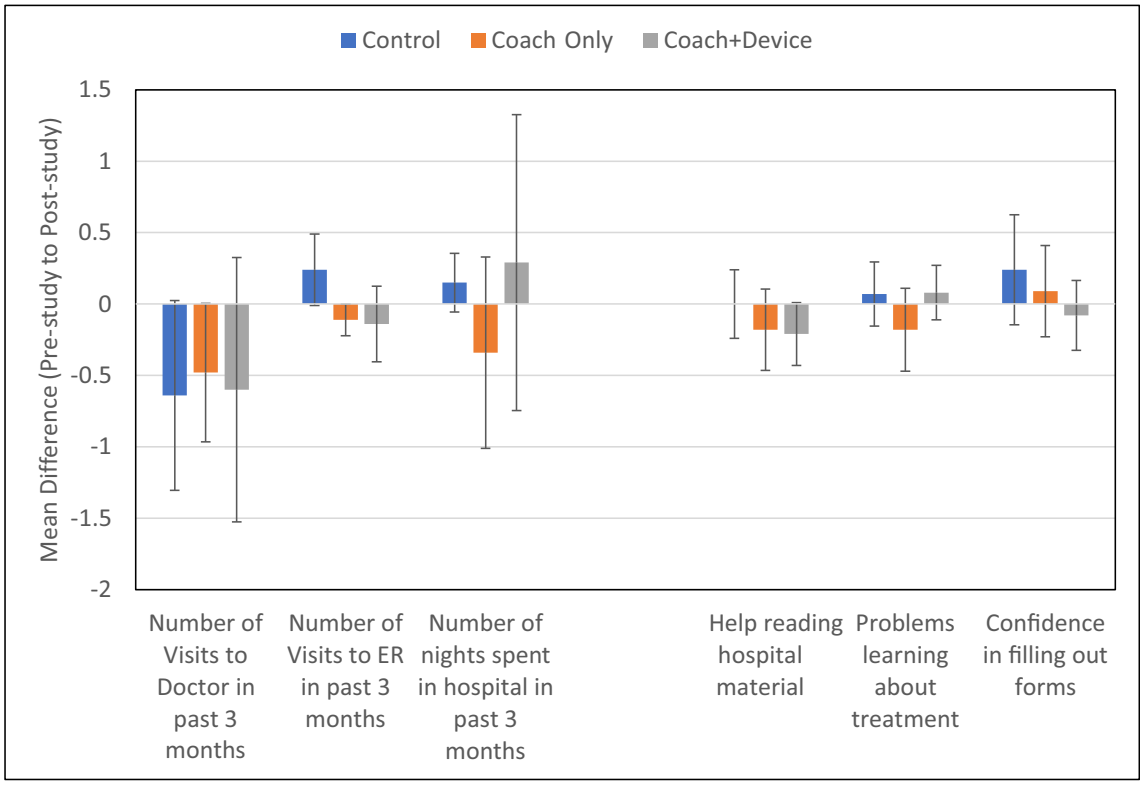

Fig. 3 Changes in participants' service utilization and self-ratings of health literacy across the three study groups (error bars are 95% confidence intervals of the mean post- minus pre-intervention differences)

measures, with even larger decreases in depression severity. In addition, participants with devices also improved in terms of their self-efficacy, better handling of role limitations due to emotional problems, higher level of emotional well-being, lower pain, and higher general health ratings. None of the covariates tested—sex, age, education level, and number of chronic conditions—contributed to the differences in outcome measures, which is consistent with the findings of another study on the effectiveness of peer coaches (McGowan et al., 2019).

Overall, participants who worked with a coach for the 3-month intervention, with or without devices, experienced improvements in several outcomes, providing evidence that the 3-month intervention works. It remains unclear, however, how the use of the three assistive devices impacted the outcome measures; that remains beyond the scope of this work. The same coaching intervention was used for both study groups, but participants in the group which also had devices had improvements on more outcome measures than the group without devices. Studies that have examined the causal link between peer coaching and outcomes have found that coaches provide practical assistance to achieve and sustain complex behaviours (Brownson & Heisler, 2009); help people access and navigate clinical care and community resources (Rees & Williams, 2009); and help people address complex multi-morbidities, serving as a bridge between primary and behavioural health (Colella & King, 2004; Dunn et al., 2003; Fisher et al., 2009). A possible explanation in this study may be that using the devices assisted persons to monitor and achieve their weekly goals, and achievement of weekly goals leads to the development of even higher levels of self-efficacy. An additional analysis will be conducted by the study Co-PI to investigate the relationship of the data collected by the three devices to outcome measure results.

Conclusion

By employing a RCT design, the current study has advanced the understanding of the effectiveness of peer health coaches assisting older persons with chronic health conditions and that including assistive devices may provide additional benefits. Future research involving assistive devices and peer health coaches would benefit by having a devices-only group and a qualitative component to bring understanding to the relative and potentially different experiences of using assistive devices and/or being involved with a peer health coach.

Table 7 Effects of sex, age, education, and health conditions on the mean differences on each outcome measure across the three study groups (*p* values)

Outcome measure	Sex[a]	Age[b]	Education[b]	Number of health conditions[b]
Self-efficacy scale score	.267	.893	.983	.987
Depression severity	.411	.481	.566	.569
If had problems, how difficult? (single item)	.828	.227	.821	.249
Communication with doctor (3-item scale score)	.968	.837	.686	.163
Number of visits to doctor in past 3 months	**.040**	.184	.401	.293
Number of visits to ER in past 3 months	.527	.463	.224	.271
Number of nights spent in hospital in past 3 months	.792	.539	.163	.070
Help read hospital material (single item)	.903	.458	.803	.557
Problems learning about treatment (single item)	.283	.602	.625	.200
Confidence in filling out forms (single item)	.768	.292	.063	.513
Patient Activation Measure (PAM activation scale score)	.543	.134	.540	.766
SF-36: Physical functioning	.366	.466	.728	.912
SF-36: Role limitations due to physical health	.941	.141	.875	.416
SF-36: Role limitations due to emotional problems	.663	.494	.104	.443
SF-36: Energy/fatigue	.799	.982	.577	.747
SF-36: Emotional well-being	.561	.804	.082	.459
SF-36: Social functioning	.795	**.020**	.716	.657
SF-36: Pain	.473	.425	.458	.874
SF-36: General health	.344	.944	.061	.796

[a] *p* values for 2 (pre-/post-study score) × 3 (study groups) × 2 (male/female) interaction effect

[b] *p* values for 2 (pre/post-study score) × covariate interaction term in ANCOVA with (1, 159) degrees of freedom

Contributions to knowledge

What does this study add to existing knowledge?

- The study provides strong evidence, from a pre-post intervention randomized control trial design, that 90 days of weekly peer-to-peer coaching improves several self-rated health outcomes for older adults with chronic health conditions.
- The additional use of home-based electronic devices connected to an app showed further benefits.
- These results held for all participants and were not impacted by the COVID-19 interruption, nor were there differential effects based on age, sex, and education level, at least in the participant group in this relatively highly educated, predominantly female and English-speaking Canadian sample.

What are the key implications for public health interventions, practice, or policy?

- The key implications for public health practice and policy are several-fold. First and foremost, the relatively inexpensive, easy to implement and run peer-delivered telephone Self-Management Health Coach Program (Self-Management BC, 2020) has been shown, in several studies now, to be very effective in helping people with chronic health conditions manage their health outcomes, even without any devices.
- The shortage of general practitioners in the province could be eased by incorporating peer coaches, with or without the devices, to help patients, likely of all ages, manage their chronic health issues.

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Author contributions The first author was responsible for developing the health coach intervention, randomizing participants to the study groups, analyzing the data, and writing the manuscript. As well, the first author hired and supervised the research staff to recruit participants, obtain consent forms and questionnaires, and recruit, train, and support coaches during the intervention period. The second author was responsible for developing the original research grant application to the funding body, making grant modifications, procuring the assistive devices used in the study, serving as the main contact with the Joint Island Health and University of Victoria Research Ethics Board, and supervising the project devices coordinator. Both authors read and approved the final manuscript.

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Availability of data and material Available upon request from corresponding author

Code availability Data were analyzed with SPSS version 22.

Declarations

Ethics approval Ethical approval was granted by the Joint Island Health and University of Victoria Research Ethics Board.

Consent to participate Participants signed the Joint Island Health and University of Victoria Research Ethics Consent Form.

Consent for publication None to declare

Conflict of interest The authors declare no competing interests.

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