Master's thesis

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

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The influence of an exercise application on physical function and user experience in older adults: A pilot feasibility study.

Master's thesis in Physical Activity and Health
Supervisor: Nina Skjæret Maroni
Co-supervisor: Astrid Ustad
May 2021

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Kunnskap for en bedre verden

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Infographic

Tablet-based exercise to improve physical function for prefrail elderly

1

Tablet-based exercise has been shown to improve cognitive and physical function in older adults.

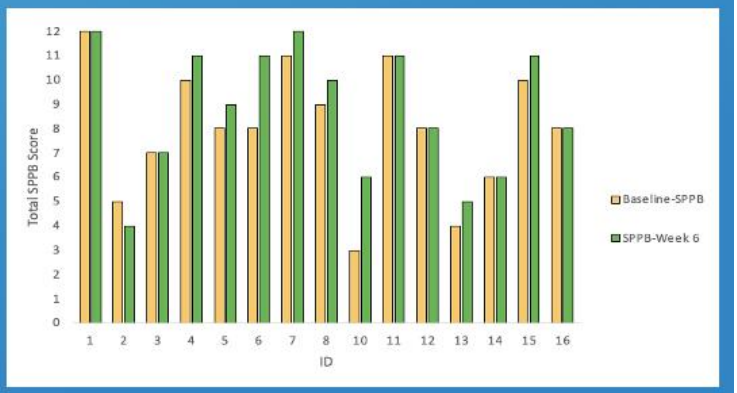
2

Our study showed that a six-week tablet-based intervention can improve physical function in individually living prefrail elderly aged 70 years or older

3

The exercise application KOKU was generally experienced as a motivating, meaningful, and easy to use way of engaging in physical activity

53% of our participants improved their physical function after only six weeks of use of KOKU! The physical function is reflected by the total score from the Short Physical Performance Battery



The results from our study show promising trends in the use of tablet-based exercise interventions' ability to motivate the elderly to participate and engage in exercise and activity. The increased SPPB scores show an encouraging trend for KOKU to be a useful tool in geriatrics and physical therapy when low physical function and risk of falling are of concern.

Abstract

Background and research aim: The increasing older population poses a great challenge on health care systems around the world as older adults are at risk of institutionalization due to reduced physical function (PF). Thus, innovative treatment tools must be developed and investigated to reduce treatment costs and ensure that older adults can achieve a healthy ageing and live independently at home longer. The purpose of this pilot study is to investigate user experience with an exercise application and how it may influence PF.

Methods: 16 prefrail older adults aged 70 years or older living independently were recruited through municipal physical therapy service and social meeting spots for older adults. Of the 16 recruited, 15 participants completed a six-week tablet-based intervention using the exercise application Keep On Keep Up (KOKU). Short physical performance battery (SPPB) was performed pre- and posttest to investigate changes in PF. Interviews regarding user experience were performed and the interview data were thematically analyzed.

Results: At baseline participants had a mean total SPPB score of 8.00 (SD=2.95), indicating an increased risk of disability and initial loss of functionality. After six weeks of using KOKU, mean (SD) total SPPB score were 8.73 (2.66). Interviews showed that KOKU was experienced as a fun and motivating way of being physically active.

Conclusion: The results from this pilot study are encouraging regarding KOKU as a fun, motivating and user-friendly tool to aid in preventative work and to increase PF.

Sammendrag

Bakgrunn og forskningsspørsmål: Den økende andelen eldre utgjør en stor utfordring for helsevesen verden over ettersom høyere alder gir en redusert fysisk funksjon og dermed større behov for sykehjemsplasser. Det er derfor et stort behov for å utvikle og undersøke effektive og innovative verktøy for forebygging for å redusere kostbare behandlinger og sørge for at eldre kan oppnå en sunn aldring og kan leve uavhengig hjemme lengre. Formålet med denne studien er å undersøke brukererfaring med en treningsapp og hvordan denne kan påvirke fysisk funksjon.

Metode 16 deltakere som var 70 år eller eldre med begynnende skrøpelighet og som bodde hjemme ble rekruttert gjennom Trondheim kommunes fysioterapi tilbud og sosiale møteplasser for eldre. Av de 16 som ble rekruttert, gjennomførte 15 deltakere en seks-ukers intervensjon med treningsappen Keep On Keep Up (KOKU). Short physical performance battery (SPPB) ble gjennomført før og etter bruk for å undersøke endringer i fysisk funksjon. Intervjuer omhandlende brukererfaring med KOKU ble gjennomført og intervjudataene ble analysert tematisk.

Resultater Ved baseline hadde deltakerne en gjennomsnittlig total SPPB score på 8.00 (SD=2.95), noe som indikerer en økt risiko for funksjonsnedsettelse og begynnende funksjonstap. Etter seks ukers bruk av KOKU var den gjennomsnittlige totale SPPB scoren 8.74 (SD=2.66). Intervjuene viste at KOKU opplevdes som en morsom, motiverende og brukervennlig måte å være fysisk aktiv.

Konklusjon Resultatene fra denne pilotstudien er oppmuntrende når det gjelder KOKU som et morsomt, motiverende og brukervennlig verktøy for å bidra i det forebyggende arbeidet og for å forbedre fysisk funksjon.

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1.0 Background and research aim

1.1 Increasing older population

The success history of preventative health care has increased the overall life expectancy in Norway and most people can expect to live into their 80's and beyond (1). The Norwegian central burau of statistics estimates that in Norway in 2030 older people will outnumber children (2) and globally between 2017 to 2050, the number of people aged 80 years or older is estimated to increase more than threefold (3). As one can expect, the increasing population of older adults puts greater pressure on social- and health care systems through institutionalization and treatment and it is of greater importance than ever that governments prioritize innovative policies and public services for older people (3). This includes housing, health care and infrastructure, among others. Health care systems around the world are giving much attention to the promotion of healthy ageing and preventing non-communicable diseases and chronic conditions (3).

Not all people can achieve a healthy, active, and successful ageing. With increasing age, older adults often become frailer. Fried's classification of frailty defines frailty as presence of one or several physical characteristics (4). These physical characteristics include unintentional weight loss, muscle weakness, exhaustion, slow walking speed, and a lower level of physical capacity (4). The presence of 1-2 of these characteristics is defined as prefrailty. Research has proven that physical exercise slows down progression of physical frailty and increase physical capacity (5). Even though physical activity (PA) and exercise does not halt the ageing process in itself, it can decrease the rate of progression of chronic disease and disabling conditions (6). Despite a large focus on prevention, epidemiolocal studies continuously find evidence of decreasing PA levels among older adults (7). Inactivity is of great concern as it is estimated to be the fourth leading cause of death worldwide, and sedentary lifestyle is associated with higher risks of type 2 diabetes mellitus, osteoporosis, some types of cancers, and cardiovascular disease (8). The burden these age-related diseases and comorbidities pose on older adults, as well as health care systems around the world, is of great public health- and economic concern. To be able to overcome the challenge of providing adequate healthcare to the older population, and the economic burden of treatment, the focus must shift towards prevention of age-related functional decline.

1.2 Preventative efforts, physical activity, and physical function

An increasing older population introduces challenges regarding age related diseases and the burden it poses on health care systems around the world and in Norway. To be able to overcome these challenges it is necessary to maintain long term self-sufficiency. One way to achieve this is by maintaining or increasing physical activity levels. The Norwegian health directorate recommends a minimum of 150 minutes of moderate intensity physical activity (PA) or 75 minutes of high intensity PA per week or a combination of moderate and high intensity (9). Exercises which strengthen large muscle groups is recommended to be performed two or more times per week and elderly with reduced mobility and balance are recommended to perform balance and strength exercises three or more times per week.

PA is defined as any bodily movement produced by the skeletal muscle that requires energy expenditure (10). PA can be performed in several different ways; through means of transportation such as walking or cycling, through leisure time physical activity such as exercise or sports, or as part of work which requires lifting or other active tasks. PA can also be performed as chores or domestic work such as cleaning, carrying and care duties (10). Some physical activities are done by choice and may give enjoyment, while others may be necessary or even mandatory, such as for example occupational physical activity, and may not provide the same mental or health benefits. Regular leisure time physical activity with sufficient duration and intensity, regardless of its nature, have proven to provide health benefits (11). Regular PA is promoted to improve physical, mental, and cognitive function which enables many older adults to live independently for a longer period of their lives (12).

Health care systems are focusing on treatment rather than prevention and results from epidemiological studies consistently finds an increase in insufficient levels of physical activity among older adults (7). A systematic review done by Baert et al. (13) identified a number of motivators and barriers for PA in older adults where physical health condition showed to be both a motivator (fitness incentive, physical benefits and pain reduction) and a barrier (poor balance, muscle weakness, worsening of pain while being physically active and shortness of breath) for many older adults. Additionally, barriers such as worsening of pain while physically active, poor balance and muscle weakness were identified, which all indicates a reduced physical function (PF) (14). Reduced PF is strongly correlated to older age and may lead to loss of independence, hospitalization, long-term care at nursing homes and premature death (14).

PF is defined as the ability to perform both basic and instrumental activities of daily living (15). The ability of older adults to live and function in the community strongly depends on their level of PF (14). Improvements in older adult's functional outcomes are important to reduce sedentariness, risk of cardiovascular disease and other noncommunicable diseases, as well as risk of falls and other age-related diseases (16).

To ensure that knowledge regarding health benefits from PA and effective, manageable, and evidence-based exercises are easily accessible and understandable for older adults, we need to address these barriers. Exercise is a subset of PA and is planned, structured and repetitive and has an objective to improve or maintain physical fitness (10). The terms PA and exercise are often used interchangeably. But to be physically active is not enough alone, it is also of importance to reduce exaggerated periods of sedentary behavior as well (17). Despite the increased focus on promotion of PA, the majority of older adults remain sedentary, contributing to increased risk of premature onset of illness, disease, functional decline and mortality (18).

1.3 Sedentary Behavior

Sedentary behavior (SB) is defined by World Health Organization (WHO) (19) as any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents (MET) such as sitting, reclining or lying down. 1 MET is equal that of resting metabolism. Such behavior is associated with abnormal cardiometabolic morbidity and glucose metabolism, as well as overall mortality (20) and findings from studies in the US and Europe has reported that objectively measured sedentary time was higher in those aged 50 years or older (21). As countries exponentially increase their wealth, so does the levels of inactivity. This is mainly attributed to the influence of new methods of transportation, use of technology and increased urbanization (22). Globally, 27.5% of adults and 81% of adolescents does not reach the global recommendations for PA for health (19). Ding et al. (23) reported that SB conservatively costs healthcare systems around the world 53.8$ billion and SB related deaths costs 13.7$ billion in productivity losses (20). In 2012, Kohl et al. (24) defined SB as a pandemic but despite the world's leading organizations acknowledgement of the pandemic and their efforts to increase PA (8) insufficient levels of PA still persist (25). If the current situation follows the exponential trajectory reported by Guthold et al. (25), the 2025 global goal of reducing insufficient PA levels by 10% will not be reached. One way to decrease the increasing levels of SP is to increase PA levels.

Alongside the pandemic of SB, a new pandemic began to spread quickly around the world in late 2019 which may have worsened the current situation of insufficient PA levels and increased SB.

1.4 Covid-19 and isolation

In December 2019, a new coronavirus (SARS-CoV-2) was identified in Wuhan, China, a virus that may cause the Coronavirus Disease 19 (covid-19) and caused the worldwide covid-19 pandemic. The pandemic had as of February 24th 2021 claimed almost 3.2 million lives across the globe according to WHO (26). Although the individual severity of covid-19 is low for the general population, it is significantly higher for those aged 60 and older (27). A study by Zunyou & McGoogan (28) showed that the highest case-fatality rate (CFR) regarding covid-19 were found in those aged 70-79 years (8.0%) and those aged 80 years and older (14.8%). CFR was also elevated amongst those with preexisting comorbid conditions such as cardiovascular disease (10.5%), diabetes (7.3%), chronic respiratory disease (6.3%), and cancer (5.6%), diseases which is associated with ageing and may result in severe complications related to covid-19 (28).

Since early 2020, the focus of the Norwegian government regarding the pandemic has been to reduce potential pressure on the health care system and shield the people at risk of developing severe health problems from covid-19. However, Covid-19 will continue to be a threat to public health, even after the population have reached sufficient immunity. The Norwegian governments report "Long term strategy for handling the covid-19 pandemic" acknowledges that the pandemic might have indirect consequences on public health through infection control measures. This may result in increased loneliness, reduced mental health and reduced physical activity, which in turn may cause changes in total mortality and sickness (27).

Social isolation due to covid-19 among older adults may increase SB which is particularly unfortunate as their risk of developing cardiovascular, autoimmune, neurocognitive, and mental health problems are heightened, possibly increasing the risk of developing severe symptoms from Covid-19. The increase in SB may provoke a rapid deterioration of cardiovascular health and premature death among populations with increased cardiovascular risk (29). Hall et al. (30) hypothesize that the change in daily activity due to the covid-19 pandemic will further

accelerate the SB pandemic and its adverse health effects. Although severe, the covid-19 pandemic will be outlived by the SB-pandemic and the severity of health and economic impacts will persist.

One way to combat the declining PF for prefrail older adults is to invent and implement innovative, user-friendly tools to increase PF, independence, and quality of life. To possibly reduce the adverse health outcomes of SB in older prefrail adults, further accelerated by the covid-19 pandemic, measures to increase PF and PA should be investigated.

1.5 Technology as a tool and user experience

As society increasingly rely on smart technology, a greater proportion of the population owns a smartphone or tablet, including older adults. This is synonymous with more people having access to applications tailored for specific target groups. Technology has been found to be a feasible and effective tool in treatment and rehabilitation of older adults and may even work as a positive motivational aspect (31, 32). Research regarding exergaming, digital games which require bodily movement to play, has been shown to be a natural, user friendly way to promote and participate in physical activity and exercise (33). These exergames needs technical skills to set up and perform, as they need a gaming console such as the Play Station, Xbox or Nintendo, as well as a suitable space to perform the game. Therefore, an exercise application may be even more user friendly and accessible as the exercises can be performed at home with minimal equipment, requires less knowledge of the technical aspect and less space to perform the exercise.

Technology is regarded as an effective tool for older adults with respect to health, independence, safety, and social connection, but there is a need for a better understanding of the interaction between older adults and technology (34). The technology needs to be easy to understand, to learn and to use for older adults to benefit from it. The interfaces need to be kept simple and the technology should not overwhelm the user; interactions should be as simple as pushing a button (35-37). To combat the decline in physical activity levels of older adults, it is important to implement innovative and easy to use ways of increasing self-sufficiency, PF, quality of life, PA-levels, and decrease sedentary behavior and lifestyle of older prefrail adults.

Another aspect of technology is flow. The theory of flow state proposed by the American psychologist Mihaly Csikszentmihalyi (38) suggests that the cognitive and emotional state relates to the degree of skill and difficulty in performing certain tasks. When the difficulty of the task is high due low ability to perform the task, it may cause anxiety and worry. If the ability to perform the task is high, this may result in boredom.

Vaportzis et al. (39) studied older adults experience of learning to use tablet computers and the results suggested that the 22 older adults participating in the study found the experience positive. Most participants said that they were likely or very likely to use tablets in the future. These findings suggest that tablet-based interventions may provide a positive user experience and that with the right training and instructions, older adults may find it motivating and encouraging to learn and use new technologies for interventional purposes.

1.6 Research aim

The increased sedentary behavior of older adults, further accelerated by the covid-19 pandemic, may have severe effects on public health and the economic burden of treatment of age-related diseases and comorbidities. Effective, innovative, and user-friendly ways of increasing PF and decreasing the severe effects of sedentary behavior and social isolation should therefore be investigated. This pilot study aims to investigate user experience with an exercise application and how it may influence PF in prefrail older adults aged 70 years or older. The hypothesis of this study is that the use of an exercise application will prove to be user friendly and increase PF.

2.0 Methods

2.1 Study design and participants

This study was conducted as a feasibility study with a pre-post design. A convenience sample of 16 community-dwelling older adults (12 females, 4 males) participated in the study. To be included, participants had to be over the age of 70 years, living at home, and have an initial loss of functionality such as reduced balance, walking speed or issues performing activities of daily living as reported by each individual participant. The participants were excluded if they; 1) used walking aids while walking around at home, 2) had any injuries or surgeries to the legs, pelvis or back the last three months or 3) had any known mental issues or diseases. Participants were recruited through different services provided by Trondheim municipality: Physical therapy service, the senior-IKT service and social meeting spots for older adults, as well as through included participants personal contacts. All who showed interest in the project were contacted by one of the project workers to provide information regarding the project and to investigate if the possible participants met the inclusion and exclusion criteria.

2.3 Technology and equipment

2.3.1Keep On Keep Up

Keep on Keep Up (KOKU) (Reason Digital) is an evidence-based exercise application developed at The University of Manchester specifically tailored for older adults. Its purpose is to help older adults be in charge of their health while also reducing the risk of falls and physical decline. KOKU includes evidence-based exercises based on the OTAGO exercise program (40) to improve strength and balance with instructions provided by an animated virtual trainer. The application includes health literacy games which purpose is to educate the user and increase their awareness of home safety, importance of hydration and ways to improve bone health and nutrition. KOKU was downloaded onto an iOS device either provided by the participants or lent out to the participants by the project.

Figure 1: KOKU user desktops. A: Desktop home screen with three daily exercises. B: Page for user progress. This page shows what program, set and session is completed and what remains to complete sessions, sets, and programs. C: Page for informational games regarding home safety, bone strength and liquid balance. D: Page containing all 16 exercises used in KOKU

2.4 Translation

Before use in the current project, KOKU was translated from English to Norwegian. This was done by two project workers over a period of two months. One translated the transcript from English to Norwegian, and the other translated back to English for quality control. The one translating back from Norwegian to English was not allowed to see the original translation. In addition, the same process was done for the voice over manuscript which was afterwards recorded by a third party and integrated in the instruction videos in the Norwegian version.

2.5 Procedure

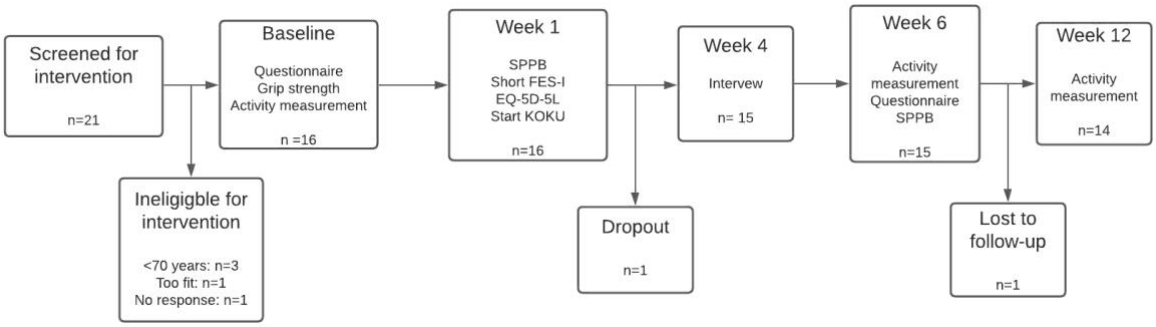

Figure 2: Flowchart of procedure

2.5.1 Baseline

At baseline participants answered a short questionnaire, measured height, and weight, as well as grip strength, and participants were equipped with two accelerometers which were to be worn for a period of 7 days.

2.5.1.1 Questionnaire

At baseline the participant answered a questionnaire regarding previous experience with exercise applications, incidents of falling without any particular reason the previous three months, physical activity and anthropometrics (See *Appendix 1*).

2.5.1.2 Grip strength

Grip strength has been proven to be a useful single marker of frailty for older people and poorer grip strength is associated with increased all-cause mortality, CVD, disability and frailty (41). Grip strength was used in this study to assess frailty and was measured using a Jamar hydraulic hand dynamometer (JLW Instruments, Chicago, USA) which measures kilograms of force. The participants were instructed to sit on a chair with the feet touching the ground and the back against the backrest. The upper arm should hang along truncus and the angle between the upper and lower arm should be 90 degrees. The participant tightens their grip with maximum force for a few seconds until told to stop. The dominant hand was tested twice before the non-dominant arm was tested twice. The results were calculated as the average on each arm.

Figure 3: Illustration of a typical hand dynamometer and position for grip strength test.

2.5.1.3 Accelerometry

Baseline physical activity levels were recorded for all participants using Axivity AX3 (Axivity, Newcastle, UK) triaxial accelerometers. The participants wore two accelerometers, one at the thigh and one on the lower back for one week. Accelerometers were set up at 100 Hz and ± 8 g and were configured with AX3 GUI software. The accelerometers were first disinfected and synchronized before application. Time synchronization was done by putting both sensors in one hand and hitting them against the palm of the opposite hand three times with 1 second intervals. The area where the sensors were mounted was prepared by disinfecting the area with 80% ethanol and paper wipes. When disinfected, the area was fitted with a small 7 x 5 cm tape before placing the monitor on top with a double-sided tape and the USB-port and small arrow pointing downward. To ensure water resistance, the sensors were secured with a 10 x 7 cm tape for practical purposes such as showering. To ensure that the sensors were as comfortable and unnoticeable as possible, the thigh mounted sensor was fastened while the participants knee was placed in a 90-degree angle sitting down. When mounting the sensor on the back, the participant leaned forward from a sitting position, supporting the weight of the upper body by placing the elbows on the knees. The 7x5 cm tape on the back was applied so that the upper line of the tape was applied in accordance with a thought line going horizontally from the lowest rib and the lower line of the tape following a thought horizontal line from the iliac crest (see *Figure 5*). This ensures that the sensor is placed approximately to the right of the L3 vertebrae. The 7x5 cm flexitape on the knee was fitted so that the bottom line of the tape was placed in accordance with a thought horizontal line, approximately 10 cm above patella. The sensors were worn at three separate 1-week periods to investigate the influence of the exercise

application on physical activity levels: at baseline, after 6 weeks and after 12 weeks of use of KOKU.

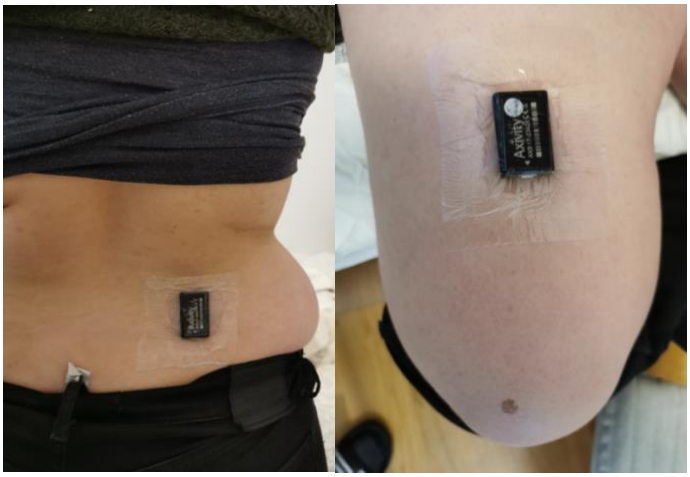

Figure 4: Accelerometer placement on back (left) and thigh (right)

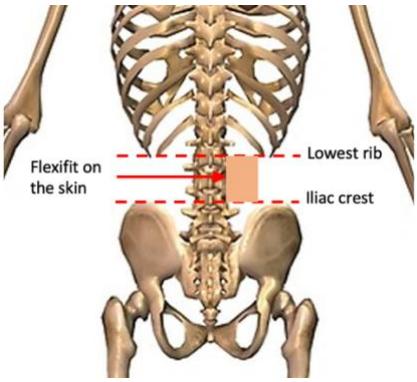

Figure 5: Placement of flexifit tape on the back.

2.5.2 Week 1

The accelerometers were removed after one week of baseline activity monitoring. The sensors were disinfected, and the date and time of removal was recorded. The participant answered two questionnaires and PF was assessed using the Short Physical Performance Battery (SPPB). Finally, the participants were introduced to KOKU and were taught how to use the application.

2.5.2.1 Questionnaires

Two questionnaires were answered by the participants at the week 1 test day. EuroQuol-5 dimensions-5 levels (EQ-5D-5L) measures health on five different levels of severity in five dimensions (42) (see *Appendix 2*). The Norwegian version of 5Q-5D-5L was used this study to investigate health-related quality of life. The 7-item Short Falls Efficacy Scale – International

(Short FES-I) questionnaire that measures the level of concern for falling in a 4-point scale (score 7-28) (43) was used to assess and measure fair of falling (see *Appendix 3*).

2.5.2.2 SPPB

The participant's PF was tested using a short physical performance battery (SPPB). The test required a measuring tape, a tape, a stopwatch, and a chair. The SPPB score consists of static balance, walking speed and a raise up/sit down test. The test is scored from 0-12 where and a lower score (0-6) indicates a lower level of function (44). A medium score ranges from 7-9 points and a high score ranges from 10-12 points. A score below 10 indicates an increased risk for disability and a score below 8 indicates an initial loss of function in activities of daily living. An increase in total SPPB score of 1 is regarded as a clinically meaningful improvement (44). Three total SPPB score categories were used according to the cutoff points provided by Guralnik et al. (45). A manuscript was used by the project workers to ensure standardization between participants, as well as between the pre and post-test.

The static balance test consists of three positions to be held for 10 seconds. The participants can move their body, use their arms, and bend their knees to keep balance. The second test measures regular walking speed over a 4-meter distance. The participants were instructed to walk at their normal pace. The final test measured the strength of the lower extremities by a timed 5 repetition stand-up and sit-down test.

2.5.2.3 KOKU

At the end of the week 1 test day, participants received an iPad with KOKU downloaded or a project worker helped the participant download the application onto their own iPad. The participants received a demonstration and a tutorial, and the project workers explained how the application and iPad worked. The time needed for each individual participant to understand the technology varied and the investigators ensured that all participants had a good understanding of the technology. The participants always had available technical support from the project workers. All participants received regular biweekly phone calls for follow up and technical support.

2.5.3 Interview

After using the application for four-five weeks, an individual semi-structured interview was conducted with all participants regarding their experience using KOKU. Qualitative methods consist of a range of different approaches which aims to understand, describe and interpret social phenomenon experienced by individuals, groups or cultures (46). Interviews are used to gain insight into human experiences. The semi structured interview is a conversation between two individuals with a balance between being an open conversation and an interview with a concrete framework. An interview guide was used to remind the project workers about certain predetermined themes. The interviewer subjectively found a balance between flexibility and controlling the interview to gain as much relevant data as possible. Hence a semi structured interview was used to answer the research question.

The interview was performed based on a pre-defined interview guide (see *Appendix 4*). Two bachelor students in physical therapy and two project workers carried out the interviews. Questions included motivational aspects from the use of KOKU, if the app might be a motivational factor for engaging in physical activity over a longer period, if they would use it in an every-day setting, previous experience with this kind of technology, and if they found it challenging or easy to learn how to use KOKU. A Marantz Professional PMD-661 MKIII (inMusic Brands inc., Cumberland US) was used to record the interviews.

2.5.4 Week 6

After six weeks of intervention, the participants performed another SPPB test and answered a questionnaire regarding their experience using KOKU (see *Appendix 5*). To measure activity levels after 6-weeks use of KOKU, participants wore two accelerometers for 1 week. After 1 week the accelerometers were removed.

2.5.5 Follow up

All participants kept KOKU with no biweekly phone calls for additional six weeks (from week 7 to week 12). After six weeks all participants PA levels were once again measured with accelerometers for one week.

2.6 Ethics

The study was approved by Regional Committee for Medical Research Ethics and the Norwegian Center for Research Data. Written informed consent was given by all included participants. The study was carried out in accordance with the Declaration of Helsinki.

2.6.1 Infection control

All included project workers completed an online infection control course provided by The Norwegian University of Science and Technology (NTNU) regarding the coronavirus pandemic. Public guidelines and infection control measures were strictly always adhered to throughout the project. All tests were performed in the participants respective homes.

2.7 Data processing and analysis

2.7.1 Interviews

This study utilizes thematic text analysis to investigate the participants subjective user experience of KOKU. The purpose of the analysis is to discover themes described by the participants through interviews which may aid in answering the research question. Thematic analysis is a method used to identify, analyze, and report themes from the data. Themes are described by Braun & Clarke (47) as groupings of data with important common features.

A step-by-step guide was used to analyze the data. These steps are: 1) familiarization with the data, 2) coding, 3) generating initial themes, 4) reviewing themes, 5) defining and naming themes and 6) writing up.

2.7.1.1 Step 1: Familiarization with the data

Initially the project workers gain an overview of and familiarize with the data. This step included reading the entire transcribed dataset and notes were made regarding data relevant for coding. In this step the project workers gained a substantial insight regarding the data relevant to answering their respective research questions.

2.7.1.2 Step 2: Coding

The codes generated in step 2 highlight important topics from the data. The codes were generated by gaining an overview over the transcribed interviews to prepare the data for

categorization. The transcriptions were re-read, and a substantial amount of the data were coded with different colored codes to make it easier to gain an overview of important themes in the dataset. The coding was performed in Google Docs. The codes identified traits of interest to the researchers and reflects the main themes of the data and made it easier to discover patterns.

2.7.1.3 Step 3: Generating initial themes

In this step, the goal was to sort and categorize codes under different themes. The codes and transcriptions from step two were re-read and the quotes and codes copied into a Google Docs titled with the overreaching themes. The codes were sorted by participants ID number to easier navigate the transcriptions. To be categorized as a theme, several participants had to mention something relevant to the theme, the participants subjective experiences should be brought to light by the theme and results should be something of importance or may be transferable to others.

2.7.1.4 Step 4: Reviewing themes

This step includes limiting the themes generated in step three (47). When reviewing themes some may be removed as it may be discovered that some themes may not be themes. One example is if the theme does not include enough data to give support to the theme or that one theme might contain similar data to another theme and can be categorized under the same theme. A theme may be divided into two separate themes as well. The contents of a theme should have a clear connection, while there should be distinct and identifiable differences. The themes together should address the research question in a meaningful way(47).

2.7.1.5 Step 5: Defining themes

The contents of the themes should be able to relate to the research question and should tell the story of each theme and main concepts (47). The previous step of reviewing the themes resulted in some themes being removed because they did not help answer the research question and themes being merged as they were relatable. The final themes should reflect the participants user experience and general experiences using KOKU. The themes that were identified were: (I) User-experience with KOKU, (II) Exercise, activity, and physical limitations, (III) COVID-19

2.7.1.6 Step 6: Writing up

The purpose of this step is to tell the reader the story the data shows. This is to convince the reader of the validity of the analysis. The writing process of the results started with writing down the main themes and the quotes were effectively used during the writing process. To illuminate each theme one or several quotes were used. The main result from the analysis is presented first under each theme before describing the themes. There is no clear distinction between writing and analysis and the process therefore involved moving back and forth between steps.

2.7.2 Statistics

The quantitative data were visually and statistically screened for normal distribution and analyzed using SPSS (version 27.0) and Windows excel, and statistical tests were applied accordingly. The assumptions to perform a paired samples t-test were violated for all variables except for the pre and posttest total scores due to the small sample size and non-normally distributed data. Hence, all variables were analyzed using a Wilcoxon signed ranks test was used to investigate the differences in the three subtest scores. A Mann-Whitney test was used to investigate differences in total SPPB scores for male and female participants at baseline and after six weeks. Significance level was set to p=0.05 and a 95% confidence interval was used.

3.0 Results

3.1 Overview

Participant's characteristics and demographics are summarized in *Table 1*. All participants were prefrail older adults living at home. None of the participants had any previous experience with exercise games, but 12 participants had some experience using computers, smartphones and/or iPad. Results showed a low average grip strength which indicates frailty.

Table 1: Participants baseline characteristic and demographics (n=15)

Characteristics	
Age, mean (SD)	82 (6.82)
Sex, n (%)	
Female	11 (73.3)
Male	4 (26.7)
BMI, mean (SD)	28.2 (5.2)
Grip strength in kg, mean (SD)	14.5 (8.8)
VAS[a], mean (SD)	70.9 (26.0)
Mobility, n (%)	
No problems	5 (33.3)
Slight problems	5 (33.3)
Moderate problems	4 (26.7)
Severe problems	1 (6.7)
Unable to walk around	0 (0)
Pain/discomfort, n (%)	
No pain/discomfort	4 (26.7)
Slight pain/discomfort	4 (26.7)
Moderate pain/discomfort	5 (33.3)
Severe pain/discomfort	2 (13.3)
Extreme pain/discomfort	0 (0)
Activity, n (%)	
Frequency	
Never	0 (0)
Less than once a week	1 (6.7)
Once a week	2 (13.3)
2-3 times per week	8 (53.3)
Almost every day	4 (26.7)
Intensity	
I go easy without being out of breath	9 (60)
I go so hard that I get sweaty and out of breath	5 (33.3)
I go almost all out	1 (6.7)
Duration	
Less than 15 minutes	1 (6.7)
15-29 minutes	7 (46.7)
30-60 minutes	4 (26.7)
More than 60 minutes	3 (20)
Short FES-I score, mean (SD)	11 (3.48)
Fell the last 3 months[b], n (%)	3 (20)

a: Visual analogue scale (a subjective perception of health on a score from 0-100 at week 1 testing).

b: Participant fell without any particular reason either inside or outside the past 3 months.

3.2 SPPB

At baseline SPPB scores ranged from 3-12 and participants total SPPB score of indicated an increased risk of disability and initial loss of functionality in activities of daily living. Mean (SD) walking speed for this population was 0.75 (.25) m/s, which indicates initial loss of function characterized by an increased risk for falls and disability and reduced mobility outside.

Table 2: Participants median total and subtest score at SPPB pretest and posttest

SPPB subtest and total (n=15)	Score, median (IQR)
Pretest	
Total	8.0 (4.0)
Balance	3.0 (2.0)
Walking speed	3.0 (2.0)
Chair sit to stand test	2.0 (3.0)
Post test	
Total	9.0 (5.0)
Balance	3.0 (1.0)
Walking speed	3.0 (2.0)
Chair sit to stand test	3.0 (2.0)

A Mann-Whitney test showed no significant difference in total SPPB score ranks between male (mean rank=6.25) and female (mean rank=8.64) participants at baseline (Z=-.924, p=.356). After six weeks of using KOKU the total SPPB score ranged from 4-12 and the median total SPPB score was 9.0 (5.0). Mean (SD) walking speed after six weeks was 0.73 (0.21) m/s. Also, there were no significant differences in total SPPB score between male (mean rank=5.88) and female (mean rank=8.77) after 6 weeks (Z=-1.123, p=2.61). The distribution of subtest scores and total scores are shown in *Figure 7.*

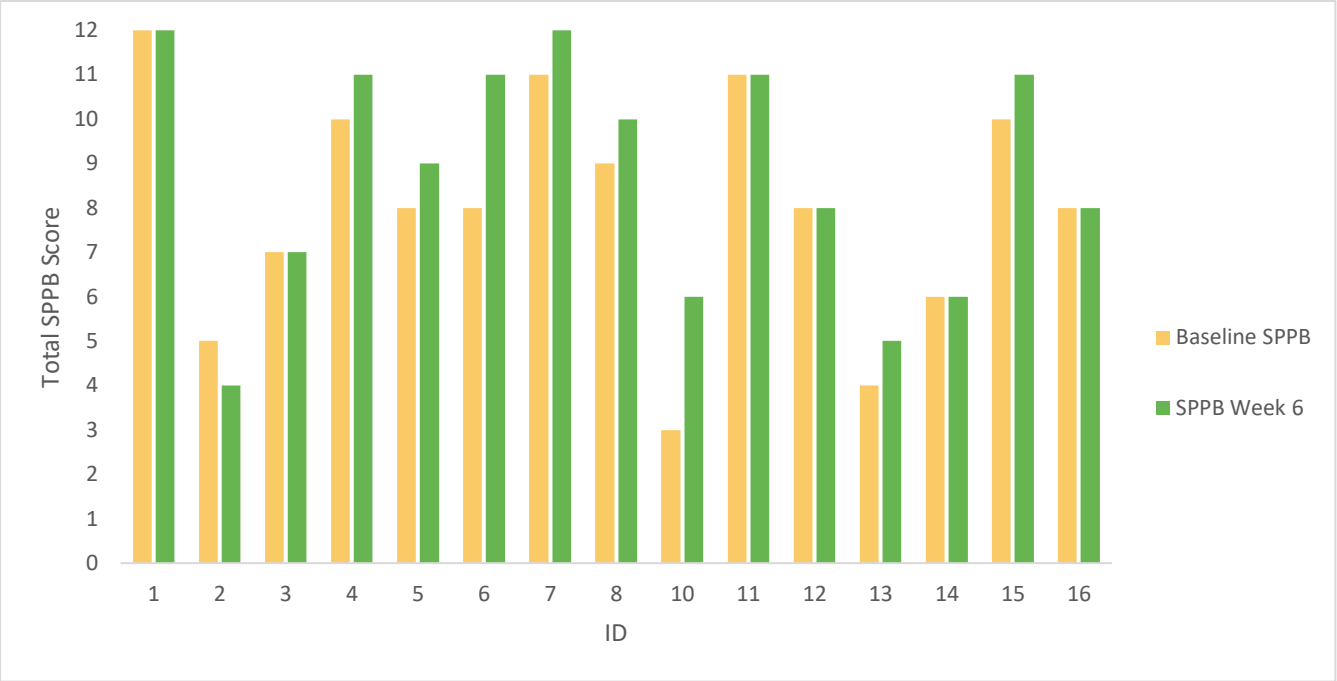

Figure 6: Total SPPB score for all participants for baseline and week 6.

A Wilcoxon signed ranks test showed that the mean rank of total SPPB score increased significantly from pretest (mean rank=4.0) to posttest (mean rank=5.13), Z=-2.310, p=.021., indicating an increased PF from baseline to week 6. There was no significant difference in change in total SPPB score between male (mean rank=7.50), and female (mean rank= 8.18) participants after six weeks use of KOKU, Z=-.279, p=.780. The statistical analysis further showed that the balance posttest mean rank (mean rank=2.50) were not statistically significantly higher than the pretest mean rank (mean rank=5.13), Z=-1.127, p=.260. The test showed that the median scores of neither the walking speed posttest (Z=-.816, p=.414) nor the chair sit to stand posttest (Z=-1.667, p=0.096) were statistically significantly higher from the median pretest scores, indicating that some participants may have increased one subtest score while scoring lower on a different subtest score. There was no significant change in total SPPB score (p=.426) between different age groups (70-74, 75-79, 80-85, >85 years).

3.2.1 Individual subtest and total scores

Figure 7: Distribution of participants subtest scores and group of total scores from pretest and posttest (n=15)

Two participants increased their total SPPB score with 3 points. Six participants increased their total SPPB score with 1 point. One participant scored 1 point lower on the total SPPB score from pre to post test, while 6 participants scored the same on their total SPPB score from pre to posttest. As *Figure 7* shows, two participants moved from the medium score category (7-9 points) and scored a high score on the posttest (10-12 points).

The analysis further showed that one participant increased their balance subtest score with 1 point, three participants increased their balance subtest score with 2 points, three participants scored 1 point lower on their balance subtest score and eight participants scored the same on the balance subtest from pre to posttest.

Regarding walking speed, one participant increased the walking speed subtest score with 1 point from pre to posttest, one participant increased with 2 points, one participant scored 1 point lower while the remaining 12 participants had the same subtest score at both pre and posttest.

Looking at the results from the pre and posttest on the chair sit to stand subtest, it showed that seven participants increased their score with 1 point, two participants scored 1 point lower on their subtest and six participants had the same subtest score at both pre and posttest.

3.3 Interviews

3.3.1 User experience with KOKU

3.3.1.1 Safety

The participants experienced KOKU as a safe, motivating, meaningful and fun way to engage in physical activity and exercise. Motivation was high for most participants to use the app and described it as a motivational "push" do begin exercising. Participants were reminded through a notification from KOKU to do todays exercises, and these notifications helped motivate participants to exercise.

> *I think you will be more motivated to do something when you have an app. You do something when there's someone on the other end who's going to see some results. You need a reminder, "now you have to".* (Female, 74)

KOKU provided good information regarding safety through all exercises and programs. The fact that participants were instructed to use support if needed, such as a kitchen counter, the back rest of a chair or a table when performing standing or walking exercises, ensured that all participants felt safe and reduced the fair of falling while exercising using KOKU.

> *… and I use the table for support if I need it.* (Female, 76)

> *… No, not particularly, I just support myself by laying a finger on something if I need to, so that's no problem*. (Female, 79)

3.3.1.2 Use

Most participants experienced KOKU as a fun and easy-to-use way of engaging in physical activity and exercise. Some used KOKU more sporadic, while for others it became part of their daily routine and some even exercised with KOKU several times a day. When they used KOKU during the day varied between participants and varied from day to day for the individual participants as well.

> *I do it during the morning, that's when I have the most energy.* (Female, 76)

… some days you are tired, and you just do a few. Other days you can do more because you feel better. (Female, 79)

3.3.1.3 Motivation

The instructions, through visual, written, and auditory instructions, was something the participants found particularly motivating and engaging. The visual instructions provided by the virtual trainer was something the participants grew fond of. The elements that participants found fun and engaging were the instructive animations which showed them how to do the different exercises. One participant stated that the visual instructions was reassuring and provided a feeling of safety.

Because then I can see that I am performing the exercises correctly. (Female, 80)

… here you can see how he's doing it. (Female, 94)

Some of the participants who borrowed an iPad for the project found KOKU so useful that they memorized some of the exercises to continue training with these exercises after the project was concluded.

I have memorized some so I can do it on my own without the app. (Female, 75)

The written instructions provided a detailed explanation of how to perform the exercises and how the exercises may improve certain physiological functions. Most participants found the written instructions useful and well explained, and they enabled the participants to gain some insight into how the exercises may improve physiological aspects.

It's nice. That you gain some insight into what they do. (Female, 85)

When asked how their experience of KOKU compared to traditional exercises provided by their physical therapist, most participants preferred the former. The fact that KOKU was always available and that they could exercise together with the virtual instructor and see how the exercises were performed proved to be a motivational factor. KOKU was easier to use than to follow exercises on a paper and led to less confusion regarding how to perform the exercises. Many older adults have issues with reading due to reduced eyesight, but even those participants

with most impaired eyesight had no trouble following the virtual instructor and preferred KOKU over reading the exercise sheets from the physical therapist. Some participants who had experience with exercise sheets from physical therapists found it easier to skip doing these exercises compared to exercising with KOKU.

> Female, 85: *Yes, the app is preferrable… yes, it is kind of more vividly explained. Rather than sitting, I don't see too well either, so for me to sit and look at a paper and… It's not the same inspiration. The app is preferrable.* (Female, 85)

> *Otherwise in those brochures it is easier to, yes, I'll just to it tomorrow or skip some.* (Female, 94)

When asked if the participants felt like something was missing to make KOKU more engaging and motivating to use most of them expressed that they found the app motivating and engaging as it is. Even though, there were some suggestions for improvement such as music while performing the exercises and some minor technical aspects such as writing in the number of repetitions rather than having to tap thirty times on the repetition registration. Some participants felt that the exercises were too easy and wanted some more challenging exercises regarding strength.

> *… it has not been much strength exercises.* (Female, 85)

> *For me, it could well have been more challenging. I think I need a bigger challenge if I'm going to be able to improve my level.* (Female, 75)

3.3.1.4 Technology

Most of the participants experienced the learning process of how to use KOKU as unproblematic and they expressed satisfaction regarding the training provided by the project workers prior to using KOKU. Phrases such as "surprisingly easy" and "childishly easy" were some phrases used to describe how the participants experienced the learning process. Low technological competence and previous experiences using smart technology seemed to be correlated with how easily the participants grasped how to use KOKU. The ones who had experience with smart technology and tablets seemed to learn to navigate and use the app easier than those without experience. The participants who had previous experience with iPads and

smart technologies also mentioned that it would have been more difficult to learn how to use KOKU without this experience. Even though, all participants effectively learned to use KOKU in their own pace, and less technical support was required as the study progressed.

> *… It was like ABC* (Female, 80)

> *… after a while I began to learn, and it went smoothly. In the beginning it was a bit difficult.* (Male, 94)

One participant was reluctant to learning new technology and told that he had always been. This participant did not bother with learning how to use KOKU and had his partner instruct him while she used KOKU for him. He had no previous experience with smart technology but had some experience with a simple mobile phone which he only used for receiving calls and messages. The lacking experience made it less motivating for this participant to learn how to use the app.

> *I decided early when this came that this was not something I wanted anything to do with, and I have stood by that decision. I'm not able to use it either.* (Male, 93)

Participants had several questions and issues throughout the study, but with continuous technical support from the project workers, most of the issues and misunderstandings were resolved. Some participants experienced technical issues during this study with KOKU freezing on screens not enabling the participants to progress any further. This proved to be a recurring problem, which some participants stated effected their motivation to exercise and their trust in the technology. This problem was solved with an updated version of KOKU and most participants were satisfied with the application during the remainder of the study.

> *A couple of days ago it froze. It said "completed, completed, completed" on the three exercises. I had to call the project worker which helped me download it and then it worked.* (Female, 75)

KOKU proved to be a bit challenging for those with little to no previous experience using a tablet. A minority of the participants had a hard time navigating the application and ended up doing exercises from the "exercises" page rather than exercising from the "today" page. Due to

fair of misclicking and in the process mess up the application, some continued to do exercises from the "exercises" page, rather than follow the program and some participants thought the four pages on the "exercise" page were programs 1 through 4.

From the participant experience with KOKU a feeling of frustration and confusion was expressed when an exercise session was completed on the "today" page, and it said "you have completed 0 exercises today" as KOKU set up the page for the next day.

> *Sometimes I believe that I have not finished the exercises when I'm done with the session. Because it says 0 when I'm done, so I look at what I have done. How far have I gotten? And then it says that you have done 0 exercises today.* (Female, 94)

3.3.2 Exercise, activity, physical limitations, and COVID-19

3.3.2.1 Exercise and activity

Most participants were aware of the benefits from exercise and physical activity and had either previously or were currently doing some form of exercise or physical activity. The modes of exercise ranged from a tailored program provided by a physical therapist to yoga to walking short or long walks. Those who had previous experience with physical activity or exercise found the exercises on KOKU familiar and had little to no problem whilst performing the exercises.

> *… I'm walking outside every day… walk outside every day for at least 1.5 hours, regardless of wind and weather.* (Female, 80)

> *I'm walking about in the area and I walk to the store and stuff. So that's pretty good, I use a walker.* (Male, 93)

When asked about KOKU as an exercise mode most participants expressed positivity towards this kind of exercise. The exercises were regarded as good any most participants enjoyed the lower extremity focus of KOKU. Many participants showed mixed feelings regarding the level of challenge the exercises posed stating that they were both too easy and would like it more challenging and that they were easy and thought it was ok. Some participants had no issue performing 30 repetitions (which was the maximal amount of repetitions KOKU registered)

and found this training mode a bit boring. Nonetheless, all participants expressed positivity towards using this form of training to improve PF and PA levels.

> *There are some exercises which may… which may be challenging, I must concentrate to do them. For example, the one where you walk on a straight line, right?* (Female, 75)

> *I think that can be very reasonable.* (Male, 77)

3.3.2.2 Physical limitations

Even though most of the participants in this study had physical limitation, that be neuropathy in feet or hands, reduced balance, or reduced walking speed, none of the participants experienced any difficulties performing the exercises. As a follow up question to the physical limitations, some participants were asked about perceived pain levels while using KOKU. The ones asked about their self-perceived pain levels stated that using KOKU did neither improve nor worsen their levels of self-perceived pain. One participant experienced some unsteadiness when performing certain exercises but worked her way around this by skipping these exercises and supplemented with other exercises from the "exercises" page.

> *No, I haven't used the exercises which has been… it's like I talked about that I can't do "this" and "that" standing on just the heels, I'm not able to do that, because I get dizzy and fall. So, I just skip those exercises where I am afraid to fall.* (Female, 75)

> *It's not been worse lately, but I don't have any less pain you know.* (Female, 79)

3.3.2.3 Subjectively reported changes in physical function from using KOKU

Most of the participants experienced individual changes in PF from exercising with KOKU. Most notably was how KOKU in only four weeks made noticeable results which the participants subjectively experienced. Some experienced improved balance, reduced fair of falling, increased energy levels, improved walking ability and gait speed.

> *It is positive because it improves my balance.* (Female, 80)

I was better when I walked uphill yesterday. Walked more and faster and I straightened my back while I walked. (Female, 75)

3.3.2.4 Covid-19

After analyzing the interviews, it became clear that Covid-19 had an impact on participants activity levels and social lives. Some participants were uneasy and had many concerns regarding the pandemic and stated a decreased level of activity compared to prior to the pandemic. Participants who were actively engaging in physical activity through exercise groups were not able to, due to the pandemic. Although most participants had their social lives and activity levels negatively influenced by Covid-19, some participants stated that their activity levels probably had increased. A few participants chose to discontinue physical therapy and group exercise due to long rides with public transport and the increased risk for infection, as well as frequent shut-downs due to the pandemic. One participant stated that due to fair of taking public transport, walking was the preferred option when getting about. Participants who mostly exercised through walking outside experienced no impact from the pandemic and were able to maintain their physical activity levels.

It has influenced… I don't know. I've just sat in a chair over there, relaxed… Nothing has been working. (Male, 78)

Well, it has not really influenced my activity level at all. Because I am… I walk around the area every day… Tillerskogen, Tillerparken… I walk outside for a minimum of 1,5 hours each day, regardless of wind and weather. And I've done so regardless of the pandemic. (Female, 80)

4.0 Discussion

4.1 Principal findings

The purpose of this study was to investigate the relationship between the use of an exercise application, PF, and user experience. This feasibility study showed that a six-week tablet-based intervention with KOKU averagely increased PF in independently living, prefrail older adults aged 70 years or older. The interviews showed that KOKU was experienced as a fun, motivating and user-friendly way of engaging in physical activity and exercise despite some misunderstandings and technical issues. These results shows that a tablet-based exercise intervention may be a motivating and useful tool to engage in physical activity and exercise. Silveira et al. (48) investigated the effects of a tablet-based strength-balance training intervention on motivation and adherence to exercise in independently living older people. Their study concluded that the adoption of these technological devices for physical intervention motivates older people and keeps them exercising for longer periods of time. These results support the findings from our study, which suggests that a tablet-based exercise intervention with KOKU was experienced as a motivating and meaningful way to engage in exercise to the participants.

4.2 SPPB

SPPB is a clinically relevant indicator for PF and is highly predictive of subsequent disability, institutionalization and mortality (45). In this respect, the results are encouraging as our study population significantly increased their total SPPB score. A strength and balance-based exercise application may be of importance, both clinically and individually for the older population (16). Balance is also of critical concern for many older adults as a poor balance impacts gait, increases the risk of falling and decreases the functional independence, which in turns may lead to institutionalization and increased need for walking aids and care (16). Old people with poor PF benefits from a combined strength and balance training which has shown to increase muscle strength and mass, increase postural control and maintenance of upright position, thus improving function and quality of life, while reducing the risk of falls (16). Our results show that a six-week tablet-based exercise intervention may improve PF, which may be of importance for future treatment and prevention of frailty and age-related declines in PF. A preventative approach to age-related physical declines could possibly have great implications on the economic burden posed by institutionalization regarding falls and reduced PF. The findings from our study support the findings of Silveira et al. (48) who found that the tablet-

based strength-balance intervention assisted and motivated the participants to autonomously perform strength-balance exercises and increasing gait speed.

4.3 Motivation and barriers

The fact that the intervention was home-based seemed to be a motivational factor for engaging in exercise and activity for the participants of the current study. Technology-based interventions has proven to be of high usability for independently living older adults (48) and home environmental interventions where older people exercise at home seems to be preferred by this population. Thus, this type of intervention has the potential to aid in overcoming barriers to exercise. Barriers to exercise may be lack of company (48), worsening of pain while physically active, poor balance and muscle weakness (14). Our results showed the ability of KOKU to increase PF through increasing balance and muscle strength of the lower extremity. Hence, these results are encouraging when evaluating KOKU's ability to help older adults overcome some of the physical barriers to PA.

Even though KOKU might help overcome barriers for physical activity, several participants experienced the exercises as too easy, and the interviews showed that those participants would prefer more challenging exercises to make KOKU more fun and motivating to use. Some of the participants were already active individuals and although all participants showed sign of prefrailty, the ones who might benefit the most from this kind of training is inactive older adults with greater physical limitations. The exercises are based on FAME and OTAGO and are easy to perform. Thus, the exercises might be particularly beneficial for this group of older adults. This may reflect that some participants had a good PF at baseline. The lacking challenge of using KOKU may be reflected by the theory of flow state proposed by the American psychologist Mihaly Csikszentmihalyi (38). Some of the participants may have experienced boredom due to the high ability to perform the exercises provided by KOKU. Boredom affects flow negatively and might have influenced their motivation to perform the exercises.

Despite the possible feeling of boredom, the project workers ensured that all participants received regular check-in phone calls, which may have increased the feeling of social support and contact. The phone calls might have increased the feeling of motivation and affirmation and might have positively influenced the state of flow of some of the participants. Older adults who regularly exercise through exercise groups should continue to do so to maintain

socialization, and KOKU may be a well-suited supplemental exercise mode. Based on the findings from our study, we can assume that KOKU is an effective tool in motivating older adults to engage in exercise for longer periods of time.

4.4 Technology and translation

The participants seemed to adapt well to and effectively learn the technology used in this study. The use of a tablet solution provides numerous potential advantages such as robustness and it has a bigger screen than a smartphone which makes it easier to read text and see the visual instructions. The fact that many older adults have an impaired eyesight, the size of the screen and readability of the text may be of importance to increase usability and adherence to a tablet-based intervention. Our study showed that KOKU is feasible and user-friendly despite some participants having impaired eyesight. The interviews showed that the visual and auditory instructions were widely appreciated and helped increase the overall usability of KOKU for this study population. One of several advantages with this type of technology is the ability to provide real-time feedback regarding performance and give reminders of when to exercise. These periodic notifications reminding the participants to exercise have shown to increase exercise adherence and encourage healthy behavior, while motivating and reminding people about their health behaviors (49).

Some participants misunderstood a few essential aspects of KOKU. For instance, some participants found it unclear on where they were supposed to find their daily exercises. This may be due to direct translation of the original English version and unclear instructions from the project workers. At least three participants exercised from the “exercises” page rather than the “today” page, and required some support to understand where they could find the exercises they were supposed to do every day. When doing the exercises from the “today” page, KOKU adapts to the participants use and ensures exercise progression. The ones doing exercises from the “exercises” page may therefore not received the adequate progression needed to increase PF which could have influenced SPPB scores. One of these participants increased her SPPB score with three points, but from the interviews, it became clear that this participant had used KOKU several times per day, while also challenging herself to do exercises she found particularly difficult to perform. On the other hand, one of the two other participants that used the app this way decreased her SPPB score with one point from pre- to posttest. It is unclear why this participant scored lower, but major issues with lower back pain and toothache, as well

as insufficient progression might be explaining factors. The last participant who exercised using the "exercises" page scored the same on both pre and post SPPB test. We may assume that this participants frequency of use of KOKU and inadequate progression might have influenced these results. However, we cannot say if these misunderstandings were due to the translation, or if the cause may be e.g., lack of technological knowledge or inadequate teaching and technical support from the project workers.

Research has shown that key determinators for adoption of new technology are perceived ease or difficulty of understanding (34). Most of our participants stated that both KOKU and the iPad were easy to use. However, most participants also experienced some technical difficulties, which might have been from their lack of knowledge. Although not controlled for in the results, the lack of technical knowledge may have influenced the results. When introduced to new technology, older adults have shown to dislike or have difficulty understanding technologies that seem unfamiliar (34). The interviews showed that the participants with technical knowledge and familiarity with tablets learned and adapted easily to the technology used in our study. These results supports the findings from the systematic review done by Lee et al. (34) which showed that familiarity with technology is an important factor for intuitive interaction. It is important that the interfaces are designed with a sufficient familiarity for the target group.

Another aspect of older adults adapting to new technology is their level of confidence. Lack of confidence may lower the users perceived benefit, satisfaction, and future use (34). Some of our participants did not feel confident about the new technology introduced to them and it is therefore important to provide appropriate training and intuitive design (34). To ensure confidence, training and education of the technology must be structured so that the users receive appropriate support and guidance. It is a possibility that the participants in our study did not receive appropriate education on how to use KOKU, and this may have led to anxiety and participants felling reluctant to the new technology, which in turn may have influenced our results negatively.

4.6 Use of KOKU

During the study it became clear that the participants had different frequencies of using KOKU. Some participants exercised using KOKU several times per day, once a day, once a week and some used it when they felt like it. This study did not set any guidelines for the use of KOKU,

but participants were encouraged to use it once every day. The frequency of use may influence the results from the SPPB, and we may assume that those who used it more frequently had greater improvements in SPPB subtest scores and total scores. The SPPB results depends on their will to use the application, if they find it motivating and the frequency of use. Future research should investigate the effects of the frequency of use either by self-report or by a digital feedback system to the researchers through KOKU. Exercise training has proven to have benefits for PF and older adults are recommended by Helsedirektoratet to exercise at least three times per week (9). Nakamura et al. (50) found that an exercise frequency of three times per week were more beneficial for improvements in muscular endurance, dynamic balance and cardiorespiratory fitness than one and two exercise sessions per week. However, the results showed no difference between one, two, or three exercise sessions per week in improving muscular strength which is of importance for PF. What is clear is that a higher frequency of using KOKU might be more beneficial than a lower frequency and that three or more days per week is desirable to improve PF.

Some participants found some of the exercises and learning new technology challenging. This may have resulted in a lower frequency of use and little to no change in SPPB scores due to worry or anxiety. Some participants stated worry or anxiety to either perform the exercises wrong, counting the repetitions wrong, and misclicking and possibly ruin the application or tablet. To ensure a flow state for those struggling with the technology or exercises, it is important to provide adequate technical and social support. On the other hand, there are those have the participants who may have found the tablet easy to learn and the exercises easy to perform. Due to the lack of challenge some of these participants may have found it boring and not used KOKU frequently. One way to ensure flow for the participants with high PF is to include more challenging exercises in KOKU and increase the adaptability to previous and current PF and activity.

4.6 Covid 19, physical activity, and sedentary behavior.

As the results from our interviews showed, Covid-19 impacted participants PA-levels. While some participants stated that their PA-levels had drastically decreased, others remained the same or even increased during the pandemic. One participant who subjectively stated an increase in activity levels, were previously dependent on public transport to complete daily activities. The subjectively experienced increased risk of infection from riding public transport,

forced this participant to walk instead. Another participant who was dependent on public transport to receive her physical therapy sessions decided to discontinue the therapy. Due to frequent shutdowns of senior activities provided by Trondheim municipality, several of our participants lost important arenas for activity and socialization.

To possibly reduce or further prevent the negative effects of sedentary behavior accelerated by Covid-19 in this vulnerable part of the population, it is of critical importance to implement easy to use ways of increasing PF in a safe environment. Many older adults were urged to socially isolate during the pandemic (27) and interventions using tabled-based strength and balance training, such as KOKU, could be a great tool to increase PF from home. To further reduce the negative impact of Covid-19, KOKU could be further developed to include a social function, where users will be able to communicate with other users to reduce the possible negative effects of social isolation, such as loneliness (34). Further, the adoption of KOKU may be important when considering the increased risk of SB and CVD posed by the social isolation due to Covid-19 (29) as a low PF is a barrier to PA (13). Therefore, we can assume that KOKU might be an important tool to aid health care workers in their preventative work and to overcome the trends of increasing SB.

4.7 Limitations

This pilot study has some limitations. Due to the one-group-design, small sample size and short duration, it is not possible to state the effect of a six-week intervention using KOKU. The study reveals positive trends on PF after a six-week tablet-based intervention. Nonetheless, this preclinical exploratory trial provides preliminary evidence on the efficacy of the intervention. To investigate the effects of KOKU on PF and user-friendliness, a randomized controlled trial should be considered as the study design along with a larger study population and longer duration by future research.

There are also some limitations regarding the methods of this study. The use EQ-5D-5L and Short FES-1after the intervention period could provide a greater knowledge regarding the effects of KOKU on self-care, anxiety, mobility, pain/discomfort, and usual activities, as well as fair of falling. To gain a greater insight into the effects of KOKU on fair of falling and quality of life, future research should apply these questionnaires at both baseline and at the end of intervention.

When considering the ongoing Covid-19 pandemic, some challenges regarding recruitment and intervention were apparent. Older adults were anxious letting the researchers into their homes, as many already socially isolated themselves. Due to this fact, the recruitment process was slow and challenging. Some participants had to quarantine during the study, which made it impossible to carry out the planned intervention. This, combined with Christmas interfering with some of the data-collection dates, prolonged the intervention period for some participants, and may have influenced the results to some extent. Regardless, the result from our study lays the foundations for future research on the topic.

Also, no confounders were controlled for in the statistical analysis of this study. Taking confounders such as BMI, income, smoking, previous activity level, pain/discomfort and/or history of disease into consideration could influence the results from this study, either negatively or positively.

4.8 Future research

Future research should prior to inclusion of participants define certain criteria for PF and prefrailty to ensure that all included participants achieve a beneficial flow state when exercising using KOKU. When testing PF, one participant scored the maximum total score on both SPPB measurements and future research should consider the participants initial PF and the possible ceiling effects from SPPB. Future research should also investigate the long-term effects of KOKU on motivation and exercise adherence and the potential benefits of KOKU in overcoming barriers to exercise, as well as looking into the experience of social contact and support while using KOKU. One participant chose to discontinue the intervention due to lack of time. With a larger study population and longer study duration we may expect more dropouts and reasons for discontinuation of the intervention should be addressed as it may give knowledge about possible improvements of KOKU or the intervention.

The technical difficulties and misunderstandings seen in our study might have influenced the results to some extent. It is of importance that these technical difficulties and misunderstandings are quickly addressed and appropriately handled to ensure progression and thus possibly maximize improvements in PF. The notifications given by KOKU might be a motivational factor (49). Future research should therefore address and investigate the short- and long-term effects of the notifications given by KOKU and how frequency and personalization of these notifications may influence exercise adherence and motivation.

The appropriate exercise prescription with KOKU for optimal benefits for older adults should be further examined. A randomized controlled experimental study design could possibly investigate how different exercise frequencies using KOKU affects PF, and what frequency is most beneficial for improvements in PF. Adherence to a tablet-based exercise intervention should also be addressed for both the study population, and between-sex differences.

5.0 Conclusion

The results from this pilot study are encouraging regarding KOKU as a fun, motivating and user-friendly tool to aid in preventative work and to increase the physical function of independently living prefrail older adults aged 70 years or older. Further research with higher quality, a randomized controlled design, a larger study population and longer duration is required to investigate the effects of KOKU on physical function.

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Appendices

Appendix 1: Baseline questionnaire

Appendix 2: EQ-5D-5L

Appendix 3: Short FES-I

Appendix 4: Predefined interview guide

Appendix 5: Week 6 questionnaire

Appendix 1: Baseline questionnaire

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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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

Appendix 2: EQ-5D-5L

Spørreskjema om helse

Norsk versjon, for Norge

(Norwegian version for Norway)

Under hver overskrift ber vi deg krysse av den ENE boksen som best beskriver helsen din I DAG.

GANGE

- Jeg har ingen problemer med å gå omkring ❑
- Jeg har litt problemer med å gå omkring ❑
- Jeg har middels store problemer med å gå omkring ❑
- Jeg har store problemer med å gå omkring ❑
- Jeg er ute av stand til å gå omkring ❑

PERSONLIG STELL

- Jeg har ingen problemer med å vaske meg eller kle meg ❑
- Jeg har litt problemer med å vaske meg eller kle meg ❑
- Jeg har middels store problemer med å vaske meg eller kle meg ❑
- Jeg har store problemer med å vaske meg eller kle meg ❑
- Jeg er ute av stand til å vaske meg eller kle meg ❑

VANLIGE GJØREMÅL *(f.eks. arbeid, studier, husarbeid, familie- eller fritidsaktiviteter)*

- Jeg har ingen problemer med å utføre mine vanlige gjøremål ❑
- Jeg har litt problemer med å utføre mine vanlige gjøremål ❑
- Jeg har middels store problemer med å utføre mine vanlige gjøremål ❑
- Jeg har store problemer med å utføre mine vanlige gjøremål ❑
- Jeg er ute av stand til å utføre mine vanlige gjøremål ❑

SMERTER / UBEHAG

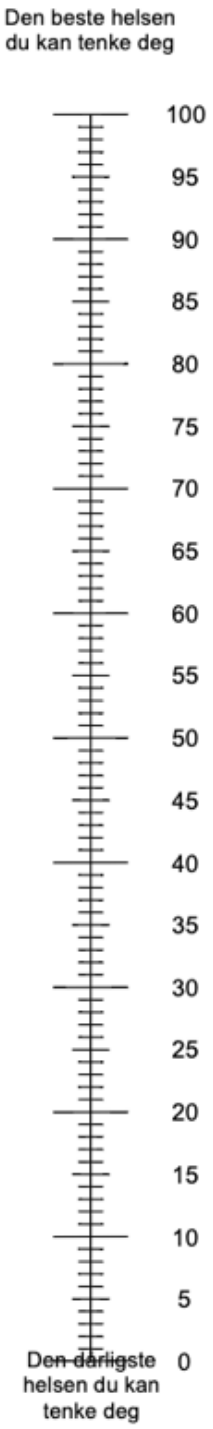
- Jeg har verken smerter eller ubehag ❑
- Jeg har litt smerter eller ubehag ❑
- Jeg har middels sterke smerter eller ubehag ❑
- Jeg har sterke smerter eller ubehag ❑
- Jeg har svært sterke smerter eller ubehag ❑

ANGST / DEPRESJON

- Jeg er verken engstelig eller deprimert ❑
- Jeg er litt engstelig eller deprimert ❑
- Jeg er middels engstelig eller deprimert ❑
- Jeg er svært engstelig eller deprimert ❑
- Jeg er ekstremt engstelig eller deprimert ❑

- Vi vil gjerne vite hvor god eller dårlig helsen din er I DAG.
- Denne skalaen er nummerert fra 0 til 100.
- 100 betyr den beste helsen du kan tenke deg.
  0 betyr den dårligste helsen du kan tenke deg.
- Sett en X på skalaen for å angi hvordan helsen din er I DAG.
- Skriv deretter tallet du merket av på skalaen inn i boksen nedenfor.

HELSEN DIN I DAG = ☐



Appendix 3: Short FES-I

Short FES-I

De følgende spørsmålene handler om hvor bekymret du er for at du kan komme til å falle. Vi ber deg om å svare ut fra hvordan du vanligvis utfører aktiviteten. Hvis du for tiden ikke utfører aktiviteten, vil vi be deg angi om du tror at du ville være bekymret for å falle HVIS du utførte aktiviteten. Kryss av for utsagnet som ligger nærmest opp til din egen opplevelse av, i hvor stor grad du er bekymret for å falle.

		Ikke bekymret i det hele tatt *1*	*Litt bekymret* *2*	*Ganske bekymret* *3*	*Veldig bekymret* *4*
1	Kle av eller på deg	*1* ☐	*2* ☐	*3* ☐	*4* ☐
2	Bade eller dusje	*1* ☐	*2* ☐	*3* ☐	*4* ☐
3	Reise deg opp fra, eller sette deg ned på en stol	*1* ☐	*2* ☐	*3* ☐	*4* ☐
4	Gå opp eller ned trapper	*1* ☐	*2* ☐	*3* ☐	*4* ☐
5	Strekke deg for å nå ting over hodehøyde eller bøye deg for å ta opp ting fra golvet	*1* ☐	*2* ☐	*3* ☐	*4* ☐
6	Gå opp eller ned en skråning	*1* ☐	*2* ☐	*3* ☐	*4* ☐
7	Delta i sosiale sammenkomster (f.eks. gudstjeneste, familiesammenkomst, møte)	*1* ☐	*2* ☐	*3* ☐	*4* ☐

FES-I translated to Norwegian by Dr Jorunn L. Helbostad from Yardley L, Todd C, et al. 2005; doi:https://doi.org/10.1093/ageing/afi196

Appendix 4: Predefined 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?

Fysisk aktivitet hos eldre ved bruk av treningsapp

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 5: Week 6 questionnaire

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:

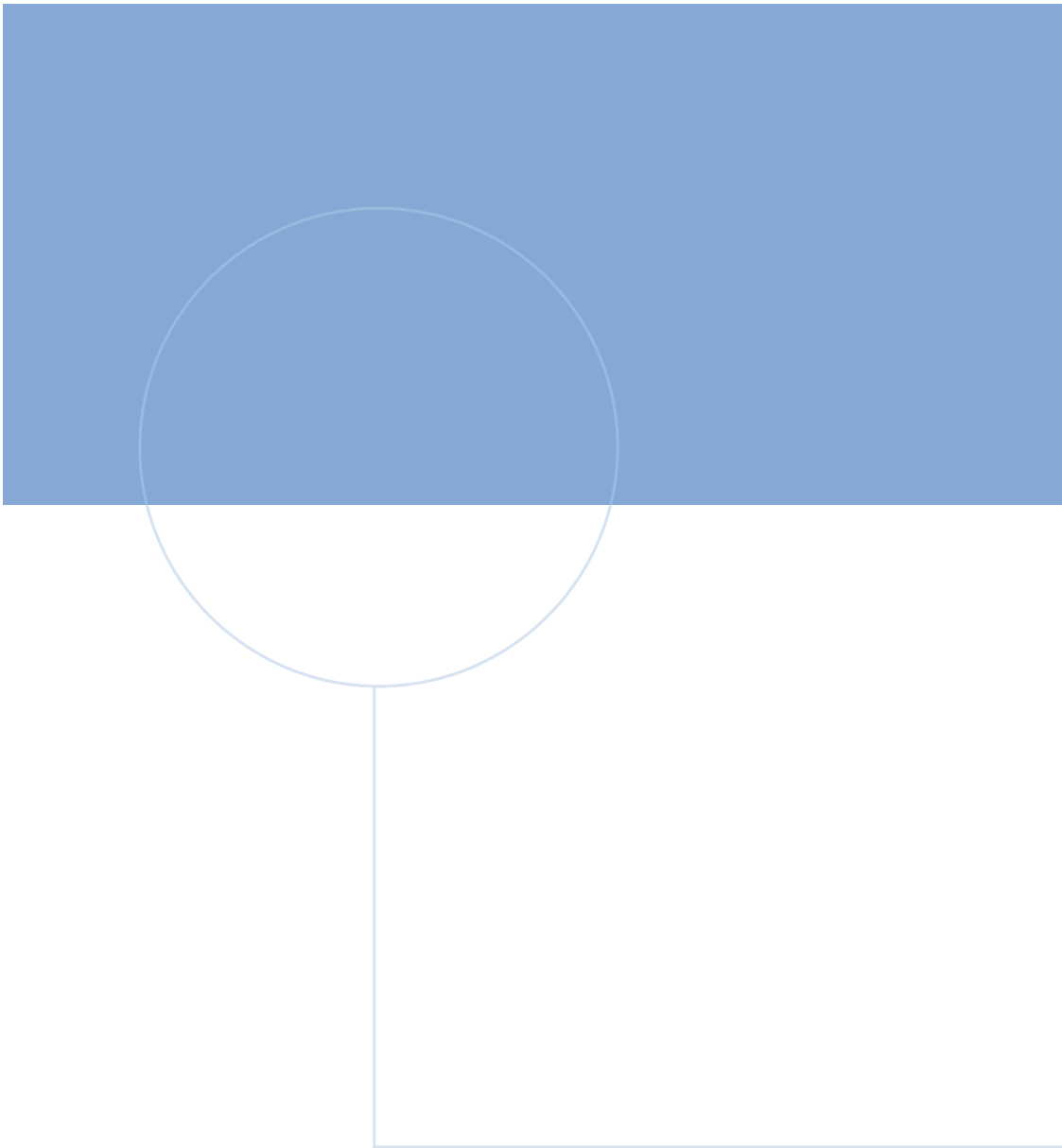
Vedlegg 2

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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