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Reducing sedentary behaviour and cognitive function in older people with Mild Cognitive Impairment: Results of a randomized feasibility study

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ABSTRACT

Background: Sedentary behaviour is associated with poorer cognitive function amongst older adults and may pose a risk to cognitive decline. We tested the feasibility and acceptability of a remotely delivered coaching intervention designed to reduce sedentary behaviour in older adults with mild cognitive impairment (MCI).
Methods: This was a 13-week unblinded, single-centered randomized feasibility study. People with MCI were recruited and randomized to receive five sessions of WALC-R intervention or information on physical activity. ActivPAL-measured sedentary behaviour, self-reported sedentary levels, pre-morbid intelligence, and verbal fluency were measured at baseline and week 13.
Results: We recruited 25 people of whom 23 were followed up. 82% of outcome data including valid accelerometer data were collected. Self-reported sedentary levels reduced by 65(36.6) min at follow-up, while device measured sedentary increased by 10.5(17) min. When interviewed, participants found the intervention acceptable.
Conclusion: The intervention was feasible and acceptable to participants. A full-scale trial is needed to examine the effectiveness of the intervention on cognitive function in community dwelling older population at risk of cognitive decline.

1. Introduction

Levels of sedentary behaviour are high amongst older adults. Indeed, globally, 67% of older adults report being sedentary for more than 8.5 h of their waking day [1]. There is evidence of deleterious health impacts of prolonged sedentary times, with possible independent associations with all-cause mortality, cardiovascular disease mortality, cardiovascular disease incidence, cancer mortality, and type 2 diabetes incidence [2]. Although observational studies have demonstrated some associations between sedentary behaviours and cognitive health, intervention studies are required to confirm the efficacy of reducing sedentary time on cognitive health [3]. In response to the need for further evidence in this area, this study proposed to test the feasibility of an established intervention-The WALC-R intervention (Walk; Address sensations; Learn; Cue- Remote) via health coaching in older adults at risk of cognitive decline with a view to test for its effectiveness on cognitive function in a later study. The WALC intervention was originally designed to motivate community-dwelling older adults to increase physical activity and was based on the Social Cognitive theory [4]. Unlike the original WALC intervention, this study delivered the intervention remotely in real time, via coaching using internet videoconferencing. The WALC intervention was selected for this study because it has been found to be effective in reducing sedentary behaviour in the adult population [4]. A feasibility study was needed before a full-scale trial to identify and address the uncertainties, which may arise in the future trial such as the acceptability of the intervention, effective recruitment and retention and other practicality of delivering the intervention.

We chose to test our intervention in an older population living with Mild Cognitive Impairment (MCI) because this population are at risk of further cognitive decline [5]. A cohort study, which explored the 2-year progression of different classifications of MCI in individuals aged 65+ years showed a higher progression from MCI to dementia when compared with people living with age-associated cognitive decline [6]. However, this study also found that up to 44.8% of the cohort reverted to normal or no cognitive impairment within this period. People living with MCI are also likely to engage in very high levels of sedentary behaviour [7]. An observational study showed that being sedentary for >=8 h/day was associated with 1.56 (95%CI=1.27–1.91) times higher odds for MCI [7]. A separate cross-sectional study indicated that people with probable MCI were less active and engaged in more sedentary behaviour, compared with people without MCI [8]. A reason why people with MCI may engage in higher sedentary behaviour in comparison with

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their counterpart with normal cognition could be due to the increased difficulty with engaging in cognitively complex tasks. Intervention studies aimed at modifying risk factors for cognitive decline are important given the challenge presented by the global rise in dementia prevalence. Therefore, this study contributes to the agenda of dementia prevention research by exploring whether influencing sedentary behaviour in older population could reduce the risk for cognitive decline.

The primary aim of the study was to establish the acceptability of a real-time remote health coaching intervention delivered via videoconferencing in community-dwelling older people living with mild cognitive impairment. In addition, the study determined how many participants could be recruited and retained, adherence rate, collection of potential outcomes for future trials and adverse events. The secondary aims were to estimate the difference between treatment and control groups at baseline and follow-up and pre-post change in (1) device- measured sedentary behaviour (2) self-reported sedentary behaviour (3) verbal fluency (4) pre-morbid intelligence (5) self-rated health.

2. Methods

The study design and intervention description have been published in detail elsewhere [9]. Briefly, this study was a 13 week unblinded, single-center randomized feasibility study. The design adhered to the Consolidated Standards of Reporting Trials statement for feasibility trials (CONSORT) [10]. The study received ethical and research governance approval from London city and East Research Ethics Committee (20/LO/0904). This study was registered on ClinicalTrials.gov (NCT04464538). A flow diagram of the study is shown in Fig. 1.

2.1. Participants and sample size

The study was conducted remotely in the community settings in England. Potential participants were identified and recruited through multiple channels including community health services, General Practitioner's practices (GP) and the Join Dementia Research database (JDR). The JDR was developed by the National Institute for Health Research (NIHR), Alzheimer Scotland, Alzheimer's Research UK and Alzheimer's Society to enable people to register their interest in participating in dementia research and be matched to suitable studies. Participants were eligible if they met the following criteria:

- Community-dwelling adults aged 50+ years.
- Clinicians diagnosis of Mild Cognitive Impairment OR MCI diagnosis which meets Petersen Criteria [11].
- Participants must have a working knowledge of English.
- Participants must be able to provide informed consent.

Participants were excluded if (a) received a clinical diagnosis of dementia (b) diagnosed with severe mental health conditions and substance use disorders (c) diagnosed with other neurological conditions. The recruitment target sample size was 24 (12 per group) after factoring a 40% attrition.

2.1.1. Control group

Participants in the control group completed baseline measures, then were given written information on the benefits of increasing activity levels in accordance with NHS guide on physical health.

2.2. Procedure

For participants recruited from community and GP practices, the clinical and care team identified potential patients and referred them to the researcher to obtain informed consent. For those identified from the Join Dementia Research database, the researcher obtained authorisation from the JDR management to approach patients registered on their website and matched to study. The initial approach by the researcher depended on the volunteers' profile and was either via phone or email. The researcher proceeded to obtain informed consent only when matched volunteers replied with interest in the study. To obtain informed consent, participants were provided with a Patient Information Sheet and given 48 h to decide whether they would like to participate. Once consent was obtained, participants' GPs were informed about their patients' enrolment to study. After receiving consent, participants were screened to confirm eligibility. Thereafter, baseline measures were completed. Participants were then randomised to either coaching (intervention) or Information (control) group. A follow-up assessment was undertaken following the end of the intervention (after 12 weeks) where all measures obtained at baseline were repeated. All study visits were completed remotely via videoconferencing. Finally, participants were rewarded with a £10-Amazon voucher for completing baseline and follow up.

2.3. Randomisation, post-randomisation withdrawals and exclusions

This study used a simple randomisation process to allocate participants into intervention and control arms. Randomisation process was overseen by the researcher using a freely available software: Sealed Envelope: https://www.sealedenvelope.com/help/simple-randomiser/students/. Participants were informed of their right to withdraw from the intervention and/or the trial at any time. Unless a subject explicitly withdrew their consent, they were followed-up wherever possible and data collected as per the protocol until the end of the trial. The reasons for withdrawal were also recorded.

2.4. Summary of intervention

The WALC-R (Walk, Address sensation, Learn exercise, Cue-Remote; Table 1) intervention is not a walking/physical activity group, rather, a forum where the concept of sedentary behaviour and strategies to reduce these behaviours are coached. The WALC intervention has been validated in several studies for use in the older population and people living with schizophrenia and more recently with serious mental illness [4,12,13]. This study adopted the WALC intervention, which incorporated elements of the COM-B (Capability, Opportunity and Motivation-Behavioural) model to address capability, opportunity, and motivational barriers to reduce sedentary behaviour [14]. Unlike original and previous versions of the WALC intervention, we delivered our intervention (WALC-R) remotely via the internet. The WALC-R consisted of fortnightly health coaching sessions and education booklet, and self-monitoring of daily activity levels using pedometer (Fitbit) and diary.

2.4.1. Education booklet (online)

Participants assigned to the WALC-R intervention were emailed an online booklet before attending their individual coaching sessions. The booklet introduced the basics of the benefits of walking for exercise and why exercise was beneficial, as well as gave information, support and motivation to help participants independently walk more in their daily routines. It also introduced the concept of sedentary behaviour and the harms and strategies to sit less and move more, including disrupting prolonged periods of sitting. Participants were sent a pedometer (Fitbit) by post at the same time the education booklet was provided to self-monitor how far they walked and a diary to record activity context throughout the day.

2.4.2. Online coaching

Participants met briefly (20–30 min) via videoconferencing (Zoom, Microsoft Teams, Skype) with their coach every 2 weeks. The participant and coach reviewed the participant's walking calendar and addressed any barriers to engaging in physical activity and reducing sedentary behaviour. Participants will receive a pedometer (Fitbit watch) in adjunct with coaching sessions. In addition to instruction manual and paper diary sent out with the pedometer, a researcher was available to discuss and assist with any issues encountered with its operation.

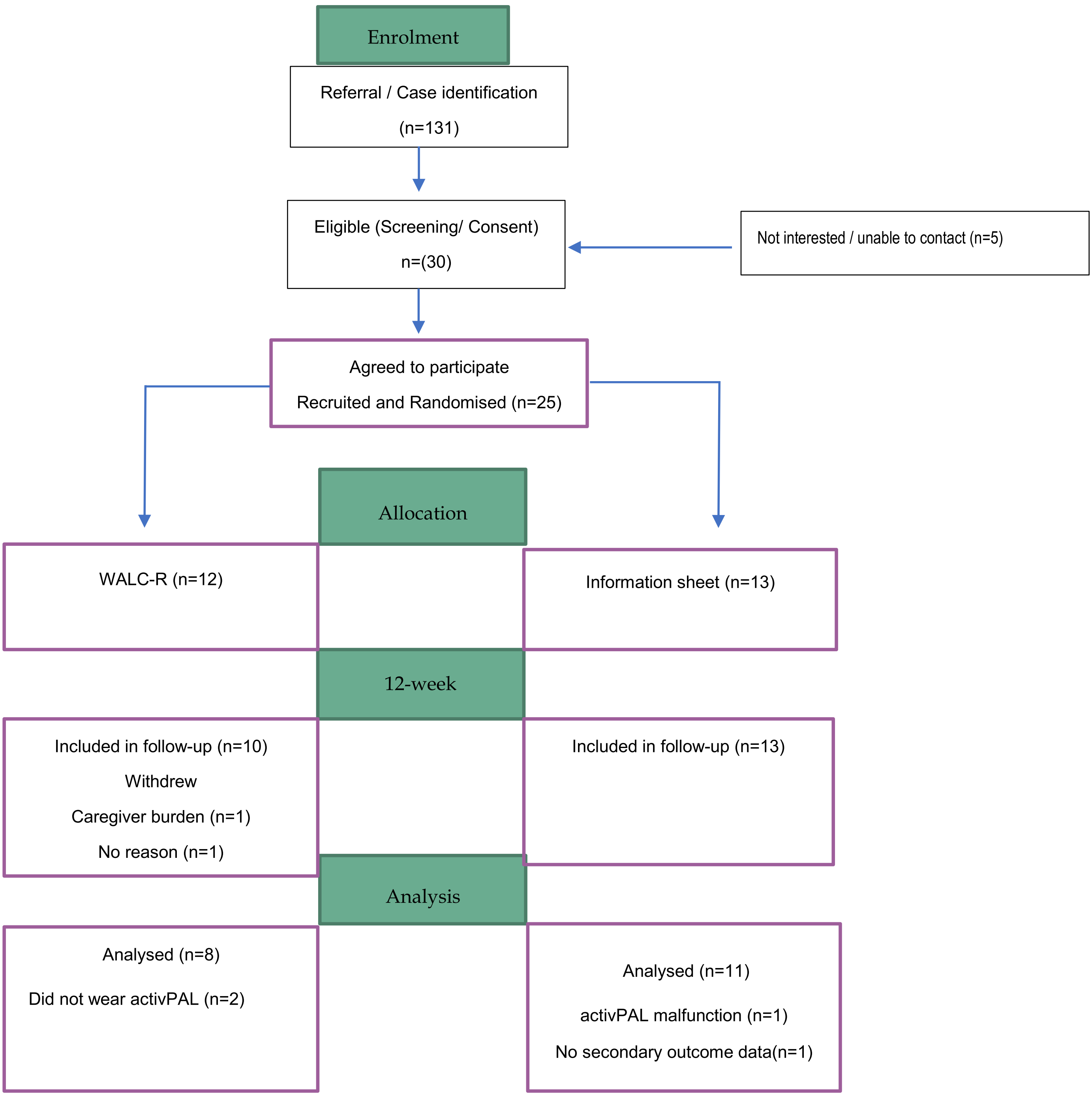

Fig. 1. Study flow diagram

Table 1
Components of the WALC-intervention.

The WALC-R Intervention	
W	Recommend walking as the most accessible and free form of exercise
A	Address unpleasant sensations (such as fear, fatigue, and pain) associated with increasing activity levels using various techniques as appropriate.
L	Learn about the benefits of increasing activity and reducing sedentary levels via the education session. Also addressing the barriers to attaining the aforementioned during coaching.
C	Cueing by self-monitoring and reminders to engage in activity using diaries and the Fitbit watch (pedometer).
R	Remote delivery of intervention

Adapted from Resnick ([46], P.42), Testing the effect of the WALC intervention on exercise adherence in older adults.

2.4.3. Health coaching

The TGROW (Topic, Goal, Reality, Options, Will) model was used to structure the coaching conversation with participants [15]. Each participant was provided with a 10 min pre-contracting call either by telephone or videoconferencing to explain the nature of the coaching conversation and number of expected sessions. The 'TGROW' coaching model stands for the following:

Topic: To understand the context, parameters of the conversations, relevance of issue with participant consent and build rapport.

Goal: To define a contextualized, relevant and controllable outcome for the session

Reality: To develop increased awareness, perspective and responsibility by exploring, challenging and confirming the current situation

Options: To create multiple possibilities to achieve the goal and recognize where new and additional choices can be made

Wrap-up: To ensure that having explored the goal for the session, the individual is able to confirm and commit to what they can take forward in terms of a plan of action that best achieves their goal within their individual context.

2.5. Follow-up assessment

A follow-up assessment was undertaken at the end of the intervention at week 13. At follow-up, all measures were repeated (apart from sociodemographic information).

2.6. Primary outcome: acceptability and feasibility

We measured the following:

- Time required to recruit 24 participants.
- How many people needed to be approached to recruit 24 participants.
- How many participants recruited to the study completed the intervention?
- What proportion of participants recruited dropped out of the study.
- How many coaching sessions participants completed (out of 5 per person)?
- Acceptability of the intervention
- Ability to collect all outcome data from all participants
- Adverse events

2.7. Secondary outcomes

Device-measured sedentary behaviour: Sedentary behaviour and physical activity time per day were recorded using activPAL inclinometer. The activPAL was the preferred device for measuring objective sedentary behaviour because of its high accuracy and precision when compared with self-reported sedentary behaviour [16]. Unlike other activity monitors and accelerometers, the activPAL can distinguish different postures and has near perfect correlation with direct observation for sitting/lying time, upright time, and sit-stand transitions (95.9%) [17]. A mean percentage difference of 0.19% (-0.68–1.06%) and 1.4% (-6.2–9.1%) between the activPAL monitor and observation for total time spent sitting and standing has been reported [17,18]. ActivPAL devices (activPAL3 micro), water-proofing material and adhesive dressings were mailed to participants expected to be returned to the researcher using paid self-return postage. Paper instruction and video on how to fit the activPAL were also provided. Participants were required to wear the activPAL continuously for 24 h/ day for at least 7 consecutive days at baseline and follow-up [16].

Event files from the activPAL devices were downloaded to Microsoft-Excel using the activPAL interface program. Data was collected and visually inspected for unusual episodes and non-wear periods. Daily times spent sitting, standing, or stepping, frequency of sit-stand transitions, step counts, were valid and calculated only for participants with a minimum of any 4 days of data. Daily data was included in the analyses only when activPALs were worn for 24 h (00:00 to 00:00) and daily sedentary levels were a measure of participants' waking day (07:00–23:59), i.e., time assumed that participants were likely to be awake. Days when activPAL was removed for any period by the participant were excluded from analysis.

Self-report sedentary behaviour using Sedentary behaviour questionnaire (SBQ) [19]*:* The SBQ was used to capture self-reported sedentary behaviour. Participants responded to the question 'on a typical weekend day/ weekday, how much time do you spend doing the following?'. Nine activities were listed including television viewing, playing video games and sitting reading a book. Responses were grouped into the categories: 'None', ≤15 min, 30, 1–5 h, 6 + h.

Verbal fluency: Participants' verbal ability was tested using the Benton Controlled and Oral Word Association Test- COWAT [20,21]. The choice of 'verbal fluency' as a proposed outcome measure for cognition was born out of prior work completed (systematic review [22] and longitudinal studies [23]), which predominantly found significant associations between executive function (verbal fluency) and sedentary behaviour. The COWAT is a widely used neuropsychological tool to assess frontal lobe and executive function in persons with Mild Cognitive Impairment or dementia [24]. Participants were required to make verbal associations to stimulus letters of the alphabet (C, F, and L) by saying all the words, which they could think of beginning with a given letter. Participants were scored based on how many correct words they could provide in 60 s.

Pre-morbid Intelligence: This was tested using the National Adult Reading Test (NART) [25]. Pre-morbid intelligence was assessed to rule out the influence of intelligence levels on cognitive test performance and to ensure that both control and treatment groups were comparable. Participants were asked to read from a list of 50 words, and then scored based on whether they pronounced each word correctly. The validity of the NART as a measure of pre-morbid intelligence is underpinned by the premise that reading ability of irregular words is crystallised, independent of brain damage. The NART scores were then used to calculate the Weschler Adult Intelligence Scale- Full Scale IQ, using the following formula:

Predicted WAIS-IV full Scale IQ= 126.41-0.9775 x errors [26]

Health Related Quality of Life (HR-QoL): The participants self-rated their health using the EQ-5D. Five dimensions were provided (mobility, self-care, usual activities, pain/discomfort and anxiety/depression) and five response levels: no, slight, moderate, severe, unable to/ extreme problems [27]. In addition, the EQ-Visual Analogue Scale (VAS) recorded the respondent's overall current health (0–100). Higher VAS scores represented best perceived health and vice versa.

2.8. Analysis

2.8.1. Statistical analysis

The proportion of eligible participants who participated in the study and how long it took to recruit 24 people was calculated. In addition, the study examined how many participants completed the intervention, total number of coaching sessions, and number of participants who did not have outcome data collected. The study tested whether secondary outcomes differed between participants in the intervention and control groups at baseline. Secondary outcomes were compared between participants in respective groups at follow-up. Further, changes in pre-post test scores between baseline and follow-up were calculated. Depending on whether the outcome variables were normally distributed (assessed visually via Kernel density plot and Shapiro-Wilk test), two-independent t-tests for independent samples or Wilcoxon-Mann Whitney tests (non-parametric) were used to assess the difference in outcomes between groups. A complete case analysis was performed to assess pre-post changes in secondary outcomes.

2.9. Qualitative analysis

All participants (n = 10) allocated to the intervention, who completed follow-up stage were interviewed to explore the acceptability of coaching received. Interviews were conducted via videoconferencing and recorded, lasting 15–20 min. Using an interview guide, participants were invited to speak about their experience of health coaching on the study; how it fitted in their daily life; and their perceptions around its limitations and benefits. Thereafter, a manifest analysis of transcribed texts was completed including a frequency count of categories and subcategories found. A manifest content analysis described the respondents' actual words or texts in a broad sense, without attempting to identify hidden or intended meanings in the texts [28,29]. A manifest content analysis was preferred because it describes findings on a level closest to the text, which ensures a level of trustworthiness and replicability [30]. Further, this level of analysis was deemed appropriate to add context to the quantitative findings of this study. Underpinned by the study objective, transcribed texts from interviews were divided into meaning units, which were condensed and coded into sub-categories and categories derived from the participants' experience of the health coaching received. A meaning unit is the smallest unit from the whole data that contains some of the insights the researcher needs to answer the research question [29].

3. Results

3.1. Baseline: sociodemographic and health

The baseline characteristics of the 23 participants are summarised in Table 2. The mean age of participants enrolled to the study was 74.6(7.5) years. Approximately 22, 56 and 22% of participants were aged between 60 and 69 years, 70 and 79 years and 80+ years respectively. 39.1% of participants were female, and all participants were of white ethnic background. 8.7% of participants reported they did not have a chronic health condition, 30.4% were living with one chronic condition and 60.9% had two or more chronic health conditions. 60.9% of participants reported cardiovascular disease risks such as hypertension, myocardial infarction, hypercholesteremia and diabetes. None of the participants were active/current smokers, but 21.7% had smoked previously.

When participants were asked to rate their perceived health status, 65.2, 30.4 and 4.4% of participants reported no problems, slight to moderate and severe problems with mobility respectively. 82.6% of participants reported no problems with washing and dressing, while 17.4% reported slight to moderate problems. 73.9 and 26.1% of participants reported no problem and slight to moderate problems with performing their usual activities respectively. 26.1% of respondents reported living without pain, 69.6% had slight-moderate pain, while 4.3% reported living with severe pain. 43.5% of respondents reported having neither anxiety nor depression, while 56.5% reported living with slight to moderate anxiety or depression. When asked to rate their health using a vertical visual analogue scale (0–100), where endpoints are labelled 'the best health you can imagine' (marked '100') and 'the worst health you can imagine' (marked '0'), the overall mean score was 83.7(9.3). The overall mean Wechsler Adult Intelligence Scale (WAIS) scores, a measure of pre-morbid intelligence for participants was 118.1 (8.2). Mean scores for the Controlled Oral and Word Association Test, used to measure verbal fluency was 36 (11.9). This study did not find associations between the baseline characteristics and group allocations (Table 2). Also, there were no statistical differences in mean pre-morbid intelligence (z = 0.5, P = 0.60) and verbal fluency (t(21) =0.9, P = 0.80) between study groups.

3.2. Baseline: sedentary activity

Participants reported spending a daily average of 553.7 (237.5) min of sedentary activities during the weekday and 552.3 (206) min during the weekend. Overall, reported mean time spent in 'cognitive activity in a sitting position' (computer use and reading) was 159.8 (123.9) min /day. When daily sedentary behaviour was measured using the activPAL device, participants spent 499.5 (124.5) min in a non-upright position during wake hours. Reported average daily sedentary time was 10% higher than device-measured mean daily sedentary time. The activPAL accelerometers were continuously worn for an average of 6.3 (1.3) valid days. The overall mean of sedentary behaviour as a percentage of total wear time during assumed wake hours of 0700H-2400H was 48% (12%). Daily mean stand and step time for participants were 249.7 (108.2) and 84.5 (43.5) min respectively. On average, participants took 6841 (SD 4450) steps daily and interrupted their sitting with 36 (12.7) sit to stand transitions. Participants spent 314 (104) min / day and 179 (91.9) min / day engaged in 30 min and 60 min sedentary bouts respectively. Further, the overall mean daily number of bouts by participants were 4.9 (1.7) for 30 min bouts and 1.8 (0.69) for 60 min bouts. There was a statistical difference in the mean reported daily sedentary time between groups (z = 3.3, P < 0.001). Participants in the information group reported to have spent less time been sedentary during the weekday: 405 (147.2) min/ day and weekend: 428.8 (142.2) min/day compared with the coaching group (weekday: 715.9 (211.6) min/day; weekend: 687.3 (181.2) min/day). Also, there was a statistical difference in the mean reported daily time spent in 'cognitive activity in sitting' (z = 2.1, P < 0.05). Participants in the coaching group reportedly spent double the time in cognitive activity in sitting (225(142.1)) min/ day compared with their counterpart (100(64.7)) min/day. However, the study did not find any statistical differences between study group of the means of all device-measured sedentary outcomes (Table 2).

3.3. Baseline: device-measured mean sedentary time by baseline characteristics (Table 3)

Participation in daily mean sedentary time, measured by the activPAL accelerometer was statistically different between participants with and without cardiovascular disease (CVD) risk factors (t (21)=-2.3, P < 0.05). Participants with CVD-related health conditions spent more time in sedentariness (543.6 (122.2) min/day) compared with their counterpart (430.8 (98.2) min/day). Although device-measured sedentary time varied amongst age groups, with those aged 80+ years spending most time in sedentariness (554.2; (139.7) min/day) compared with 60-69 years (496.3 (128.1) min/ day) and 70–79 years (479.5; (121.5) min/ day), there was no statistically significant difference across age categories (F(2)=0.63, P = 0.50). Male participants spent more time in sedentary time (524.5 (120.2) min/day) compared with female participants (460.5 (127.9) min/ day). But this was not statistically significantly different (t (21)= -1.21, P = 0.10). Similarly, participants who reported no chronic health conditions spent approximately 45 min less in daily sedentary time (428.2; (47.7) min/day) compared with those with at least one chronic condition (500.4 (145.9) min/ day) or more than two conditions (509.2 (123.9) min/ day). However, the findings were not statistically significantly different (F(2)=0.35, P = 0.70). There were no statistical differences in mean daily sedentary time by smoking (t(21)=-0.1, P = 0.40); self-reported mobility (F(3)=1.06, P = 0.40); self-reported washing and dressing ability (F(2)=0.82, P = 0.50); self-reported usual activities (F(2)=0.53, P = 0.60); self-reported pain (F(3)=0.62, P = 0.60); and self-reported anxiety or depression (F(2)=0.04, P = 0.90).

3.4. Primary outcomes- quantitative

131 participants were identified from the NIHR-Join Dementia Research website (n = 121), and community / voluntary services (n = 10,

Table 2
Baseline characteristics[c] and secondary outcomes of participants and their associations with / between study groups ($n = 23$).

Characteristics	Overall (min)	Coaching ($n = 11$) (min)	Information ($n = 12$) (min)	Associations ($P < 0.05$) ß
Age (years)				
60-69	21.7	27.3	16.7	$P = 0.80$*
70-79	56.6	54.6	58.3	
80+	21.7	18.2	25.0	
Sex				
Male	60.9	45.5	75.0	$P = 0.20$*
Female	39.1	54.5	25.0	
CVD risk				
No	39.1	27.3	50	$P = 0.40$*
Yes	60.9	72.7	50	
Chronic condition				
None	8.7	0	16.7	$P = 0.50$*
1	30.4	27.3	33.3	
2+	60.9	72.7	50.0	
Smoking				
Non-smoker	78.3	63.6	91.7	$P = 0.20$*
Previous smoker	21.7	36.4	8.3	
Alcohol Mean (SD)	7.7(8.1)	7.8(8.4)	7.6(8.3)	t(21)=0.05, $P = 0.50$**
EQ-5D (Mobility)				
No problem	65.2	72.7	58.3	$P = 0.60$*
Slight/Moderate	30.4	18.2	41.7	
Severe	4.4	9.1	0.0	
EQ-5D (Self-care)				
No problem	82.6	100	66.7	$P = 0.10$*
Slight/Moderate	17.4	0	33.3	
EQ-5D (usual activity)				
No problem	73.9	81.8	66.7	$P = 1.00$*
Slight	26.1	18.2	25.0	
Severe	0	0	8.3	
EQ-5D (Pain)				
No pain	26.1	9.1	41.7	$P = 0.07$*
Slight/Moderate pain	69.6	90.9	50.0	
Severe pain	4.3	0	8.3	
EQ-5D (Anxiety/depression)				
None	43.5	54.5	33.3	$P = 0.50$*
Slight/ Moderate	56.5	45.5	66.7	
EQ-5D VAS (Mean(SD)	83.7(9.3)	84.5(7.9)	82.9(10.8)	t(21)=0.41, $P = 0.70$**
Premorbid Intelligence [a] (Mean (SD)	118.1(8.2)	119.7(116.8)	116.8(9.8)	z=0.5, $P = 0.60$#
Verbal Fluency [b] (Mean(SD)	36(11.9)	38.3(11.6)	33.9(12.5)	t(21)=0.9, $P = 0.80$**
Valid days (wear time)[c] (Mean (SD)	6.3(1.3)	6.6(1.7)	6.1(0.7)	t(21)=1.0, $P = 0.80$**
Device-measure sedentary time (min) (Mean(SD)	499.5(124.5)	500.8(106.9)	498.2(143.6)	t(21)=0.05, $P = 0.50$**
Self-reported sedentary time (weekday)-(min) (Mean(SD)	553.7(237.5)	715.9(211.6)	405(147.2)	z=3.3, $P < 0.01$*# ß
Self-reported sedentary time (weekend)- (min) (Mean (SD)	552.3(206)	687.3(181.2)	428.8(142.2)	z=3.1, $P < 0.01$*# ß
Time spent in CAS (min) (Mean(SD)	159.8(123.9)	225(142.1)	100(64.7)	z=2.1, $P < 0.05$# ß
Sedentary as % of wear-time [c] (Mean(SD)	48(12)	49(10.4)	48(14.1)	t(21)=0.05, $P = 0.50$**
Stand time (min)[c] (Mean(SD)	249.7(108.2)	237.5(107)	260.9(112)	z=-0.6, $P = 0.60$#
Step count (min)[c] (Mean(SD)	6841(4450)	7518(4766)	6220(4250)	z=0.9, $P = 0.30$#
Sit to Stand transition (Mean(SD)	36(12.7)	38(14)	34(11)	t(21)=0.8, $P = 0.80$**
Time spent in 60-mins bout (min) [c] (Mean(SD)	179 (91.9)	181(88.3)	178(98.9)	z=0.09, $P = 0.90$#
No. of 30-mins bouts [c] (Mean(SD)	4.9(1.7)	5.1(1.9)	4.7(1.6)	t(21)=0.6, $P = 0.70$**
No. of 60-mins bouts [c] (Mean(SD)	1.8(0.7)	1.8(0.6)	1.7(0.7)	t(21)=0.16, $P = 0.50$**

Data are in percentages unless stated otherwise.
SD, standard deviation; EQ-5D, EuroQoL- 5 Dimension; EQ-VAS, EuroQoL-5 Dimension Visual Analogue Scale; CAS, Cognitive Activities in Sitting.
*Fisher's Exact test, **Two independent sample t-test, #Wilcoxon-Mann-Whitney test.
[a] Premorbid intelligence was measured by calculating the Wechsler Adult Intelligence Score IV- Full Scale Intelligence Quotient from the National Adult Reading Test.
[b] Verbal fluency was measured using the Controlled Oral Word Association Test.
[c] Device -measured sedentary outcomes using the activPAL.

Table 3
Daily mean sedentary time (device-measured) stratified by baseline characteristics of participants ($N = 23$).

Characteristics	Category	Mean sedentary time/day (min)	Difference in means test ($P < 0.05$) ß
Age (years)	60-69	496.3 (128.1)	F(2)=0.63, $P = 0.50$#
	70-79	479.5 (121.5)	
	80+	554.2 (139.7)	
Sex	Male	524.5 (120.2)	t(21)=-1.21, $P = 0.10$*
	Female	460.5 (127.9)	
CVD risk	No	430.8 (98.2)	t(21)=-2.3, $P < 0.05$*
	Yes	543.6 (122.2)	
Chronic health condition	None	428.2 (47.7)	F(2)=0.35, $P = 0.70$#
	1	500.4 (145.9)	
	2+	509.2 (123.9)	
Smoking	Non-smoker	497.4 (129.5)	t(21)=-0.14, $P = 0.40$*
	Previous smoker	506.8 (118.2)	
EQ-5D (Mobility)	No problem	502 (130.5)	F(2)=1.06, $P = 0.40$#
	Slight	518 (103.9)	
	Moderate	371.6 (102.5)	
EQ-5D (Self-care)	No problem	514.5 (124.5)	F(1)=0.82, $P = 0.50$ #ß
	Slight	436.9 (134.3)	
EQ-5D (usual activity)	No problem	494.3 (125.1)	F(1)=0.53, $P = 0.50$#
	Slight	536.7 (135.3)	
EQ-5D (Pain)	No pain	459 (135.5)	F(2)=0.61. $P = 0.60$#
	Slight	532.1 (132.9)	
	Moderate pain	501.9 (109.4)	
EQ-5D (Anxiety/depression)	None	508.6 (127.4)	F(2)=0.04, $P = 0.90$#
	Slight	491.8 (151.5)	
	Moderate	492.8 (114.6)	

Data are in mean (Standard deviation).
SD, standard deviation; EQ-5D, EuroQoL- 5 Dimension; CAS, Cognitive Activities in Sitting.
*Two independent sample t-test, #One-way analysis of variance.

Fig. 1). Following screening, 30/131 were eligible to participate. Of those who were eligible, 25/30 (83%) consented and were enrolled to the study between October 2020 and May 2021, a duration of 7 months. The researcher was unable to contact 5/30 eligible participants. At baseline, 13 were randomised to receive information on physical activity and 12 were randomised to receive coaching. At follow-up visit (week 12), 2/12 participants from the intervention group withdrew from the study, while none from the control group withdrew. The combined attrition rate between baseline and end of study was 8%. The remaining participants randomized to coaching completed 5 sessions / fortnight as per protocol. At baseline, outcome data from all who received allocated intervention/control ($n = 23$) was collected in full. Also, all participants at baseline (100%) wore their activPAL and returned full data for more than the minimum required 4 valid days (mean:6.3(1.3). However, at follow-up, secondary outcome data was missing for four participants due to 1/23 malfunctioned activPAL monitor, 2/23 participants not wearing the activPAL or worn incorrectly and 1/23 not attending their visit. Therefore, these data were excluded from final analysis. 82% of participants returned valid activPAL data, with a mean wear period of 6.5(0.9) days. An adverse event was reported by one participant. The participant reported that they sustained a fall, without mild bruising, during the early phase of the study. This incident was discussed with the researcher during a routine check on participant. Ten participants allocated to coaching at follow-up agreed to be interviewed. Findings from the interview analysis are presented in the following section.

3.5. *Secondary outcomes- quantitative*

12-week follow-up: Secondary outcomes (Table 4)

Overall, 19 out of 23 (82%) participants had complete outcome data including valid accelerometer data at follow-up. Participants averaged a valid wear period of 6.5(0.9) days, without any statistically significant difference between groups (t(17)=0.63, $P = 0.50$). Valid wear period refers to a number of days during which wear time was adequate to capture sufficient data during waking hours (0700-2400H). Overall mean wear period for participants remained the same between baseline and follow-up 6.5(0.9) days. Except from self-reported sedentary behaviour, there were no statistical differences in pre-post changes between groups. Overall, self-reported daily mean sedentary levels reduced by 65 (36.6) min at follow-up with the coaching group accounting for the reduction (-166.7 (54.6) min) while the control group increased their daily sedentary time by 25.5 (27.7) min. There was a statistically significant difference in pre-post changes between groups (t(17)=-3.23, $P = 0.002$). On the contrary, device measured sedentary levels increased overall by 10.5 (16.8) min with increases in the coaching: 9.5(27.4) min and control: 11.5(21.8) min, without a statistically significant difference between groups (t(17)=-0.05, $P = 0.52$). Sedentary behaviour as percentage of wear time barely changed with a 1% increase across groups. Overall daily mean standing and stepping time increased by 14.5 (9.2) and 7.6(6.9) min respectively. Overall step counts increased by 508.1(705.5), with a greater increase in the coaching group: 643.3(1433.8) when compared with the control group: 386.5(493.4). While time spent in 60 min of sedentary bout decreased overall by 13.6(18.2) min and equally in both groups, time spent in 30 min sedentary bouts increased in the control group by 4.9 (20.8) min, while it reduced in coaching group by 3.8(32.1) min, with no statistically significant difference (t(17=-0.23, $P = 0.41$). Verbal fluency and Weschler Adult full-scale IQ-IV scores increased overall by 2.4(1.5) and 1.1(0.5) respectively. Finally, there was a slight and non-clinically significant increase in overall EQ-VAS (self-rated health) scores (0.52(5.5)).

3.6. *Primary outcomes- qualitative*

Overall, the participants' experience of coaching was positive, albeit with some challenges. None of the participants had experienced health coaching in the past. Transcribed texts were collected, interpreted and grouped into the following main categories (1) Accessibility (2) Coaching style/approach (3) Limitations (4) Perceived benefits. The quotations embedded with the findings below exemplify key findings.

3.6.1. *Accessibility*

49 out of the 50 coaching sessions attended, meaning that adherence to appointments was high. The flexible approach to accessing coach-

Table 4
Follow up and pre-post intervention change in secondary outcomes ($N = 19$).

	Follow-up ($n = 19$) mean(SE)				Baseline to Follow-up ($n = 19$) mean(SE)			
	Overall	Coaching	Control	P	Overall	Coaching	Control	P
SB (% wear time)	49.5(3.0)	48.2(4.3)	50.8(4.6)	0.65	1.0 (1.6)	1.0(2.7)	1.1(2.1)	0.52
SB time (mins)	505.5(31.3)	491.6(43.6)	518.1(46.5)	0.65	10.5 (16.8)	9.5(27.4)	11.5(21.8)	0.52
Stand time (mins)	265.6(24.7)	262.6(37.3)	268.3(34.5)	0.54	14.5(9.2)	9.2(17.4)	19.3(8.7)	0.70
Step time (mins)	87.4(12.9)	98.5(23.8)	77.4(12.9)	0.22	7.6(6.9)	5.3(13.6)	9.7(6.1)	0.62
Step count (mins)	6931.2(1452.2)	8574.9(2863.4)	5451.8(970.2)	0.15	508.1(705.5)	643.3(1433.8)	386.5(493.4)	0.43
Sit-to-Stand min)	38.1(2.9)	37.6(3.8)	38.6(4.7)	0.56	2.9(1.9)	-0.05(2.2)	5.7(2.9)	0.93
30 min bout time (min)	314.7(22.9)	308.5(31.3)	320.4(34.6)	0.59	0.7(18.2)	-3.8(32.1)	4.9(20.8)	0.41
60 min bout time (min)	175.2(16.7)	176.1(18.1)	174.4(28.1)	0.48	-13.6(18.2)	-13.5(27.1)	-13.7(25.9)	0.50
Self-reported SB time	464.2(39.3)	526.7(61.7)	408(45.8)	0.06	-65(36.6)	-166.7(54.6)	25.5(27.7)	0.01*
CAS time	147(28.4)	182(48.8)	115.5(30.3)	0.12	-9.3(19.4)	-34.7(33.4)	13.5(20.5)	0.88
Verbal Fluency	37.6(3.2)	37(4.5)	38.1(4.9)	0.56	2.4(1.5)	0.9(2.2)	3.7(2.1)	0.82
Pre-morbid Intelligence	119.5(1.8)	120.8(1.8)	118.3(3.1)	0.25	1.1(0.5)	1.6(0.9)	0.7(0.4)	0.37
EQ-5D VAS	82.9(2.7)	81.7(4.2)	84(3.6)	0.70	0.52(5.5)	-1.7(4.4)	2.5(3.4)	0.77

Data are in mean (Standard Error).
SB, Sedentary Behaviour; SD, standard deviation; EQ-5D VAS, EuroQoL- 5 Dimension- Visual Analogue Scale; CAS, Cognitive Activities in Sitting.
*Two independent sample t-test.

ing may have contributed to the high attendance rate. Coaching appointments were agreed between coach and participants and offered based on availability. The texts revealed that participants were afforded a choice of how to receive coaching, which were either via telephone or videoconferencing. 5 out of 10 participants accessed their coaching sessions via the telephone only, while 1 out of 10 reported using a blend of telephone and videoconferencing. Flexible arrangements were available if participants were unable to make their booked appointments. Where possible, alternative sessions were provided to participants without disrupting the study timeline. Also, flexibility enabled coaching sessions to fit into their daily routine, while minimizing interruptions. Participants repeatedly spoke of a range of flexibility afforded to them in organising appointments, and indicated that this process was straightforward:

‘I think had to change for their appointments and, you know, move them. But we again, we agreed an alternative time slot, which was fine (M, 64).’

‘It was quite easy. Except for the one time, we had to move it an hour because it was interrupting the family’s zoom meeting (M, 75)’

3.6.2. Coaching style

The texts showed that the sessions were a partnership, which involved conversation and / or discussion between the coach and participants. Participants were not only involved in the discussion around reducing sedentary behaviour but were also supported to make positive lifestyle or behavioural changes. Participants used words such as ‘friendly’, ‘nice’ and ‘lovely’ to describe the coach, which suggested that they had a likeable personality. Transcribed texts indicated that the coaching approach was quite supportive and often involved developing a rapport with participants. One of the respondents described how the support received helped realize benefits outside the original objectives of the coaching. Specifically, they were grieving the loss of a family member and the coaching created a safe space to help continue the process of healing:

‘If I had not had [coach], I would have had to have gone and found a therapist. Because, as I say. I was in a very dark place, and they were very, very supportive. I want to say that that was the rapport between myself and [coach] and I was in a rubbish place’ (F, 77).

Participants reported how the coach’s expertise and professional status helped to instill confidence and positively re-enforced their achievements and / or progress. Despite the coach’s expertise, participants reported how important it was that their approach was motivational rather than authoritative. This style of coaching appeared to have empowered participants to be self-accountable, and facilitated engagement with the process:

‘She encourages without making you feel without making you feel awkward or bad if you had not done exactly what you said you do’ (F, 77).

When she prompted me to think about an area, I then went off to look and say, well, what could I do that could help keep my motivation there and give me some feedback as well (M, 64).

3.6.3. Perceived limitation

The text revealed some challenges experienced by participants during the coaching. 3 out of 10 participants felt they were already active enough and that coaching sessions was not beneficial. One respondent expressed that the coaching would have better benefitted people who were more inactive than they were. Some participants expressed that the sessions merely re-affirmed what they already knew or did or believed in, while one respondent described the process as common sense:

‘I was already sort of recognizing what I wanted to do more exercises for instance, walking, which I love. She was keen to see I was organised; set some goals and I was monitoring against them. But effectively I was already there. In some respects, we were one because everything we did sort of married together (M, 75).’

Participants encountered barriers during the coaching process including environmental, health status, wearable device (Fitbit), lack of access to preferred activities and amenities during lockdown and intermittent access to internet. Participants were unable to enact some of their agreed change plans because their environment was not suited. For example, a respondent, who was limited because they lived in bungalow, could not successfully implement stepping to displace sedentary behaviour:

‘I think if there were more practical suggestions. OK, I am limited because I live in a bungalow and there are no steps that one can not bring those into all those stairs (F, 86).

Some participants had chronic health conditions with resulting functional limitations, which impacted on their ability to fully engage in activation, while others felt that some of the activities advised were incompatible with daily living or unrealistic:

‘I love walking, but, um, I’m a bit worried about, you know, like the, the jarring on the knees (M, 74).’

‘But I tend to communicate these days via messaging on iPad. And you have to sit down to do that. So, it’s just not possible to walk around doing that (F, 63)’

Due to the pandemic restrictions, amenities that could facilitate increased activities, which participants deemed pleasurable or preferred were not available, e.g., swimming and gymnasium. The Fitbit was an issue for many of the participants as they either struggled with operating it or were worried about being overly dependent on it. 3 out of 10 participants would have liked to have more frequent or longer sessions. Access to consistent and good internet quality was a barrier to coaching sessions for one of the participants. But they were offered coaching via telephone as an alternative. Finally, texts showed that the sessions were challenging for some participants due to their memory problems. They found it difficult to remember their appointments and sometimes their agreed goals from the coaching sessions. Participants suggested that the coaching would have been more beneficial had they received reminders, auto-reminders of their appointment and summary emails of the coaching sessions:

'To be honest with you, I have no memory of anything like that in my memory, as you know, is absolutely horrendous (F, 86).'

'I appreciated [coach] obviously did suggest things because I reacted to them and did things, but I have no good recall of what those were (M,64).'

Perceived benefits

The findings indicated that participants found coaching beneficial because it made them more active and displaced sedentary levels. Seated activities were commonly displaced for light and moderate activities such as standing and walking. Due to the nation-wide pandemic restrictions, participants were creative about how they reduced sedentary levels and engaged in more 'moving' activities such as breaking up prolonged sitting, switching workstations, 'going up and down stair' and 'moving while cooking':

'I try to set my alarm, so I did not sit down for too long (F, 63)'

'I have a work computer and a home computer, and I used to have the two at the same desk. And so, what I did was I moved my home computer into a different room, which meant that when I switched between work activity and doing some stuff like studying, I also moved my study materials upstairs. So, it meant when I switched between activities, I had to physically get up and move to a different area (M, 64).'

Finally, some respondents expressed that the Fitbit monitors used as an adjunct to coaching were helpful because they could self-monitor against set goals, which consequently spurred them on to increase their activity levels.

4. Discussion

This study aimed to test the feasibility of remote health coaching as a sedentary behaviour (SB) modifying intervention in older people with Mild cognitive Impairment (MCI), with the aim of conducting future trial to test the effectiveness of the intervention on cognitive function. In response to calls for intervention studies to the test the efficacy of reducing sedentary behaviour and cognitive function, our study is the first (to the best of knowledge) to examine this link using a trial design in community dwelling at-risk population [3,22]. Up to the present time, two cross-over trials have examined short term effects of interrupted sitting on cognitive function in adults and older adults but found none [31,32]. The more recent cross-over trial by Maasakker and colleagues [32] examined the short term effects of three hours of interrupted sitting on cerebral function and cognitive in a controlled laboratory setting. The study did not find any effect of interrupted sitting on the executive function and working memory possibly due to the short-term duration of the interrupted sitting and cerebral autoregulation, which reacts to preserve the cerebral blood flow and consequently acute cognitive performance. In addition, these studies were conducted in a controlled setting, thus evidence may not be generalisable to the free-living older population.

We found that this study was feasible and would be worth scaling up to full-scale randomised controlled trial. 83% of eligible participants consented and 104% of the target sample (n = 24) was achieved over the duration of 7 months. We consider this study as successful because it was conducted during a global pandemic, when memory / dementia clinical services were temporarily suspended, and dementia research was halted nation-wide to allow capacity for COVID-19 studies designated as urgent public health need. Despite these challenges, the drop-out rate was low (n = 2, 8%) and recruitment and retention rates were comparable with other dementia studies in the United Kingdom [33]. In addition, this study was able to collect between 82–100% of our outcome data. Our study performance could be attributable to the change in our approach from face to face to remote delivery of study activities using videoconferencing, mail delivery, and telephone. This study was not alone in shifting to remote delivery of research during the pandemic. A survey of 245 clinical studies reported that proportion of participant interactions conducted remotely increased during the first wave of the pandemic by 48% [34]. However, in-person visits for participants should not be totally abandoned in favour of remotely delivered trials because it is not currently expedient nor cost-effective to deliver certain investigations such as imaging, blood testing, tissue biopsy remotely. Although not related to our trial intervention, one adverse event was recorded and reported in our findings. This was important because non-pharmacological studies do not adequately report nor publish adverse events when compared with pharmacological trials [35,36].

Our study intervention was deemed acceptable to our recipient participants. Participants reported that the coaching received was accessible, enjoyable and beneficial to them. Participants successfully used the learning from the coaching session to displace sedentary behaviour and increase their activity levels. The participants consistently attributed their satisfaction to the supportive and motivational coaching approach. However, participants expressed some limitations to the coaching received. Despite the health coaching, some participant experienced barriers to engaging the agreed plans aimed at increasing their activity level such as health status, environment, restricted access to the outdoors and amenities during the pandemic, and access to good quality internet. These issues were similar to well-established and documented barriers to physical activity uptake in the older population and perhaps could have been better addressed during coaching [37]. A separate challenge highlighted was the inability of participants with significant memory problems to fully engage and realise benefits from health coaching. However, not all participants in our study experienced this problem probably because people living with MCI vary in their main domain of cognitive deficit namely: memory, language, visuospatial, processing speed and executive function [38]. Therefore, an area of future improvement to this intervention should include tools aimed at assisting memory recall to improve the experience of people mainly with the memory domain type of MCI.

Our sample was comparable to older population living with MCI and who engage in research. They were predominantly from a white ethnic background, did not smoke, drank safe levels of alcohol (7 units/week), were functionally independent and lived with 1-2 controlled chronic health conditions. Allocated groups did not differ on baseline characteristics except for self-reported sedentary level. More importantly the participants' pre-morbid intelligence scores did not differ between groups indicating that their cognitive performance was not influenced by their intelligence. Participants engaged in high levels of sedentary behaviour, averaging 500 min (8.3 h) a day when measured objectively with an activPAL. When self-reported, sedentary levels were about 553 min (9.2 h) / day. Our findings are in line with widely reported data on sedentary behaviour in the older population [1,39–41]. Levels of sedentariness in our participants was comparable with a study by Falck et al. which reported that older adults with probable MCI spent 61% of their day in sedentary activities [8]. Our study showed that participants spent 48% of wear time/day in sedentary activities. The Falck et al. study did not report actual time spent in sedentary behaviour and MCI was not diagnosed in the participants [8]. Contrary to current evidence, this study found that participants over-estimated self-reported sedentary levels by an average of 53 min when compared with device measured sedentary behaviour. Previous literature suggested that older adults tend to underestimate self-reported sedentariness by about 2.4 h when compared with device-measured sedentary behaviour [42,43]. This was possibly due to restricted movement imposed on participants from government measures during the COVID-19 pandemic, which consequently may have increased their propensity to report/recall spending more time in sedentariness. Participants engaged cognitive activities during sitting such as reading, computer work, office work for an average of 2.6 h/day. This is important for our participants because cognitive activity during sitting has been shown to offer some protective association with cognitive impairment (OR= 0.61, 95%CI, 0.55, 0.68) [44]. Further, engaging in 3+ h of mentally active sedentary behaviour may confer some benefits on adults mental well-being [45].

Self-reported daily mean sedentary level reduced by one hour between baseline and follow-up, with the coaching group accounting for the greater proportion-(166(54.60) min) compared with the information group which increased their sedentary level by 25(27) min. This is contrary to device-measured sedentary behaviour which increased, overall, by 10 min/day. Self-reported sedentary behaviour is subject to recall bias and may have been understated at follow-up. Overall, device measured step counts increased by 508 steps/day, while 60 min bouts of sedentariness reduced by 13 min/day indicating some displacement of sedentary activities for light physical activity by participants. This is encouraging because light physical activity may also confer health benefits, especially in some older people who are not able to participate in moderate to vigorous physical activity.

Our study has strengths and limitations. First, this is the first study to use an intervention design to test the feasibility of a sedentary reducing intervention with a view to examine its effectiveness on the cognitive function in a free-living high risk population group in a future trial. Secondly, sedentary behaviour was assessed objectively using the activPAL inclinometer, which was a limitation in previous studies that opted for self-reported measures. Thirdly, this study recruited to target and within the planned duration during a pandemic. Finally, we were able to deliver all study activities remotely without needing an in-person interaction. A limitation of this study was that it had a small sample size (n = 23) and not sufficiently powered to infer any statistical / clinical significance of pre-post changes in secondary outcomes. We predominantly recruited our participants from the JDR database. While this is a valuable resource for dementia studies, there is a possibility that some of the self-reported MCI diagnosis may have been inaccurate or out of date. A future clinical trial may consider further screening tests to confirm an MCI diagnosis. The resulting suspension of memory and dementia clinical services during the pandemic posed a challenge to recruitment. The fact that we recruited mostly from the JDR may have inadvertently contributed to sampling bias. Recruiting to a future trial should consider multiple sources including clinical services, which would increase representation and ensure that results are more generalizable to the target population. Also, a future trial may need to explore whether there is any carry-over effect of a 13-week intervention in the medium to long term on cognition because of entrenched sedentary behaviour. We did not cover all aspects of cognition, instead focused on areas known to have associations with high sedentary levels. However, other areas of cognitive function could be considered in a full-scale trial. Finally, our study intervention could improve its accessibility to participants with memory-dominant MCI by adding tools that would assist with appointment reminders and recall of health coaching proceedings.

5. Conclusion

Studies have demonstrated diverse associations between sedentary behaviour (SB) and cognitive function, independently of physical activity, in the older population but confirmatory causal association is lacking. This study demonstrates that reducing SB through remote health coaching is acceptable and feasible in the older population living with Mild Cognitive Impairment. Reducing dementia and cognitive risk in the older population is a public health priority. To further the evidence in this area, a future trial now needs to be completed to determine the effectiveness of reducing sedentary behaviour on the cognitive function in this population.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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