Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

Emilie Bertelsen

"As long as I can and as long as I live..."

A pre-post feasibility study investigating motivation for and influence of a game-based exercise app on physical activity level in older adults

Master's thesis in Physical Activity and Health
Supervisor: Nina Skjæret Maroni
Co-supervisor: Astrid Ustad
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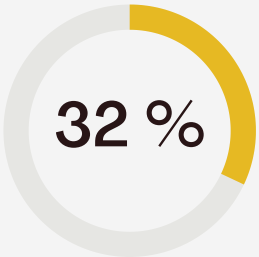
GAME-BASED EXERCISE FOR OLDER ADULTS

MOTIVATION AND PHYSICAL ACTIVITY LEVEL

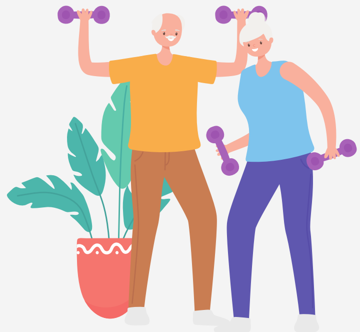


Only 32 % of Norwegian older adults are sufficiently physically active

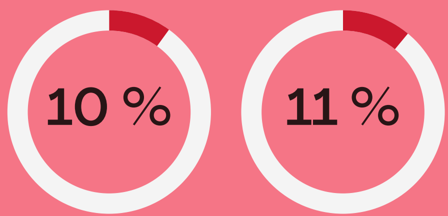
Physical activity can give substantial health benefits. Home-based exercise using technology have shown to improve physical activity level, walking quality and balance. It has also shown high adherence, motivation and enjoyment

6 weeks use of game-based exercise app 'Keep On Keep Up' (KOKU)

Activity level was measured using Axivity AX3 accelerometers before and after use of KOKU. Whether KOKU could motivate for physical activity was assessed through semi-structured interviews after four weeks use



Daily activity level before/after use of KOKU



of daily time awake. No significant change was discovered

KOKU was experienced as

Motivating

Enjoying

Easy to use

Some participants experienced physical improvements: walking capacity, balance, strength and perceived improved activity level

Although no change in activity level was discovered, the participants were generally positive towards using KOKU as a means to include more physical activity in everyday life

For more information and references, see Bertelsen E. "As long as I can and as long as I live...": A pre-post feasibility study investigating motivation for and influence of a game-based exercise app on physical activity level in community-dwelling older adults. 2021.

Abstract

Introduction: Physical activity (PA) can reduce risk of non-communicable diseases, but few older adults fulfill the World Health Organizations PA recommendations. Exercise that can be performed at home might reduce exercise-barriers. Enjoyment is an important PA-motivator, and technology- and game-based exercise appears motivating, enjoying and to improve physical function in older adults. However, few studies have investigated whether exercise apps for older adults can increase PA. Therefore, the aim of this thesis was to investigate if a game-based app can be used to motivate for and increase PA level in community-dwelling older adults with incipient loss of function.

Methods: A pre-post feasibility study with 16 community-dwelling older adults, recruited in Trondheim, Norway from October 2020 to February 2021, was conducted. To be included participants had to be over the age of 70 years; live independently; walk without walking aids indoors; have self-perceived incipient loss of function; have no injury/surgery in the lower extremity/back the last 3 months, and; no known cognitive disorders/diseases. Participants used the exercise app 'Keep On Keep Up' (KOKU) at home for six weeks. PA level was assessed using accelerometers at Baseline and Week Six, and semi-structured interviews assessed motivation at Week Four. Analyses were conducted using Acti4 and thematic analysis, respectively.

Results: 15 participants were included in the analysis. Average daily PA level was 10.37 % (± 5.72) of mean daily time awake at Baseline, and 10.65 % (± 5.82) at Week Six. Daily time standing changed from 17.89 % (± 15.95) to 16.59 % (± 10.62), while sedentary time was 71.62 % (± 4.89) at Baseline and 73.36 % (± 3.45) at Week Six. No significant change was discovered ($p = 0.610$ [95 % CI: -1.489, 0.901]; $Z = -0.227$, $p = 0.820$; $Z = -0.511$, $p = 0.609$, respectively). KOKU was experienced as motivating, enjoying and easy to use, and some perceived their physical function improved. Improving/maintaining physical function, the visual instructor and presence of the iPad were emphasized as motivating factors.

Conclusion: Even though KOKU did not significantly increase PA level in community-dwelling older adults with incipient loss of function after 6 weeks, the app was experienced as motivating and enjoying, and perceived as intuitive and easy to use. This indicates that tailored exercise apps can be useful to implement activity in older adults.

Keywords: Physical activity, exercise technology, game-based app, motivation, accelerometer, semi-structured interview, older adults

Sammendrag

Introduksjon: Fysisk aktivitet (FA) kan redusere risikoen for ikke-overførbare sykdommer, men få eldre oppfyller Verdens Helseorganisasjons anbefalinger om FA. Trening som kan utføres hjemme kan redusere treningsbarrierer. Fornøyelse er en viktig motivator for FA, og teknologi- og spillbaserte treningsapper ser ut til å være motiverende, fornøyelige og forbedrer fysisk funksjon hos eldre. Imidlertid er det få studier som har undersøkt om treningsapper for eldre kan øke FA-nivå. Derfor er målet med denne oppgaven å undersøke om en spillbasert app kan brukes for å motivere for og å øke FA-nivå hos hjemmeboende eldre med begynnende funksjonstap.

Metode: En pre-post gjennomførbarhetsstudie med 16 hjemmeboende eldre, rekruttert i Trondheim, Norge fra oktober 2020 til februar 2021, ble utført. For å bli inkludert måtte deltakerne være over 70 år; hjemmeboende; gå uten hjelpemidler innendørs; ha selvoppfattet begynnende funksjonstap; ingen skade/operasjon i underekstremiteten/ryggen de siste 3 månedene, og; ingen kjente kognitive tilstander/sykdommer. Deltakerne brukte treningsappen 'Keep On Keep Up' (KOKU) i eget hjem i seks uker. FA-nivå ble estimert ved bruk av akselerometre ved Baseline og Uke Seks, og semi-strukturerte intervjuer undersøkte motivasjon i Uke Fire. Analyser ble gjennomført ved bruk av henholdsvis Acti4 og tematisk analyse.

Resultater: 15 deltakere ble inkludert i analysen. Gjennomsnittlig daglig FA-nivå var 10.37 % (± 5.72) av gjennomsnittlig våken tid ved Baseline, og 10.65 % (± 5.82) i Uke Seks. Daglig tid stående endret seg fra 17.89 % (± 15.95) til 16.59 % (± 10.62), mens stillesittende tid var 71.62 % (± 4.89) ved Baseline og 73.36 % (± 3.45) i Uke Seks. Ingen signifikant endring ble oppdaget ($p = 0.610$ [95 % CI: -1.489, 0.901]; $Z = -0.227$, $p = 0.820$; $Z = -0.511$, $p = 0.609$, henholdsvis). KOKU ble opplevd som motiverende, fornøyelig og lett å bruke, og noen opplevde bedret fysisk funksjon. Forbedre/opprettholde fysisk funksjon, den visuelle instruktøren og nærværet av iPaden ble understreket som motiverende faktorer.

Konklusjon: Selv om KOKU ikke signifikant økte FA-nivå etter 6 uker hos hjemmeboende eldre med begynnende funksjonstap, ble appen opplevd som motiverende og fornøyelig og oppfattet som intuitiv og lett å bruke. Dette indikerer at skreddersydde treningsapper er nyttige for å innføre aktivitet hos eldre.

Nøkkelord: Fysisk aktivitet, treningsteknologi, spillbasert app, motivasjon, akselerometer, semi-strukturert intervju, eldre

Acknowledgements

This year, with COVID-19 and everything following it, has been different and challenging. Still, I have had a nice year with many fun experiences and learned a lot while working with this project. One thing that has always been stable is the delivery date of this master thesis. Incredibly enough, it has now come.

First, I would like to thank my supervisors, Nina Skjæret Maroni and Astrid Ustad, who have been important supporters, motivators and inspirers throughout the year. This thesis would never have seen the light of day without you, and I greatly appreciate all your help and guidance. I would also like to thank Anders Glorvigen Lundstein, my partner in crime through recruitment, data collection and analysis.

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Lastly, but not least, I would like to thank my family and friends, who have been motivating, supportive and eager to do something fun in the evenings. A special thanks to my friends at campus, for the way too long lunch breaks, giggling at the end of long writing days, and excellent workouts. Thank you to Josefine and Anders for helping me proofreading and completing this thesis.

Emilie Bertelsen

Trondheim, May 2021

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1. Introduction

According to the World Health Organization (WHO), the global amount of older adults over the age of 60 years will nearly double between 2015 and 2050 (1). Worldwide, life expectancy is increasing. In Norway, more than half of those born in 1935 lived to be 80 years or older (2). The risk of developing chronic diseases and geriatric syndromes, as well as dependency upon health care resources, increases with age (1,3). With a growing proportion of older adults and increased risk for disease with higher age, the demand upon health care resources expands. Research has shown that physical activity (PA) and exercise can contribute to a risk reduction of several age-associated diseases and disorders, increase independence from health care resources, and counteract age-related loss of function (3,4).

WHO recommends older adults to perform a weekly minimum of 150-300 minutes moderate-intensity aerobic PA, two sessions of strength exercise, and three sessions of multicomponent exercise that emphasizes functional balance (4). Additionally, older adults should aim to reduce sedentary behavior. Increased activity levels are recommended for additional health benefits, as there is an inverse dose-response relationship between the volume of aerobic physical activity and risk of functional limitations (4). The health benefits following PA include improved all-cause mortality, physical and cognitive health, and preventing falls (4). Older adults who are physically active are more independent in everyday life activities, have improved health and quality of life, and live longer in their own homes than their inactive counterparts (5,6). Sedentary behavior is associated with increased risk of several non-communicable diseases, such as coronary heart disease, diabetes, and breast and colon cancer (4,7). It has also been linked to as much as 9 % of all-cause premature mortality worldwide (7). Despite the recommendations and research showing exercise as an important part of healthy aging, only 32 % of Norwegian older adults fulfill WHO's PA recommendations (8).

Research findings illustrate that enjoyment is particularly effective as a motivating factor for physical activity and exercise in older adults (9,10). The feeling of enjoyment is considered an intrinsic motivation according to the self-determination theory (SDT) (11). SDT postulates that motivation exists along a continuum in different subsystems, from amotivation to intrinsic motivation. Amotivation is described as a lack of motivation, while nonself-determined extrinsic motivation is characterized by controlled behavior that is carried out to avoid negative consequences as a response to behavior. Self-determined extrinsic motivation is when a behavior is performed due to extrinsic reasons, but the outcome is deemed intrinsic. With intrinsic motivation, the behavior is performed due to the interest and engagement in the behavior itself. The subsystems of self-determined extrinsic motivation and intrinsic motivation is positively associated with increased PA behavior in older adults (9,10). This indicates that feelings of satisfaction, enjoyment and genuine need and interest for activity may be important motivators for PA.

However, several barriers may contribute to the low physical activity and exercise level among older adults. Common barriers include health problems, lack of motivation, bad weather, fear of falling, boredom, lack of time and environmental considerations such as inconvenience of going to a gym, accessibility of activity arenas, lack of safety, and costs (8,12). However, Cohen-Mansfield and colleagues (12) found barriers like these to be highly related to motivators for exericse. In their study, health problems were the most frequently reported barriers to exercise, while improved physical function was the most recurring motivator for exercise. In accordance, those who reported lack of time as a barrier also reported more time as a motivator. Similarly, a Canadian survey found mental health as both a barrier and a motivator for exercise during the COVID-19 pandemic: respondents wanted to be more physically active to improve their mental health, although poor mental health made it difficult to be active (13).

COVID-19 and the community restrictions following the global pandemic introduced additional barriers to exercise. Research has found that the community-lockdown following the pandemic has resulted in decreased objectively (14) and subjectively (15) reported activity level among older adults. Those who were regularly physically active have lost many of their exercise arenas, and the fear of being infected as an at-risk individual may have contributed to lower daily PA level. COVID-19 has increased the need for exercise modes that can be performed individually and safely at home by community-dwelling older adults.

Home-based exercise can contribute to maintained or increased cardiorespiratory fitness, strength, and functional ability in community-dwelling older adults (16,17). Findings suggest this exercise mode plays a role in health-related quality of life, activities of daily living (18), walking capacity and PA level (19). Additionally, home-based exercise including two or more of the components strength, balance, flexibility, or endurance, have been shown to reduce both the rate and risk of falls in older adults (4). In an era where technology is everywhere in society, it is likely that exercise technology could be a part of safe, home-based exercise for older adults.

A systematic review found indications that technology-based exercise interventions are experienced as engaging, have good adherence and may be a sustainable exercise mode for increased levels of PA and preventing functional decline in older adults (20). Mobile health (mHealth) apps are software apps on mobile devices such as tablets or smart phones. Systematic reviews and meta-analyses have found that mHealth app interventions have the potential to promote positive changes in activity level in the short term (21,22). Reve and colleagues (23) reported significant improvements in walking quality and physical performance, clinically relevant changes in gait speed and good adherence to a tablet-based strength and balance exercise program in older adults. Although more research is needed, the results to this date indicate a positive impact from exercise technology such as mHealth apps. However, most of these apps are based on health education-style programs and does not necessarily include exercise for enjoyment and fun.

Game-based exercise has emerged the last two decades. Interfaces that use touchscreen, as tablets, seems to be preferred and experienced as not too difficult to use by the elderly (24). Exergames using portable devices, such as laptops or tablets, have shown improvements in physical and cognitive functions (25,26) and motivation (27). Game-based exercise seems to be experienced as enjoyable and engaging by older adults, and includes components that could improve quality of life (26). Games using virtual reality (VR) has emerged, and app-based exercise through augmented reality (AR) as Pokémon Go have shown great improvements in activity level in the general population (28). However, there is a lack in knowledge regarding the possibilities of using game-based apps for increased PA in older adults.

Traditionally, research exploring PA level in older adults have most commonly used subjective methods such as questionnaires (29–31). Questionnaires are vulnerable to recall bias, reporting error and are considered less accurate than objective methods (29,30). Light intensity activities may be especially difficult to register correctly, and as older adults spend a majority of their active time in light intensity activities, questionnaires might have an even higher uncertainty when trying to capture the whole activity span. Additionally, older adults report only half the time of sedentary behavior in subjective measures when compared to objective measures of sedentary behavior (29). Although objective methods can be more expensive and time consuming, they offer a more reliable and accurate measure of activity level (30). An inexpensive and applicable method is use of accelerometers, which measures movement by changes in acceleration and is the most commonly used method to objectively measure PA level (30,31). Findings indicate that accelerometers shows promise as an appropriate and sensitive measuring method for changes in PA behavior in older adults (30,31).

Exercise technology can contribute to reducing existing exercise barriers, such as lack of time, environmental considerations, and the current fear of COVID-19 exposure, as it can easily be employed at home. There are promising indications that exercise applications may be useful to maintain and improve PA in older adults. However, there are few studies that have investigated whether a specifically tailored exercise app for older adults is motivating and useful for this age group and whether it can contribute to increase daily activity level. Therefore, the main research aim of this thesis was to investigate whether a game-based app can be used to motivate for and increase PA level in community-dwelling older adults with incipient loss of function.

2. Methods

2.1. Study design

A pre-post feasibility study was conducted to investigate whether a game-based app can motivate for and increase PA level in older adults.

2.1.1. Participants

A convenience sample of 16 community-dwelling older adults participated in the study. To be included, participants had to be over the age of 70 years, live independently; be able to walk without walking aids indoors; have self-perceived incipient loss of function; have no injury or surgery in the lower extremity or back during the last three months, or; have any known cognitive disorders or diseases.

Participants were recruited in collaboration with Trondheim municipality, Norway, from October 2020 until February 2021. The participants were recruited via their physiotherapists, civic social meeting spots for seniors, senior-IKT, or by their already participating friends. Physiotherapists with eligible patients obtained consent to share contact information with study personnel. Researchers EB, AL and two additional researchers showed up in person to the civic social meeting spots for seniors to give information about the project. Those who were interested in joining the project provided their phone number for an informative phone call.

2.2. Keep On Keep Up

Reason Digital Ltd. (Manchester, UK) launched the tablet-based exercise application 'Keep On Keep Up' (KOKU) in 2020. KOKU is aimed at increasing the accessibility, adherence and engagement to fall prevention exercises in older adults, and uses health behavior change theory and gamification in conjunction to increase adherence to strength and balance exercises (32). The app is developed in collaboration with older adults and is designed to be used independently. KOKU has been certified and approved by the United Kingdom National Health Service (NHS) (32) and is to this date available for download on iPads from the Apple App Store.

2.2.1. Translation

KOKU was translated from English to Norwegian by researchers EB and AL from June 2020 until August 2020. EB translated the application to Norwegian and then AL, who was blinded to the original English app-content, re-translated the application back to English. The Norwegian translation was quality controlled by researcher NSM and necessary adjustments were made. The app developers generated a beta-version of the Norwegian version of the app which allowed for additional quality control performed by EB, AL and NSM. A jurist translated the legal content, e.g., 'terms and conditions', and the audio exercise instructions were recorded in Norwegian by a third party.

2.2.2. App content

KOKU includes 12 strength- and balance exercises based on the Otago Exercise Program (OTAGO) and Falls Management Exercise Program (FaME) principle (32). For more information regarding OTAGO and FaME, see Thomas and colleagues (33) and Skelton and colleagues (34), respectively. The exercises in KOKU includes, among others, rise and sit, sitting and standing heel raise, sitting and standing toe raise, walking exercises, different types of lunges, and squats.

Questions regarding self-perceived physical fitness guides KOKU to choose exercises suitable for the user's physical fitness level. The user receives three exercises in each daily session and enters the completed number of repetitions after every exercise. Three daily sessions consisting of three exercises each make up a set. As the user, based on performance, may receive more challenging exercises after each set, the app follows the generally accepted training principle of progression.

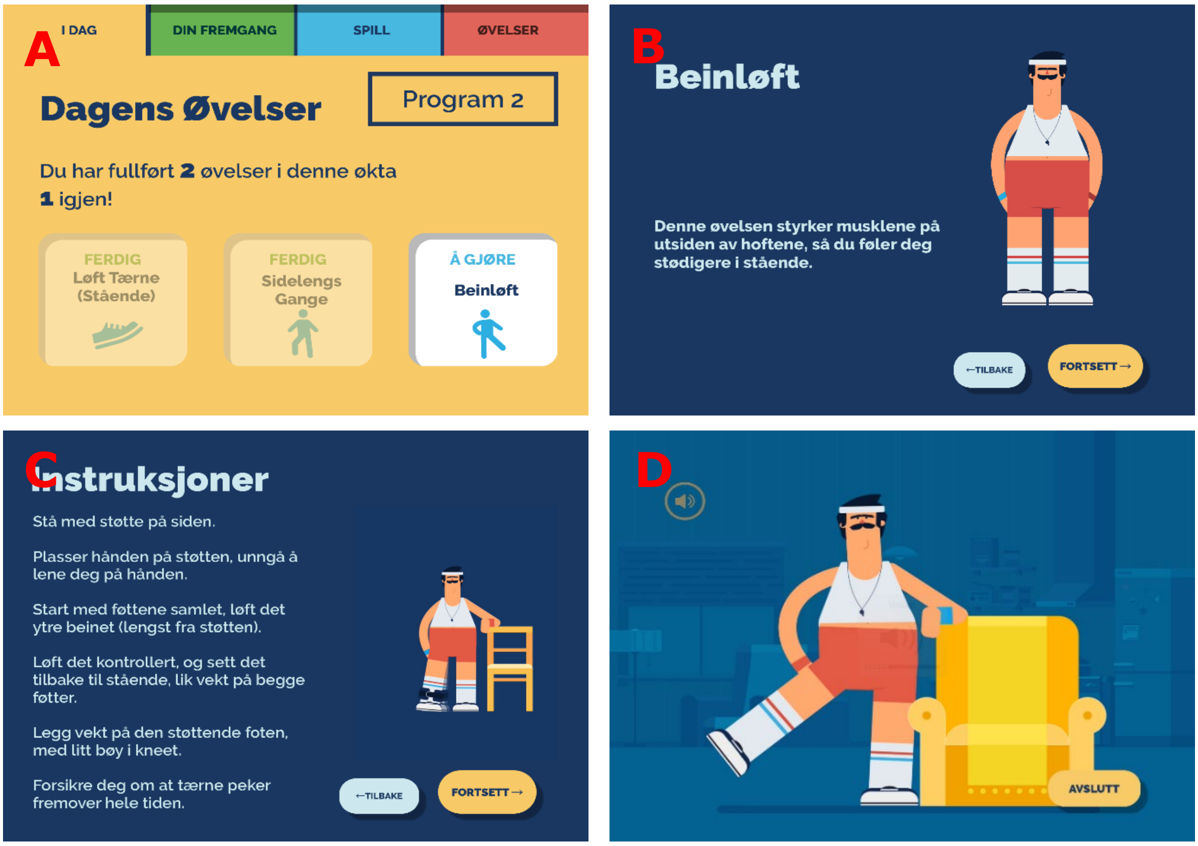

Figure 1: Screen captures from the Norwegian version of KOKU. A: Exercises of the day, B: Description of exercise effects, C: Written instructions, D: Animated video instruction with the avatar, including audio instructions.

Before each exercise, the user gets written instructions on how to perform the exercise and possible exercise effects. While doing the exercise, there is a visual animated video instruction and audio instructions on how to perform the exercise (see Figure 1).

The user can follow their own progression through a tab in the app called 'Your progress'. Completed exercise sessions are marked with a green tick. KOKU also gives the opportunity of completing exercises of own choice in addition to or without using the daily exercise sessions (Exercise tab). The progress and exercises tabs are shown in Figure 2.

Figure 2: Screen captures from the Norwegian version of KOKU, showing 'Your progress' to the left and 'Exercises' to the right.

In addition to the physical exercises, the user has the opportunity to play four different informative games (Figure 3). The games are designed to inform and teach the user about healthy nutrition, fluid balance and fall risk in their own home.

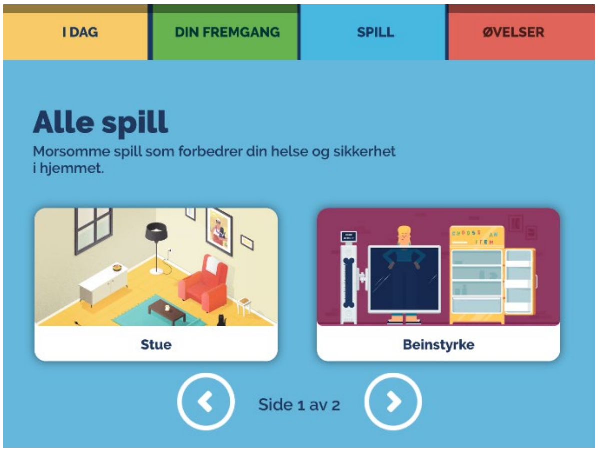

Figure 3: Screen capture from the Norwegian version of KOKU, showing the games tab.

2.3. Procedure

During an initial phone call, interested older adults were informed about the study and infection control measures. Those who agreed to join the study provided their home address and the first home visit was scheduled.

2.3.1. Baseline

At baseline, during the first home visit, the participants signed the written consent form (appendix A). They answered a health and PA questionnaire (provided in appendix B), and height, weight, and grip strength were measured. At the end of the visit, Axivity AX3 accelerometers were attached, and contact information for researchers EB and AL was provided in case of questions.

Grip strength was assessed using a Jamar hydraulic hand dynamometer (JLW Instruments, Chicago, US). Measures of grip strength is considered an indicator of overall physical strength in older adults, and is found to be inversely associated with all-cause mortality (35). While assessing grip strength, the participant sat on a chair with both feet on the floor and the back against the back rest, with the upper arm hanging down alongside the truncus and a 90-degree angle in the elbow. The dynamometer was adjusted to fit the participants hand grip. Grip strength was tested twice on the dominant hand, the participant squeezing their maximum, prior to testing twice on the non-dominant hand. The participant had one minute rest between each test. The result was registered as the average of the tests on the right and left hand, respectively.

Axivity AX3 (Axivity Ltd., Newcastle upon Tyne, UK) accelerometers were used to objectively measure the participants PA level. The AX3, shown in Figure 4, is a small (23 x 32.5 x 7.6 mm) triaxial accelerometer that registers acceleration of the inertial measurement unit in three directions (X, Y, Z). The sensor weighs 11 grams and can record up to 14 days at 100 Hz and accelerometer range of ± 2/4/8/16g with a 512 MB memory (36). The sensors were configured using the AX3 OMGUI software (Newcastle University, UK). The sampling frequency was set to 100 Hz, the range to ± 8g and recording interval to 8 days.

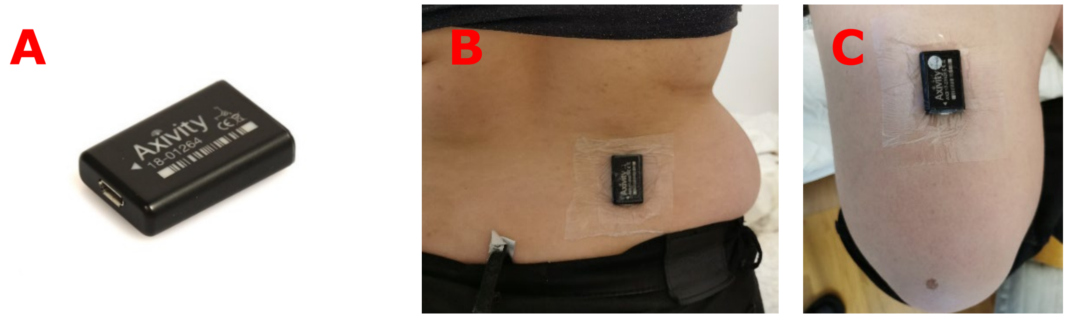

Figure 4: A: The Axivity AX3 accelerometer (36), B: Accelerometer placement on the back, C: Accelerometer placement on the thigh.

Before use, the sensors were synchronized by clapping them together and the skin was cleaned with disinfectant. An Opsite Flexifix film was placed on the cleaned skin area, before placing the sensor vertically on top of the film. A new Flexifix film was attached on top of the sensor to ensure waterproofness and retainment of the sensor. One sensor was attached medially on the muscle belly of the thigh, approximately 10 cm above the proximal part of the patella. The other was attached on the lower back by L3. Accelerometer placement is shown in Figure 4. When placing the sensor on the thigh, the participant sat with the leg fixated and bent, and on the lower back, the participant sat bent forward. The participants were asked to wear the accelerometers for one week, and the date and time for attachment and removal was registered. The participants were asked to not use the sauna, take a bath, or use swimming pools in this one week-period.

2.3.2. Week One

The second visit, Week One, was scheduled one week after the first, and consisted of removal of accelerometers, the European Quality of Life 5 Dimensions (EQ-5D-5L) and Short Falls Efficacy Scale-International (FES-I) questionnaires, and the Short Physical Performance Battery (SPPB). The participants were then taught how to use the iPad and KOKU app. Those who did not own an iPad were lent one.

The EQ-5D-5L is a standardized generic instrument to measure health outcomes and consists of the five categories mobility, self-care, usual activities, pain/discomfort and anxiety/depression (37). Every category has five levels, and the sum of the five levels indicate health status. It also provides a visual analogue scale (VAS) for subjective evaluation of health. The Short FES-I standardized questionnaire assesses fear of falling in various everyday activities (38). The various activities are scored from 1 to 4, where 1 is not worried at all and 4 is very worried.

SPPB was conducted to assess physical function, using a standardized protocol in Norwegian (provided in appendix C). SPPB is a screening test that includes static balance, walking speed and chair stand tests. Each test gives a score from 0 to 4 points, with the total score being the respective sums added together (0-12). A total score of ≤ 10 points is considered an indication of increased risk of loss of function (6).

After the two home visits, the participants started six-weeks KOKU-based strength and balance training in their own homes. Phone calls were made to every participant after one, two and four weeks. The first phone call was an opportunity for the participants to ask any questions about use of the iPad or KOKU, while the subsequent calls also were of a motivational nature.

2.3.3. Week Four

Four weeks into using KOKU, the participants were interviewed in their own home. The interviews were conducted either by EB, AL or two additional researchers. The semi-structured interview was based on the UTAUT-model (The unified theory of acceptance and use of technology) (39) and concerned the participants experience with the app in terms of user-friendliness, motivation, and PA. Questions as described in the full interview guide provided in appendix D were asked by the researchers, and additional follow-up questions were added when deemed necessary. A Marantz Professional PMD-661 MKIII (inMusic Brands inc., Cumberland, US) audio recorder was used to record the interviews.

2.3.4. Week Six and Follow-Up

After six weeks use of KOKU, the SPPB and activity measurements with accelerometers were repeated. Additionally, the participants answered a questionnaire regarding user-friendliness of KOKU (appendix E). The participants were then able to exercise by using KOKU for six more weeks, before a follow-up consisting of a new activity measurement. A flow chart illustrating the study progression from recruitment to follow-up, including the participant flow, is shown in Figure 5.

2.3.5. True timeline of data collection

Some of the data collection had to be temporarily postponed as a consequence of COVID-19 and the following community-restrictions. The true number of weeks between Baseline and Week Six for all participants is shown in Table 1.

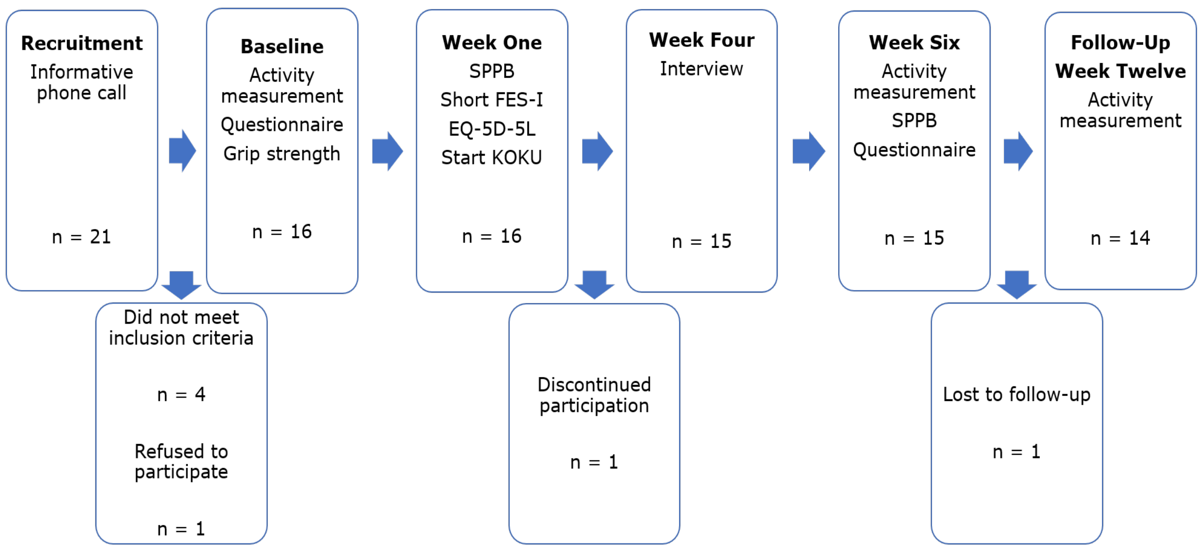

Figure 5: Flow chart illustrating study progression and participant flow.

2.4. Outcome measures

2.4.1. Physical activity level

Possible changes in PA level from Baseline to Week Six was investigated using Axivity AX3 accelerometers placed on the thigh. The participants' average daily PA level, time standing, and sedentary time as a percentage of average daily time awake was calculated and analyzed as described below.

2.4.2. Motivations for use of game-based app

To investigate whether a game-based app can motivate for PA, the interviews conducted at Week Four were systematically analyzed as described below. The interview content that was perceived important to answer the research question of motivation is presented in results.

Table 1: Weeks between Baseline and Week Six for all participants.

Participant ID	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16
Weeks, Baseline – Week Six	12	6	6	10	10	10	9	9	6	10	7	6	6	6	6

2.5. Data analysis

2.5.1. Activity measurements

The accelerometer data were analyzed with the Acti4 program version 1807A, developed by Skotte and colleagues (40). Acti4 is a Matlab-based program that classifies accelerometer data in the activities lying, sitting, standing, moving, walking, running, stair walking, cycling and rowing. The default settings of the Acti4 program were used (40). The Acti4 is a validated method that has been shown to give precise estimates of activity type classification in free-living settings using raw accelerometer data derived from Axivity AX3 monitors (41,42). A visual inspection of the accelerometer raw data was conducted to exclude the bedtime hours from the 24-hours data. This manual assessment of waking time was done by a researcher experienced with raw acceleration data. The waking time intervals were specified in the Acti4 program.

Each participants' daily activity level was calculated by merging the categories of an upright posture (moving, walking, running, stair walking, cycling and rowing), hereby called PA. Daily time standing was derived from the category 'Standing', while the categories 'Lying' and 'Sitting' were merged to sedentary time. To only get full days of activity measurements, the days of attachment and removal of accelerometers were not included in the analysis. This gave six days of activity measures. ID14 removed the accelerometers one day early due to external reasons and ID15 had irregularities in the data the last full day of measurements, consequently only five days of activity measures were used for these two participants.

2.5.2. Interviews

Interviews with participant IDs 1-8 were transcribed by two additional researchers, while EB and AL transcribed the interviews from IDs 10-16. The interviews were then analyzed using theoretical thematic analysis with a realist and semantic approach, as described by Braun and Clarke (43). First, researchers EB and AL read through all the transcribed interviews to get familiar with the content. Secondly, the interviews were coded. The codes were keywords that described the content of the interviews. EB coded interviews from uneven ID numbers, while AL coded those of even ID numbers. EB and AL together quality controlled the coding of all the interviews before necessary adjustments were made. Third, the generated codes were sorted under themes that reflected the content of the codes. Next, the researchers quality controlled the sorting by reading through the coded interviews. As a fifth step, AL and EB together identified and named six themes from the content: *Exercise and activity*; *User-friendliness*; *Positive and negative experiences from using the app*; *General use of the app*; *COVID-19,* and; *Physical challenges.* Lastly, EB identified the themes of *Exercise and activity* and *User-friendliness* to be relevant to answer the research question of motivation, and consequently, these key themes were presented in results.

2.6. Statistical analysis

All data was calculated and analyzed using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA) and Microsoft Excel (365). Descriptive statistics (means and standard deviations, frequency counts and percentages) were calculated to describe participant characteristics. The mean daily PA level, time standing, sedentary time and daily time awake of each participant was calculated, before computing average daily PA level, average daily time standing and average daily time sedentary as a percentage of average daily time awake. The individual pre-post results were presented using a bar chart. The results for the whole group were checked for normality with significance level $p < 0.05$ by using Q-Q plots, histograms and Shapiro-Wilk test. Non-parametric tests were used with non-normal distributions.

2.7. Ethical considerations

This study was approved by the Regional Committee for Medical Research (case number 165120) and the Norwegian Centre for Research Data (case number 572598). All included participants gave their written informed consent (appendix A) and were informed of their right to discontinue their participation at any point in time. The study was conducted in accordance with the Declaration of Helsinki.

2.7.1. Infection control

Current infection control measures from local and national authorities due to COVID-19 were followed at all times. Study personnel called the participants the day of every home visit to make sure they or anyone in their household did not experience any symptoms of COVID-19, were in quarantine or had been traveling internationally the last 14 days. If so, the home visit was postponed. Study personnel wore face masks when visiting the participants homes, sanitized hands before, during and after the visits, and disinfected equipment after every use. Study personnel kept at least one meter distance from the participants when possible.

Table 2: Participant characteristics.

	Mean ± SD or n (%)
Age, years	81.4 ± 7.03
Females, n (%)	11 (73.3)
BMI, kg/m²	28.07 ± 5.30
Grip strength, kg	
Right hand	15.67 ± 8.13
Left hand	13.80 ± 10.16
SPPB Baseline sum	8.00 ± 2.65
SPPB Week Six sum	8.73 ± 2.66
SPA frequency, days/week	
Never, n (%)	0 (0)
Less than once per week, n (%)	2 (10.5)
Once per week, n (%)	1 (5.3)
2-3 times per week, n (%)	8 (42.1)
Almost every day, n (%)	4 (21.1)
SPA intensity	
Easy without being sweaty/out of breath, n (%)	9 (47.4)
Hard being sweaty/out of breath, n (%)	5 (26.3)
Almost all out, n (%)	1 (5.3)
SPA duration, min/time	
Less than 15 min, n (%)	1 (5.3)
15-29 min, n (%)	7 (36.8)
30-60 min, n (%)	4 (21.1)
More than 60 min, n (%)	3 (15.8)
EQ-5D-5L mean	1.81 ± 0.71
EQ-5D-5L VAS	71.33 ± 26.89
Short FES-I mean	2.77 ± 0.90

Values are expressed as mean ± standard deviation (SD) or absolute (n) and relative (%) frequencies. Abbreviations: BMI, body mass index; SPPB, short physical performance battery; SPA, subjectively reported physical activity; min, minutes; EQ-5D-5L, European Quality of Life 5 Dimensions; VAS, visual analogue scale; Short FES-I, Short Falls Efficacy Scale-International.

3. Results

3.1. Sample characteristics

A total of 16 participants were recruited and gave their written consent to participate in this study. As one dropped out (subject ID 9) due to lack of time, 15 participants (3 males and 11 females) with age ranging from 74 to 94 were included in the data analysis. Participant characteristics are provided in Table 2.

The participants in this study were mostly female, somewhat overweight (BMI > 27), mature adults, but relatively sprightly and active, as indicated by SPPB, subjectively reported PA and EQ-5D-5L. Still, the participants had, on average, relatively low grip strength and an SPPB score before and after six weeks use of KOKU that indicates increased risk of loss of function (< 10). The change in SPPB is not considered clinically relevant (< 1), although a paired samples t-test shows the change is statistically significant ($p = 0.022$ [95 % CI: 0.124, 1.342]). In addition, most of the participants reported that they were physically active in light intensity 2-3 times per week, for 15-29 minutes at a time, indicating that they did not fulfill WHO's recommendations of 150 minutes moderate intensity PA per week. The participants had a moderate fear of falling as reported by FES-I (2.77 ± 0.90) and described their health as good to moderate by the EQ-5D-5L questionnaire (1.81 ± 0.71) and on a visual analogue scale from 0 to 100 (71.33 ± 26.89), respectively.

3.2. Physical activity level

Figure 6 shows the average daily PA level, time standing and sedentary time for all participants at Baseline and after six weeks of using KOKU. There were large individual differences, but on average, they were physically active for 10.37 % (± 5.72, range 18.67) of daily time awake before using KOKU and 10.65 % (± 5.82, range 21.23) at Week Six. Most participants did not have a marked change of activity level in either direction. The participants stood on average 17.89 % (± 15.95) of their daily time awake, with a range of 66.83. Week Six showed mean standing time of 16.59 % (± 10.62) with range 36.22. As with the PA level, the average daily time standing varied between participants, and only subject IDs 3 and 7 appeared to have a noteworthy change from Baseline to Week Six. The mean daily sedentary time was 71.62 % (± 4.89) of average daily time awake before 6 weeks use of KOKU. After six weeks, it had increased to 73.36 % (± 3.45). Similarly to PA level and time standing, there were considerable variations in sedentary time between participants, with a Baseline range of 67.46 and 44.30 at Week Six. Again, the only participants with a noteworthy change were IDs 3 and 7, as seen in Figure 6.

For all the participants, a Wilcoxon Signed Rank-test discovered no significant change from Baseline to Week Six in mean daily PA level ($Z = -0.057$, $p = 0.955$), indicating that even though activity level increased, the change was not of a considerable amount and could be due to chance. Further, the Wilcoxon Signed Rank-test revealed no significant change in mean daily time standing ($Z = -0.227$, $p = 0.820$). This was also the case for the difference in average daily sedentary time from Baseline to Week Six ($Z = -0.511$, $p = 0.609$).

3.3. Motivations for use of game-based app

The thematic analysis discovered two relevant themes in the interviews: *Exercise and activity*, and *User-friendliness.*

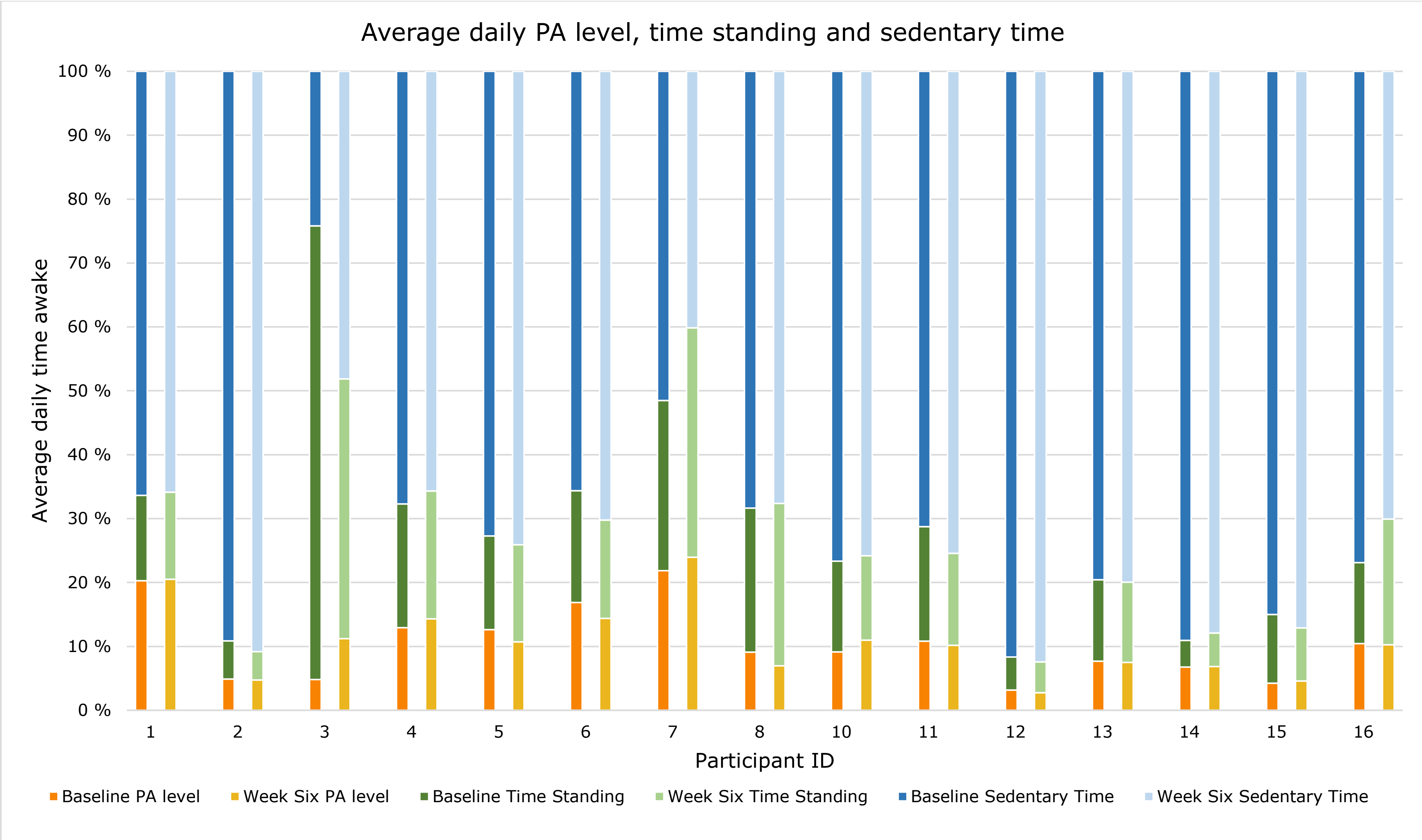

Figure 6: Baseline and Week Six results for PA level, time standing and sedentary time for all participants.

3.3.1. Exercise and activity

Almost every participant mentioned exercise and/or PA on a general level as an important part of their everyday life, as it contributed to their own healthy aging. The most frequently mentioned motivations for regular activity were enjoyment of being physically active and to stay healthy. KOKU was experienced as a fun and meaningful way to do daily exercises and to improve physical shape. For the participants who already were physically active, KOKU was seen as a useful supplement to their daily routines. Some specifically mentioned that KOKU would be particularly helpful during winter months, as their regular outdoor activities were not as easy to perform in the winter. One participant who stated that she was not regularly physically active, thought using KOKU could motivate her to be more active in her everyday life.

"It is nice, because when you get as old as I am now, the weather might be bad, black ice, yes, there might be things that makes it less tempting to go outside. And then it can be nice to do a program in the app." (Female, 85 years).

Most of the participants enjoyed the exercises provided in the app, and some stated that they preferred this form of exercise when comparing it to exercises provided by an informational sheet or brochure. This was mainly explained by the visual exercise instructions given by the avatar, which every participant highlighted as motivating, supporting, or enjoying. The avatar made the exercise instructions seem more 'alive' than having a written instruction only. In addition, the avatar contributed to increased self-confidence when performing the exercises, as the fear of performing the exercises wrong was disposed of.

"Yes, the app is to prefer… yes, the explanation is, in a way, more alive. Instead of sitting, when my eyesight is so bad as well, so for me to sit and watch a sheet and… it its not the same inspiration. The app is to prefer." (Female, 85 years).

"…and then that guy comes and blows the whistle and then you do what you are supposed to do. And I think it is very nice that it is illustrated with pictures, because then I know exactly what I am supposed to do. There is no room for misunderstanding because you can misunderstand if you only have a text. But if you have pictures it is much easier. So I think that is nice." (Female, 75 years).

Almost every participant stated that they found the app motivating and meaningful to use as the exercises they received through the app were perceived as an important and useful part of their daily PA level and for their physical function. Other describing words that were used included inspiring, fun, engaging, interesting, encouraging, and informative. Several of the participants explained that the presence of the iPad and KOKU in the room was experienced as a positive warning finger or a 'push', where they were reminded and motivated to do the daily exercises. Some participants even said they performed the exercises in KOKU multiple times a day, because they were motivated every time they saw the iPad. However, some felt the exercises were boring, as they had repeated the exercises so many times that they remembered them by heart. This was put forth as a need for more diverse exercises and progression in difficulty.

"Yes, because for those who have been very or used very little exercise before, it is clear that it is motivating to have something that you are supposed to do every day. I feel it motivates me to do some. Because I need a little push to get started." (Female, 79 years).

"It was pleasant to repeat it every day. Yes, it must be meaningful, because there is a background to it, that you should be moving and exercising. In the age I am in, they all say that. It is in a way encouraging me. Reminders and encouragement." (Male, 94 years).

Most of the participants would like to continue to use KOKU after the end of the study, and one participant even stated that she enjoyed the app so much that she would continue to use the exercises for the rest of her life. Although most of the participants enjoyed KOKU and would like it to be a part of their daily activity, some mentioned the need for more challenging exercises and more progression throughout the exercise programs. One specifically mentioned that the exercises were not challenging enough for her level, although she appreciated the intent of the app. Another was stuck at one program for a long while, because KOKUs algorithms did not assume she was 'ready' for more progression, which was perceived as frustrating. The only other thing that was mentioned as something missing from KOKU, was music. Some participants felt that background music would increase the motivation and enjoyment while exercising.

"It would be nice to improve physical function… But, I think it would have to be more challenging exercises if I am supposed to improve my level." (Female, 75 years).

A few participants felt that KOKU improved different aspects of their physical function. Some mentioned improved balance, walking capacity or energy level, while others felt the activity had a positive impact in general. None of the participants stated that they experienced any negative events or decreased physical function while using KOKU.

"Yes, at least we do not have any worse [activity level]. So if it has increased very much, I will not say that, but at least we have not decreased our physical shape in the time period we have used it." (Female, 79 years).

"There are many exercises I am sure I will continue to use in the future. As long as I can and as long as I live." (Female, 80 years).

3.3.2. User-friendliness

Many of the participants stated that they had previous experience with touchscreen interfaces, such as smart phones or tablets, and believed their knowledge positively impacted their app experience and how easily they learnt how to use the app. Only one participant stated that the app was 'not his cup of tea', mainly because he found the technology difficult. For those who did not have much experience with iPads or similar technology, there was mentioned a 'fear' of not being able to learn how to use it or being too old to be able to understand how the technology worked. However, this 'fear' of the iPad was not repeated as something they experienced after they learnt how the iPad and KOKU worked.

"It was easy. Yes, very easy. I think it must be understandable for most people my age. But, I think it is harder to learn without any app experience." (Female, 75 years).

Some participants experienced technical issues with the app or the iPad, and one of them mentioned that the motivation for doing the exercises decreased by this. A few participants also brought up that the iPad-screen was difficult to handle, as they had limited sensibility in their fingers. A couple of participants found certain elements of the app confusing, especially that the tab with exercises of the day (Figure 1) said "0 exercises completed in this session, 3 to go!" when they had completed their three exercises of the day. This was perceived as demotivating, as they did not feel they got recognition for the exercises they had done. Still, most of the participants found it easy to learn and use KOKU.

"I do not find it that easy, because as I said, I sometimes think I have not done any exercises when I have completed the exercises. Because it says 0 when I am finished…" (Female, 94 years).

"In the beginning, I fumbled a bit, but after a while I started to learn it and then it went fine." (Male, 94 years).

In general, KOKU was described as easy and intuitive to use, and the visual instruction with the avatar was emphasized by most of the participants as an easy way to understand how to perform the daily exercises. Some of the participants also mentioned the written instructions, both with possible exercise effects and how to do the exercise, as motivating and informative. One participant stated that the audio instruction was too computer-like and boring, while another experienced it as calm and pleasant.

"It has been very easy, I think. Easy beginning, so that has been nice. Easy to use. […] There is both sound and picture if you want, and you can just tap it and then you are in the program right away, and it is automatic. So it is a very nice exercise arrangement for everyone." (Female, 80 years).

4. Discussion

This thesis aimed at investigating whether a game-based app can be used to motivate for and increase PA level in community-dwelling older adults with incipient loss of function. The study featured six weeks use of an exercise app, KOKU, designed in collaboration with older adults and aimed at increasing the accessibility, adherence and engagement to fall prevention exercises in older adults. PA level, time standing and sedentary time, as measured by accelerometry, and interviews were used for the outcome measures of activity level and motivation, respectively. The results of this study indicated that the use of KOKU did not remarkably alter activity level in either direction, neither when looking at PA level, time standing or sedentary time, both on individual and group level. However, KOKU was generally experienced as motivating, useful, meaningful and engaging, and most of the participants would continue to use KOKU as a part of their daily activity.

4.1. Outcome measures

4.1.1. Physical activity level

None of the participants had marked changes in average daily PA level as percentage of mean daily time awake from Baseline to Week Six. Small increases were seen in four participants, while a small decrease was seen in five participants. For all participants, even though it was not statistically significant, average daily activity level slightly increased from Baseline to Week Six. This indicates that the positive change in activity level might be due to external reasons, or chance, and not to use of KOKU. However, other studies investigating change in activity level after game-based and mHealth exercise interventions have also found increases in activity. For instance, Tabak and colleagues (27) used a game-based, PA coaching application for older adults and found that activity level measured as mean daily steps improved from 5852 (± 3652) to 7236 (± 3335) in active users of the app (27). Self-monitoring and challenge were underlined as important features and motivational factors for engagement with the app. Further, a systematic review conducted by Yerrakalva and colleagues (21) investigated effects of mHealth app interventions on sedentary time, PA, and fitness in community-dwelling older adults and concluded that mHealth app interventions can be associated with an increase in physical activity in trials of both short (< 3 months) and long (≥ 6 months) duration (21). This might point to that the study duration in the present study was too short to observe changes in activity level in the participants. Yerrakalva and colleagues (21) also found that interventions using behavioral change techniques such as goal setting or smart activity monitors seemed to have larger improvements than apps without these properties (21). Another systematic review and meta-analysis by Romeo et al. (22) investigating whether smartphone apps can increase activity level in the general population observed similar results as Yerrakalva and colleagues (21) with regards to physical activity. In addition, the smartphone apps focusing on physical activity only, achieved better results than apps combining PA and other health behaviors. These three studies all indicate that the features provided in exercise technology are important for whether the app is perceived as engaging, and consequently, the resulting activity level (21,22,27). Providing the right amount of challenge, input and the ability to self-monitor daily activity level in game-based and mHealth apps might contribute to increased activity through engagement and increased motivation for use.

In the current study, the participants decreased in mean daily time standing when awake between Baseline and Week Six, while sedentary time increased. Only two participants appeared to have marked changes in these variables. A study by Grant and colleagues (44) found that 20 community-dwelling healthy older adults spent 42.5 % of their daily time upright, which indicates a considerably higher activity level and less sedentary time than our study. When merging the categories of time standing and PA in our study, the participants were in an upright posture for 28.6 and 27.4 % of the day at Baseline and Week Six, respectively. Some of this discrepancy may be explained by different approaches in analyzing daytime activity from 24-hour accelerometer data. The study by Grant and colleagues (44) used a fixed 12-hour daytime period (8 a.m. – 8 p.m.), while our study used a better estimate for daily time awake. Grant and colleagues (44) also report a high level of sedentary time after 8 p.m., indicating that activity level when awake was lower than what was calculated from the 12-hour window.

In addition to increased activity level and decreased sedentary time, studies conducted on technology- and game-based exercise in older adults have found improvements in other parameters that are important for healthy aging. One systematic review conducted by Valenzuela and colleagues (20) that investigated adherence to technology-based exercise interventions found that adherence was high, and higher than in traditional exercise interventions (20). High adherence has also been found in a study exploring a game-based mobile application for improved physical and cognitive performance in older adults (26). Furthermore, Valenzuela and colleagues (20) found improvements in quality of life, physical function, balance, and fall risk, among others. This is substantiated by the findings of other researchers. For instance, Choi and colleagues (25) observed with their systematic review that exergame interventions can improve several outcome measures, as balance, gait, mobility, and strength, and that exergame interventions are superior to no intervention in regards to effectiveness in these parameters. However, when comparing exergames with traditional exercise interventions, the results show great variations and often contradict each other. Taken all together, the existing evidence on technology- and game-based exercise indicates that this exercise mode is useful in improving important physical functions and quality of life and is perceived as engaging among older adults. This shows that even though the current study only found small improvements in PA, other key aspects in healthy aging can be positively affected by game-based exercise.

To this date, there is only one published study involving use of KOKU. Choi, Stanmore, Caamano, Vences and Gell (45) performed a feasibility study of multi-component fall prevention for community-dwelling older adults (45). They investigated changes between pre- and post-test for exercise efficacy and frequency, with 28 participants that received four intervention sessions and follow-up assessment at 12 weeks. Significant improvements were found between baseline and 12 weeks in exercise efficacy and frequency (45), although these results were not only based on use of KOKU. This indicates that KOKU might contribute to noteworthy positive changes in both amount of physical activity and the effects the older adults themselves perceive they can receive from the exercise.

The most popular mode of recreational PA among older adults is outdoor walking, an activity that is likely to be affected by weather and surface conditions (46). The data collection in the current study was conducted in the winter months, where precipitation often causes snowy or icy surfaces. This can increase the risk and fear of falling, and consequently affect activity level. Weekly variations in activity might be caused by weekly variations in weather and surface conditions, and both bad weather and fear of falling are known barriers towards exercise (8,12). A study conducted on 1219 older adults (70-77 years) in Trondheim, Norway found that older adults were less physically active during the winter months (November to March) than the warmer months (46). In addition, precipitation appeared to be a barrier to physical activity in the less fit older adults. These findings are supported by the mapping survey Kan2, conducted by The Norwegian Directorate of Health, which shows that the Norwegian population are 14 % less active in the winter than the summer months (8). Thus, it is likely to believe that in our study, the participants PA level could have been affected by the winter weather.

As with weather, several other factors can contribute to explain why the changes in time standing and sedentary time occurred. The time points at which the activity measurements were conducted were not necessarily representative for the participants' general activity level for the rest of the year. What the current study captures with the accelerometers is just two random weeks out of 52, and consequently, it is not possible to know whether our results estimate the general average activity level throughout a normal year. Illness, holidays, community-restrictions following COVID-19, motivation boosts, changes in life situation and other uncontrollable factors may all cause great variations in activity level for a shorter or longer period of time and thereby influence the results. Known exercise barriers as health problems, lack of motivation and fear of falling might have a negative affect at activity level at one point, while their related opposite motivators might positively influence PA at another point in time (8,12). Furthermore, our study does not measure efficiency, but whether KOKU may influence activity in everyday life. The participants did not get specific instructions on how much or often they were supposed to use KOKU, and with such a small group, changes may not necessarily be discovered at all. Therefore, the eventuality of other external, uncontrollable factors influencing the measured activity level is evident.

Another important point when interpreting the PA results of our study, is the difference of the exercises performed and what is measured. The exercises provided in KOKU are strength and balance exercises for the lower extremity. These exercises are based on the FaME and OTAGO principle, which have shown to reduce risk of death and rate of falls (33), and reduce risk of falls and improve lower limb strength (34,47), respectively. However, exercise is a purposeful activity, and the exercises provided in KOKU were performed over a relatively short amount of time. The activity itself was therefore probably not of an amount that would be visible when measuring PA. In addition, accelerometers have limitations with detecting activities such as strength and balance (31,46). However, improved function, reduced fear of falling, more energy, etc. as a consequence of the exercise, could deflect as an increase in activity level, and our study did show a significant improvement in SPPB from Baseline to Week Six. Nevertheless, only small, non-significant changes in PA were discovered after six weeks use of KOKU in this group.

4.1.2. Motivations for use of game-based app

Most of the participants were already motivated for physical activity before using the app, because they wanted to maintain or improve their physical function as they aged. Frequently mentioned motivators for activity were staying healthy and enjoyment. Staying healthy is considered a self-determined extrinsic motivation, as it is a personal value that usually does not depend on external approval, while enjoyment is an intrinsic motivator due to the immanent joy and satisfaction of the activity (11). Both Dacey and colleagues (9) and Kirkland and colleagues (10) found that intrinsic and self-determined extrinsic motivation are the strongest motivators for exercise and PA in older adults (9,10). Higher levels of self-determined extrinsic motivation were reported to be associated with increased commitment and engagement to activities, and enjoyment seemed to be increasingly important with higher levels of activity. Findings from both studies supports the SDTs postulation of association between intrinsic motivation for PA and higher levels of PA (9,10), which is that intrinsic motivations increases the likelihood of a higher frequency of the activity the motivation is aimed at. Likewise, the participants in our study experienced both intrinsic and self-determined extrinsic motivations for using KOKU. As with physical activity in general, the most frequently mentioned motivators for using the app were enjoyment and maintaining or improving physical function. Some participants perceived that KOKU improved their physical function, which might have contributed to enhance motivation for use.

One of the most mentioned motivating elements of KOKU was the feeling of a fun and meaningful way to improve physical function, and the visual instructor that performed the exercises together with the participants. This can be categorized as a self-determined extrinsic motivator, as the motivation and support from the avatar together with the wish for and genuine enjoyment of exercising motivated them to perform the exercises. The participants stated that they enjoyed exercising with the visual avatar more than with an informational sheet or brochure. A study by Reve and colleagues (23) exploring the motivation and adherence to exercise from tablet-based strength and balance training in community-dwelling older adults, found that those who used a tablet in addition to receiving social support were more active than the ones only receiving a brochure with exercise instructions (23). Even though the results of the present study were non-significant, the increase in PA found by Reve and colleagues (23) might indicate that activity via apps and tablets are experienced as more engaging and motivating than instructions via brochures only. It is possible that the social aspect of the exercise in their study was an important part of improving activity level. The participants in our study did receive motivational phone calls after two and four weeks use of KOKU, which might have been perceived as a social aspect during the exercise period. In addition, the visual instructor in KOKU could, potentially, have been experienced as a form of social component during the performance of the exercises. The phone calls and the avatar might have influenced motivation and how the participants used and experienced the use of KOKU.

KOKU as a reminder could also be perceived as a self-determined extrinsic motivator. The presence of the iPad and the app was by some of the participants experienced as a positive 'push' or 'warning finger', that reminded and encouraged them to accomplish their exercise goals. This was experienced as useful. However, if this reminder was experienced as only a 'warning finger', where they would experience negative consequences if they did not perform their exercises, it would be a nonself-determined extrinsic motivator and perhaps even a barrier to exercise. Nevertheless, this did not appear to be the case among the participants in the current study. In a study looking into user-experience of a game-based coaching application for older adults, the participants were motivated by being able to compare their daily activity level with previous days and their personalized activity goal (27). Not being able to reach their goal, or decreasing their activity from the previous days, can also be interpreted as a kind of 'warning finger'. The participants in our study did also have the opportunity to monitor their progression in the exercise program, by using the 'Your progress' tab in KOKU (Figure 2). Awareness of their own activity behavior appeared to motivate for physical activity both in the study investigating user-experience and the present study.

Some aspects of KOKU were experienced as demotivating by a couple of participants. This included the technology itself, technical issues and elements that were perceived as confusing. However, the participants who experienced these issues did not drop out of the study or state that they stopped using KOKU. As a matter of fact, only one participant dropped out between Baseline and Week Six due to lack of time, which suggests that most participants liked using the app. Some technological difficulties might always appear, although it did not seem like the participants found this as a great setback when it was fixed relatively quickly. The 'fear' of technology that was mentioned by some of the older adults did not seem to obstruct them from learning and using the app. Studies have found that even though older adults seem to enjoy using tablets, they often do not feel confident when first using the technology (24). The 'fear' or lack of confidence did not appear to be a prolonged demotivating factor or prominent barrier that affected how the app was used, and most of the participants experienced the iPad and KOKU to be intuitive and easy to learn. In fact, a systematic review investigating adherence to technology-based exercise in older adults found that the commercially available exergame Nintendo Wii™ was experienced as 'much better' or 'better' than traditional exercise programs (20). This is similar to what the participants in the current study stated when talking about the difference between KOKU and traditional brochures with exercise instructions. The systematic review also found that exercise technology was described as motivating, enjoyable and acceptable (20). This indicates that even though older adults might feel less confident when starting to use a new type of exercise technology, this barrier is not a brick wall, and the end result is often a positive attitude towards this form of exercise.

Another point that indicates enjoyment of the app was that very few suggestions for improvements of the app were made. Some mentioned that music would increase their motivation for exercise, but the most frequently mentioned improvement was more challenging exercises. With only 12 exercises in the app, it is likely that some of the more physically fit participants experienced a ceiling effect where they did not get enough challenge when exercising. In addition, some felt the exercises were boring when they were repeated several times. This might be perceived as demotivating. The right amount of challenge can be an important aspect for enjoyment and feeling of accomplishment with this exercise mode (21,27), and enjoyment is tightly connected to exercise motivation (9–11).

The only published study about KOKU did also, in addition to exercise frequency and efficacy, investigate acceptance of the app, perceived helpfulness and intervention experience (45). Choi and colleagues (45) assessed acceptability of KOKU at 6 weeks using questionnaires, while perceived helpfulness was assessed through a semi-structured interview. KOKU was highly rated on intention to use, usefulness, attitudes toward using, ease of use and system usability in the questionnaires (45). Similarly to our study, the semi-structured interview revealed positive responses towards KOKU. Structure, convenience, enjoyment and usefulness of the visual instructor was the most common themes. The participants reported a need for more challenging exercises, but still, as in our study, they experienced improvements in physical functioning. Choi and colleagues (45) also found that KOKU was perceived as a motivational source for exercise. The results from this study are comparable to the results of our study, and similarly, it had 71 % female participants, one group, and a pre-post mixed method design with short-term follow-up. The study of Choi and colleagues (45) indicates that KOKU was experienced as motivating, engaging and useful by older adults, which supports the findings from the interviews in our study.

4.2. Methods

4.4.1. Activity measurements

Traditionally, PA has been assessed by the use of questionnaires (29–31). Although this method provides a comprehensive picture of PA level, there are great limitations, including recall bias and overestimation of activity. Objective methods, as accelerometry, removes some of these limitations and has been widely used in research investigating physical activity and activity behavior in the recent years (30,31). The Acti4 program utilized for analysis in the current study has shown high specificity (≥ 94 %) for all physical behaviors when analyzing Axivity AX3 thigh sensors and high sensitivity (≥ 91 %) for the activities sit, walk, run and cycle (42).

The studies proving high specificity and sensitivity with Acti4 have used younger participants (40–42), which may have affected how the algorithms interpreted the movement signals. As older adults might have a lower physical capacity and different moving pattern than younger adults when walking, walking might not be easily detected when using algorithms developed for younger populations (30,46). In addition, there is no standardized method for quantifying accelerometer data in older adults and the method used for analysis greatly impacts the results, which can make it difficult to compare activity data from different studies (30,31). To quality control the output from Acti4 in our study, the raw data in OMGUI was actively used. When investigating the raw data, it was obvious that some of the older adults had very little or no time in the walking-categories derived from Acti4. Instead, this activity seemed to be present in the category of 'moving'. Moving is a 'leftover'-category that includes small movements performed while standing, that cannot be classified as walking or standing still (40). To reduce the risk of this error affecting the results, the category of moving was merged with the other activity categories (walking, running, stair walking, cycling and rowing) when performing the analyses. Because it only was feasible to use the thigh sensor when analyzing accelerometer data with Acti4, it was not possible to differentiate between sitting and lying postures. As the back is in dissimilar positions in these two postures, adding the back sensor to the analysis could have made it possible to distinguish between sitting and lying. However, the sitting and lying postures were merged to the category sedentary time to try to accommodate this problem.

The Axivity AX3 accelerometers are small and were attached with Flexifix film that does not cause nuisance when worn. Except for the one participant that removed the accelerometers one day early due to external reasons, none of the participants removed their accelerometers during the one week-period. One participant complained on itching from the Flexifix, but no other unpleasantness was mentioned by any participants. Three of the participants experienced that the Flexifix film loosened on one of their accelerometers. This did probably not affect the activity measurements noticeably, as they either managed to reattach the film on their own or were assisted in reattaching the film by the researchers.

4.4.2. Interview

Qualitative methods, such as interviews, give the possibility of more depth than what is possible from just numbers, data and objective measurement methods derived from quantitative measures (48). Semi-structured interviews with personal experiences enrichened our data and complemented the objective method by giving a deeper meaning to the results. The appearance and tone of voice of the interviewer was important, as this had the possibility to affect how the respondents answered the questions asked (48). The interview guide used in our study assured that all participants received the same main questions, however, as the interviews were performed by four different researchers, the results were most likely affected by the differing personalities asking questions. Likewise, some of the follow-up questions asked depended on the interviewer in question. It is also possible that the small number of participants in our study affected the results. A higher number of participants might be necessary to give a more nuanced estimate of motivation and experiences while using the app (48). The UTAUT-model provided the foundation for the design of the semi-structured interview. UTAUT is a tool for assessing the likelihood for success and the drivers of acceptance when implementing new technology, and is found to explain as much as 70 % of the variance in intention to use new technology (39).

Thematic analysis is a flexible approach to analyze qualitative data (43). It is used to identify, analyze, and report patterns, and helped to produce a detailed and rich description of the interview data in the present study. Given the research aim in question, a realist semantic approach was used in the analysis. A realist approach gives the possibility to straightforward theorize motivations, experience and meaning, while the semantic approach includes identifying the interview themes through the direct meaning of the data (43). These approaches were seen as appropriate in our analysis to be able to justly convey the participants experiences from using KOKU.

4.5. Strengths

A prominent strength of the current study is the use of the objective measurement method of accelerometry, as opposed to subjective methods, to obtain activity levels. In addition, the participants wore the accelerometers constantly for the entire measurement period, which limits the potential problems of differencing sedentary time from non-wear time (30). The sensors were worn for a whole week to capture both weekday and weekend activity, and the daily average of the week was used to estimate mean daily activity level. This also limits the possibilities of day-to-day weather changes greatly influencing the results. The results were presented as both PA level, time standing and sedentary time, which gives a better picture of the whole activity span than PA level only (29). Average daily activity level, time standing, and sedentary time was calculated as the percentage of mean daily time awake for the individual participants. This gave a more precise estimate of the participants physical activity pattern than if a predetermined time was used for daily time awake, as older adults might have a more variable circadian rhythm than i.e., 8 a.m. to 8 p.m. In addition, raw data was actively used to quality control the output from the Acti4 program.

Using semi-structured interviews gave the ability for a more detailed picture of the experience while using the game-based exercise app. It appeared that even though KOKU only slightly increased activity level, the participants experienced the app to be motivating, useful and easy to use, and some even perceived results in terms of improved physical function. Even if KOKU had shown to greatly increase activity level, adding the participants experience from using the app provides a more nuanced picture of KOKUs potentials. Another strength is that the participants were always able to contact the researchers if they had any questions, or if they experienced any technological issues with the iPad or app. The technological issues that appeared were therefore quickly solved. Adding to this, only one participant dropped out between Baseline and Week Six.

McGarrigle, Boulton and Todd (49) identified, quality controlled and evaluated the evidence for effectiveness in publicly available digital resources that can support older adults to independently perform strength and balance exercises. KOKUs quality was rated as 'good' on the Mobile Application Rating Scale from 'inadequate' to 'excellent', which assesses engagement, functionality, aesthetics, information quality, and subjective quality. Additionally, the health and care app evaluator and reviewer ORCHA reviewed KOKU to 84 %, which leaves KOKU in the top range of all NHS approved apps (50). These results showing KOKU as an app of good quality can contribute to explain why most of the participants in our study had positive attitudes towards KOKU.

4.6. Limitations

There was difficulty recruiting participants to this study. The ongoing COVID-19 pandemic was a prominent barrier, most likely causing some otherwise eligible older adults to avoid joining due to fear of exposure and infection from the virus. The 'fear of technology' that was mentioned by some participants in the interview was also mentioned as a barrier from joining the study at the civic social meeting spots for seniors. Others pronounced old age and lack of time as barriers. In addition, the physiotherapists had difficulty finding eligible participants among their patients. In the end, this resulted in only 16 participants, where 15 were included in the final analysis.

The recruited participants were asked if they fit the inclusion criteria during the initial informative phone call. The researchers did not have the opportunity to verify the information provided by the participants, and, therefore, some of the participants may not have fit the inclusion criteria as intended, which could have affected the results. The participants previous activity level, which was not stated as an inclusion or exclusion criteria, might also have affected how much effect they got from using KOKU. In the interview, some participants mentioned that they would need more challenging exercises to improve their physical function. This could indicate that these participants experienced a 'ceiling effect', where their physical function was too good to receive advantages from the exercises provided in KOKU, even though they had incipient loss of function.

More than 70 % of the participants in the current study were female. This is not surprising, given that females have a higher life expectancy than men which indicates that there are more females in the ≥ 70 years age group (2). Investigating whether there were any gender differences in our study with respect to PA level or perceived motivation while using the app would not have given robust results due to the substantial preponderance of female participants, and consequently, this was not analyzed. The results might have been different with more male participants. Another limitation is that this study was conducted with one group only. Therefore, it was not possible to investigate whether the participants' PA level after using KOKU differed from a control group not using KOKU. Examining whether a control group maintained their activity level in approximately the same manner would have been interesting, as results from a control group could have given a broader impression of whether KOKU had an impact or not, even with the results from the participants in our study being non-significant. Measuring EQ-5D-5L and Short FES-I at

Week Six in addition to Baseline could have given further knowledge of improvements in physical factors other than PA only.

Due to the constant changing local and national community-restrictions following the pandemic, some testing and data collection had to be temporarily postponed. At one point, the national authorities asked all citizens to avoid home visits for two weeks, and consequently, it was not considered safe for study personnell to collect data from the participants' homes at this time. One participant had as much as twelve weeks between Baseline and Week Six, due to a personal quarantine quickly followed by Christmas holidays and national lockdown. The prolonged use of KOKU might have implicated the results. If the exercises in the app were performed daily for 10-12 weeks, the participants might have improved more than what would have been observed at Week Six. However, if the participants stopped using KOKU or reduced the amount of exercise sessions per week, the results might have been impacted in the other direction. As none the participants were asked to register how much or how often they used KOKU, it is not possible to know whether the prolonged time between Baseline and Week Six affected the results in either direction, or how much any of the participants used the app. A limitation regarding future use of the app, is that KOKU is, to this date, only available in App Store accessed by Apple iPads. iPads are more expensive than tablets from other brands and might therefore introduce a barrier to accessing KOKU for those who do not already own an iPad.

The semi-structured interviews were performed by four researchers. This was not possible to avoid due to limited time and funding. Researchers may have used different tone of voice and body language when asking questions, causing the participants to interpret the questions dissimilarly. Having just one researcher conducting the interviews might have limited the possibilities of error and discrepancies. In addition, one interview had to be conducted by phone due to the national lockdown following COVID-19. During the analytic process, the two researchers may have interpreted the meaning and content of interviews differently. The researchers quality controlled and frequently discussed to reduce the risk of this error. However, improved quality control could have been conducted by examining inter-rater reliability.

4.7. Conclusion

This pre-post feasibility study showed that a tailored game-based app did not significantly change PA level in community-dwelling older adults with incipient loss of function during a 6-week period. However, the app was experienced as motivating and enjoying, and perceived as intuitive and easy to use. This indicates that this kind of exercise apps can be useful to implement physical activity in an older adult population. As this was a small study with only one group, mostly female participants, and no verification of the participants inclusion criteria, results should be interpreted with caution. Yet, this study increases the knowledge of whether tailored game-based exercise apps can influence older adults' PA level, and how this group experiences using this type of app. The results affirm that this is an area of research that should be investigated further. In the future, larger, randomized studies should be conducted, including a higher number of participants, gender equality within the participant groups, and control groups for comparison.

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Appendices

Appendix A: Consent form

Appendix B: Questionnaire Baseline

Appendix C: SPPB

Appendix D: Interview guide

Appendix E: Questionnaire Week Six

Appendix A: Consent form

Fysisk aktivitet hos eldre ved bruk av treningsapp

NTNU
Kunnskap for en bedre verden

FORESPØRSEL OM DELTAKELSE I FORSKNINGSPROSJEKTET

FYSISK AKTIVITET HOS ELDRE VED BRUK AV TRENINGSAPP

Dette er et spørsmål til deg om å delta i et forskningsprosjekt som er et samarbeid mellom Institutt for nevromedisin og bevegelsesvitenskap ved NTNU og Trondheim Kommune. Hensikten med studien er å gjennomføre en brukertest av en spillbasert treningsapp blant hjemmeboende eldre med fokus på brukeropplevelser og om den kan påvirke nivå av fysisk aktivitet i hverdagen. Du forespørres om å delta i dette prosjektet da du er over 70 år og bor hjemme. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

HVA INNEBÆRER PROSJEKTET?

Formålet med studiet er teste ut den spillbaserte treningsapplikasjon «Keep On Keep Up» (KOKU) som er utviklet i Storbritannia og er designet for eldre. Appen har blitt oversatt til norsk og det er ønskelig å teste den på norske eldre. Studien er en gjennomførbarhetsstudie der du blir bedt om å teste ut en applikasjon som lastes ned på en iPad. Dersom du ikke har egen iPad vil du få låne en under prosjektets varighet. KOKU oppfordrer deg til å gjennomføre noen treningsøvelser hver dag og vil sende deg påminnelser om disse. Dersom alle øvelsene gjennomføres, vil du gradvis få progresjon i vanskelighetsgrad av øvelser. I tillegg inneholder appen noen spill som gir deg informasjon om blant annet ernæring og fallrisiko i hjemmet.

Personer som blir bedt om å delta i dette prosjektet er selvhjulpende personer over 70 år som bor hjemme. Selve studiet vil vare i 6 uker, med en oppfølging etter nye 6 uker. Før du laster ned appen er det ønskelig å måle din fysiske aktivitet i løpet av en vanlig uke. Dette gjøres ved å feste to aktivitetsmålere på kroppen (et på lår og et på ryggen). Aktivitetsmålerne er små (2x3x0,7 cm) og påvirker ikke hva du kan gjøre i løpet av en uke, men det er ønskelig at du ikke er i basseng den uken du har på disse. Du vil bli bedt om å bruke disse aktivitetsmålerne igjen etter å ha brukt appen i 6 uker. Deretter er det ønskelig å gjennomføre en oppfølging etter nye 6 uker for å se hvordan ditt aktivitetsnivå er ved dette tidspunktet. Du vil ha tilgang til KOKU og eventuelt låne iPad i hele 12 ukers perioden.

Vi vil også be deg gjennomføre noen tester for å vurdere balanse, styrke og gangfunksjon samt noen korte spørreskjema om helse, teknologibruk og fall ved oppstart og igjen etter 6 uker. Testingen tar ca 1 time. I tillegg er det ønskelig at du deltar på et intervju etter ca 4 ukers bruk for å få dine tilbakemeldinger om KOKU. Det vil bli gjort lydopptak av intervjuet.

HVEM ER ANSVARLIG FOR FORSKNINGSPROSJEKTET?

Norges teknisk-naturvitenskapelige universitet (NTNU) er ansvarlig for prosjektet. Prosjektet gjennomføres i samarbeid mellom Institutt for nevromedisin og bevegelsesvitenskap og Trondheim Kommune. Prosjektet gjennomføres hovedsakelig av to masterstudenter ved Fysisk aktivitet og helse, samt studenter som tar sin bachelorgrad ved fysioterapiutdanningen. Resultater fra studien vil derfor bidra til flere studentoppgaver, og vil også bli forsøkt publisert i et vitenskapelig tidsskrift, samt presentert på nasjonale og internasjonale konferanser.

MULIGE FORDELER OG ULEMPER

Å være i fysisk aktivitet er vist å være et av de viktigste tiltakene for å forhindre, eller minske alvorlighetsgraden av, mange kroniske sykdommer. Å bruke en teknologibasert løsning som minner deg på å gjennomføre aktivitet kan være nyttig for å imøtekomme de anbefalinger for fysisk aktivitet.

Det forventes ingen ulemper eller sikkerhetsrisiko ved deltakelse i prosjektet. Risikoen for uønskede hendelser (fall og/eller skader) er veldig lav, men kan forekomme når man er i fysisk aktivitet. Vi ber deg derfor om å følge sikkerhetsrådene som oppgis i appen.

I forbindelse med COVID-19 pandemien vil alle prosjektmedarbeidere bli bedt om å ta NTNU og Trondheim Kommunes smittevernkurs før de deltar i prosjektet. Smittevernhensyn i henhold til Folkehelseinstituttets (FHI) generelle anbefalinger samt anbefalinger for helsepersonell følges under hele prosjektet.

FRIVILLIG DELTAKELSE OG MULIGHET FOR Å TREKKE SITT SAMTYKKE

Det er frivillig å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg. Dersom du trekker tilbake samtykket, vil det ikke forskes videre på dine helseopplysninger. Du kan også kreve at dine helseopplysninger i prosjektet slettes eller utleveres innen 30 dager, og du har rett til å sende klage til Datatilsynet om behandlingen av dine personopplysninger. Adgangen til å kreve sletting eller utlevering gjelder ikke dersom opplysningene er anonymisert. Denne adgangen kan også begrenses dersom opplysningene er inngått i utførte analyser.

Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte prosjektleder (se kontaktinformasjon på siste side).

HVA SKJER MED INFORMASJONEN OM DEG?

Opplysningene som registreres om deg skal kun brukes slik som beskrevet under formålet med prosjektet, og planlegges brukt til 2022. Eventuelle utvidelser i bruk og oppbevaringstid kan kun skje etter godkjenning fra Regional komité for medisinsk og helsefaglig forskningsetikk (REK) og andre relevante myndigheter. Du har rett til innsyn i hvilke opplysninger som er registrert om deg og rett til å få korrigert eventuelle feil i de opplysningene som er registrert. Du har også rett til å få innsyn i sikkerhetstiltakene ved behandling av opplysningene. Du kan klage på behandlingen av dine opplysninger til Datatilsynet og institusjonen sitt personvernombud.

Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger (=kodede opplysninger). En kode knytter deg til dine opplysninger gjennom en navneliste. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Det er kun prosjektleder Nina Skjæret Maroni og prosjektmedarbeidere Astrid Ustad, Emilie Bertelsen og Anders Glorvigen Lundstein som har tilgang til denne listen.

Opplysningene om deg vil bli oppbevart i fem år etter prosjektslutt av kontrollhensyn. Det skal ikke være mulig å gjenkjenne deg i hverken studentoppgaven eller eventuelle vitenskapelige publikasjoner.

Du vil bli orientert så raskt som mulig dersom ny informasjon blir tilgjengelig som kan påvirke din villighet til å delta i studien. Du vil også opplyses om mulige beslutninger/situasjoner som gjør at din deltagelse i studien kan bli avsluttet tidligere enn planlagt. Vi behandler opplysninger om deg basert på ditt samtykke.

FORSIKRING

Hvis det skulle oppstå skader underveis i testingen som kan knyttes til testsituasjonen, så må deltaker melde dette til prosjektleder. For skade på forskningsdeltaker som oppstår under testing, gjelder pasientrettighetsloven og Norsk pasientskadeerstatning (NPE).

GODKJENNING

Regional komité for medisinsk og helsefaglig forskningsetikk har gjort en forskningsetisk vurdering og godkjent prosjektet med saksnr. 165120. NSD- Norsk senter for forskningsdata AS har også vurdert at personopplysninger i dette prosjektet samsvarer med personvernregelverket (saksnr. 572598).

NTNU og prosjektleder Nina Skjæret Maroni er ansvarlig for personvernet i prosjektet.

Vi behandler opplysningene basert på ditt samtykke.

KONTAKTOPPLYSNINGER

Dersom du har spørsmål til prosjektet eller ønsker å trekke deg fra deltakelse, kan du kontakte Nina Skjæret Maroni, tlf: 995 05 704, e-post: nina.skjaret.maroni@ntnu.no

Dersom du har spørsmål om personvernet i prosjektet, kan du kontakte personvernombudet ved NTNU: thomas.helgesen@ntnu.no

Hvis du har spørsmål knyttet til NSD sin vurdering av prosjektet, kan du ta kontakt med:

NSD – Norsk senter for forskningsdata AS på epost (personverntjenester@nsd.no) eller på telefon: 55 58 21 17.

SAMTYKKE TIL DELTAKELSE I PROSJEKTET

Jeg har mottatt og forstått informasjon om prosjektet Fysisk aktivitet hos eldre ved bruk av treningsapp, og har fått anledning til å stille spørsmål.

JEG ER VILLIG TIL Å DELTA I PROSJEKTET

Sted og dato

Deltakers signatur

Deltakers navn med trykte bokstaver

Jeg bekrefter å ha gitt informasjon om prosjektet

Sted og dato

Signatur

Rolle i prosjektet

Appendix B: Questionnaire Baseline

Vedlegg 1

Spørreskjema baseline

På følgende spørsmål ønsker vi at du svarer så presist og ærlig som mulig. Hvis du ikke finner et svaralternativ som passer nøyaktig for deg, vil vi at du gir det svaret som er nærmest din virkelige verdi.

Deltaker nummer:

Fødselsår:

Kjønn: KVINNE ☐ MANN ☐

Høyde (måles): cm

Vekt (måles): kg

Har du prøvd lignende spill tidligere? JA ☐ NEI ☐

Hvis ja, vennligst noter hvilke(t):

Har du opplevd å falle uten særlig grunn i løpet av de siste 3 månedene? JA ☐ NEI ☐

Hvis ja, hvor skjedde fallet? Utendørs ☐ Innendørs ☐

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Vedlegg 1

Mosjon/fysisk aktivitet på fritiden (i løpet av en gjennomsnittlig uke. Med mosjon/fysisk aktivitet mener vi at du f.eks går tur, går på ski, sykler, svømmer eller driver trening/idrett)

Hvor ofte driver du mosjon (ta et gjennomsnitt)**?**

- ☐ Aldri
- ☐ Sjeldnere enn en gang i uka
- ☐ En gang i uka
- ☐ 2-3 ganger i uka
- ☐ Omtrent hver dag

Dersom du driver slik mosjon, så ofte som en eller flere ganger i uke; hvor hardt mosjonerer du (ta et gjennomsnitt)**?**

- ☐ Tar det rolig uten å bli andpusten eller svett
- ☐ Tar det så hardt at jeg blir andpusten eller svett
- ☐ Tar meg nesten helt ut

Hvor lenge holder du på hver gang (ta et gjennomsnitt)?

- ☐ Mindre enn 15 minutter
- ☐ 15-29 minutter
- ☐ 30-60 minutter
- ☐ Mer enn 60 minutter

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Appendix C: SPPB

Short Physical Performance Battery (SPPB)

Oversatt til norsk april 2013 v/Sverre Bergh[1], Heidi Lyshol[2], Geir Selbæk[1], Bjørn Heine Strand[2,] Kristin Taraldsen[3], Pernille Thingstad[3] *1. Alderspsykiatrisk forskningssenter, Sykehuset Innlandet HF 2. Folkehelseinstituttet 3. Forsknings gruppe for geriatri, St. Olavs hospital og NTNU*

Innhold:

1. Manual for testprotokoll
2. Registreringsark for testing
3. Scoringsark for poengberegning
4. Vedlegg:
   - Scoring for 3m gangtest der 4m ikke er praktisk mulig
   - Tillegg til originaltesten:
     Registrering av ganghastighet og reise/sette seg x5 med bruk av armene

Bakgrunn:
Short Physical Performance Battery er en test for screening av fysisk funksjon hos eldre. Testen var opprinnelig utviklet for bruk i en større amerikansk studie av eldre over 65 år, EPESE studien. Testen har vist seg å ha god prediksjonsevne for død og sykehjemsinnleggelser [1], fremtidig funksjonsfall og økt hjelpebehov [4], sykehusinnleggelser [5] og reinnleggelser i sykehus [6]. Den har vist seg egnet til bruk i sykehus på akutt syke eldre [7], som screeningtest i primærhelsetjenesten[8] og på hjemmeboende eldre [9]. Testen er oversatt fra engelsk til norsk i tråd med gjeldende retningslinjer og den norske versjon er gratis og fritt tilgjengelig for bruk.

Tillegg til originalversjonen:
Utregning og registrering av ganghastighet er ikke en del av originaltesten. Ganghastighet kan brukes som en selvstendig test, er et anbefalt mål på helse og funksjon hos eldre og har veletablerte referanse verdier [10]. Den originale SPPB versjonen kan ha en gulveffekt ved testing av eldre med lavt funksjonsnivå. For eldre som scorer 0 poeng på reise/sette seg kan tiden med bruk av armene registreres i tillegg. Denne tiden regnes ikke inn i totalscoren SPPB, men registreres som en egen test.

Testprosedyre:
Nødvendig utstyr: Stoppeklokke, målebånd, farget markerings teip, stol
Det anbefales at manualen og instruksjoner innøves på forhånd. Kun registreringsarket brukes under testing, og beregning av totalscore gjøres i etterkant. Det anbefales å laste ned instruksjonsvideo og informasjonsmateriell fra hjemmesiden til originaltesten: http://www.grc.nia.nih.gov/branches/ledb/sppb/.
Ganghjelpemiddel kan brukes under gangtesten om nødvendig. Det er viktig å registrere og bruke samme ganghjelpemiddel ved retest, evt. velge det pasienten går raskest med for å kunne fange opp bedring. Ved testing av statisk balanse og reise/sette seg x5 settes eventuelle ganghjelpemiddel til siden (ikke ha rullator foran pasienten). Årsak til at deltageren ikke gjennomfører testen er viktig å registrere for å skille mellom deltagere som fysisk ikke er i stand til å gjennomføre testen pga utrygghet og redusert funksjon (scorer null poeng) og de som kan fysisk, men ikke lar seg teste av andre grunner (missing). Denne vurderingen baseres på tester sin kliniske vurdering.

Tolkning [1, 2]:
Lav score: 0-6 poeng
Middels score: 7-9 poeng
Høy score: 10-12 poeng.

< 10 poeng indikerer økt risiko for funksjonssvikt
< 8 poeng indikerer begynnende svikt i ADL funksjoner

Klinisk meningsfull endring (totalscore): 1 poeng [3]

For mer detaljerte referanseverdier i forhold til alder og kjønn anbefales originalartikkelen [2]. Referanseverdier for ganghastighet som selvstendig test er oppgitt i vedlegget.

1. Guralnik, J.M., et al., *A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission.* J Gerontol, 1994. **49**(2): p. M85-94.
2. Guralnik, J.M., et al., *Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery.* J Gerontol A Biol Sci Med Sci, 2000. **55**(4): p. M221-31.
3. Perera, S., et al., *Meaningful change and responsiveness in common physical performance measures in older adults.* J Am Geriatr Soc, 2006. **54**(5): p. 743-9.
4. Guralnik, J.M., et al., *Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability.* N Engl J Med, 1995. **332**(9): p. 556-61.
5. Studenski, S., et al., *Physical performance measures in the clinical setting.* J Am Geriatr Soc, 2003. **51**(3): p. 314-22.
6. Volpato, S., et al., *Predictive value of the Short Physical Performance Battery following hospitalization in older patients.* J Gerontol A Biol Sci Med Sci, 2011. **66**(1): p. 89-96.
7. Volpato, S., et al., *Performance-based functional assessment in older hospitalized patients: feasibility and clinical correlates.* J Gerontol A Biol Sci Med Sci, 2008. **63**(12): p. 1393-8.
8. Cavazzini, C., et al., *Screening for poor performance of lower extremity in primary care: the Camucia Project.* Aging Clin Exp Res, 2004. **16**(4): p. 331-6.
9. Freiberger, E., et al., *Performance-based physical function in older community-dwelling persons: a systematic review of instruments.* Age Ageing, 2012. **41**(6): p. 712-21.
10. Studenski, S., *Bradypedia: is gait speed ready for clinical use?* J Nutr Health Aging, 2009. **13**(10): p. 878-80.

SHORT PHYSICAL PERFORMANCE BATTERY, TEST MANUAL

Alle testene bør gjennomføres i samme rekkefølge som de er presentert i denne manualen. Instruksjoner til deltagerne er vist i uthevet kursiv og skal formuleres på nøyaktig samme måte som beskrevet i dette dokumentet.

1. STATISK BALANSE

Deltageren må være i stand til å stå uten støtte, uten hjelp av stokk eller rullator. Du kan hjelpe deltageren opp i stående.

> ***La oss nå begynne kartleggingen. Nå vil jeg at du skal prøve å innta ulike stillinger. Jeg vil først beskrive og vise hver stilling for deg. Så vil jeg at du skal prøve å gjøre det samme. Du skal ikke gjøre noe du føler er utrygt eller noe du ikke klarer.***
>
> ***Har du noen spørsmål før vi starter?***

A. Stående stilling, samlede føtter

1. ***Nå vil jeg vise deg den første stillingen.***
2. (Demonstrer) ***Jeg vil at du skal forsøke å stå med føttene samlet, inntil hverandre, i ca 10 sekunder.***
3. ***Du kan bruke armene, bøye knærne eller bevege kroppen for å holde balansen, men prøv å ikke flytte på føttene. Prøv å holde stillingen helt til jeg ber deg stoppe.***
4. Stå ved siden av deltagerne for å hjelpe han/henne inn i stillingen.
5. Gi akkurat nok støtte til deltagerens arm for å unngå at han/hun mister balansen.
6. Når deltageren står med føttene samlet, spør **"Er du klar?"**
7. Slipp så taket og start tidtakingen idet du sier, **"Klar, start"**
8. Stopp stoppeklokken og si **"stopp"** etter 10 sekunder eller hvis deltageren flytter føttene og forlater stillingen eller griper tak i armen din.
9. Hvis deltageren ikke klarer å holde stillingen i 10 sekunder, noter resultatet og gå videre til ganghastighetstesten.

B. Stående stilling, semi-tandem

1. ***Nå vil jeg vise deg den andre stillingen.***
2. (Demonstrer) ***Nå vil jeg at du skal forsøke å stå med siden av hælen på den ene foten inntil stortåen på den andre foten i ca 10 sekunder. Du kan velge hvilken fot du har fremst, den som føles mest naturlig for deg.***
3. ***Du kan bruke armene, bøye knærne eller bevege kroppen for å holde balansen, men prøv å ikke flytte på føttene. Prøv å holde stillingen helt til jeg ber deg stoppe.***
4. Stå ved siden av deltageren for å hjelpe han/henne inn i semi-tandem stilling.
5. Gi akkurat nok støtte til deltagerens arm for å unngå at han/hun mister balansen.
6. Når deltageren står med føttene samlet, spør **"Er du klar?"**
7. Slipp så taket og start tidtakingen idet du sier, **"Klar, start"**
8. Stopp stoppeklokken og si **"stopp"** etter 10 sekunder eller hvis deltageren flytter føttene og forlater stillingen eller griper tak i armen din.
9. Hvis deltageren ikke klarer å holde stillingen i 10 sekunder, noter resultatet og gå videre til ganghastighetstesten.

C. Stående stilling, tandem

1. ***Nå vil jeg vise deg den tredje stillingen.***
2. (Demonstrer) ***Nå vil jeg at du skal forsøke å stå med hælen på den ene foten foran og inntil tærne på den andre foten i ca 10 sekunder. Du kan velge hvilken fot du har fremst, den som føles mest naturlig for deg.***
3. ***Du kan bruke armene, bøye knærne eller bevege kroppen for å holde balansen, men prøv å ikke flytte på føttene. Prøv å holde stillingen helt til jeg ber deg stoppe.***
4. Stå ved siden av deltageren for å hjelpe han/henne inn i tandem stilling.
5. Gi akkurat nok støtte til deltagerens arm for å unngå at han/hun mister balansen.
6. Når deltageren står med føttene samlet, spør **"Er du klar?"**
7. Slipp så taket og start tidtakingen idet du sier, **"Klar, start"**
8. Stopp stoppeklokken og si **"stopp"** etter 10 sekunder eller hvis deltageren flytter føttene og forlater stillingen eller griper tak i armen din.

2. 4m GANGTEST

Nå skal jeg observere hvordan du vanligvis går. Hvis du bruker stokk eller andre ganghjelpemidler, og føler at du trenger det for å gå en kort distanse, kan du bruke det.

A. Første test av ganghastighet

1. ***Dette er distansen du skal gå. Jeg vil at du skal gå til den andre enden, i din vanlige hastighet, som om du gikk nedover gaten til butikken.***
2. Demonstrer øvelsen for deltageren
3. ***Gå hele lengden, over og forbi teip-markeringen før du stopper. Jeg kommer til å gå sammen med deg. Føler du at dette er trygt?***
4. La deltageren stå med begge føttene inntil startlinjen.
5. ***Når jeg vil du skal starte, sier jeg: "Klar, start".*** Når deltageren bekrefter å ha forstått instruksjonen, si: ***"Klar, start."***
6. Start tidtakingen idet deltageren begynner å gå.
7. Gå bak og til siden for deltageren.
8. Stopp tidtakingen når en av deltagerens føtter er helt over mållinjen.

B. Andre test av ganghastighet

1. ***Nå vil jeg at du skal gjøre det samme en gang til. Husk å gå i din vanlige hastighet, og gå helt over og forbi teip-markeringen.***
2. La deltageren stå med begge føttene inntil startlinjen.
3. ***Når jeg vil at du starter, sier jeg: "Klar, start".*** Når deltageren bekrefter å ha forstått instruksjonen, si: ***"Klar, start."***
4. Start tidtakingen idet deltageren begynner å gå.
5. Gå bak og til siden for deltageren.
6. Stopp tidtakingen når en av deltagerens føtter er helt over mållinjen.

3. REISE SEG TEST

Reise seg fra stol én gang

1. ***Dette er den siste øvelsen. Er det trygt for deg å reise deg opp fra stolen uten å bruke armene?***
2. ***Den neste testen måler styrken i beina dine.***
3. (Demonstrer og forklar øvelsen.) ***Først, kryss armene over brystet, og sitt slik at føttene er plassert på gulvet; så reiser du deg opp, behold armene i kryss over brystet.***
4. ***Nå vil jeg at du skal prøve å reise deg opp med armene i kryss over brystet.*** (Noter resultatet).
5. Hvis deltageren ikke klarer å reise seg uten å bruke armene, si ***"OK, prøv å reise deg med bruk av armene."*** Dette avslutter testen. Noter resultatet og gå til scoringsarket.

Reise/ sette seg x5

1. ***Tror du det vil være trygt for deg å reise deg opp fra stolen fem ganger uten å bruke armene?***
2. (Demonstrer og forklar øvelsen.) ***Nå vil jeg at du skal reise deg <u>helt opp</u> så RASKT du kan fem ganger, uten stopp. Etter at du har reist deg hver gang, sett deg ned og reis deg opp igjen. Behold armene i kryss over brystet. Jeg tar tiden med en stoppeklokke.***
3. Når deltageren sitter på riktig måte, si: **"Klar? Reis deg"** og start tidtakingen.
4. Tell høyt hver gang deltageren reiser seg, opp til fem ganger.
5. Stopp om deltageren blir sliten eller tungpustet av å reise seg fra stolen flere ganger.
6. Stopp stoppeklokka når han/hun har reist seg helt opp den femte gangen.
7. Stopp også
    - Hvis deltageren bruker armene
    - Etter 1 minutt, hvis deltageren ikke har fullført 5 repetisjoner
    - Hvis du bekymrer deg for deltakerens sikkerhet
8. Hvis deltageren er utslitt og stopper før fem repetisjoner, spør "**Kan du fortsette?"** for å bekrefte dette.
9. Hvis deltageren sier "Ja," fortsett tidtakingen. Hvis deltageren sier "Nei," stopp og nullstill stoppeklokken.

Registreringsark

dd/mnd/år: __ __ / __ __ / __ __ __ __

ID/navn:

1. Balansetest

1.Samlede føtter
10 sekunder

1. __ __ . __ __ sek

↓

2.Semi-tandem
10 sekunder

2. __ __ . __ __ sek

↓

3.Tandem
10 sekunder

3. __ __ . __ __ sek

↓

Gå til gangtest

---

2. Gangtest

Ganghjelpemidler ved test (kryss av):

1. ☐ uten
2. ☐ krykke/stokk (er)
3. ☐ rollator
4. ☐ Annet (spesifiser)__________________

Tid test 1: __ __ . __ __ sek

Tid test 2: __ __ . __ __ sek

---

3. Reise/ sette seg

Pre-test

↓ I stand til

5 repetisjoner

→ Avslutt

Ikke i stand til

Setehøyde ☐ cm

Tid 5 repetisjoner uten armbruk: __ __ . __ __ sek

Tester:

SCORING SPPB:

dd/mnd/år: [ ][ ] [ ][ ] [ ][ ][ ][ ]

ID/navn:

1. Score statisk balanse

Hvis deltageren ikke har forsøkt eller mislyktes, kryss av hvorfor:

1. ☐ Forsøkte, men ikke i stand til(0p)
2. ☐ Deltageren kunne ikke holde stillingen uten hjelp(0p)
3. ☐ Ikke forsøkt, tester følte det utrygg(0p)
4. ☐ Ikke forsøkt, deltager følte seg utrygg(0p)
5. ☐ Deltager tar ikke instruksjon(missing)
6. ☐ Annet (spesifiser)___________________
7. ☐ Deltager nektet(missing)

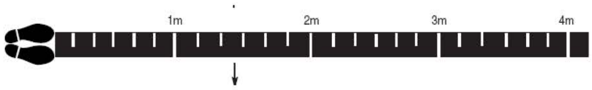
Samlede føtter	=10 sek = 1 p <10 sek = 0 p	☐
	+	
Semi-tandem	=10 sek = 1 p <10 sek = 0 p	☐
	+	
Tandem	=10 sek = 2 p 3 - 9.99 sek = 1 p < 3 sek = 0 p	☐
	=	

Sum poeng balanse: ☐

2. Score 4m gangtest

Hvis deltageren ikke har forsøkt eller mislyktes, kryss av hvorfor:

1. ☐ Forsøkte, men ikke i stand til(0p)
2. ☐ Deltageren kunne ikke gå uten assistanse(0p)
3. ☐ Ikke forsøkt, tester følte det utrygg(0p)
4. ☐ Ikke forsøkt, deltager følte seg utrygg(0p)
5. ☐ Deltager tar ikke instruksjon(missing)
6. ☐ Annet (spesifiser)___________________
7. ☐ Deltager nektet(missing)



Deltager var ikke i stand til:		= 0 poeng
Hvis tiden var	> 8.7	= 1 poeng
Hvis tiden var	6.21 - 8.70	= 2 poeng
Hvis tiden var	4.82 - 6.20	= 3 poeng
Hvis tiden var	< 4.82	= 4 poeng

Poeng ganghastighet (beste av to forsøk): ☐

3. Score reise/sette seg x5

Hvis deltageren ikke har forsøkt eller mislyktes, kryss av hvorfor:

1. ☐ Forsøkte, men ikke i stand til(0p)
2. ☐ Deltageren kunne ikke reise seg uten hjelp(0p)
3. ☐ Ikke forsøkt, tester følte det utrygg(0p)
4. ☐ Ikke forsøkt, deltager følte seg utrygg(0p)
5. ☐ Deltager tar ikke instruksjon(missing)
6. ☐ Annet (spesifiser)___________________
7. ☐ Deltager nektet(missing)

Deltager var ikke istand til/brukte >60 sek	= 0 poeng
Hvis tiden var ≥16.7 sek	= 1 poeng
Hvis tiden var 13.7 – 16.69 sek	= 2 poeng
Hvis tiden var 11.20 – 13.69 sek	= 3 poeng
Hvis tiden var ≤ 11.19 sek	= 4 poeng

Poeng reise/sette seg x5: ☐

tester:

TOTAL SCORE SPPB 1.+2.+3.: ☐

Vedlegg/tillegg til orginaltesten:

1. Ganghastighet-test
2. Reise/sette x5 m/armbruk
3. Scoring for 3m gangtest (der 4m ikke er mulig)

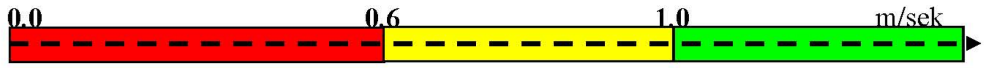
Ganghastighet-test:

Ganghastighet = Distanse(m)/ tid (sekunder):

Test 1. ☐m / ☐☐.☐☐sek = ☐.☐☐ m/sek

Test 2. ☐m / ☐☐.☐☐sek = ☐.☐☐ m/sek

Tolkning [1-3]:



Skrøpelig:	**Begynnende funksjonssvikt:**	**Normal:**
Økt risiko for fall Økt risiko for funksjonssvikt Økt risiko for sykehusinnleggelse Redusert innendørs og utendørsmobiltiet	Økt risiko for fall og funksjonsvikt Selvhjulpen i ADL Redusert utendørsmobilitet	Ingen økt risiko eller begrensninger i ADL og mobilitet

Reise/sette seg x5 m/armbruk: Samme instruksjon som SPPB, men med bruk av armlener på stolen.

Tid 5 repetisjoner m/armbruk: ☐☐.☐☐**sek**

Ved testing av skrøpelige populasjoner anbefales å legge til et ekstra element i tillegg til originaltesten i form av registrert tid på reise/sette seg x5 med bruk av armer (armlener på stol) der deltager ikke klarer å reise seg uten støtte.

Skåring for 3m distanse (hvis 4m ikke er mulig å gjennomføre):

Deltager var ikke i stand til:	= 0 poeng
Hvis tiden var > 6.52	= 1 poeng
Hvis tiden var 4.66 - 6.52	= 2 poeng
Hvis tiden var 3.62 - 4.65	= 3 poeng
Hvis tiden var < 3.62	= 4 poeng

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3. Fritz, S. and M. Lusardi, *White paper: "walking speed: the sixth vital sign".* J Geriatr Phys Ther, 2009. **32**(2): p. 46-9.
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Appendix D: Interview guide

Fysisk aktivitet hos eldre ved bruk av treningsapp

Intervjuguide

Introduksjon:

Tusen takk for at du har takket ja til å delta i prosjektet. Prosjektet handler om å kartlegge bruken av en spillbasert treningsapp for å opprettholde fysisk aktivitet blant eldre mennesker. Som deltagende student i dette prosjektet skal jeg intervju deltakere om deres egne opplevelser av appen KOKU (Keep On Keep Up). Dette forskningsintervjuet vil gjennomføres som en samtale mellom oss to hvor det ikke er noen svar som er rett eller feil. Det er frivillig å delta. Du kan når som helst trekke deg fra prosjektet og be om at intervjuet blir slettet.

Intervjuet blir tatt opp på lydfil, og det er bare meg og min veileder som har tilgang til denne lydfilen som blir slettet når prosjektet er ferdig. Det vil ikke være mulig for andre å finne ut hvem som har deltatt i studien gjennom å lese studentoppgaven. (litt pause) Intervjuet vil ta mellom 30 min og en time. Har du noen spørsmål før vi begynner?

1. Kan du fortelle om hvordan du har opplevd å bruke appen KOKU?
   - Hvorfor / hvorfor ikke opplevde du den som engasjerende å bruke?
   - Kan du fortelle om du opplevde noe form for ubehag / svimmelhet/fallrisiko?

2. Opplevde du spillet som meningsfullt eller motiverende?
   - Kan du fortelle litt om hvorfor (hvorfor ikke) spillet var meningsfullt/motiverende?

3. Kan du fortelle om det var noe du savnet for å gjøre spillet mer motiverende / gøy å bruke?
   - Hvordan ser du for deg at et slikt spill må være for at det skal være motiverende for deg å bruke i hverdagen?

4. Kan du fortelle meg om du ville brukt KOKU som en måte å være i daglig fysisk aktivitet på over tid?
   - Hvorfor ikke? Hvorfor?
   - Hva kan være positivt/negativt med å bruke app for å være i aktivitet?

5. Hvordan var det å lære seg hvordan KOKU fungerer?
   - Hvorfor utfordrende / hvorfor lett?

6. Hva tenker du om å ha denne formen for trening for å forbedre fysisk funksjon og aktivitetsnivå?
    - Hvorfor / hvorfor ikke?

7. Kan du fortelle om dine tidligere erfaringer med dataspill eller app-teknologi?
    - Hvordan påvirket tidligere erfaring bruken av KOKU? Påvirket det ikke?

8. Før vi avslutter, er det noe du vil snakke mer om eller noe annet du tenker på i forhold til KOKU som vi ikke har snakket om?

Tusen takk for din deltagelse.

Appendix E: Questionnaire Week Six

Vedlegg 2

Spørreskjema 6 uker

På følgende spørsmål ønsker vi at du svarer så presist og ærlig som mulig.

Deltaker nummer:

Synes du appen KOKU var artig å bruke? JA☐ NEI☐

Forklar kort hvorfor/hvorfor ikke:

Kunne du brukt denne appen for å holde deg fysisk aktiv i hverdagen? JA☐ NEI☐

Forklar kort hvorfor/hvorfor ikke:

Synes du KOKU var fysisk anstrengende? JA☐ NEI☐

Forklar kort hvorfor/hvorfor ikke:

Vedlegg 2

Var du redd for å falle mens du brukte KOKU? JA☐ NEI☐

Forklar kort hvorfor/hvorfor ikke:

Har du opplevd et fall eller annet ubehag når du har brukt KOKU? JA☐ NEI ☐

Hvis ja, forklar kort hvilken type ubehag (f.eks svimmelhet, fall osv):

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