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WHEELERI: AN ACTIVITY TRACKER FOR PEOPLE USING WHEELCHAIRS – EXPERIMENTAL STUDY AMONG SCHOOL-AGED CHILDREN

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In Finland, studies have shown the persistent issue of students not meeting physical activity recommendations. National programs to promote physical activity for school-aged children have been implemented. In these programs there is, so far, little focus on children using wheelchairs. The aim of this thesis was to measure the average daily movement distance and time of school-aged children using wheelchairs during school days, to study the effect of an activity tracking device and mobile application on their movement levels, and to collect their user experiences of these devices. The study project was done at Valteri school Ruskis, Finland, in collaboration with Satakunta University of Applied Sciences' research group Accessibility and Siru Innovations Oy.

The methods of this thesis combined quantitative and qualitative data with a focus on school-aged children using wheelchairs. The study used a modified A-B design of an N=1 trial with multiple baselines, where nine students using manual wheelchairs were recruited. The novel wheelchair-mounted activity tracker Wheeleri and its mobile application were used to collect quantitative data of daily wheelchair movement distance and time. In the baseline phase, the daily movement was recorded without participants having insight into their movement data. During intervention, participants were provided with the Wheeleri mobile application to track their own activities. For further insight into usability and feasibility of Wheeleri, qualitative data was collected using a questionnaire at the end of intervention. From the recorded quantitative data, the average values per school day were calculated. Statistical analysis and calculation of p-values was done with the Microsoft Excel-plugin Tixel. Qualitative answers were analysed using a thematic coding system. As a result, the average wheelchair movement data on school days during baseline was 674.5 meters and 115.3 minutes. During intervention, daily average wheelchair movement distance increased by 85.1 meters (n=7, SD: ±151.8, p-value: 0.094) from baseline, while movement time decreased by -2.2 minutes (n=7, SD: ±15.9 minutes, p-value: 0.361) from baseline. 78% of the participants reported that using the Wheeleri device itself increased their activity levels, while 44% felt that using the application in combination with Wheeleri increased their activity levels.

To date, this is the first study in Finland to objectively evaluate physical activity levels of children using manual wheelchairs during their school days. Children with special needs are, so far, not the main focus of physical activity promotion programs in Finnish schools. This thesis can be the base for further research of developing physical activity promotion and objective measures for school-aged children with special needs.

CONTENTS

1 INTRODUCTION

Physical activity is essential to living and staying healthy. Numerous health benefits are associated with regular physical activity, such as reduced risk for coronary heart disease, diabetes, hypertension, or obesity. (Macera et al. 2003, 122.) Many healthy individuals from various age groups do not meet the recommended amount of physical activity. For children, health guidelines currently recommend at least 60 minutes of moderate to vigorous physical activity per day. However, many children and teenagers with disabilities do not meet the recommended amount of physical activity and are insufficiently physically active to avoid negative effects on their overall health status. (Sit et al. 2019, 1395.) The World Health Organization (WHO) recommends a global strategy for increasing physical activity levels in children and youngsters which includes governments, civil society and the private sector for their vital roles in shaping a healthy environment (Website of WHO 2019). In Finland, there are several national programs and projects to evaluate and promote physical activity levels among school-aged children and teenagers. For example, Liikkuva Koulu (Finnish Schools on the Move) is a national program run and coordinated by the Finnish National Agency of Education and the Ministry of Education and Culture (Website of Liikkuva Koulu 2019). Research and follow-up of this program are done by LIKES Research Centre for Physical Activity and Health, which also monitors and evaluates the progress of participating schools and performs research related to the program (Website of LIKES 2019). The project's goal is to increase physical activity and decrease sedentary time among school-aged children in Finnish comprehensive schools of 90% of Finnish municipalities from ages seven to fifteen (Website of Liikkuva Koulu 2019). Similar programs for promoting an increase in physical activity levels during school days in Finland include Liikkuva Opiskelu, for secondary and tertiary education (Website of Liikkuva Opiskelu 2019), Let's Move It by University of Helsinki (Website of Let's Move It 2019), and Terve Koululainen (Healthy Pupil) by UKK institute and the Finnish Ministry of Education and Culture (Website of Terve Koululainen 2019). These programs focus on physical activity levels and sedentary times during school days in pupils and students not using assistive devices. Their strategies to increase activity levels do not include children using assistive aids such as wheelchairs. While there are efforts to extend programs and offers to school-aged children with special needs, such as the project Iloon yli esteiden (Towards joy over barriers) run by Valteri within the Liikkuva Koulu program (Website of Liikkuva Koulu 2019), programs to specifically collect quantitative as well as qualitative data about school-aged children with special needs in Finland have not come to the attention of the authors.

Therefore, the aim of this experimental study is to explore quantitative data about wheelchair movement distance and time of school-aged children using manual wheelchairs during school days and qualitative data about the participants' experiences using an activity tracker for wheelchairs. The study will be done in collaboration with Valteri School Ruskis, located in Helsinki, and Satakunta University of Applied Sciences (SAMK) research group Accessibility. An overview of this study can be seen in figure 1, where green colour shows the theoretical background; light blue demonstrates the need for this study; dark blue shows the study design and purple the research questions and outcome measures.

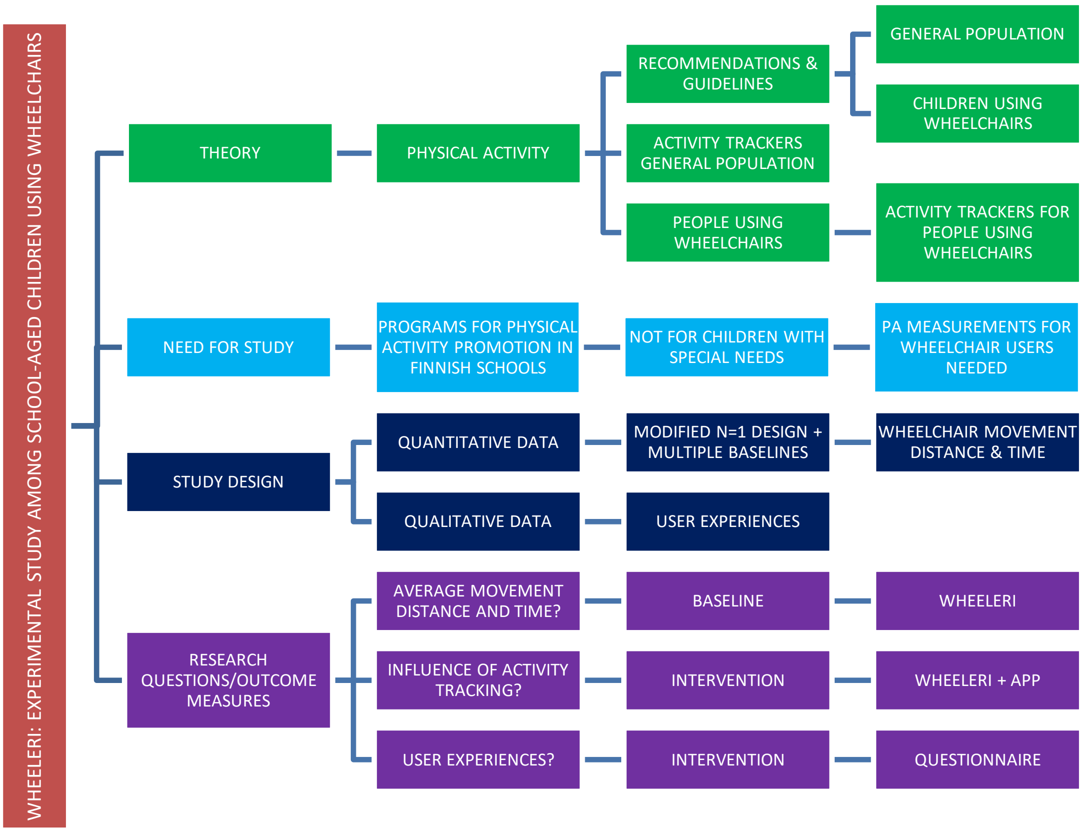

Figure 1. Overview of this study.

2 THEORETICAL BACKGROUND

2.1 Physical Activity

According to the World Health Organization (WHO), physical activity is defined as any movement produced by skeletal muscles that requires expenditure of energy. Regular physical activity at adequate levels can reduce the risk of hypertension, coronary heart disease, stroke, diabetes, some types of cancer, falls, or depression. Physical activity plays an important role in managing energy expenditure and in weight control. For children, teenagers and young adults, physical activity includes play, games, sports, transportation, chores, recreation, physical education, or planned exercise, within the context of family life, school, and community activities. To improve cardiorespiratory and muscular fitness, bone health, and cardiovascular and metabolic health, WHO recommends that children and youth aged five to 17 years accumulate at least 60 minutes of moderate to vigorous physical activity daily. Any exceeding amount can provide additional health benefits. (Website of WHO 2019.)

Within the national Liikkuva Koulu program for promoting physical activity in Finnish comprehensive schools, Tammelin et al. conducted research about the physical activity levels of school-aged children, using hip-worn acceleration sensors for seven days (Tammelin et al. 2015, 1). With 1186 participating students, their results showed that, on average, among 20 students eight meet daily activity recommendations and two remain inactive, for all of which 47% of daily sedentary time occurs at school (Tammelin et al. 2015, 2). Based on these results they recommend more physical activity and less sedentary time at and outside of school (Tammelin et al. 2015, 4).

2.2 Physical activity among children and teenagers with special needs

Children and teenagers with disabilities should meet the general physical activity recommendations whenever possible. With the help of health care providers, these can be met appropriately in consideration of their disability. (Website of WHO 2019.) In Finland, incentives to increase physical activity among children with disability have been implemented in different forms, such as having variety of sports adapted to custom needs of children with disabilities. With this idea in mind, a Para School Day has been implemented, on which children and young adults with disabilities can try out adapted games and sports, and can also give teachers, health care providers new ideas on how to encourage an increase of physical activity and create positive experiences. (Website of Paralympia 2019.) LIKES research centre has performed an online-survey in autumn of 2016, in which 128 teenagers and young adults with special needs between the ages 12 and 29 have answered to a qualitative questionnaire about their physical activity habits and levels, as well as factors in their personal lives beneficial or limiting to their physical activity habits (Liikanen 2018, 12). On average, participants in this survey participated in physical activity and exercise sessions several times per week, usually under instruction and together with others with the goal to improve their physical, mental and social conditions (Liikanen 2018, 25). Quantitative data were missing from this survey.

2.3 Activity trackers for the general population and users with special needs

There are studies about tracking and assessing physical activity with activity trackers in the general population. However, studies about physical activity and activity trackers in children and teenagers with special needs are less studied, especially regarding the effects of using activity trackers on promoting physical activity. Activity trackers are sensors, mostly wearable, which record and store data about physical activities in exercise and daily living for later review, analysis and goal-setting (Cuartilles Ruiz & Göransson, 2015, 141). Originally, activity trackers were designed to provide feedback on a user’s step activity. However, this feedback has little value for users once the novelty of the device decreases and it has been shown that 50% of US consumers that bought activity trackers stop using them at some point, a third of those within six months of purchase. (Finkelstein et al. 2016, 2.) In the past few years consumer-interest in these devices has increased, which has led to more advanced activity trackers with more complex sensors and functionalities. Owning an activity tracker is more likely to improve physical activity short-term rather than long-term. To improve longevity of beneficial effects, many studies have suggested to combine activity trackers with additional measures, for example a mobile application for data analysis, consultation with health care professionals for monitoring progress, social support from peers, or regular group activities. (Brickwood et al. 2019, 13-14.)

While the use of activity monitors has become popular in the general public and their validity has been studied, availability and research of activity monitors for wheelchair users is still scarce (Tsang et al 2016, 642). Currently, commercially available activity monitors for wheelchair users have already shown fair accuracy, but their performance is not on a par yet with those for the general population (Tsang et al 2016, 653).

2.4 Wheeleri: An activity tracker for people using wheelchairs

Since people using wheelchairs are a heterogenous group and show various different movement patterns, assessing their physical activity levels is challenging (Tsang et al 2016, 641). Satakunta University of Applied Sciences and Siru Innovations Oy collaborated in 2013 and implemented the wheelchair-mounted activity tracking device Wheeleri for people using manual wheelchairs (Karinharju et al. 2019b). Users can access the information about the wheelchair's movement distance and time with a mobile application developed for data-recording and self-monitoring. The Wheeleri activity tracking device is an embedded system consisting of an accelerometer, gyroscope, central processing unit, clock and calendar. The gyroscope is outputting angular velocity of the device, which is then integrated with time to calculate the travelled distance. The wheel's angular velocity is used to estimate linear speeds and distances travelled by the user. (Karinharju et al. 2019b.) An accelerometer records motion in one or more planes and provides an indication of the frequency, duration and intensity of physical activity, based on the travelled distance and the active runtime (Butte, Ekelund & Westertrep 2012, 6). This way, Wheeleri can calculate wheelchair movement distance and time indoors and outdoors, since no GPS-signal is required. (Karinharju et al. 2019b)

Tsang et al. conducted a systematic review, in which they identified three types of physical activity measures that were used in various studies about activity trackers for people using wheelchairs to assess physical activity: energy cost, user movement, and wheelchair movement (Tsang et al. 2016, 641). Comparable measures in this study, which the Wheeleri device can provide, are the distance and time the wheelchair is moving. These measures will be used in this study to collect data about the participants’ activities during their school days.

The Wheeleri device communicates via Bluetooth with an end-device, which currently needs to be an Android-device running the accompanying mobile application (Karinharju et al. 2019b). This application is based on three main pages: an overview over the current day’s activity (“Tänään”), a continuously updated view of the current activity (“Harjoitus”) and an overview of the previous activity history with monthly subpages (“Historia”). The current day’s overview shows the time of activity in the format hh:mm:ss, the distance covered in meters and the average movement speed, as well as the top movement speed in kilometers per hour (km/h). The overview of the current activity shows the current movement speed in km/h. Also, on this page, an exercise session can be started which will then show separate statistics for this session: time active, distance covered, average movement speed and top movement speed. Lastly, the history page shows a monthly overview of the daily covered distance in a graph where the day is on the x-axis and the distance covered on the y-axis. Each day of the month can be shown in a separate graph where the time of day is represented on the x-axis and distance covered on the y-axis. This can be further subdivided into hourly numerical values for distance covered, time active and average and top speed.

3 AIM AND OBJECTIVES OF THIS THESIS

3.1 Aim of this study

The aim of this thesis is to measure the daily wheelchair movement distance and time of school-aged children and teenagers using wheelchairs during their school days (based on movement distance and time), to study effects of using an activity tracking mobile application on the participants' previously measured daily activity, and to study their subjective experiences using these devices regarding feasibility and usability.

3.2 Research questions

To reach its aim, this study will be concentrating on the following five research questions:

1. *What is the average wheelchair movement distance of children using manual wheelchairs during their school days?*
2. *What is the average wheelchair movement time of children using manual wheelchairs during their school days?*
3. *How does using the Wheeleri activity tracking device and mobile application influence the average wheelchair movement distance of children using manual wheelchairs during their school days?*
4. *How does using the Wheeleri activity tracking device and mobile application influence the average wheelchair movement time of children using manual wheelchairs during their school days?*
5. *How do children using manual wheelchairs and their adult assistants experience the usability and functionality of the Wheeleri activity tracking device and mobile application?*

3.3 Methods

3.3.1 Study design

Mixed-methods research

Mixed-methods research describes research in which both quantitative and qualitative data are collected in the same study (Littlewood & May 2013, 15). The term quantitative data is used to describe numerical data, for example to evaluate the effectiveness of an intervention, and qualitative data means non-numerical data, for example to gain understanding of how the intervention was delivered and experienced in practice (Littlewood & May 2013, 15 & 119). A common mixed-methods research design is the convergent parallel design, in which quantitative and qualitative data are collected concurrently during the same study period. This mixed-methods design is efficient, since both kinds of data collection can be implemented within the same study period and both data sets can be analysed independent from each other. This design is useful to enhance the understanding of quantitative results with qualitative ones. (Petrosyan 2014, 1.) Possible challenges with this research method include disagreement between results or different sample sizes due to different procedures for data collection (Petrosyan 2014, 2). Once collected, both quantitative and qualitative data can be integrated by reporting their results separately and comparing them in a study's discussion section (Petrosyan 2014, 5).

Single-subject design (N=1 design)

The term single-subject design, also known as N=1 design or N-of-1 design, describes a study design in which a chosen study subject functions as its own control, in order to assess whether or not an intervention, implemented within the study period, is effective in changing the subject's behaviour (Satake, Jagaroo & Maxwell 2008, 3). When only a limited amount of study participants is available for a study project, single-subject design is of advantage compared to implementing a control group, as this would require more participants. While single-subject design as a type of intrasubject study design is suitable to record a participant's behaviour over a certain period of time, it still allows for intersubject comparison between several study participants, instead of implementing a separate control group. (Satake, Jagaroo &

Maxwell 2008, 4.) There can also be cases when using control groups can be deemed unethical, for example when it cannot be ethically justified to use possibly ineffective control treatment during a study on a medical condition (Littlewood & May 2013, 92). In short, Tate and Perdices describe four cardinal features that distinguish single-subject experimental study designs:

- A certain number of discrete study phases
- Clear definition of the study's dependent variable (behaviour or treatment)
- Frequent measurement of said variable throughout all study phases
- Manipulation of one variable at a time and control of extraneous variables

(Tate & Perdices 2015, 22)

However, since in single-subject designs no control groups are being implemented, the validity of generalizing a study's results to a broader target population is limited. Care must be taken to note and keep in mind possible internal validity issues throughout the research process. (Satake, Jagaroo & Maxwell 2008, 4.) In order to increase a single-subject study's validity in regard to drawing conclusions for a more general target population, replication of the study is usually an effective procedure (Satake, Jagaroo & Maxwell 2008, 6). Additionally, the 15-item Risk of Bias in N-of-1 Trials (RoBiNT) Scale, published by Tate et al. in 2013, provides a tool for assessing an N-of-1 study's quality, as well as internal and external validity (Tate et al. 2013, 619). This scale can also be used as a checklist for planning and conducting studies with N-of-1 designs (Tate & Perdices 2015, 24). See appendix 6 for the full scale.

The most basic subtype of single-subject study designs is the A-B design in which a baseline measurement (A) of a condition or behaviour is established over a certain period of time, after which an intervention period (B) is introduced (Satake, Jagaroo & Maxwell 2008, 4). In both study phases, frequently repeated measurement of the target behaviour in a study subject is being conducted (Tate & Perdices 2015, 26). There are limitations in reliability of results in the A-B study design, as, opposed to an A-B-A design, no second A-period to withdraw the intervention again is implemented after the B-period. Using a second A-period would increase the reliability of evidence for observed changes during the intervention. (Tate & Perdices 2015, 26.) This study will use a modified A-B design of an N=1 trial, in which statistical analysis will be based on average values of recorded quantitative data during both phases of the study.

As Tate & Perdices describe, this procedure (comparing differences in average score between study periods) can be appropriate when assessing the effect of an intervention on data from baseline measurements (Tate & Perdices 2015, 22).

Multiple-baseline design

When the intervention cannot be withdrawn after its implementation for practical, ethical or other reasons, a study can be planned with a multiple-baseline design to test the efficacy and reliability of an intervention's effects on the study subject. In a multiple-baseline design, several participants are recruited, and each participant is being followed in a basic A-B design. (Tate & Perdices 2015, 29.) The intervention for one study participant is implemented, while one or more other participants are still in their baseline period, for which the intervention starts at another later point in the study (Satake, Jagaroo & Maxwell 2008, 5). This can demonstrate and further validate an intervention's effectiveness, if similar changes in each participant's results can be seen at their respective points of the intervention's implementation, in other words: across multiple baselines in the study's timeline (Satake, Jagaroo & Maxwell 2008, 4). In a multiple-baseline design, adequate experimental control can be achieved when the study design involves at least three tiers (participants or study group) being followed in an A-B design (Tate & Perdices 2015, 30).

3.3.2 Study collaborators

The research project for this thesis will be done in collaboration between three different institutions.

Valteri School Ruskis

Valteri is a national center for learning and consulting operating nationally under the Finnish National Agency for Education. Valteri Ruskis, located in Helsinki, is one of Valteri's six school units. In addition to pre-primary and basic education, Valteri Ruskis provides additional voluntary education. The school's class groups are arranged by age groups and consist of the school's students as well as temporary support period students, who are being assessed for their learning capabilities and needs before being admitted as permanent students. As all Valteri schools, Ruskis supports their students' learning with rehabilitation and counselling by a multidisciplinary team to promote functional capacity. (Website of Valteri 2018.) Among the staff members are several physiotherapists, who utilize the school's gym and aqua therapy facilities among other methods to work with the students. Two physiotherapists will assist this research project with communication to the students' personal assistants, regular collection of the movement data recorded by the Wheeleri devices and as contact persons to the thesis authors in general.

Satakunta University of Applied Sciences / Research Group Accessibility

Satakunta University of Applied Sciences (SAMK) is located in Pori, Finland. Active among SAMK's several research groups, is the research group Accessibility, which is working since 2008 to contribute to the know-how and awareness about accessibility in Finland in general and in the Satakunta region specifically. The Wheeleri device and mobile application to provide activity tracking for people using wheelchairs have been in the research group's development since 2013 under guidance of senior lecturer Kati Karinharju. (Website of SAMK 2019.) The thesis authors conducting this research project are physiotherapy students in SAMK's English-language degree program.

Siru Innovations Oy

Siru Innovations Oy is a technology design and manufacturing management company based in Ulvila, Finland. The company is the owner and manufacturer of the Wheeleri device and software developer of the accompanying mobile application. Staff members of Siru Innovations Oy will serve as contact persons for technical support during the study period.

3.3.3 Participant recruitment and inclusion criteria

For the purpose of this study project, nine suitable study participants will be selected by physiotherapists working at Valteri School Ruskis. The following inclusion criteria are chosen:

1. Students using manual wheelchairs during their school days
2. Students possessing cognitive skills to use and read the information provided by the Wheeleri mobile application (wheelchair movement distance and time)
3. Students capable of giving comments about usage and usability of Wheeleri and the mobile application in written form or by communicating verbally for a staff member to make written notes

The research project at Valteri School Ruskis will be performed anonymously and personal information will be protected. The following information is made known to the thesis authors: gender, year of birth, name's initials. Specific individual impairments/diagnoses are not made known to the authors. Only the distribution of specific diagnoses among all nine study participants is shared with the authors. During randomization each participant is assigned one number (1-9) by which the participants are referred to throughout the thesis process. Information and permissions about the study and the Wheeleri device are provided to the participants and their parents in written form. See appendices 1-3 for facsimiles of those documents.

3.3.4 Outcome measures for quantitative data: Wheeleri device and mobile application

The Wheeleri wheelchair-mounted activity tracker and its accompanying mobile application are used in this study to record quantitative data about the participants' wheelchair movement distance and time during their school days. Using these instruments, the research questions 1-4 will be answered:

1. *What is the average wheelchair movement distance of children using manual wheelchairs during their school days?*
2. *What is the average wheelchair movement time of children using manual wheelchairs during their school days?*
3. *How does using the Wheeleri activity tracking device and mobile application influence the average wheelchair movement distance of children using manual wheelchairs during their school days?*

4. *How does using the Wheeleri activity tracking device and mobile application influence the average wheelchair movement time of children using manual wheelchairs during their school days?*

At the beginning of the study, each participant's Wheeleri device is paired via Bluetooth with the participant's smartphone, which is provided by Valteri School Ruskis, and calibrated. Additionally, each participant's wheelchair's wheel diameter is added to their mobile application's settings, as this is important information for recording the movement data correctly. When everything is in order, the device is attached to the right wheel of each participant's wheelchair. The device attaches to the spokes of wheelchair, as close to the wheel's center as possible, but at a distance from the wheel's center where the device's diameter fits the gaps between the wheel's spokes. To attach the Wheeleri device, its holding disc is tightened to the spokes with cable binders. The device itself then attaches magnetically to the metal center of its holding disc.

From the moment of initial pairing on, the device is continuously recording data when it registers movement, even when the Bluetooth connection is not active and as long as it receives power from two AAA-batteries (Wheeleri information 2018). The movement data can be collected and stored in a Microsoft Excel file by re-establishing the Bluetooth connection to the phone. For establishing the connection, each Wheeleri device has a unique identity code in the format 20:C3:8F:D2:XX:XX, where in this example XX:XX is a placeholder for a unique combination of four additional capital letters or digits. This way, each Wheeleri remains uniquely identifiable, even when one smartphone is detecting several Bluetooth signals. The school physiotherapists will collect this data weekly and export them to Microsoft Excel files. They also check each device's battery status. On school visits, at least once per month during the study period, the thesis authors then collect the Excel files for safe-keeping and further processing.

Using the Wheeleri activity tracker, the user's movement data is recorded in maximum intervals of 600 seconds (ten minutes). If the wheelchair user is active for that entire interval a new interval of maximum 600 seconds is started and recorded. If the user is not active for part of that maximum interval, only the time the user is actually active is recorded. If the device registers no movement during a 600 second interval, no data is recorded. When exporting the recorded data to Excel, each interval of maximum 600 seconds (or less, depending on the time the user is moving) is entered as output into a separate data line. If no movement data is recorded, no data line in Excel is used. The output in the exported Excel-file shows date and time of the activity in the first data column. The recorded active time in seconds (s) is saved in the second column and the recorded movement distance in meters (m) for that interval is saved in the third column. Additionally, the maximum speed travelled in kilometers per hour (km/h) within each recorded time interval of maximum 600 seconds is saved in the fourth data column. Figure 2 shows an example of the device setup and the Wheeleri mobile application.

Figure 2. Example photo of Wheeleri, attached to a wheelchair’s right wheel, and the mobile application. (Photo: Adam Galle photography, provided by Kati Karinharju)

Analysis of quantitative data

The quantitative data of wheelchair movement distance and time is recorded by the Wheeleri tracking devices. The collected movement data will be analysed after the end of the intervention phase of all study participants. Microsoft Excel is used to sort the data and perform basic calculation of absolute and average values. The statistical analysis of those values will be done with the Excel-plugin Tixel.

Supportive data: diaries

For the duration of the study, the participants are provided with A6-notebooks to be used as diaries. In these diaries, the participants as well as their assistant staff members are instructed to note any irregularities in their school days that would affect their wheelchair movement measurements, such as times and distances of prolonged passive movement of the wheelchair. These notes are then used as supportive data to fill possible gaps in the quantitative and the qualitative data and to exclude data from analysis when required, e.g. on days of school excursions where a participant's wheelchair might be pushed passively by a staff member more than the participants are moving actively themselves.

3.3.5 Outcome measure for qualitative data: Questionnaire

A subjective questionnaire is used to collect qualitative data regarding research question 5: "*How do children using manual wheelchairs and their adult assistants experience the usability and functionality of the Wheeleri activity tracking device and mobile application?"*

The questionnaire is three A4-pages long and contains open- and closed-ended questions. Pictures are added to help the participants understand the questions asked. At the end of the study, participants and staff members will fill out the questionnaire and each individual questionnaire will be saved in electronic form. The purpose of the questionnaire is to collect data about user experience using the Wheeleri device and its mobile application, possible issues with Wheeleri device or the mobile application, Wheeleri's influence on wheelchair movement distance and time, and if the displayed data is interesting. See appendix 4 for the questionnaire.

Analysis of qualitative data

Qualitative data from the questionnaire will be exported to Microsoft Excel. To explore the participants' responses to the questionnaire thematic analysis will be used. Each response will be coded to provide an overview of the answers.

3.4 Study procedure and timeline

3.4.1 Baseline: Average movement distance and time during school days

The nine study participants are randomized into three different study groups with multiple baselines. Group 1 has a baseline period of 15 school days, Group 2 of 26 school days and Group 3 of 36 school days. At the beginning of each baseline period, the Wheeleri tracking device is attached to each participant's wheelchair. The participants will be instructed to use the Wheeleri device during their time spent at school, to remove and store it before leaving the school and to move as they normally would during their school days. The participants are not yet provided with the Wheeleri mobile application, and so have no insights into their movement data. This way, information relating to research questions 1 and 2 is collected: "*What is the average movement distance and time of children using manual wheelchairs during their school days?"*

As agreed with the school physiotherapists, only data that is recorded between 9.00 and 14.30 (5.5 hours) per school day will be included in analysis of the quantitative results. This decision is made because students at Valteri School Ruskis tend to arrive to and leave from school at slightly different times, so they will also attach the Wheeleri devices to their wheelchairs at different times. Additionally, handling the devices when they are not attached to the participants' wheelchairs or during the process of attachment could cause false movement data. This way, the recorded data to be analysed will be better standardized and more reliable.

Data collection for the baseline measurement is set to start for all groups on February 7th, 2019. Public holidays and school holidays, according to Valteri's calendar, are excepted from measurement (Valteri työ- ja loma-ajat 2018-2019 Helsinki, 2019).

3.4.2 Intervention: Influence of mobile application on average movement distance and time

After each group's end of its baseline measurement period, that group enters the intervention period. Study participants are then provided with smartphones on which the Wheeleri application is installed. They will receive instructions in how to use the application and how to read and interpret the data it showed about their wheelchair's movement. This way, the participants are able to continuously track and review their own movement and activity data. Analysis of possible changes in the recorded data will allow to collect information towards an answer to research questions 3 and 4: "*How does using the Wheeleri activity tracking device and mobile application influence the average movement distance and time of children using manual wheelchairs during their school days?*"

Since week 8 is a school holiday week, the first group's intervention phase will start after 15 school days on March 7th, 2019. The second group's intervention phase on March 22nd, 2019, after 26 school days of baseline measurements and the third group's intervention phase on April 5th, 2019, after 36 school days of baseline measurements. The intervention phase is set to end on May 24th for all study groups. Therefore, Group 1 is in the intervention phase for 53 school days, Group 2 for 42 school days and Group 3 for 32 school days. Figure 3 shows an overview of the study's timeline.

Project Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Calendar Week	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Baseline (without app)																
Group 1 (Participants 1, 5, 9)	O	O		O												
Group 2 (Participants 3, 4, 7)	O	O		O	O	O										
Group 3 (Participants 2, 6, 8)	O	O		O	O	O	O	O								
Intervention (with app)																
Group 1 (Participants 1, 5, 9)					X	X	X	X	X	X	X	X	X	X	X	X
Group 2 (Participants 3, 4, 7)							X	X	X	X	X	X	X	X	X	X
Group 3 (Participants 2, 6, 8)									X	X	X	X	X	X	X	X

Figure 3. Study procedure and timeline, showing the duration of baseline and intervention periods for each study group. Being a school holiday, calendar week 8 is excluded from measurements. O = Baseline, X = Intervention

Towards the end of the study period, all study participants, their personal assistants and the school's physiotherapists involved in the study project will be provided with the questionnaires, in order to collect qualitative data regarding research question 5: "*How do children using manual wheelchairs and their adult assistants experience the usability and functionality of the Wheeleri activity tracking device and mobile application?"*

4 RESULTS

4.1 Participants

In total, three female and six male participants (n=9) were recruited. One study participant dropped out of the research project due to on-going health problems shortly after the randomization but was replaced immediately by a similar participant. At the time of the study, three participants (one female and two male) were 14 years old or older. Another three of the participants (one female and two male) were 11 to 13 years old and three (one female and two male) were ten years old or younger.

Five out of the nine study participants (55%) had a diagnosis of myelomeningocele (MMC), also known as spina bifida. Three study participants (33%) had a diagnosis of cerebral palsy (CP) and one participant had a diagnosis of a rare condition. In order to guarantee the anonymity of the small number of study participants, only the information about year of birth and gender was made known to the thesis authors in combination. The information about the medical diagnosis was only shared with the thesis authors as a general distribution among the study participants, and the diagnosis of the ‘rare condition’ of one of the participants was not made known. Furthermore, it was decided that it was not relevant to the central research question of this thesis, why specifically each study participant is using a wheelchair.

Table 1. Participant characteristics (N=9)

Year of birth	**Average**	**Standard deviation**
	2006	±3 years
Other characteristics	**Amount**	**Percentage**
Sex		
Female	3	33%
Male	6	67%
Diagnoses		
MMC	5	56%
CP	3	33%
Rare condition	1	11%
Wheelchair diameter (inches)		
22	1	11%
24	7	78%
25	1	11%

4.2 Quantitative data: wheelchair movement distance and time

4.2.1 Data and participants excluded from quantitative data

At the end of the study period, the final movement data were exported and collected by the thesis authors. Since only movement from a set time frame between 9.00 and 14.30 each school day was to be included in data analysis, any movement data that was recorded outside of that time frame was excluded. Additionally, data from within that time frame could be missing in case of a participant's absence from school, them forgetting to attach the Wheeleri device or due to technical reasons. Participant 2 from Group 3 and Participant 7 from Group 2 had to be excluded from analysis of quantitative movement data entirely, due to insufficient data from either the baseline period or the intervention period. Participant 2 showed only records on 18 out of 36 possible baseline school days, and on six days out of 32 possible school days in the intervention period. Additionally, this participant's recorded data in the intervention showed only low amounts of data lines. Participant 2 was provided with two different Wheeleri devices during the study period. The first device showed unspecified technical problems and did not record data continuously. The second device could not be connected with the smartphone as of 18.4.2019. The device's Bluetooth connection could be found in the Wheeleri mobile application, but the connection could not be completed. Participant 7 from Group 2 showed no data at all during the baseline period, so there was no data for comparison, and only data from four out of 42 possible school days during the intervention. This participant used three Wheeleri devices during the entire study period. The first device's battery attachment had broken, so the power supply was cut off. The second device connected successfully via Bluetooth but had no recorded data. The third device the participant received could be detected via Bluetooth but could not be accessed from the mobile application as of 15.4.2019, similar to Participant 2's replacement device.

4.2.2 Average wheelchair movement distance during school days

After exclusion of participants and data, the total recorded wheelchair movement distance and time and the number of measured school days were used to calculate the average values of wheelchair movement distance and time per measured school day for each participant during both study periods. See appendix 5 for an overview of total recorded data. Table 2 shows the average wheelchair movement distance and time per measured school day during baseline measurements for each study participant and the average values for all participants.

Table 2. Average wheelchair movement distance and time per measured school day during baseline periods.

ID	*Average baseline distance (m) per measured school day*	*Average baseline time (min) per measured school day*
Group 1	**706.1**	**122.9**
Participant 1	694.7	146.8
Participant 5	834.5	117.1
Participant 9	469.0	93.5
Group 2*	**792.9**	**136.6**
Participant 3	973.2	152.2
Participant 4	621.2	121.7
Group 3*	**537.4**	**84.0**
Participant 6	728.0	110.1
Participant 8	401.1	65.4
All participants n=7*	**674.5**	**115.3**

*Participant 7 excluded from Group 2, Participant 2 excluded from Group 3. See chapter *4.2.1 Data and participants excluded from quantitative data* for clarification.

The average movement distance of the participants using manual wheelchairs during the measured school days in the uninfluenced baseline period was calculated in order to answer to research question 1: *"What is the average movement distance of children using manual wheelchairs during their school days?"*

The average wheelchair movement distance during the baseline period was calculated to be: 706.1 meters for Group 1, 792.9 meters for Group 2 and 537.4 meters for Group 3. The individual average wheelchair movement distances for the baseline period range, lowest to highest, from 401.16 meters for Participant 8 in Group 3 to 973.20 meters for Participant 3 in Group 2. The average wheelchair movement distance per measured school day during the baseline measurements for all participants (n=7) was 674.5 meters. (Table 2)

4.2.3 Average wheelchair movement time during school days

Similarly, the same values were used to answer Research Question 2: *"What is the average movement time of children using manual wheelchairs during their school days?"*

The average wheelchair movement time per measured school day during the uninfluenced baseline was calculated to be 122.9 minutes for Group 1, 136.6 minutes for Group 2 and 84.0 minutes for Group 3. The individual participants' average wheelchair movement times range from, lowest to highest, 65.4 minutes for Participant 8 in Group 3 to 152.2 minutes for Participant 3 in Group 2. For all participants (n=7), the average wheelchair movement time during the baseline measurements was 115.3 minutes. (Table 2)

4.3 Quantitative data: Influence of the Wheeleri mobile application on wheelchair movement distance and time

The average movement distances and times, as well as their changes in comparison to the baseline measurements, have been calculated and statistically analysed in order to answer to Research Questions 3 and Research Question 4: *"How does using the Wheeleri activity tracking device and mobile application influence the average movement distance of children using manual wheelchairs during their school days?"* and *"How does using the Wheeleri activity tracking device and mobile application influence the average movement time of children using manual wheelchairs during their school days?"*

4.3.1 Change of average wheelchair movement distance from baseline to intervention

During each group's respective intervention periods, the average wheelchair movement distances per measured school day were 722.0 meters for Group 1, 799.4 meters for Group 2, and 827.7 meters for Group 3. On the individual level, they ranged from 352.9 meters for Participant 9 in Group 1 to 949.4 meters for Participant 5 in Group 1. The individual values resulted in an average wheelchair movement distance per measured school day during the intervention periods for all participants (n=7) of 759.6 meters. See table 3.

Based on these values, the change in average movement distance between baseline and intervention could be calculated by subtracting the baseline-values from the intervention-values. By calculating this way, a positive result of subtraction indicates an increase in average movement distance and a negative result indicates a decrease. Except for two participants (Participant 3 in Group 2 and Participant 9 in Group 1), all average movement distances have increased, on the individual as well as on the group level. (Table 3)

On the individual participant level (n=7), the average wheelchair movement distance increased by 85.1 meters, with a standard deviation of ±151.8 meters. With the null hypothesis of the change between the two study periods being equal to zero, a p-value of 0.094 was calculated in a one-tailed t-test (using the Microsoft Excel plugin Tixel). Therefore, this result on the individual participant level has a 9.4%-chance of being caused by random chance and can be considered statistically significant. (Table 3)

Of additional interest within this study's multiple-baseline design is how the average wheelchair movement distance and time changed over time during the study period. Specifically, changes in average wheelchair movement data of each participant at the starting point of their intervention period can provide additional information to Research Questions 3 and 4. Changes at these specific points during the study period can further indicate if the intervention (participants tracking their own movement during school days) shows an effect on the recorded quantitative data.

Figure 4 shows the development of average daily wheelchair movement distance during each school week from the start of baseline measurements to each participant's third school week of intervention. All participants except Participant 6 show a relative increase in average daily wheelchair movement distance in school week 5 of the study period. While this week was the second week of intervention for Group 1, there was no record in the participants' diaries as to what could have caused this relative increase for all study participants at this point in the study. Participant 1 and Participant 9 show no distinct increase or decrease at the start of their intervention. Participant 3, Participant 4 and Participant 8 show a relative decrease at the start of their intervention. The remaining participants show a relative increase at the start of their intervention.

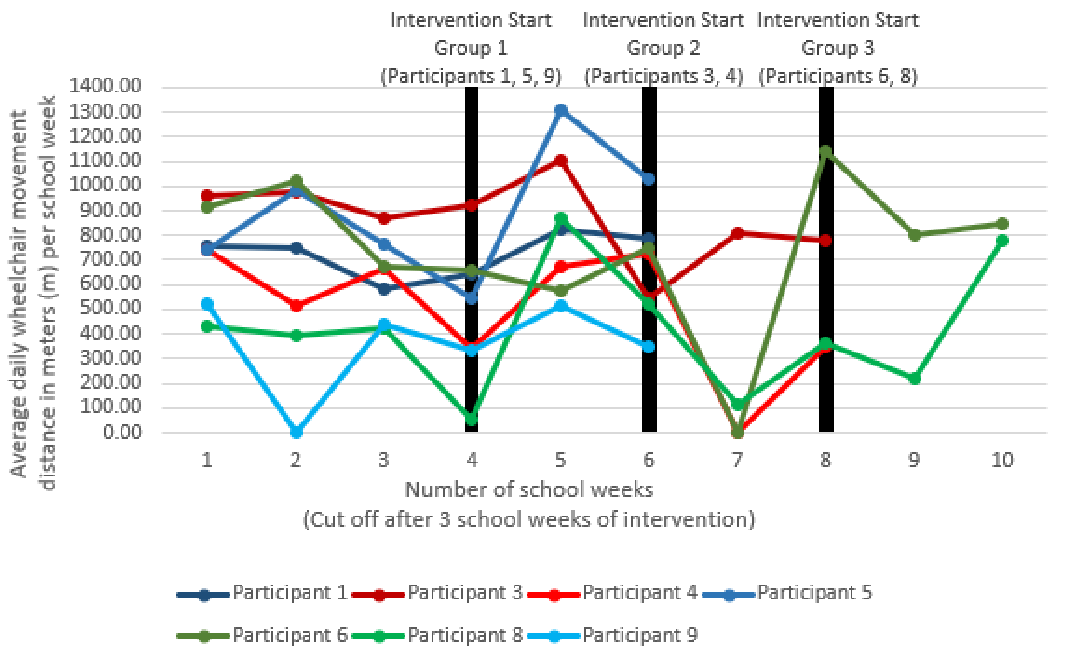

Figure 4. Development of average daily wheelchair movement distance in meters (m) during each school week (from start of baseline to third school week of each participant's intervention)

4.3.2 Change of average wheelchair movement time from baseline to intervention

For three out of the seven participants the average wheelchair movement time has decreased in the intervention period, compared to the baseline. On the group level, it has decreased from baseline to intervention by -2.8 minutes for Group 1 and -19.9 minutes for Group 2, while it has increased for Group 3 by 15.9 minutes. See table 4. Calculated for all participants (n=7), the average change of wheelchair movement time per measured school day shows a decrease by -2.2 minutes with a standard deviation of ±15.9 minutes. With a p-value of 0.361, this result is 36.1% likely to be random and, therefore, statistically not significant. (Table 4)

Figure 5 shows the development of daily average wheelchair movement time per school week. Similar to the movement distance (figure 4), the time also shows an unexplained increase in school week 5, except for Participant 6. Distinct relative increase at the start of the intervention periods can be seen in Participant 1, Participant

5 and Participant 9, a relative decrease in Participant 4 and Participant 8. The remaining participants show a slight decrease or maintenance of average wheelchair movement time at the start of their intervention periods, compared to baseline.

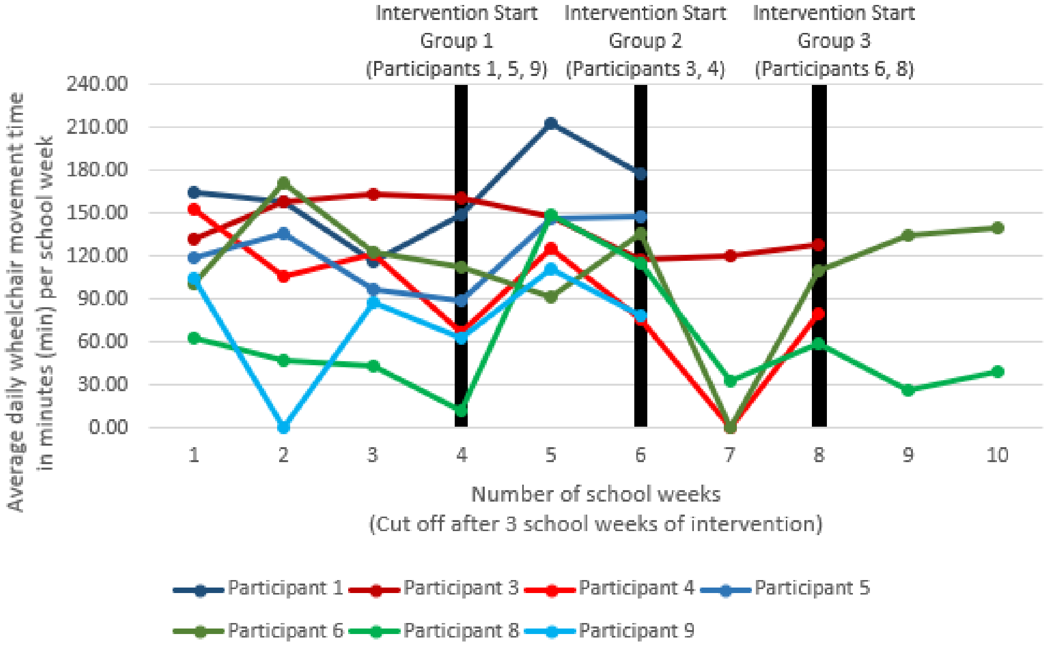

Figure 5. Development of average daily wheelchair movement time in minutes (min) during each school week (from start of baseline to third school week of each participant's intervention)

Table 3. Average movement distance in meters during baseline and intervention periods and the average change in intervention compared to baseline.

ID	*Average baseline distance (m) per measured school day*	*Average intervention distance (m) per measured school day*	*Average change Intervention-Baseline (m)*	*Increase ↑ / decrease ↓*	*Standard deviation (m)*	*p-value*
Group 1	706.1	722.0	15.9	↑		
Group 2*	792.9	799.4	6.5	↑		
Group 3*	537.4	827.7	290.4	↑		
Participant 1	694.7	768.7	73.9	↑		
Participant 3	973.2	882.4	-90.8	↓		
Participant 4	621.2	724.9	103.8	↑		
Participant 5	834.5	949.4	114.9	↑		
Participant 6	728.0	920.9	192.9	↑		
Participant 8	401.1	718.3	317.0	↑		
Participant 9	469.0	352.9	-116.2	↓		
All participants n=7*	**674.5**	**759.6**	**85.1**	↑	**±151.8**	**0.094**

*Participant 7 excluded from Group 2, Participant 2 excluded from Group 3. See chapter *4.2.1 Data and participants excluded from quantitative data* for clarification.

Table 4. Average movement time in minutes during baseline and intervention periods and the average change in intervention compared to baseline.

ID	*Average baseline time (min) per measured school day*	*Average intervention time (min) per measured school day*	*Average change Intervention-Baseline (min)*	*Increase ↑ / decrease ↓*	*Standard deviation (min)*	*p-value*
Group 1	122.9	120.1	-2.8	↓		
Group 2*	136.6	116.6	-19.9	↓		
Group 3*	84.0	99.9	15.9	↑		
Participant 1	146.8	156.9	10.0	↑		
Participant 3	152.2	122.8	-29.4	↓		
Participant 4	121.7	111.1	-10.6	↓		
Participant 5	117.1	124.3	7.1	↑		
Participant 6	110.1	126.1	16.0	↑		
Participant 8	65.4	69.1	3.7	↑		
Participant 9	93.5	80.9	-12.6	↓		
All participants n=7*	**115.3**	**113.0**	**-2.2**	↓	**±15.9**	**0.361**

*Participant 7 excluded from Group 2, Participant 2 excluded from Group 3. See chapter *4.2.1 Data and participants excluded from quantitative data* for clarification.

4.4 Qualitative Data: questionnaire about user experience, perceived changes in activity and device functionalities

The qualitative data was collected throughout the study by exchanging email conversations with the staff members and a questionnaire form was filled at the end of the intervention phase. A total of ten questionnaires was sent and ten questionnaires were received. All nine study participants filled the questionnaire form and one partner school physiotherapist filled one questionnaire form. Caretakers/Instructors of the participants gave feedback as well but did not fill their own questionnaire form. Their feedback was written on the participant's questionnaire form and was distinguished with abbreviations to indicate that the feedback is the caretakers/instructors own remark. Also, staff members helped participants to interpret some of the questions if the participants did not understand it.

4.4.1 Qualitative data: questionnaire answers from participants

All nine study participants, together with their caretakers/instructors, filled the questionnaire form at the end of the intervention phase. In cases in which participants did not understand a question, it was left blank or marked with a '-'sign. The questions were categorized into different themes that would touch on specific subjects, such as user experience, experienced change in physical activity, usefulness of information, and improvement ideas. From the 13 questions, six were related to user experience, two were related to experienced change in physical activity, four were related to data tracking and one was related to improvement ideas. Two questions were open-ended questions and nine of them were closed-ended. All the closed-ended questions had a follow-up question, where participant could answer freely. From the nine closed-ended questions, two had multiple choices to choose from as an answer, but only one could be chosen. In open-ended questions, results were analysed if they could be considered positive or negative related to the question (e.g. Question 1: How would you describe your experience using Wheeleri and its mobile application? If the answer is e.g. good, fantastic, great, it's considered positive and if the answer would be e.g. bad, not interested, it would be considered negative).

User experience

The questionnaire form included six questions related to user experience with the Wheeleri device and Wheeleri mobile application (questions 1, 2, 3, 4, 11 and 12). Participants were asked about their experiences using Wheeleri, if using Wheeleri or Wheeleri application was complicated, if participants found using Wheeleri and Wheeleri application enjoyable/fun, if were there things about using Wheeleri or Wheeleri application that were uncomfortable/frustrating, if there were the times when participant did not use Wheeleri actively and if the participants would keep using Wheeleri and its mobile application. Figure 6 presents these questions and the participants' answers graphically. The study participants had mostly positive experiences (88%) using Wheeleri, but a majority of the participants (66%) reported that they found using either Wheeleri or its mobile application complicated. Complications were related to connectivity issues with Wheeleri and the Wheeleri mobile application (66%), forgetting instructions (17%) and Wheeleri falling off the wheelchair multiple times (17%). All of the study participants unanimously agreed that using Wheeleri and Wheeleri application has been fun, with one of the reasons being that they could see how much they have manually propelled. Part of the participants did not find using Wheeleri or Wheeleri application uncomfortable/frustrating (44%) and part of the participants did (44%). One participant left this part unanswered. 75% of the participants who found it uncomfortable/frustrating reported that either Wheeleri or the Wheeleri mobile application did not work properly or stopped working spontaneously.

More than half of the participants (66%) reported times when they did not use Wheeleri actively. From the follow-up question, 33% of the participants reported cases when their caretaker/instructor did not remind them to use Wheeleri. One of the participants had other activities as well during the day, another participant was too tired, and a caretaker/instructor helped with propelling. One participant was walking with an assistive device at times during the school day and one other participant had an undefined special occasion. 75% of the participants would keep using Wheeleri and its mobile application if they could. Half of the participants that answered “yes” found it nice to use. One participant reported that they would have accumulated even more travel distance, one other participant would use Wheeleri and its mobile application to keep track how much the participant had manually propelled during the school day.

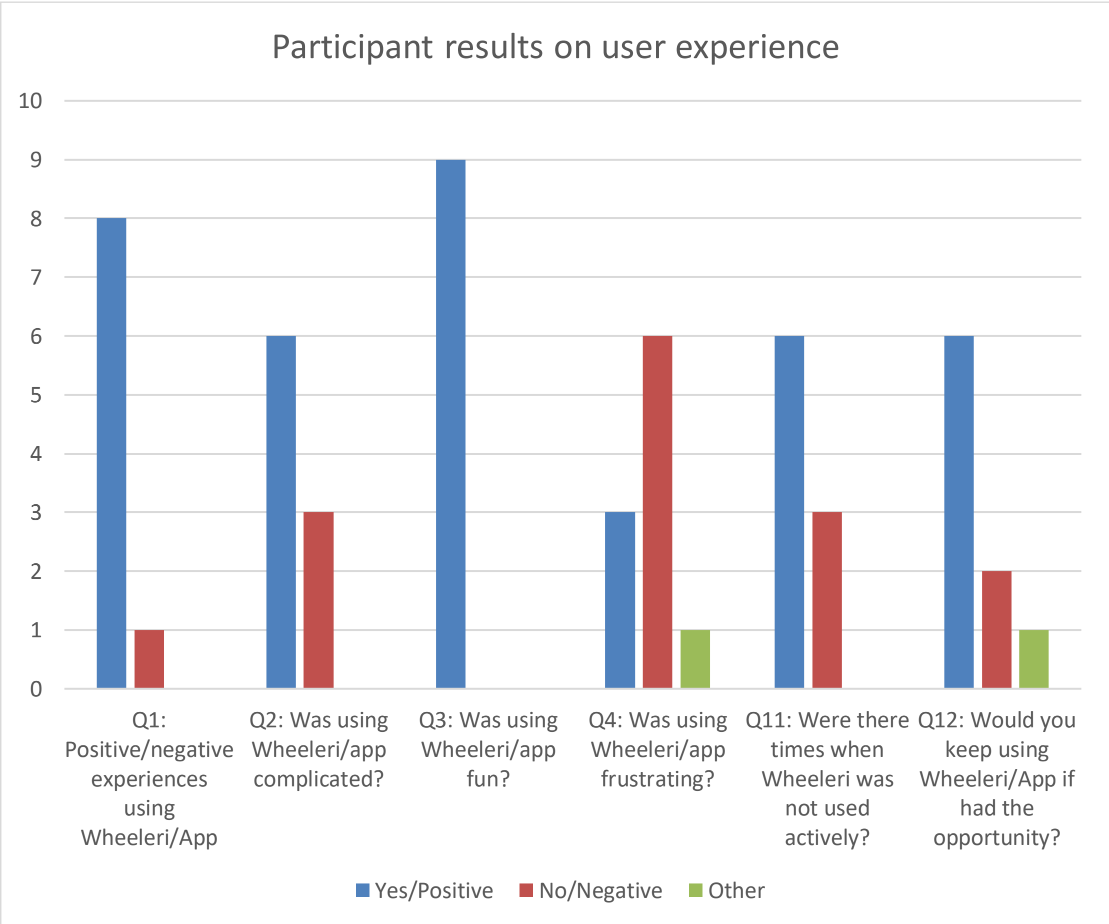

Figure 6. Participants experiences using Wheeleri and its mobile application.

Experienced changes in physical activity

The questionnaire form included two questions (questions 5 and 6) related to experienced changes in physical activity when using Wheeleri and Wheeleri mobile application. Participants were asked if they felt using only Wheeleri on their wheelchair influenced their level of activity and, separately, if they felt using Wheeleri mobile application with Wheeleri influenced their level of activity. As figure 7 shows, a majority of participants (78%) felt that using the Wheeleri device influenced their levels of activity positively. Participants, who answered positively to question 5, reported in the follow-up question that the Wheeleri device made them manually propel longer distances. Less than half of the participants (44%) felt that using the Wheeleri device with Wheeleri mobile application influenced their activity levels positively. One participant, who answered positively to question 6, reported in the follow-up question that Wheeleri application made them manually propel faster.

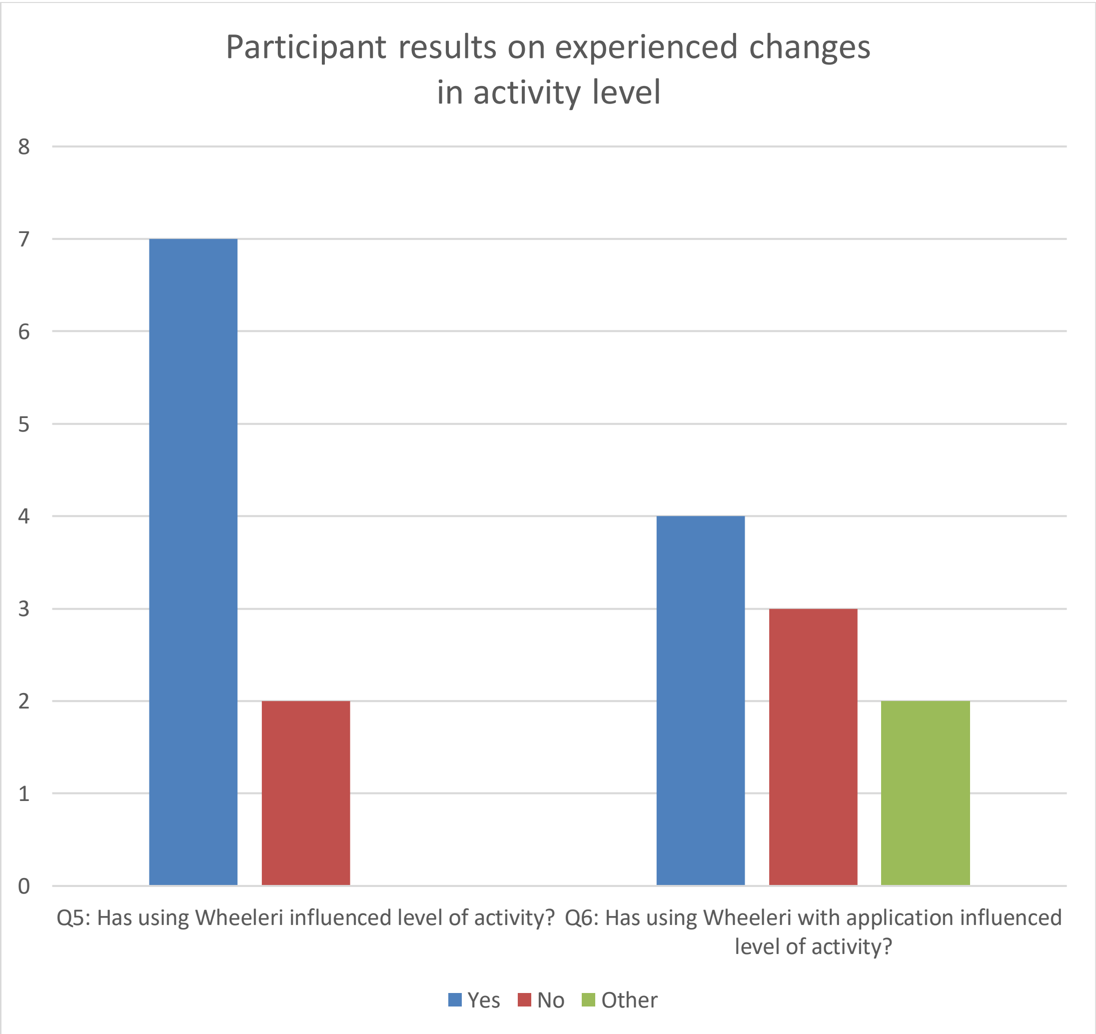

Figure 7. Participants result on experienced changes in activity level.

Data tracking

The questionnaire form included four questions (questions 7, 8, 9 and 10) related to data tracking in the Wheeleri mobile application. Participants were asked if the information in the mobile application was understandable, if the information was interesting, if the participants checked the information by their own initiative or if they were encouraged by their caretaker/instructor and how often the participants checked information from the mobile application. Figure 8 shows that more than half of the participants (55%) reported the information in the mobile application to be understandable. Two of the participants reported that they required their caretaker's/instructor's help to understand the information better. Less than half of the participants (44%) thought the information to be interesting. Two of the participants, who thought the information to be interesting, reported that it was interesting to know how long distances had been manually propelled, one participant reported that average and top speed was interesting to track. Over half of the participants (55%) reported to have checked information in the mobile application by their own initiative.

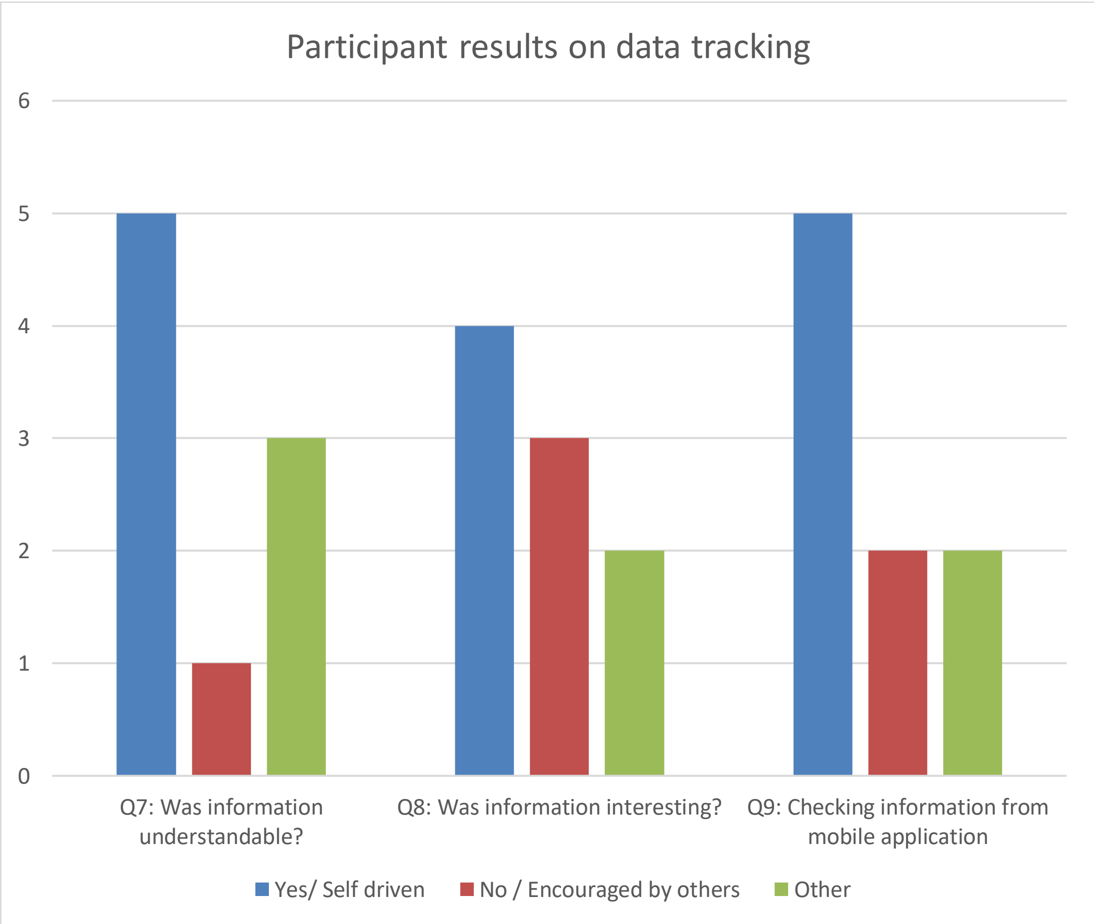

Figure 8. Participants results on data tracking.

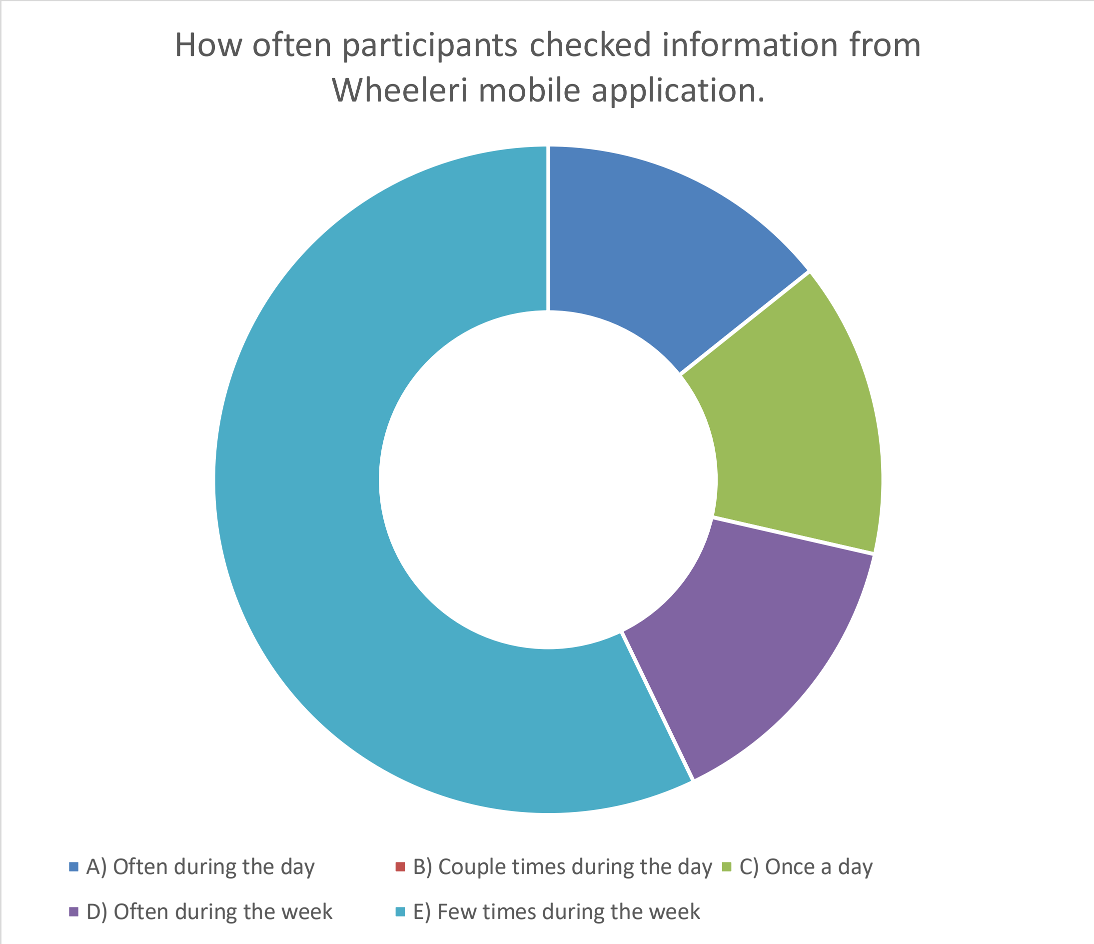

Figure 9. How often did participants check their own information from the Wheeleri application.

Improvement ideas

The questionnaire form's last question (question 13) was related to improvement ideas. Participants were asked how they would improve Wheeleri and Wheeleri application. Less than half of the participants (44%) did not know how they would improve Wheeleri or Wheeleri mobile application. One third of the participants was content with how Wheeleri and Wheeleri mobile application are right now.

4.4.2 Qualitative data: questionnaire answers from Valteri Ruskis staff members

One physiotherapist from the partner school filled the questionnaire form at the end of the participants intervention phase. The physiotherapist did not answer to questions 9 to 11, as the questions were about checking the information from Wheeleri application and about times when the participants were not using Wheeleri actively. Regarding the user experience questions (question 1, 2, 3, 4, 11 and 12) the physiotherapist reported that the Wheeleri device brought motivation to the participants to move by themselves and it was interesting to get know the device and mobile application. Some of the participants were able to use the device by themselves and they were more interested in using the device than others. However, it has a lot of possibilities to be developed to become more useable. The device had multiple connection issues when in use. Because of connection errors, some of the devices did not collect all the data when the device was being used. Some participants expressed it being frustrating and many of the devices got broke during the study. The physiotherapist expressed that if the device would be easier to use in daily use, then it would be more interesting to use Wheeleri again. According to the physiotherapist’s opinion, in its current state, the device is too clumsy as it is too big, has a bad attachment system, and shows errors in data connection and transfer.

For the questions about experienced changes in physical activity (questions 5 and 6), the physiotherapist subjectively reported that for some of the participants, the use of the device has increased the activity a lot. The fact that someone/something was following their movement levels was enough to increase them. For other participants it did not make any difference, because they were already quite active. Some of the participants were using the mobile application actively and especially the exercise program while, for example, being outdoors.

The physiotherapist reported in the data tracking questions (questions 7, 8, 9 and 10) that the front page of the application is clear and easy to read, but the device did not always update the front page while Wheeleri was in use. The activity levels in different time frames (daily, weekly, monthly) and average velocity were interesting to follow.

Regarding the last question (question 13), the improvement of the Wheeleri device and its mobile application, the physiotherapist reported that the Wheeleri device needs to be much smaller and the attachment system requires more development. The magnet plates, that attach the Wheeleri device to wheelchair, are currently unreliable in daily use and the overall design makes it difficult for the device to be attached to some types of wheels.

5 DISCUSSION

This study measured the average daily wheelchair movement distance and time of school-aged children and teenagers using manual wheelchairs during their school days, the effects of an activity tracking mobile application on their daily wheelchair movement distance and time, and subjective experiences using these devices. Currently, there are not many studies available which objectively measure the amount of daily wheelchair movement of school-aged children using wheelchairs. In Finland, there are programs assessing and promoting physical activity at schools for able-bodied children. Less focus has been directed at children using wheelchairs.

The average wheelchair movement distance and time of the study participants using manual wheelchairs was calculated based on measurements during their school days. The recorded quantitative data show that the study participants (n=7, born between 2003 and 2009) moved 674.5 meters in 115.3 minutes on average per school day. (Table 2) To increase consistency, only data during a set time frame from 9.00-14.30 (5.5 hours per school day) were included in analysis. In a study among children between eight to seventeen years old, which similar to this study used a wheelchair-mounted tracking device, Cooper et al. measured average values of 1602.31 meters (n=9) per 24-hour-period using manual wheelchairs, with average active times ranging among the nine participants from 16.40 minutes to 81.88 minutes (Cooper et al. 2008, 980-981). Considering the difference of time frames in which movement data was analysed during these two studies (5.5 hours and 24 hours), this study's participants at Valteri School Ruskis, moved a considerably longer average distance over a longer average period of time. Adding to this, data was only collected at school, where longer stationary periods during lessons are to be expected. Sonenblum et al. found in a study among 28 adults using wheelchairs, that those study participants moved primarily in short, slow bouts shorter than 30 seconds and 13 meters, and slower than 0.5 meters per second. They found these results to be consistent with walking patterns of able-bodied adults. (Sonenblum, Sprigle & Lopez 2012, 5.) Using the Wheeleri tracking device, bouts cannot be analysed on this level of detail, and the diaries of the participants which could give further insight into quantitative data, did not provide enough information about the participants' specific school day activities during the study period to draw relating conclusions. Still, general wheelchair movement behaviour during a typical school day could be similar to what Sonenblum et al. described.

After measuring the average wheelchair movement distance and time during school days in the baseline period, in the intervention period, the influence of using the Wheeleri mobile application, to allow the study participants to track their own activities on the activity levels compared to baseline, was studied. During the course of the intervention period, the participants (n=7) moved on average 759.6 meters in 113.0 minutes per school day. The average wheelchair movement distance increased by 85.1 meters, compared to the baseline average. According to statistical analysis (n=7, average change: +85.1 meters, SD: ±151.8, p-value: 0.094), this change is statistically significant. Average movement times have slightly decreased from baseline to intervention by 2.2 minutes. According to statistical analysis (n=7, average change: -2.2 minutes, SD: ±15.9 minutes, p-value: 0.361), this change is not statistically significant. (Tables 3 and 4)

In short, quantitative data indicates that slightly more average distance was covered in the same or in a slightly shorter amount of average time during the intervention periods, compared to the baseline periods. However, the development of average movement distance and time during the study period does not appear to be directly correlated with the start of the intervention period and external factors as well as limited measurement reliability cannot be disregarded. (Figures 4 and 5)

While it cannot be said with confidence that the quantitative data show a significant effect of using the Wheeleri wheelchair-mounted activity tracker and mobile application on daily average wheelchair movement distance and time during this study, according to the collected qualitative data, the majority of study participants (88%) found the overall experience of tracking their activities to be good, most of the participants (78%) subjectively felt that using Wheeleri increased their activity levels and almost half of the participants (44%) found the mobile application in combination with Wheeleri to have a positive influence on their activity levels.

When asked about the user experience of the participants and school staff members with the Wheeleri tracking device and mobile application in a qualitative questionnaire, most of the participants reported positive experiences when using Wheeleri and its mobile application. However, there are issues regarding the technical aspects of the device, which influence measurement reliability as well as usability. Specifically asked if they found using Wheeleri and its mobile application to be complicated, six out of nine participants reported so. Issues related to connectivity between Wheeleri and its mobile application occasionally added challenges in usability, since they led to loss of data which affected both user experience and quantitative data collection. Staff members reported similar answers. Analysis of qualitative data showed that some of the questions were left blank or that some participants had challenges understanding what specifically was asked, even with help from their caretaker/instructor.

5.1 Limitations of this study

Limitations of this study are due to factors both from the study design and from the outcome measures that were used to collect quantitative and qualitative data.

5.1.1 Limitations of the study's design

The number of available suitable participants at Valteri School Ruskis was low (n=9), out of which two more participants had to be excluded from analysis of the collected quantitative movement data (resulting in n=7). Given this small number of participants, an N-of-1 design was a fitting design for conducting the study. The N-of-1 design already has limitations in external validity and tenuous grounds for generalization of results. (Tate & Perdices 2015, 21.) In addition to this, this study was further restricted by time limitations due to length of the school's semester. It was decided not to implement a second A-phase in which the use of the mobile application would have been withdrawn again to observe possible changes after the intervention. This could have further strengthened any observed reason for changes in daily average wheelchair movement distance and time during the intervention phase. (Tate & Perdices 2015, 26.) For future similar studies we recommend strengthening external validity and reliability by recruiting more participants and by additionally implementing a follow-up A-phase to further investigate reasons for changes in recorded movement data.

5.1.2 Limitations of used outcome measures

Technical limitations in this study are due to the Wheeleri's functionalities. With this wheelchair-mounted activity tracker, the recorded movement data of the wheelchair's wheel do not allow to distinguish between active movements by the study participants and passive movements when a wheelchair is being pushed by another person. Measures were taken to decrease the likelihood of passive movement showing up in the data: limiting the time frame to be analysed to 9.00 until 14.30 during school days and providing the participants with diaries with the instructions for them and staff members to note down times of passive movement with date, time and duration. With this procedure it was possible to exclude corresponding quantitative data from analysis, but it cannot be with confidence assumed that all passive movements were recorded in the diaries. Additionally, the wheelchair movement data recorded by Wheeleri does not relate to the kind of activity and the intensity level that was recorded. In a 2019 study, Karinharju et al. studied the validity of the Apple Watch® for monitoring push counts in people using manual wheelchairs. They concluded that this wearable tracking device can provide acceptable estimates of average push counts in larger samples, which can relate to a wheelchair user's activity level. (Karinharju et al. 2019a, 7.) Combining the movement data from both wheelchair-mounted and wearable activity tracking devices in future studies could give more reliable data about physical activity levels in people using wheelchairs (Karinharju et al. 2019b). Another limitation of Wheeleri was that the technical and structural reliability of Wheeleri in its current state were at times challenging for study participants and staff members. This resulted in loss of some data and required replacement of some devices. These issues could be resolved in future development of the device.

Regarding the qualitative outcome measure, it seems that some of the questions were found to be challenging to understand. On six out of 13 questions (46%), some participants' answers to the questions were indefinite. Most indefinite answers were given to questions regarding the tracking of wheelchair. While several of the data tracking questions were first answered by a yes-or-no statement, the follow-up questions could case those answers to be difficult to categorize. Additionally, in retrospect the questionnaire's design could have been better structured. Some of the questions combined experiences from both the Wheeleri device and the mobile application, but other questions asked for user experiences from either the Wheeleri device or the mobile application separately. In some cases, the length and the wording of the questions seemed challenging to participants as well.

5.2 Strengths of this study

5.2.1 Strengths of the study's design

Using a multiple-baseline design strengthens the efficacy of an intervention in a single-subject (N=1 design) A-B design, when no second A-phase is implemented (Tate & Perdices 2015, 29). A multiple-baseline design can be considered adequate, when it is based on at least three different tiers each following an A-B design, and so implementing the intervention on three different occasions (Tate & Perdices 2015, 30). This study has used a modified multiple-baseline design with, in total, nine participants randomized into three groups with three different baselines of length from 15 to 36 school days. Average values per measured school day were calculated. The RoBiNT scale for assessing risk of bias in N=1-trials contains seven items in its subscale for assessing internal validity of a study (Tate & Perdices 2015, 23). These seven items and their implementation within this study are as follows:

1. Design: this study's design met requirements to demonstrate experimental control adequately for the given number of participants.
2. Randomization: the commencement of phases was randomized for each participant due to randomization into three study groups.
3. Sampling: in the quantitative movement data of seven out of nine participants, there was a sufficient number of data points in each baseline and intervention phases to calculate meaningful average values per measured day. The two participants with insufficient data were excluded from analysis.

4. Blind participant/therapists: given the nature of the intervention being the active use of the mobile application, and the need for instructing the participants in using it, it was not possible to blind this study's participants or its conductors.
5. Blind assessors: see 4.
6. Inter-rater reliability: not applicable.
7. Treatment adherence: this study's intervention was delivered in the way it was originally planned.

While, with four out of seven, not all the criteria have been met, this study met a majority of the RoBiNT scale's internal validity requirements. The external validity and interpretation subscale's items should be assessed externally. (Tate & Perdices 2015, 23.) See also appendix 6. Using a mixed-method approach with both quantitative and qualitative data in this study allowed for enhancing insights into the applicability of the Wheeleri device as a wheelchair-mounted measure to track a promote physical activity for wheelchair users.

5.2.2 Strengths of used outcome measures

When studying the effects of activity trackers on physical activity levels, it must be taken into consideration that simply having, let alone using, an activity tracker could influence participants and their levels of activity (Sullivan & Lachman 2017, 8). To use the Wheeleri tracking device it is attached near the center of the wheelchair's wheel. This way, it can be considered as being less visible to study participants than, for example, a wrist-worn activity tracker. Additionally, no interaction with the device was required during the baseline period, since it recorded movement continuously once attached to the wheel. Therefore, during baseline measurements of wheelchair movement the strength of this outcome measure was that it kept its influence on activity levels low. Only at the start of the intervention period the participants were provided with mobile phones to track their activities and interaction with the device increased. Furthermore, since the Wheeleri device is recording and calculating the wheelchair's movement distance and time based on the movement of the wheel, it does not require a GPS-signal and can, therefore, be used indoors as well as outdoors without restrictions.

6 CONCLUSION

In conclusion, the results of this study, within its limitations, provides an indication towards how much children between the ages ten and sixteen using manual wheelchairs are moving during their school days. The use of an activity tracking mobile application via a wheelchair-mounted movement tracking device seems to be subjectively motivating to become more active, but objective quantitative data of this study does not show a directly correlated positive effect on either wheelchair movement distance or wheelchair movement time.

In Finland, several nation-wide programs have been implemented in recent years. These programs have the goals to promote physical activity in schools, during the children's school days. This is in general important to keep in mind, since children and teenagers spend a lot of time at school and school involves a large amount of sedentary time which decreases physical activity levels. However, children with special needs and/or children using wheelchair are not, so far, the main focus of such programs. For this reason, it is important to also raise awareness about physical activity about these children and teenagers. Our thesis can contribute to this, since it was focusing exclusively on children using wheelchairs during their school days. Within at least one of the national programs to promote physical activity in Finnish schools, there was research done about children with special needs as well. However, this research only focused on collecting subjective information about the participants' current activity levels and habits. Our study combined subjective, qualitative data with quantitative measurements about the wheelchair movement distance and time. By combining these two methods more insights can be gained, rather than by one of them alone. In general, efforts to improve accessibility for and inclusion of people with special needs should also include physical activity, since various physical activities can be an effective way to socialize with others, in daily private life and in schools. The approach we took in our thesis might provide one part towards this, since research of physical activity and its promotion in this field has still been lacking compared to the general population. One important step to further validate and clarify measurements and results of study participants using manual wheelchairs would be to combine the use of wheelchair-mounted and wearable activity trackers when collecting quantitative data, as well as to improve outcome measures for qualitative data.

Working as a physiotherapist usually includes both treatments of certain medical conditions as well as recommendations for and promotion of healthy living and maintenance of good overall health condition. Since the challenges of following physical activity recommendations, as well as time spent sedentary, seem to increase in society, this part of the profession will likely also become more important. In order to be able to give recommendations to clients, it is important that there are evidence-based guidelines one can refer to and base their recommendations on. This should not only include the able-bodied population, but also the population with special needs. Because both of those groups should be able to lead a healthy life according to their individual situations within society. However, one of the current challenges with this is that people with special needs are not a homogenous group and measures that can effectively assess their activity levels still need to be developed. Once this is achieved, guidelines and recommendations for daily physical activity levels can be developed. After that, it will be more effective and more feasible to give recommendations to clients with special needs as a physiotherapist. Our thesis and future research within its area can provide a first step towards this.

During this thesis process, we personally as future physiotherapists, have learned important things about scientific research. While there are many things to be considered when implementing such a study project, one must be careful to not take an approach that is too broad. Reducing the approach and focusing on the things that are directly important to the asked research questions is important. Even when the end results are just small parts of a bigger picture, they can still become an important contribution to the profession and to society.

6.1 Acknowledgements

The authors would like to thank the study participants for taking part in this study, Jonna Ilves, Henni Huttunen and Mari Jokitalo-Trebs of Valteri Ruskis for their co-operation, staff members of Siru Innovations Oy and Satakunta University of Applied

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6.2 Conflicts of interest

The authors have no conflicts of interest to declare.

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APPENDIX 1

Information letter about and agreement to participation in the study. Created by Juha Duong.

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Satakunta University of Applied Sciences

Infokirje tutkimukseen osallistuvalle

Tutkimuksen nimi: WHEELERI -AKTIIVISUUSMITTARI PYÖRÄTUOLIA KÄYTTÄVILLE-KOKEELLINEN TUTKIMUS KOULUIKÄISTEN KESKUUDESSA

(WHEELERI: AN ACTIVITY TRACKER FOR PEOPLE USING WHEELCHAIRS – EXPERIMENTAL STUDY AMONG SCHOOL-AGED CHILDREN)

Tutkijat: Juha Duong & Matthias Rigal (juha.duong@student.samk.fi), (matthias.rigal@student.samk.fi)

Yhteyshenkilö: Kati Karinharju (kati.karinharju@samk.fi)

Kiitos halukkuudestasi osallistua tutkimukseemme. Tämä kirje sisältää 3 sivua, joista kaksi ensimmäistä sivua sisältää tietoa tutkimuksesta ja viimeinen sivu osallistujasopimuksen. Kirjeen tavoitteena on varmistaa, että olette saanut kaiken tarvittavan tiedon tutkimuksesta sekä siihen liittyvistä vaiheista ja tehtävistä. Kun olette lukenut kirjeen sisällön ja olet varmistunut siitä, että ymmärrät tutkimuksen sisällön, pyydämme sinua allekirjoittamaan liitteenä olevan osallistujasopimuslomakkeen.

Mistä tutkimuksessa on kyse?

Tämän tutkimuksen tavoitteena on tutkia fyysisen aktiivisuuden mittarin Wheelerin käytettävyyttä ja käyttäjäkokemuksia henkilöillä, jotka käyttävät pyörätuolia päivittäiseen liikkumiseen. Tavoitteenamme on mitata aktiivisuustasoja kouluikäisten pyörätuoli käyttäjien keskuudessa.

Wheeleri on ensimmäinen pyörätuolia käyttävien henkilöiden henkilökohtaiseen käyttöön suunniteltu matkamittari. Wheeleri -laite koostuu pienestä levystä, joka kiinnitetään pyörätuoli pyörien pinnojen väliin, sensorista, joka kiinnitetään levyyn magneetin avulla ja puhelinsovelluksesta, joka muodostaa yhteyden sensoriin. Yhteyden muodostettua Wheeleri -laite mittaa matkaa (m), nopeutta (km/h), aikaa (h/min/sek), keskinopeutta (km/h) ja huippunopeutta (km/h).

Tämä tutkimus on tärkeä, koska sen avulla voimme kehittää mittaria, jonka avulla voidaan luotettavasti mitata pyörätuoliakäyttävien henkilöiden fyysisen aktiivisuuden määrää.

Mitä tutkimukseen osallistujaa pyydetään tekemään tutkimuksessa?

- Käyttämään Wheeleri -laitetta ja siihen liittyvää sovellusta koulupäivien aikana,
- Raportoimaan ruutuvihkoon kokemukset laitteesta ja sovelluksen käytöstä koulupäivien aikana

Kuinka kauan tutkimus kestää?

Tutkimus kestää vähintään 11 viikkoa ja pisimmillään 15 viikkoa, riippuen ryhmästä, mihin osallistuja arvotaan sattumanvaraisesti.

Miten henkilökohtainen tieto käsitellään?

Takaamme osallistujien anonyymiyden.
Mitään tunnistettavaa henkilökohtaista tietoa ei julkaista ja yksilön tietoihin kuten ikään, sukupuoleen tai terveyteen liittyvät tiedot käsitellään ryhmäkohtaisesti.

Liittyykö tutkimukseen osallistumiseen riskejä?

Wheeleri kiinnitetään pyörätuoli pyörien pintoihin, eikä aiheuta harmia tuolin rakenteisiin.

Osallistujan oikeudet:

Tutkimukseen osallistujana sinun on hyvä tietää, että:

- Voit keskeyttää tutkimuksen, milloin tahansa. Vaikka olisit allekirjoittanut tutkimuksen lomakkeet, ei mahdollisesta keskeyttämisestä aiheudu sinulle harmia.
- Osallistujan suostumusta valokuvien ja videomateriaalien käyttöön vain tutkimuksen osana tai osana laajempaa käyttöä (opetuskäyttö, julkaisut ja luennot) kysytään erikseen osallistujasopimuksessa.
- Kaikkia tutkimuksessa kerättyjä tietoja käsitellään luottamuksellisesti ja tiedot säilytetään salasanan takana olevalla tietokoneella ja puhelimella.

Tämän tutkimuksen suunnitelma on hyväksytty Satakunnan ammattikorkeakoulun SAMKin tutkimuslupa/ sopimus) sekä Valteri Ruskis (Oppimis- ja ohjauskeskus Valteri) toimesta (Valterin hankesopimus).

Mikäli sinulla on kysyttävää tutkimukseen liittyen, voit ottaa yhteyttä tutkimuksesta vastaaviin henkilöihin.

Kiitos vielä ajastasi ja osallistumisestasi tutkimukseen!

Juha Duong & Matthias Rigal

Tutkimuksen nimi:
WHEELERI -AKTIIVISUUSMITTARI PYÖRÄTUOLIA KÄYTTÄVILLE-KOKEELLINEN TUTKIMUS KOULUIKÄISTEN KESKUUDESSA

Tutkijat: Juha Duong & Matthias Rigal (juha.duong@student.samk.fi), (matthias.rigal@student.samk.fi)
Yhteyshenkilö: Kati Karinharju (kati.karinharju@samk.fi)

OSALLISTUJAN SUOSTUMUS

- Olen lukenut osallistujan informaatiokirjeen ja saanut vastauksen mahdollisiin esiin tulleisiin kysymyksiin tutkimusryhmältä.
- Olen ymmärätnyt tukimuksen sisällön sekä tiedän mitä laitteita tutkimuksessa käytetään.
- Ymmärrän, että kaikkea tutkimuksessa saatua tietoa käsitellään luottamuksellisesti.
- Ymmärrän, että saan kopion omista tutkimustuloksista, mutta tiedot eivät suoranaisesti hyödytä minua henkilökohtaisesti, mutta ovat tärkeitä tutkimuksen kannalta.
- Ymmärrän, että voin keskeyttää osallistumiseni tutkimukseen milloin tahansa.
- Olen vastannut erikseen testitilaisuuden videokuvaamiseen ja valokuvaamiseen liittyvään lomakkeeseen.
- Voin keskeyttää tutkimuksen halutessani, vaikka olisin allekirjoittanut tutkimuslomakkeet.

SUOSTUMUS TIETOJEN KÄYTTÄMISESTÄ TUTKIMUKSEN JÄLKEEN.

Tutkimuksessa hankittuja tietoja käytetään:
Tutkimusta koskevaan opetusmateriaalien kuten julkaisujen ja esitysten tekemiseen sekä tutkimusta käsitteleviin uutisiin. Mitään tunnistettavaa henkilökohtaista tietoa ei julkaista ja yksilön tietoihin kuten ikään, sukupuoleen tai terveyteen liittyvät tiedot käsitellään ryhmäkohtaisesti.

- Annan tutkimuksen aikana kerätyn minun lastani koskevan tiedon tämän tutkimuksen käyttöön:
  Kyllä / Ei
- Annan luvan käyttää minun lastani koskevaa tietoa tutkimusta koskevaan opetuskäyttöön kuten osaksi julkaisuja, luentoja ja kongressiesityksiä.
  Kyllä / Ei
- Annan luvan käyttää minun lastani koskevaa tietoa tutkimuksen jälkeen erilaisissa julkaisuissa, luennoissa ja kongressiesityksissä.
  Kyllä / Ei

Olen lukenut ja ymmärtänyt tämän sopimuksen tiedot ja osallistun tutkimukseen

____
Osallistujan nimen selvennys

____
Osallistuijan huoltajan allekirjoitus Päivämäärä

APPENDIX 2

Instructions for participants and staff members about using the diary notebook. Created by Juha Duong.

OHJEET MUISTIVIHKOLLE

Kun kirjoitat muistivihkoon, muista päivämäärä alleviivattuna ja jätä 1 rivi väliä ennen kuin alat kirjoittaa.

Esim. 6.2.2019

Tänään minua avustettiin työntämällä 10 minuuttia.
Osallistuin tänään pyörätuolisählyyn.

Kirjoita muistivihkoon:

- Kun joku avustaa sinua työntämällä pyörätuolia
- Omat tuntemuksesi laitteesta
- Mihin aktiviteetteihin olet osallistunut tänään

Muista irrottaa laite ennen kuin lähdet kotiin ja laittaa takaisin, kun tulet kouluun.

APPENDIX 3

Instructions for staff members about the study procedures. Created by Matthias Rigal and Juha Duong.

Instructions about the Study Procedure

Thank you for assisting us in performing this study. Please read these short instructions carefully and feel free to contact us, if you have questions:
juha.duong@student.samk.fi
matthias.rigal@student.samk.fi

Timeline

+ Planned start of baseline measurements: Thursday, 7.2.2019
+ Duration of baseline measurements:
Group 1: 3 weeks, Group 2: 5 weeks, Group 3: 7 weeks
+ Duration of Intervention (during which, the participants can use the app to track their own activity): 8 weeks for all groups, following the baseline measurements
+ For the duration of the study, we will plan regular personal visits to Ruskis on a bi-weekly basis.

Participant Information & Device Assignment

+ To ensure anonymity of the participants, we do not know personal information other than gender, year of birth and name's initials. During the randomization process for the study each participant has received a number (1-9). Please use only these numbers when referring to participants in communication with us.
+ The Wheeleri devices and phones will be marked with these numbers and each participant should keep the same device for the duration of the study. If device needs to be replaced (for technical reasons or similar), make sure you mark down the number-code of the device on that participant's note book.

Measurements & Data

+ Wheeleri records data of manual wheelchair movement continuously
+ The aim of this study is to collect data during the participants' school days. If the wheelchairs they are using at school are taken home with them, please remove the Wheeleri at the end of the school day and store the Wheeleri in a safe place. Also, remember to re-place the Wheeleri to the wheelchair first thing in the morning.
+ Data should be exported into an excel-file once per week. Each exported excel-file will have a standard file name "wheeleri_exported.xls". Please, rename the excel-file according to the following format: "participant number_Date of export YYMMDD".
For example, if a file from participant 2 has been exported on 14.2.2019: rename excel-file to "2_190214.xls". Send the participant's excel-files to both of the above mentioned e-mail-addresses.
For detailed instructions about exporting data from the Wheeleri-app, see Technical Instructions.
+ Data can be exported via wheeleri app (see technical instructions). Once exported, it will be saved in the phones' internal storage which can be found using phones' file explorer or connect phone to computer via usb cable
+ In addition to the movement data, every participant will have a personal notebook in which they and caretakers can note down feedback and possible exceptions to the study procedure. During our personal visits we will collect (scan) the data from these notebooks.
+ Ideally, data will be recorded continuously throughout the school days for the duration of the study. However, if there are short-term interruptions for technical or other reasons, make sure that any such interruptions will be marked in the participants' notebooks (date, time, comment of the issue: flat battery etc.)

Measurement Procedures

+ The Wheeleri records every movement of the wheelchair's wheel. Even when the wheelchair is not manually moved by the participants themselves. For this reason, please try to minimize the times when a wheelchair is being moved by someone else during the school days. Short periods are not an issue, but if continuous periods of 10 minutes or longer are required, please mark down the duration of and reason for moving the wheelchair passively (or, if applicable, for not using the wheelchair) in the participant's notebook.

+ The aim of this study is to measure the participants' regular activity levels during the baseline measurements and possible effects of using the tracking app during the intervention phase. For this reason, please do not give specific instructions/encouragement to the participant. (For example, if a participant is using both a walker and a wheelchair, no encouragement to use the wheelchair with the Wheeler more often than usually.)

Comments in the participant's notebook

+ How to make notes:

Start every entry with the underlined date "DD.MM.YY". Participant's notes should be marked with underlined "P Participantnumber", any caretaker's notes should be marked with underlined "CT". Example, entries on 14.2.2019 in notebook of participant 2:

<u>14.02.19</u>

<u>P2:</u>
[Text here]

<u>CT:</u>
[Text here]

+ What to note down:

- All technical issues, such as: specific problems in using/handling the device or the app (e.g. issues in running the app, exporting data, positioning of devices,...), low or empty batteries (including suspected time period, in which batteries were empty)
- Periods of longer than 10 minutes in which participant's wheelchair has been moved passively or has not been used, including starting and ending time of that period
- Participant's and caretaker's comments on the Wheeleri device, such as feelings using it, positive or negative experiences
- Participant's and caretaker's comments on the Wheeleri application, such as feelings using it, positive or negative experiences (in what kind of situations participant was motivated to use wheeleri or see data (speed or distance) from Wheeleri?
- Comments related to physical activity performed during study period: subjectively perceived increased or decreased overall level of physical activity, specific periods of physical activities performed during school days aside from regular movement (e.g. sports games including time period in which they were performed)
- Weekly numerical rating by participant and caretaker during the 8-week intervention period:

    How difficult/easy is it to use the Wheeleri application?
    Scale 1-5, 1=very difficult, 5=very easy

- Weekly assessment, how often the application was checked during the school day, on average: A=0-5 times, B=6-10 times, C=11-20 times or D=more than 20 times

APPENDIX 4

Questionnaire to acquire qualitative data and user feedback from study participants and staff members. Created by Juha Duong.

Wheeleri interview for participants and adults

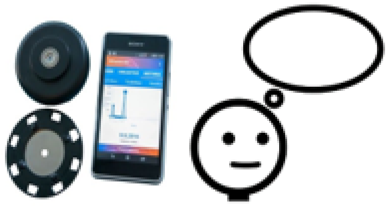
Wheeleri kysely osallistujille ja ohjaajille

Thank you for participating in our study by using Wheeleri and its phone application!

Kiitos tutkimukseen osallistumisesta käyttämällä Wheeleriä ja sen puhelin sovellusta!

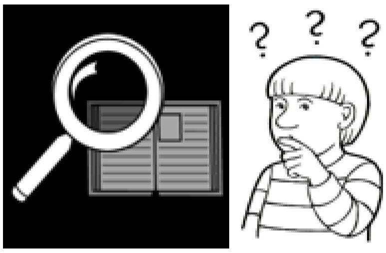
1. How would you describe your experience using Wheeleri and its phone application?

1. Millaisia kokemuksia heräsi Wheelerin ja Wheeleri sovelluksen käytössä?



2. Did you find using Wheeleri or Wheeleri application complicated? If yes, why and how? Were there any specific problems?

2. Oliko Wheeleri tai Wheeleri sovelluksen käytössä haasteita? Jos oli, miksi ja miten? Oliko jotain tiettyä ongelmaa?



3. Did you find using Wheeleri and Wheeleri application enjoyable/fun? If yes, why?

3. Oliko Wheelerin ja Wheeleri sovelluksen käyttö mukavaa/hauskaa? Jos oli, miksi?

4. Were there things about using Wheeleri or Wheeleri application that was discomfortable/frustrating to you? If yes, can you describe what things?

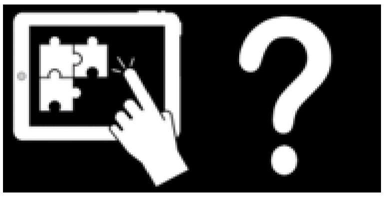
4. Oliko Wheelerissä tai Wheeleri sovelluksessa asioita, jotka tuntuivat epämukavalta tai turhauttavalta sinulle? Jos oli, osaatko kertoa mitä?

5. In your own opinion, has using Wheeleri on your wheelchair influenced your level of activity?

5. Onko Wheelerin käyttö mielestäsi vaikuttanut sinun liikkumiseesi pyörätuolilla?

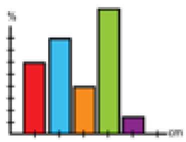
6. In your own opinion, has using the phone application with Wheeleri influenced your level of activity?

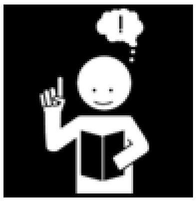
6. Onko Wheeleri sovelluksen käyttö Wheelerin kanssa vaikuttanut sinun liikkumiseesi pyörätuolilla?



7. Was the information the phone application is providing understandable to you? If yes, can you explain how?

7. Onko Wheeleri sovelluksessa näkyvä tieto ymmärrettävää? Osaatko selittää miten?





8.Did you find the information in the application interesting for you? If yes, can you describe what kind of information felt interesting?

8. Onko Wheeleri sovelluksesta näkyvä tieto mielestäsi kiinnostavaa? Osaatko kuivailla miksi ja jos vastasit kyllä, niin minkälaisen tiedon koit kiinnostavaksi?

9. I checked information….

9. Seurasin oma-aloitteisesti tietojani Wheeleri sovelluksesta

Kyllä, (muistin itse oma-aloitteisesti kysyä tai katsoa tietoja)

En, (seurasin tietoja vain aikuisen tai ohjaajan toimesta)

10. How often did you check your own information from the app?

10. Kuinka usein seurasit tietojasi sovelluksesta?

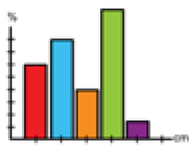
a) Often during the day/Useamman kerran päivässä

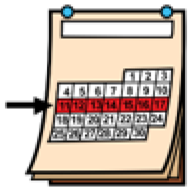
b) Couple times during the day/Pari kertaa päivässä

c) Once a day /Kerran päivässä

d) Often during the week/Useamman kerran viikossa

e) Few times during the week/Muutamia kerran viikossa



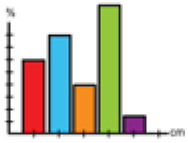
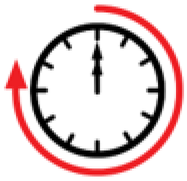


11. Where there times when you did not use Wheeleri actively, why was that?

11. Oliko koulupäivien aikana hetkiä, jolloin et käyttänyt Wheeleri sovellusta aktiivisesti, mistä se johtui?

12. If you would have opportunity, would you keep using Wheeleri and its phone application? If yes or no, why?

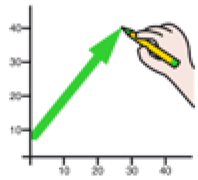
12. Jos sinulla olisi mahdollisuus, käyttäisitkö jatkossa Wheeleriä ja Wheeleri sovellusta? Jos kyllä tai ei, miksi?

13. How would you improve Wheeleri and Wheeleri application?

13. Miten kehittäisit Wheeleriä ja/tai Wheeleri sovellusta entisestään? Millaisia tietoja ja toimintoja toivoisit laitteelta?

WHEELERI



Recorded data of total movement distance in kilometers (km) and total movement time in hours (h).

ID	*Number of measured days (Baseline + Intervention)*	*Overall total distance (km)*	*Total baseline distance (km)*	*Total intervention Distance (km)*
Group 1	**140 (33+107)**	**100.6**	**23.3**	**77.3**
Participant 1	41 (12+29)	30.6	8.3	22.3
Participant 5	60 (14+46)	55.4	11.7	43.7
Participant 9	39 (7+32)	14.6	3.3	11.3
Group 2*	**96 (41+55)**	**76.5**	**32.6**	**43.9**
Participant 3	46 (20+26)	42.4	19.5	22.9
Participant 4	50 (21+29)	34.1	13.1	21.0
Group 3*	**98 (48+50)**	**67.2**	**25.8**	**41.4**
Participant 6	47 (20+27)	39.4	14.6	24.8
Participant 8	51 (28+23)	27.8	11.2	16.6
ID	*Number of measured days (Baseline + Intervention)*	*Overall time (h)*	*Baseline time (h)*	*Intervention time (h)*
Group 1	**140 (33+107)**	**281.8**	**67.6**	**214.2**
Participant 1	41 (12+29)	105.2	29.4	75.8
Participant 5	60 (14+46)	122.6	27.3	95.3
Participant 9	39 (7+32)	54.0	10.9	43.1
Group 2*	**96 (41+55)**	**200.2**	**93.3**	**106.9**
Participant 3	46 (20+26)	103.9	50.7	53.2
Participant 4	50 (21+29)	96.3	42.6	53.7
Group 3*	**98 (48+50)**	**150.4**	**67.2**	**83.2**
Participant 6	47 (20+27)	93.4	36.7	56.7
Participant 8	51 (28+23)	57.0	30.5	26.5

*Participant 7 excluded from Group 2, Participant 2 excluded from Group 3. See chapter *4.2.1 Data and participants excluded from quantitative data* for clarification.

APPENDIX 6

Item content of the risk of bias in N-of-1 trials (RoBiNT) scale (Tate & Perdices 2015, 23)

Internal validity subscale	*External validity and interpretation subscale*
1. Design: Does the design of the study meet requirements to demonstrate experimental control?	8. Baseline characteristics: Were the participant's relevant demographic and clinical characteristics, as well as characteristics maintaining the condition adequately described?
2. Randomization: Was the phase sequence and/or phase commencement randomized?	9. Therapeutic setting: Were both the specific environment and general location of the investigation adequately described?
3. Sampling: Were there a sufficient number of data points (as defined) in each of baseline and intervention phases?	10. Dependent variable (target behavior): Was the target behavior defined, operationalized, and the method of its measurement adequately described?
4. Blind participants/therapists: Were the participants and therapists blinded to the treatment condition (phase of study)?	11. Independent variable (intervention): Was intervention described in sufficient detail, including the number, duration and periodicity of sessions?
5. Blind assessors: Were assessors blinded to treatment condition (phase of study)?	12. Raw data record: Were the data from the target behavior provided for each session?
6. Inter-rater reliability (IRR): Was IRR adequately conducted for the required proportion of data, and did it reach a sufficiently high level (as defined)?	13. Data analysis: Was a method of data analysis applied and rationale provided for its use?
7. Treatment adherence: Was the intervention delivered in the way it was planned?	14. Replication: Was systematic and/or inter-subject replication incorporated into the design?
	15. Generalization: Were generalization measures taken prior to, during, and at the conclusion of treatment?