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Master thesis Health Psychology and Technology

Improving physical exercise in people with visual impairment using technology.

Exploratory research

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Abstract

Regular exercising is important for general health, it reduces the chance on many different diseases as cardiovascular diseases, diabetes and depressive symptoms. Especially middle-aged and elderly with visual impairments could benefit from this. Physical exercise ensures that people gain more experience with their environment and it strengthens their sense of balance. However, studies showed that people with a visual impairment live mostly a sedentary lifestyle (approximately 10 hours per day) and most of them do not reach the standards of the NNGB, meaning at least 30 minutes moderately physical activity for 5 days per week. This current study explored the underlying factors of this sedentary behavior, the attitude towards technological aids regarding exercise and user requirements of these technological aids.

A semi-structured interview was conducted with 13 persons with visual impairment. The average age of this study group was 64 years and 69% was male. This interview consisted of two parts; the first part included questions based on the Theory of Planned Behavior to explore the determinants of exercise behavior. The second part included three cases in which possible technologies were described, the questions here were about usability and motivation and preconditions of technological aids for this target group.

The results showed that the attitude towards exercise is high within this study sample. However, about half of the respondents (54%) met the Dutch standard for healthy exercise set by the Ministry of Health. Internal and external barriers were mentioned that contributed to being less physical active. Next to weather circumstances, giving up independency and fear of accidents were most frequently sited. The attitude towards technology is also positive. The majority of the respondents are open to technological aids. The google home and the hydraulic fitness device scored high on perceived usability and intention to use. The wearable pedometer scored high on perceived usability but low on intention to use, this device could work, but not for this target group.

This current study confirms earlier findings of exercise patterns in middle aged and elderly with a visual impairment and the influence of attitude and intention on actual behavior. Future research should focus on the influence of barriers and how to diminish this. In this sample, attitude and intentions to use assistive technology regarding exercise behavior are high. Used technologies were labeled as motivating mostly because the perceived ease of use. Future research should focus on using real devices in order to test the technology and search for possible difficulties. Results are not very generalizable; the sample size was to homogenous and respondents were possibly more active in daily live than the target group.

Samenvatting

Regelmatige lichaamsbeweging is belangrijk voor de algemene gezondheid, het vermindert de kans op verschillende ziekten als hart- en vaatziekten. Vooral mensen van middelbare leeftijd en ouderen met een visuele handicap zouden hiervan kunnen profiteren. Het zorgt ervoor dat mensen meer ervaring opdoen met hun omgeving en het versterkt hun evenwichtsgevoel. Studies hebben echter aangetoond dat mensen met een visuele beperking meestal een zittende levensstijl hebben en de meesten van hen voldoen niet aan de normen van de NNGB, wat betekent dat ze gedurende 5 dagen per week minstens 30 minuten matig intensief moeten bewegen. Deze huidige studie onderzocht de onderliggende factoren van dit zittende gedrag, de houding ten opzichte van technologische hulpmiddelen met betrekking tot lichaamsbeweging en gebruikerseisen van deze technologische hulpmiddelen.

Een semigestructureerd interview werd uitgevoerd met 13 personen met een visuele beperking. De gemiddelde leeftijd van deze studiegroep was 64 jaar en 69% was man. Hierin werden ten eerste de determinanten van bewegingsgedrag in kaart gebracht met vragen gebaseerd op de theorie van gepland gedrag. Als tweede omvatte het drie casussen waarin mogelijke technologieën werden beschreven, de vragen hier waren over bruikbaarheid en motivatie en voorwaarden voor technologische hulpmiddelen voor deze doelgroep.

De resultaten toonden aan dat de houding ten opzichte van lichaamsbeweging positief is in deze steekproef. Ongeveer de helft van de deelnemers (54%) voldeed echter aan de NNGB. Interne en externe barrières werden genoemd die bijdragen aan minder lichamelijke activiteit. Naast weersomstandigheden werden het opgeven van onafhankelijkheid en angst het meest genoemd. De Google Home en het hydraulische fitnessapparaat scoorden hoog op waargenomen bruikbaarheid en intentie om te gebruiken. De draagbare stappenteller scoorde hoog op de waargenomen bruikbaarheid maar laag bij de intentie om te gebruiken.

Dit huidige onderzoek bevestigt eerdere bevindingen van bewegingspatronen bij middelbare leeftijd en ouderen met een visuele beperking en de invloed van houding en intentie op werkelijk gedrag. Toekomstig onderzoek moet zich richten op de invloed van barrières en hoe dit te verminderen. In deze steekproef zijn de houding en intenties om ondersteunende technologie te gebruiken met betrekking tot trainingsgedrag hoog. Gebruikte technologieën werden als motiverend bestempeld, voornamelijk vanwege het waargenomen gebruiksgemak. Toekomstig onderzoek moet zich concentreren op het testen van de technologieën om op zoek te gaan naar mogelijke problemen. Resultaten zijn niet goed te generaliseren; de steekproefomvang was te homogeen en respondenten waren mogelijk actiever in het dagelijks leven dan de doelgroep.

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Introduction

Visual impairment and prevalence

According to the World Health Organization 1.3 billion people live with vision impairment of which 36 million are blind and approximately 1.2 billion have a moderate to severe vision impairment (WHO). Most of them are aged 50 and above (Mariotti, 2012). In the Netherlands there are an estimated 320.000 people with visual impairments. 85% of the people who are visually impaired are aged 50 years or older (Keunen, Verezen, & Imhof, 2011; Vreeken, van Rens, Limburg, & van Nispen, 2005). Also, above the age of 50 the prevalence of visual impairment is increasing exponentially with age (VISION 2020, 2005). Based on calculation models, between 2010 and 2020 the number of visually impaired patients will grow with 20% (volksgezondheidenzorg.info, 2018).

According to the World Health Organization a distinction can be made between visual impairment and blindness. According to the 10th revision of the International Classification of Diseases (ICD-10) visual impaired can be defined as: vision less than 0.3 (30%) but better or equal to 0.05 (5%), or a visual field of 30 degrees or less but greater than 10 degrees in the best eye with best correction (ICD-10 category 1 and 2) (Limburg, 2007). Blindness is defined as: vision is less than 0.05 (or 5%), or a field of view of 10 degrees or less with the best eye with best correction (ICD-10 category 3, 4, 5).

Visual impairment and physical activity

Studies have shown that people with visual impairments live mostly a sedentary lifestyle, although regular exercise has some important benefits for this particular group. According to Starkoff, Lenz, Lieberman and Foley (2016), for example, people with vision impairments engage in approximately 10 hours per day in sedentary behavior (Starkoff, Lenz, Lieberman, & Foley, 2016). In comparison, people without any disability from the same age group engage in approximately 7.7 hours a day in sedentary behaviors (Matthews et al., 2008). These sedentary lifestyles could cause various problems as eg. cardiovascular diseases and diabetes. The ministry of Health, Wellbeing and Sports in the Netherlands set up guidelines for physical activity for a healthy lifestyle; Nederlanse Norm Gezond Bewegen (NNGB), which states that people aged 55 years and older should engage in moderate to active physical activity at least 30 minutes, 5 days per week. Physical activity according to these guidelines will lower the chance on many different diseases as cardiovascular disaeses, diabetes, depressive symptoms, different types of cancer etc. (Blumenthal et al., 1999; Carter,

Meade, & Callaghan, 2016; Colcombe et al., 2018; Gezondheidsraad, 2017; Lampinen, Heikkinen, & Ruoppila, 2000; Mammen & Faulkner, 2013; ministerie van Volksgezondheid Welzijn en Sport, 2017).

People with visual impairments have twice the risk of mortality as people with normal vision. Causes are an increased risk of falling (twice as normal), increased risk of hip fractures (4x more as normal) and increased risk of depression (3x more as normal) (Langelaan et al., 2007; VISION 2020, 2005). Besides this, people with a vision impairment report increased feelings of fatigue. Consequences of fatigue include difficulties maintaining energy to endure daily activities (eg, housekeeping chores), processing and memorizing information and requiring extra effort to perceive and process visual stimuli (Schakel et al., 2017, 2018). Most of these consequences of visual impairment can be decreased through healthy physical activity. Especially for people with visual impairment being physical active may have various important benefits for people with visual impairment. It ensures that patients get to know their environment and learn to understand it better. This makes them more confident in engaging in physical activity. Secondly, it improves the sense of balance, which could reduce the number of fall incidents amongst visual impaired patients. Besides this, exercising improves the muscles to be stronger, which contributes to a better health and reduces the change on fall incidents (Colcombe et al., 2018; Hilgenkamp, Reis, Wijck, & Evenhuis, 2012). People with a visual impairment must rely more on their somatosensory and vestibular information to maintain postural stability. In older people, standing balance appears to be diminished due to lack of visual feedback which negatively affects the vestibular system, with regular physical activity this balance could be increased (Ray, Horvat, Croce, Christopher Mason, & Wolf, 2008). Next to these benefits, it is proven that regular exercising reduces depressive symptoms as wel as feelings of fatigue (Blumenthal et al., 1999; Carter et al., 2016; Lampinen et al., 2000; Mulier instituut, 2018; Schakel et al., 2017).

Despite the benefits of physical activity, people with visual impairment or blindness are significantly less physical active than people without vision impairment (Lindert & Breedveld, 2013). The exercise standards for people aged 55 and older appoint physical exercise on a moderately intensive base (eg, walking or cycling) at least half an hour a day for at least five days a week. Only 63% of the healthy people meets the exercise standards regarding these NNGB guidelines (ministerie van Volksgezondheid Welzijn en Sport, 2017). The numbers for people with a visual impairment are globally 10 points lower, about 53% of those people meet the standards of the NNGB (Lindert & Breedveld, 2013).

Determinants of exercise behavior

Up until now a few studies have examined the determinants of physical activity in people with visual impairments. Haegele, Hodge and Kuzob (2017) found that visually impaired people scored high on attitude and perceived behavioral control regarding being physically active most of the time. However, intentions to be active for 30-60 minutes per day were very indecisive amongst all respondents. Intentions are somehow the most important predictors of behavior as they are considered the immediate predictor of actual behavior performance. In most cases it seemed that intentions to engage in sedentary behavior were stronger than intentions to be physical active (Haegele, Hodge, & Kozub, 2017). Reason for this could be the identified barriers that impede engagements in being physical active. These include personal factors (being dependent on others, lack of discipline) as well as environmental factors (transportation issues, few possibilities to exercise). In order to determine which factors play a role in this behavior further research is necessary.

Various reasons are mentioned why exercising can be difficult. Partially these reasons are the same as for people without any visual impairment like, lack of intrinsic motivation to sport (Greguol, Gobbi, & Carraro, 2015). Other reasons arise more from the disability to see, such as lack of help/guidance while sporting and problems with transport and accessibility, also concerns of family about safety and underestimation of physical possibilities are seen as barriers to exercise (Mulier instituut, 2018; VISION 2020, 2005). Another reason that is mentioned regarding sedentary behavior is low self-esteem or anxiety to fall (Evans, Fletcher, & Wormald, 2007; Papadopoulos, Montgomery, & Chronopoulou, 2013). As mentioned earlier, people with a visual impairment must rely more on their somatosensory and vestibular information to maintain postural stability. Due to the loss of balance, people could become more insecure to exercise.

Another study using the social cognitive theory found that social support was an important predictor of physical activity (Haegele, Brian, & Lieberman, 2017). Social support includes the influence and support of family and friends on one's ability to overcome common barriers and actively participate in physical activity. Social support is important in many cases to overcome perceived physical barriers like transportation issues. Research into social support and overcoming mental barriers could provide insight in the level of support needed regarding mental and physical barriers.

Although exercise is considered important, sedentary behavior is most commonly exhibited. Intentions to move are less strong than the perceived barriers. Research into determinants of sedentary lifestyle and barriers regarding physical activity for the target

group of visually impaired of 55 years and older are scarce. To get more knowledge of the influence of these determinants and which determinants are most of influence within this particular group more research is needed in order to change lifestyles. Regarding barriers the influence of the perceived barriers is important. In order to diminish the influence of these barriers, knowledge is needed in which perceived barriers are most common and which barriers have the most influence on behavior.

Existing technological aids

Despite the fact that technological aids can assist in daily exercise, technological aids for this particular group are scarce. Technological aids can help people with visual impairments do exercises or physical activity more easily. Many visual impaired people make use of assistive technology (Elmannai & Elleithy, 2017). With the ongoing development of technology, the opportunities for visual impaired people become more extensive. Especially in the field of visual impaired athletes, technological aids are being applied more and more but also for younger children and adolescents technological aids are being designed. However, technologies for middle-aged and elderly with a visual impairment are less common. Despite the importance of physical activity within this group, literature provides no examples or requirements for technologies for this particular group.

One of the opportunities for exercising at home is the Visually Impaired Yoga Mat (Rousettus.com, 2018). Another possibility to increase exercise are so called exergames, digital games who combine exercise with game play (Morelli, Foley, & Folmer, 2010; Staiano & Calvert, 2011). These are games which use a webcam like device who registers movement of the player, by moving in particular ways, the game will be played e.g. playing a tennis game by swinging the arm as if a ball is being hit. These games are developed to increase physical activity (Rector, Bennett, & Kientz, 2013). Graves, Ridgers, Williams, Stratton, Atkinson and Cable (2010) found that exergames are more enjoyable for adolescents and adults than treadmill walking or jogging and are stimulating light-to-moderate intensity activity (Graves et al., 2010). Rector, Bennett and Kientz (2013) developed and evaluated a yoga game which works with the same device.

Outside the exergames there are more opportunities, most technological aids can be found in the field of sports, the remote guide is one of those (Ventura & Fernandes, 2011). Ventura and Fernandes designed a remote control to guide visual impaired athletes. Headphones and a remote control replace the guide on the track. Instead of running in front of the athlete the guide stands on the side of the track and uses the remote control to guide the

athlete. Results show an excellent reliability and helps the visual impaired athletes with the same efficacy as a guided runner.

Theory of Planned Behavior

In the current study the theory of planned behavior will be used to explore the determinants of exercise behavior and perceived barriers and the influence of these on behavior. The theory of planned behavior explains intentions to perform a certain behavior and actual behavior. Ajzen (1991) states that intentions to perform behavior can be predicted by three different determinants; 1) attitudes towards the behavior, 2) subjective norms and 3) perceived behavior control. Attitudes towards the behavior refer to the degree in which a person has a beneficial or unbeneficial valuation of the behavior. Subjective norm refers to the perceived social influence to perform a behavior. Perceived behavior control refers to the perceived ease or difficulty of performing the behavior (Ajzen, 2002). Perceived behavior control does not only influence the intention to perform a behavior but also influences behavior in a direct way. Perceived behavioral control, together with behavioral intention can be used to predict behavioral achievement (Ajzen, 1991).

Human centered design

This current study is based on a human centered design approach. Within this approach end-users of the system are being involved in the development of the system. In stead of designing “for users” the human centered approach is about designing “with users”. In this process users are considered as the experts in interaction and experiences with products (Tschimmel, 2012). Human-centered design is used to obtain and understand the needs, desires and experiences of the end-users. Involving the end-users in the design of new products leads to products which are physically, perceptually and cognitively more compatible with the physics of the end-user (Giacomin, 2014). Furthermore, involving the end-user can enhance the acceptance of and the commitment to a new technology, this way implementing the system could become easier (Maguire, 2001). Within this study the end-users will be used in evaluating current persuasive technologies that are made to improve physical activity.

Study aim

The NNGB guidelines be attained by roughly half of the middle-aged and elderly with a visual impairment. The organization of Koninklijke Visio want insights in determinants of behavior for this particular group. Also, they want to know how the target group perceives

the use of technological aids and which requirements these aids have.

As previously stated, motivation, lack of guidance and opportunities and lack of knowledge about possibilities could have influence on this sedentary lifestyle. However, literature provides no research into determinants and barriers in this particular target group. Within Koninklijke Visio the main group are elderly, most of the technological aids describe before are developed for children or athletes. To understand the needs of the most important group of clients within Koninklijke Visio, two research questions arise.

1: What are the determinants of exercise in people with a visual impairment?

2: How does the target group oppose technology and how can technology help with increasing exercise?

In order to answer the first research question the theory of planned behavior was used to examine the attitude toward exercising, the social support and the perceived behavioral control. Next to this, barriers for exercising have been questioned.

The second research question will be answered by using a human-centered design study in which the attitude towards technology and current use of technologies were asked. Next to this some current technologies were evaluated with the clients. Through this evaluation, the needs of the clients in the field of technological aids will emerge and the preconditions of this technological aid will emerge and be translated into user requirements.

Method

Study design

A qualitative research design was chosen to examine the research questions. Semi-structured interviews were conducted with people with a visual impairment. With the design of a semi-structured interview more detailed information can be obtained than with a structured interview (Roto et al., 2011). Another advantage of semi-structured interviews is having the option to ask for explanations and examples (van Teijlingen, 2014). Some quantitative questions were added to make categorization of data easier. The interviews were conducted via telephone.

Respondents

Respondents were recruited with the help of Koninklijke Visio through social media and on a fair for people with a visual impairment. Semi-structured interviews were held with 14 respondents, data from one respondent are not included because no diagnosis could be made despite the fact there was loss of vision. Data from n=13 respondents was used. When

selecting the respondents, no requirements were made on gender, educational level, marital status and race as long as there was sufficient mastery of the Dutch language in speech. As the focus of this study is on middle-aged and elderly with a visual impairment, respondents had to be aged between 55 and 80 and had to live at home. respondents had a self-reported visual impairment with a gradual course and a vision less than 30% or a visual field less than 30 degrees. Hearing difficulties, mental disability or physical disability, which made physical activity even more difficult were exclusion criteria.

Procedure

Ethical approval for this study was obtained from the Ethics Committee of the BMS faculty of the University of Twente, case number 18905. respondents that met the inclusion criteria were informed about this study with an information letter (Appendix A). With this letter they were informed about what this study entailed, and that participation was completely voluntary. In case the respondent was recruited via social media, the informed consent (Appendix B) was not signed in the presence of the interviewer. In this case, the informed consents were sent with a self-addressed envelope to the respondent so they could return the filled in informed consents. The information letter was sent by mail. In case of recruitment on the fair, the information letter was given and the informed consents were signed immediately.

It was made clear that the respondent had the right to stop the interview at any time without submitting a reason. All interviews were audio recorded and transcribed verbatim. The average interview lasted 45 minutes. After conducting and transcribing the first two interviews a meeting with the supervisor was arranged with the aim of evaluating the interview process and to make changes in the interviews when needed. Changes in the order of the questions were made, the questions stayed the same.

Interview schedule

The semi-structured interviews that were used were developed based on the theory of planned behavior. The complete interview schedule can be found in Appendix C. the interview consisted of three parts. The first part, respondents were asked about demographics. The second part of the interview was about attitude, current physical behavior, and TPB variables. The questions in this part were constructed with the use of "constructing a theory of planned behavior questionnaire" by Ajzen (2010) and by using a table of elicitation questions from the book "health behavior and health education, page 83" (Ajzen, 2010; Glanz, Rimer, & Viswanath, 2017). Also, for each determinant, one quantitative question was

opposed. This was amongst other things about meeting the NNGB, the extent to which the respondent considered exercise important, the motivation to exercise. This was done on a 5-point Likert scale. Integrating this data made it possible to compare the different determinants. The third part of the interview consisted of questions regarding the attitude towards technology and intention to use specific technological aids that may assist in exercise were asked. Question about current technologies or preferred requirements in future technological aids and question about intention to use the technology, motivation and expected barriers were integrated in the third part of the interview. Three different cases were used to provide information about current technologies, respondents were asked about their opinions and experiences regarding similar technology.

Description of cases

The cases included several possible assistive technologies for increasing exercise. First a wearable pedometer which tracks steps. Goals can be set up within this device and users get physical signals in the form of vibrations. When goals are reached the vibrations are longer or when goals almost expire and are not reached yet the vibrations will be short (like 250 steps an hour). These signals can be set in between hours eg. from 8 am to 8 pm.

A google home device. Within this device a workout program can be installed through an app on a smartphone. The google home is completely voice controlled and reacts only with audio. The workout program contains options for exercises and explains what to do and which muscle groups are important for each exercise. During exercises it motivates to pull through with the exercises and count down the amount of repetitions.

The last device is a hydraulic fitness device that works with a personal card on which training data of each device is saved. These data are set by a fitness trainer of physiotherapist. The user can put the card in the card reader and the device sets up itself. This way the user does have to figure out with which weight it is working and there is less change of working with the wrong weights. The weight saved on the card can be adjusted with a plus and a minus button, the new data is being saved automatically on the card.

Analysis

Transcribing and Coding

All interviews were transcribed verbatim and additional analyses were carried out to identify patterns using inductive and deductive thematic analyses (Braun & Clarke, 2006). This was done with the method of constant comparison while coding. Initially, transcripts were read and re-read to familiarize with the data. Subsequently, deductive analysis was used

to analyze the first part of each interview. General codes that were compiled based on the themes in the interview guide to identify the determinants of behavior were; current exercise behavior, changes since visual impairments, attitude, social support, and perceived behavioral control. To identify the opinions about assistive technology the codes; current usage of technology, attitude towards technology, usefulness of described technology and requirements of technology were used. Inductive analyze was used in the third part of each interview to generate initial codes and determine further needs and preferences for future technological aids. While analyzing patterns and themes were noted, this resulted in clustering of codes by setting them into categories as described by Cohen, Manion and Morrison (2011)

Formulating determinants and user-requirements

Based on outcomes of the analyses, determinants and user-requirements were formulated. At first, the codes, themes and sub themes of the first part of the interview were analyzed. Expressions were transformed into determinants of behavior when they were described frequently. When possible, these determinants were translated into needs from the clients.

Expressions in the second part of the interview were transformed into user-requirements, which are needs that the target group deem important related to goals and functions of technological aids. Issues where translated into user-requirements when described frequently and by different respondents. An example of this generation from expression toward user-requirement is provided in Table 1.

Table 1. Generation of user-requirements.

User expression	Needs	User-requirement
Ik zit te denken aan enkelvoudig, ja wat bedoel ik daarmee, je hebt tegenwoordig apparaten met heel veel extra functies en dat is niet handig. (PA002) Niet al te ingewikkeld, dus niet te veel functies. (PA010)	Simple and clear device which is easy to use and has not too many functions	The device needs to be clear in usage.

Statistical analyses

Statistical analyses were performed using IBM SPSS 25.

First descriptive statistics of the sample were computed in order to see what the general results were and what the sample consists of. This was done by retrieving the mean and the standard deviation of the variable age, the extent to which the sample considered exercise as important and the attitude of social environment. An analyze of the frequencies of

exercise behavior was computed in order to measure actual behavior regarding the standards of the NNGB. Frequencies were computed of use of technologies, perceived usefulness and intention to use technology in order to compare these factors with each other.

Results

Demographics and exercise behavior

Table 2 shows the demographics of the sample of this current study. respondents with diverse eye conditions took part in this study. None of the respondents had a job at time of the interview, their eye condition caused most of them to quit their job, some were retired. The age of the respondents that entered this current study ranged from 55 to 78, with an average age of 63,5 years (SD = 7). The majority of the sample was male (69%) and 54% of the respondents reported they met the standards of the NNGB, 46% of the respondents said they met the standards somewhat.

Table 2.

Characteristics of the respondents

Respondent number	Gender	Age	Meets the NNGB	Eye condition
PA002	Male	63	Somewhat	Retinus pigmentosa
PA009	Male	60	Completely	Retinus pigmentosa
PA010	Female	69	Somewhat	Retinus pigmentosa
PA006	Female	57	Somewhat	Retinus pigmentosa + macula degeneration
PA003	Male	68	Completely	Macula degeneration
PA011	Male	67	Completely	Macula degeneration
PA008	Male	67	Completely	Macula degeneration
PA005	Male	57	Somewhat	Sigma retinopathy + no visual memory
PA001	Female	55	Completely	Uveitis posterior + glaucoma
PA004	Male	57	Somewhat	Cone-rod dystrophy
PA012	Male	71	Somewhat	Optic atrophy
PA013	Female	57	Completely	Nearsighted + hypersensitivity to light
PA014	Male	78	Completely	Visually impaired by rubella, later on failed retinal transplant

Behavioral change

Due to their visual impairment the respondents had undergone some behavioral changes with regards to physical activity. Most of the respondents indicated it was harder to get enough exercise since their visual impairment. Interestingly, three respondents mentioned that their exercise levels had increased since their visual impairment. These behavioral changes could be subdivided into different categories which can be found in Table 3.

Table 3.
Changes in behavior since visual impaired

		N	Example quote
Getting more exercise		3	"Sinds mijn slechtziendheid wandel ik veel meer dan voorheen"
Getting less exercise			
	Not able to walk longer distances	8	"Einden lopen durf ik alleen als er iemand anders bij is, maar niet alleen."
	Inability to ride a bike	5	"Het buiten fietsen moet je beëindigen, dat vond ik vooral heel lastig en jammer." "Ik kan niet meer zelfstandig fietsen"
	Mobility issues	3	"Ik mocht graag scooter en autorijden. Maar ja dat kan ik niet meer, ik heb mijn lidmaatschap bij de sportclub daardoor op moeten zeggen"

Note. N refers to the number of respondents that have addressed this particular category

Getting more exercise

Interestingly, there were three respondents who mentioned they actually got more exercise since their visual impairment. These respondents mentioned this was mostly due to the fact that they could not drive a car anymore and replaced the car trips with walks, eg. the car trips to the grocery store became walks to the store.

Getting less exercise

Three categories regarding getting less exercise were mentioned. Most of these had to do with being dependent of others. The respondents mentioned they were not able to walk longer distances on their own anymore. Also, the inability to ride a bike and other mobility issues were mentioned. Because of these issues, respondents had to cancel their gym membership and other sport related activities.

Determinants

Attitude

Exercise is seen as very important by these respondents as can be seen in Table 4.

Table 4.
Importance of exercise

		N
Importance of exercise	Very important	12
	Slightly important	1
	No opinion	0
	Not very important	0
	Not important	0

Note. N refers to the number of respondents that have addressed this particular category

Several positive and negative statements about being physical active were made, the respondents mentioned these as advantages and disadvantages of exercising. An overview of these and their sub-categories is provided in Table 5.

Table 5.
Attitude: advantages and disadvantages of exercising

		N	Example quote
Advantages			
	Feeling good physically	10	"Fit blijven is belangrijk op mijn leeftijd, ik wil nog veel zelfstandig kunnen doen"
	Feeling good mentally	9	"Het geeft me rust en ontspant me"
	Getting social contacts	6	"Je komt in contact met anderen, het breekt je wereld open"
	To not gain weight	5	"Ja ook om het gewicht he… om niet te zwaar te worden"
	Enjoying nature	1	"Ik geniet gewoon heel erg van de natuur"
Disadvantages			
	Being dependent from somebody else	5	"De afhankelijkheid die je hebt, dat is heel lastig"
	Physical impairments and fear because of previous accidents	2	"Ja ik ben een keer gevallen en toen brak ik mijn been"

Note. N refers to the number of respondents that have addressed this particular category

Advantages

Several advantages were mentioned. Advantages as feeling good physically and feeling good mentally were mentioned most. Staying fit and independent is an important factor of feeling good physically. Next to this, exercise causes relaxation of the mind and gives a positive feeling mentally. Other advantages mentioned were getting social contacts, to not gain weight and enjoying nature. Social contacts are important, especially for this group of respondents, since they do not have a social work environment anymore and have to get their social contacts elsewhere to ensure they do not become socially isolated.

Disadvantages

Only two disadvantages were mentioned when asked for disadvantages of exercise: Being dependent from somebody else and physical impairments and fear because of previous accidents. However, these are better defined as barriers to exercise. These and other barriers will be discussed later under perceived behavioral control.

Social support

Table 6.
Social support of the environment

		N
Opinions of social environment	Not important at all	0
	Not important	1
	No opinion	6
	Slightly important	1
	Very important	5
Social support is needed in exercise	Yes	3
	No	10

Note. N refers to the number of respondents that have addressed this particular category

Table 6 represents the opinions and the need of social support in order to exercise. The mean of the attitude of the social environment came out on 2.8, which means that the attitude regarding importance of exercising of the social environment scored just lower as

"slightly important". This was due to the fact that almost half of the respondents did not know the thoughts of their social environment or did not have a social environment anymore.

While interviewing, some beliefs and opinions emerged regarding social support. These were categorized in positive and negative beliefs and opinions.

Table 7.
Social support believes and opinions

		n	Example quote
Positive			
	Mental support	8	"Ja de waardering en complimenten die je krijgt zorgen er wel voor dat ik wel blijf fietsen"
	Practical support	5	"We gaan samen naar de sportschool en dan helpt m'n vrouw me op weg zeg maar, daarna doen we ieder ons eigen rondje"
Negative			
	Concerns of social environment	5	"Dan vragen mensen me of ik wel zeker ben dat ik dat nog kan doen, bijvoorbeeld met fietsen"
	Not wanting to be a burden	2	"Je wil geen last zijn voor anderen, dus vraag ik het maar niet en doe ik het maar niet"

Note. N refers to the number of respondents that have addressed this particular category

Positive beliefs and opinions

Positive beliefs and opinions of social support were mentioned by every respondent. The positive aspects mentioned were; mental support and practical support, from which mental support was most mentioned. The respondents mentioned that the mental support gave them a good feeling and motivated them to get on with exercising. Practical support was mostly support they really needed in order to exercise, like transportation.

Negative beliefs and opinions

Also some negative beliefs and opinions of social support were mentioned. The more negative aspects were; concerns of social environment and not wanting to be a burden. The concerns of the social environment withheld some respondents of exercising because they did not want their social environment to worry too much about them. Also, respondents did not want to be a burden for others. Constantly having to ask for help withheld them to perform certain exercise behavior.

Perceived behavioral control

Table 8 shows the perceived behavioral control and self-efficacy of the respondents. On the first statement most respondents said that they would not do particular exercise behavior if they were not a 100% sure they could do it independently. On the second statement, which measures the trust in own exercise behavior, almost all of the respondents (85%) claimed that they were sure about the possibility of meeting the NNGB. Earlier only 54% of the respondents reported they met the standards of the NNGB. It can be assumed that

perceived barriers in exercising is one of the reasons there is such a big difference between capabilities of meeting the NNGB and actually getting enough exercise regarding these standards.

Table 8.
Perceived behavioral control and self-efficacy

		N	**Frequency**
when I want to exercise, I am sure that I can do this independently despite my visual impairment	Not sure at all	0	-
	Not sure	0	-
	No opinion	0	-
	Slightly sure	6	46%
	Very sure	7	54%
I am confident that I can be moderately intensively active for half an hour a day, 5 days a week	Not true at all	0	-
	Not true	0	-
	No opinion	0	-
	Slightly true	2	15%
	True	11	85%

Barriers

People with visual impairments have a lot of barriers to overcome when exercising. When interviewing several barriers occurred. These barriers could be categorized as internal barriers and external barriers. Table 9 shows these barriers.

Table 9.
Internal and external barriers

		n	Example quote
Internal			
	Giving up independency	5	"Je moet altijd iemand anders vragen om je te brengen, je geeft je onafhankelijkheid op. Dat is lastig om onder ogen te komen"
	Fear or anxiousness	5	"Ik ben een x gevallen, sindsdien vind ik sommige dingen wel eng en vermijd ik die"
	Confrontation with handicap	4	"Als je naar buiten gaat word je altijd geconfronteerd met je handicap, en soms wil ik dat niet en blijf ik dus thuis"
	Energy level	2	"Soms heb ik er gewoon de energie niet voor om een stuk te wandelen, als ik mentaal al een drukke dag heb gehad bijvoorbeeld"
External			
	Weather circumstances	7	"Als het vriest ga ik zo snel niet meer naar buiten, dan haalt iemand anders ook voor mij de boodschappen etc. Ik ben veel te bang dat ik val en m'n been breek dan"
	Walkability of roads	3	"Het is best een heel gedoe om ergens te komen door dat er constant dingen zijn opgebroken, bestelbussen die half op het trottoir staan …"
	Other people's behavior	3	"Hier zit een fietspad en een voetpad … daar kwam iemand met een scooter, heel doelbewust op mij af rijden. En ... ja weet je dat, … dan ben je zo van je stuk gebracht"
	Physical complaints	3	"Ik heb ooit mijn heup gebroken gehad, daar heb ik snel last van met bewegen"
	Light influence	2	"Zonlicht is soms heel vervelend als je slecht ziet, daardoor wordt je zicht nog minder"
	Night blindness	2	"'s Avonds zie ik helemaal niets meer, dan kan ik de deur niet meer zelfstandig uit"
	Transportation issues	1	"Vervoer naar sportschool bijvoorbeeld is lastig te regelen"
	Incomprehension of others	1	"En daar kwam iemand naar me toe en die zei van "goh waarom heeft u een stok want u bent helemaal niet blind, ik zie dat u op uw telefoon zit te kijken"

Note. N refers to the number of respondents that have addressed this particular category

Internal barriers

Several internal barriers were mentioned by the respondents. Most of these barriers were mental like giving up independency, fear or anxiousness and confrontation with handicap. These mental barriers were very confronting for the respondents and at times these withheld them from exercising. Next to this, there was the energy level which was a barrier. Being visually impaired daily activities cost more energy than with normal vision. Due to this, respondents mentioned they were more tired and did not have the energy to exercise on a regular basis.

External

Also some external barriers were mentioned. These barriers mostly were barriers the respondent did not could control like; weather circumstances, walkability of roads, light influence, night blindness, incomprehension of others and other people's behavior. These all were barriers the respondent had to deal with without having anything to say or do about it. Next to this some external barriers were mentioned the respondent possibly could have some influence on like physical complaints and transportation issues. By taking these perceived barriers into account and learning how to deal with them some influence could be exerted on these factors, like taking rest when necessary, which may make exercise easier.

Attitude towards technology for exercising

Table 10 shows the current usage of smartphone and/or tablet. Most respondents used a smartphone, only two respondents who did not make use of a smartphone. In total 11 (84,7%) people made use of a smartphone of which 5 (38,5%) also made use of a tablet.

Table 10.
Usage of smartphone and tablet

		Frequency	Percent
Valid	No use	2	15,4
	Smartphone	6	46,2
	smartphone and tablet	5	38,5

Table 11 shows the experiences and opinions about the three provided technologies. This table shows; 1) If the respondents ever used a device like the provided technology before, 2) the perceived usefulness of the provided technology on the basis of a description of the technology and 3) the intention of ever using this particular technology in the future. Notable scores are the perceived usefulness of the google home and the hydraulic fitness device, both were relatively high. However, the intention to use on both devices was low.

This could be due to the fact that some of the respondents scored the device high on perceived usefulness but thought the device would not work for them or they thought they did not need any technological device to increase their exercise behavior. Also, the scores on the perceived usefulness and intention to use of the wearable pedometer are very different than the scores of the other two technologies. Where the intention to use of the google home and the hydraulic fitness device are more on the positive side, the intention to use of the wearable pedometer is relatively low. Reasons for this could be that many respondents found it a useful device but would not use one themselves. Also, the device has a lot of barriers for usage, devices as watches are very hard to read, and thereby not very useful for this target group.

Table 11.
Experiences and thoughts about new technologies.

	1) Used before		2) Perceived usefulness				3) Intention to use			
	No	Yes	Not useful	Not sure	Partly useful	Very useful	Not at all	No	No opinion	Possibly	Certainly
Wearable pedometer	6 (46%)	7 (54%)	3 (23%)	-	8 (62%)	2 (15%)	5 (39%)	2 (15%)	1 (8%)	3 (23%)	2 (15%)
Google home	10 (77%)	3 (23%)	1 (8%)	-	8 (62%)	4 (31%)	3 (23%)	3 (23%)	1 (8%)	5 (39%)	1 (8%)
Hydraulic fitness device	10 (77%)	3 (23%)	-	-	4 (31%)	9 (69%)	2 (15%)	1 (8%)	2 (15%)	8 (62%)	-

Note. Numbers refer to the number of respondents that have addressed this opinion

During the interviews some advantages, disadvantages and requirements emerged. These advantages, disadvantages and requirements were all put together to create user requirements for each technology.

Wearable pedometer

The wearable pedometer has more disadvantages than advantages, but advantages were more mentioned than disadvantages. The most important disadvantages were; distraction and frustration. The wearable pedometer is seen as motivating and can give insight in daily activity. Yet, the intentions to use are low, this could have something to do with the amount of user requirements the respondents mentioned.

Table 12 shows these advantages, disadvantages and user requirements of the wearable pedometer.

Table 12.

Advantages, disadvantages and user requirements of wearable pedometer.

		N	Example quote
Advantages			
	Motivating	5	“Ja, ik denk dat dit heel motiverend kan werken ja”
	Gives insights in daily activity	5	“Het geeft wel een goed beeld aan het eind van de dag of je goed bezig bent geweest ja”
Disadvantages			
	Works frustrating if goal is not reached	3	“Je bent te veel gesteld op doelen halen dan, en dat werkt frustrerend wanneer je het niet haalt”
	Device is distracting	3	“Ik zou alleen maar afgeleid worden of ik wel genoeg stappen haal”
	Display is too small	1	“Ik had er 1 maar die heb ik afgegeven, ik kan het niet aflezen, het beeld is veel te klein”
	Setting the device is difficult	1	“Het instellen van de stappenteller is lastig wanneer je bijna niets ziet”
User requirements			
	Device needs audio feedback	7	“Als er iets van audio feedback in zou zitten zou dat wel heel handig zijn ook, vooral wanneer je bezig bent met een functie opzoeken”
	Device needs to be clear in use	7	“Het moet wel duidelijk zijn wat het doet en in welke functie je bezig bent”
	Device needs to be easy to use	5	“Het moet wel makkelijk te gebruiken zijn, je moet niet iedere dag dat opnieuw moeten aanzetten en instellen etc.”
	The device may not be to small	5	“Het apparaatje op zich moet niet te klein zijn, het moet wel afleesbaar zijn voor ons. Het mag best een groot horloge zijn”
	Setting up the device needs to be simple	3	“Het instellen moet makkelijk gaan, via een app bijvoorbeeld”
	The device has to make good use of color	2	“Het kleurgebruik moet afgestemd zijn op slechtzienden, er moet geen rood led gebruikt worden bijvoorbeeld op een zwarte achtergrond”
	The device needs to make use of an app	1	“Het zou het makkelijkst zijn als de data ook via een app afleesbaar zijn, dan is het goed te gebruiken d.m.v. vergrotingssoftware op de telefoon”

Note. N refers to the number of respondents that have addressed this particular category

Google home

Advantages, disadvantages and user requirements of the google home can be found in table 13.

Table 13.

Advantages, disadvantages and user requirements of Google home

		N	Example quote
Advantages			
	Motivating	5	“Het is wel makkelijk even snel aan te zetten denk ik”
	Usable inside own house	5	“Wanneer je je huis niet meer uit kan is dit heel handig ja”
	Rises awareness of important muscles	5	“Het is goed dat het heel bewust aangeeft welke spieren belangrijk zijn bij de oefeningen”
	Clear explanation of exercises	4	“Die uitleg van de oefeningen is wel fijn ja”
	Controlled with speech	1	“Ja dat het met je stem bestuurbaar is is natuurlijk geweldig”
Disadvantages			
	Commands must be learned	2	“Je met even doorhebben welke commando’s je moet gebruiken”
	The device saves all of your personal data	1	“Het slaat al je gegevens op, dat vind ik wel naar”
	Affinity with technology is needed	1	“Je moet affiniteit hebben met technologie om het te gebruiken”
User requirements			
	Device needs to be easy to use	6	“Het moet makkelijk zijn in gebruik, het moet duidelijk zijn”
	Device needs audio feedback	5	“Het is wel handig dat het terug praat, dat maakt het heel makkelijk”
	Intensity level should be changeable	1	“Het intensiteitsniveau moet instelbaar zijn, voor beginners en gevorderden bijvoorbeeld”

Note. N refers to the number of respondents that have addressed this particular category

The google home has more advantages than disadvantages. Also, the advantages were more mentioned than the disadvantages. Most important advantages were that it works motivating, the device is usable at home and it rises awareness of important muscles.

Hydraulic fitness device

The hydraulic fitness device scored high on perceived usefulness. The respondents were enthusiastic about the fact that there was no need to struggle with pens and holes to set the right weight, it gave respondents the feeling that they could do this independently once they made it to the gym.

Most respondents mentioned that they would try it for once to see if it could work for them but foresaw problems with transportation to the gym which could withhold them to become a member at the gym.

The user requirements of the hydraulic fitness device can be found in Table 14. The most important requirements will be the use of audio feedback and the system needs to be easy to use. Next to these user requirements, the respondents mentioned that the set-up of the fitness hall itself had to be logical and spacious.

Table 14.
Advantages, disadvantages and user requirement of hydraulic fitness device

		N	Example quote
Advantages			
	Usage of personal card	7	"Dat alles op een kaart staat is ideaal, dan hoef je zelf niets in te stellen"
	More independent of others	5	"Je bent niet meer afhankelijk van anderen bij het instellen van het gewicht"
	Motivating to go to the gym	4	"Dit zou mij wel motiveren naar de sportschool te gaan ja"
	Weight regulation with buttons	3	"Dat er knoppen opzitten om het gewicht in te stellen is ook handig"
Disadvantages			
	Reading data of screens	3	"Het aflezen van data blijft lastig, ik wil graag weten hoeveel ik heb gelopen bijvoorbeeld"
	Set up of the fitness hall	3	"Die fitnesshallen worden zo vaak omgegooid, dan staat alles weer ergens anders, dat is lastig"
	Presence of other people	1	"Je ziet niet of er anderen aanwezig zijn, en als je dan te kort langs iemand loop kan het zijn dat je zomaar iets tegen je hoofd krijgt"
User requirements			
	The device needs to be easy to use	6	"De apparaten moet uniform zijn in gebruik en opstelling"
	Device needs to make use of audio feedback	4	"Het zou handig zijn als je audio feedback krijgt wanneer je het gewicht aanpast"
	Good color use and vividness of color needs to be adjustable	4	"De helderheid van de displays moet instelbaar zijn"
	Set up of fitness hall needs to be constant	3	'De positie van de apparaten moet niet steeds veranderen"
	The device needs to have clear buttons	2	"Misschien zelfs een brailleschrift op de knoppen zodat het duidelijk is"

***Note. N** refers to the number of respondents that have addressed this particular category*

The hydraulic fitness device has more advantages than disadvantages. Advantages were; the use of a data card, gives some independency back to the user and it is motivating. Most mentioned disadvantages were; the set-up of the fitness hall has to be spacious enough and reading the data from the displays stays difficult. Intentions to use this device are high, if they are in a gym or physio nearby.

User-requirements

Most common and important user requirements found were that devices need to be clear and easy to use. Controlling the devices needs to be as easy as possible and functions need to be clear. The system should come in its most simple form, to many functions, buttons etc. are confusing for people with a visual impairment. Also, the change of doing something wrong and disrupting the device becomes bigger when the device has more functions. The use of audio feedback within the system could minimize the changes of doing something wrong. Next to this, audio feedback makes the devices easier to use. Preferably, the system should work completely voice controlled. By doing this no buttons, screens etc. need to be used within the device. This makes the device as accessible to visually impaired as for not visually impaired users. Another user requirement is the size of the technology. The technology cannot be too small. When making use of screens in the devices, color use is an important factor. Next to this, the vividness of the color needs to be adjustable.

Discussion

In order to eventually develop an assistive technology that corresponds to the needs of people with a visual impairment this study aimed to obtain insights in the actual exercise behavior and the determinants of exercise behavior within people with a visual impairment. The second aim was to obtain on which degree this target group makes use of technology, how technology could be used in order to help exercising and which requirements these technologies must meet.

Main findings

What are the determinants of exercise in people with a visual impairment?

The first aim of this study was to determine what the actual behavior of the respondents was. Despite the fact that all respondents found it important to exercise on a regular basis only 54% of the respondents did meet the standards of the NNGB. This is in line with earlier research of Lindert and Breedveld (2013) who reported 53%. However, our study

was self-reported, there was no possibility to verify this, so actual exercise behavior is not studied. Though the numbers from our study are in line with research from Heagele, Hodge and Kuzob (2017). It has to be noted that the study sample of Heagele, Hodge and Kuzob (2017) is much larger (N=209), has a bigger age span (18-80) and the study is done in North America. An interesting result in our study is the fact that some respondents mentioned they actually became more physical active since their visual impairment. This was mostly because short car trips were replaced by walking trips. For future research actual behavior could be measured by giving each respondent a move monitor which needs to be worn for one week. By doing this a better distinction can be made between self-reported activity and actual activity.

Attitude towards exercising

Intention to be physical active and social support are the most important determinants to predict behavior (Haegele, Brian, et al., 2017). In contrast with the research of Heagele, Hodge and Kuzob (2017) most respondents of the current study did not have the intention to exercise more, despite the attitude towards being physical active was high. Respondents thought being physically active on a regular basis was important to maintain a good mental and physical health, which contributes to staying independent of others as long as possible. An explanation of this could be the fact that most of the respondents found housekeeping and daily chores moderately intensive due to their visual impairment. Also, the respondents who claimed they met the standards of the NNGB somewhat stated that it was mostly in the winter period that they did not meet the standards due to frost and slippery roads which made them anxious to get outside which is logical as people with visual impairment are twice as normal at risk of falling (Langelaan et al., 2007).

Necessity of social support in physical activity

Social support is one of the most important determinants to predict physical activity in visually impaired. In this study however, social support was low, however most respondents stated they did not need social support to exercise, but when they got some support it was motivating. On the other hand, Haegele, Brian and Lieberman (2017) stated that the social support was needed to overcome barriers as transportation issues etc. and thus mostly was physical support. In our study the respondents mostly mentioned getting mental support over physical support. The thoughts of the environment on physical activity did not withhold the respondents from being physically active. It can be assumed that in this study, in contrast to earlier research from Heagele, Brian and Lieberman (2017), subjective norm has less

influence on physical activity. For future research a distinction could be made between mental support and physical support and their importance in exercise behavior. By this, the difference in importance of mental and physical support can be studied.

Perceived behavioral control

No previous study about exercising with a visual impairment discusses this part of the theory of planned behavior. From our study it appears that the respondents score high on perceived behavioral control. They mention they know what they can and cannot do on their own. Furthermore, most of them (85%) were very sure they could meet the standards of the NNGB on physical activity but only 54% of the respondents actually claimed they met the standards. This contrast could have to do something with the barriers the respondents perceive. It could be that being physical active is possible and they could meet the standards, but it requires too much energy. Generally, the perceived behavioral control is high despite the barriers that are perceived.

Most of these barriers did not relate to barriers found in earlier studies, like lack of motivation was not mention in this study but was mentioned in earlier studies (Mulier instituut, 2018; VISION 2020, 2005). Also, some new barriers of being physical active emerge in this study, like amongst others walkability of roads, confrontation with handicap, incomprehension of others. Some of these barriers were more general barriers like the weather circumstances holding them back to take a walk, other barriers were more specific for the target group like being dependent on others.

The barriers emerged in this study could be divided in two subcategories: internal barriers and external barriers. In this study internal barriers were mental barriers, these included: confrontation with handicap, giving up independency, low energy level and anxiety. External barriers were barriers that were related to the physical health or environment. External barriers included among others incomprehension of others, light influence, physical complaints, walkability of roads and weather circumstances.

These two categories, internal and external barriers, can be subdivided in variable and stable barriers. Variable internal barriers are; energy level and mental barriers, stable internal variables would be confrontation with handicap and giving up independency. For external barriers the variable barriers are; weather circumstances and light influences. Stable barriers would be physical complaints, walkability of roads and the incomprehension of others. When asked for perceived behavioral control of situations most respondents mentioned adjustment to deal with the weather circumstances and light influence. Interestingly, no perceived control

was mentioned for the internal or stable external barriers, what could mean respondents do not know how to adjust to these barriers. In order to learn how to deal with the internal barriers as the mental ones like acceptation Koninklijke Visio could provide a training within their revalidation program to increase acceptation and help dealing with the condition. This could be e.g. in the form of acceptance and commitment therapy (ACT) (Hayes, Luoma, Bond, Masuda & Lillis, 2006). ACT is about learning to stop the meaningless fight with negative and annoying thoughts, emotions and physical sensation, to improve psychological flexibility and to reconnect with what is important in life. This could help dealing with incomprehension of other and confrontation with their own handicap.

The attribution theory of Kelley and Michela (1980) states that internal stable factors are attributed to competence, internal variable factors are attributed to effort, external stable factors are attributed to task difficulty and external variable factors are attributed to coincidence. So, the respondents only thought that they could control their behavior on a factor that is attributed to coincidence. One assumption that can be made here is that respondents lack feelings of competence and lack effort to control their own behavior. The revalidation program within Koninklijke Visio is something that could focus on these factors. By doing this, feelings of competence could be increased, by increasing these the effort to control own behavior could increase with it.

For future research the attribution theory of Kelley and Michela (1980) could be used during the study and alongside the theory of planned behavior (Ajzen, 1991) in order to divide the barriers into the four categories mentioned in this theory. In this current study, the theory is used to categorize barriers afterwards and nothing of this is mentioned in the result section. By using this theory during the study, it is possible to form more focused questions on different types of barriers. Next to this it will become easier to ask further questions in order to get a better picture of why and how these barriers occurred. Next to that it will become clear in which category most of the barriers are classified. When knowing this it also becomes clear if respondents have lack of feeling of competence or effort, or if exercising is just too difficult or relies on coincidence. Questions on perceived behavioral control could be focused on these categories of barriers. When using a human centered design, subsequently to the data collection intervention focused on the most common barriers could be developed, tested and analyzed.

How does the target group view technology and how can technology help with increasing exercise?

In the current study the respondents had a positive attitude regarding the use of technology, most respondents used a smartphone and other technological tools like Siri (a virtual assistant of iOS), magnification software and audio books. Also, the idea of an assistive technology for physical exercise was something the respondents were interested in. In order to give the respondents an idea of possible technological aids that could motivate and help getting enough exercise three divergent cases were presented.

Wearable pedometer

First case was a wearable pedometer which was linked to an app on a smartphone. Some of the respondents stated to have had some experience with similar technology. Because of the small design of those pedometers the respondents did not found them very useful, also a motivating element was missing which could ensure that the device would be used in the future. User requirements of this device as mentioned were need of audio feedback. This could be integrated but could give problems for the surrounding of the user. Also, the amount of feedback needs to be adjustable to the user preferences. A third possible problem could be reading the data in the app. The app has to have the possibility of voice over to make this data readable.

Google home

Second case was the google home. A device that could be used in and around house to adjust smart devices. The google home makes use of a virtual personal assistant. Whereas some respondents made use of Siri almost no respondents had experience with a similar technology as the google home which is a device on its own. The user requirements of the google home as mentioned were need of audio feedback and the device had to be easy to use. The google home is a device that only works on audio and audio feedback. With the user requirements emerged in this study the google home can be implemented as it is.

Hydraulic fitness device

Third a description of a hydraulic fitness device was presented. This device works with a card reader and a personal card with training data on it. The user requirements of this device also contained audio feedback. This audio feedback had to be in the form of feedback when weight was adjusted and start/stop signals when walking on a treadmill for instance. Barrier for usage was transportation to the gym and picking up the card at a desk, respondents found stated that a personal card who could be taken home would give them more independency.

User-requirements

The user-requirements that occurred during this study show that devices need to be clear and easy to use. Controlling the device needs to be easy and functions need to be clear. Use of buttons needs to be minimalized. The device should come in its most simple form. Next to this the use of audio feedback within the system is an important feature. By using this the user get automatically feedback on what is going on within the device and usage will be easier. By making usage easier, the device will be more attractive to use. A complete voice-controlled system would be the best in this case. When developing a wearable, the size is important. Most watches are too small for this target group, buttons and screens need to be bigger as normal for this target group to work. Next to this the use of color and adjustment of vividness is important when making use of screens within the technology. Not every color or color combination is readable for this target group. The use of red and orange e.g. which is used mostly is not readable for a lot of people with visual impairment. As well as color, vividness is an important feature in screens. Most people with visual impairment need to make use of dimmed lights and screens or else they cannot read them.

Use of theory of planned behavior

This study made use of the theory of planned behavior, which is a good theory to study determinants of behavior. In future research this theory can be used again but the focus should be on the perceived behavioral control. The attitude towards behavior and the social support in this recent study and prior studies are in line. The perceived behavioral control was never studied before, more research is needed. This study highlighted only a small part of the perceived behavioral control and with the barriers in being physical active that have emerged in this study some more research in perceived behavioral control and barriers is desirable. As said earlier, the attribution theory of Kelley and Michela can be used to categorize the perceived barriers. With categorization some further research of those barriers and possible interventions to overcome them could be designed.

At last, adding quantitative questions makes it possible to compare data on another level. More in-group comparisons are possible when using quantitative data as wel. Quantitative questions are more categorized, they provide a quick overview of answers and give possibilities to ask more in-depth questions when striking answers are given.

Use of technological devices

In this study only a short description of each assistive technology was used. In future research, the use of the technological devices themselves would be recommended to

Koninklijke Visio. In this study respondents could not mention possible difficulties of the technologies without using them. When using the same assistive devices as mentioned in this study some adjustments can be made before usage. Like the feedback system on the hydraulic fitness device was a user requirement that should be integrated on forehand. This way more possible difficulties in usage and more user requirements can be discovered. Also, the wearable should be replaced or left out because this device is too small and intentions to use were too low.

Strengths and limitations.

Strengths

With regard to the current study, several strengths and limitations can be named. The first strength of the current study is the use of a human-centered design approach. Including people with visual impairments have led to a better understanding of barriers in physical activity and better requirements of assistive technology. This made it possible to formulate user requirements for each assistive technology, which will most likely improve the implementation of future technological devices.

The second strength of this study is the use of quantitative questions in a qualitative study. The use of quantitative and qualitative data complemented each other, which made it possible to map and compare more data. Besides that, it gives the possibility to ask more in-depth question when quantitative data seemed striking like within the perceived behavioral control in this case.

A third strength is the use of already existing technological devices in the cases. No technological device has to be designed for possible future research. Some of technological aids of the devices could be expanded regarding the user requirements that emerged is this current study.

Limitations

One of the limitations of the current study is the small sample size (n=13), contributing a low internal validity (Campbell, 1986). By interviewing only thirteen respondents it is difficult to be sure saturation of information has occurred. Secondly, respondents in this current study were not screened on condition, progression of condition and the visual field they had. Therefore, there cannot be claimed this study sample is a good reflection of the target group. In order to get a good reflection, the study group needs to be more diverse in visual impairments. Also screening on visual field and percentage of sight is necessary in order to make a study sample that is representative for the whole population.

However, due to time limitations and limited possibilities to recruit respondents, among other things due to privacy legislation, this was the best diverse group attainable in this situation.

The third limitation of the current study was that nearly all respondents were approached on the same place, a fair for people with visual impairment. This could have led to a more uniform group than desirable, all the respondents approached here were active in daily life. Therefore, there is a possibility that this sample size is not a good reflection for the whole target group. Possibly this sample size was slightly more active in daily life than the whole target group. This makes results less generalizable.

A fourth limitation of the current study was the average age of the sample size. The average age of the respondents was 63,5 years, while the intention for the current study was to approach respondents aged 55 to 80. This could have contributed to an on average younger study group than desirable. Due to the low average age this sample size could be more active than the actual target group with more higher aged people. Therefore, in future study the sample size needs to be expanded with more respondents and screening needs to be done on age to get a good reflection of the whole target group and make results more generalizable.

Conclusion

Intention to exercise and actual exercise behavior are corresponding in this study. Social support seems to have less influence than thought within this study sample and perceived behavioral control is high within this sample. Reasons for not exercising enough could be the many different perceived barriers the respondents have to overcome when being physical active. For future research more in-depth research in behavior of this target group is necessary. This can be done with the theory of planned behavior (Ajzen, 1991), but also with the attribution theory of Kelly and Michela (1980). This attribution theory can be used to get a more in-depth image of the perceived barriers this group has to overcome in being physical active. With this, intention to exercise is an important determinant that needs further research, mostly because the results in this study are not in line with prior studies. Although respondents were positive about technology to support exercise, we suggest more research using actual prototypes or technologies which can be used. By doing this we learn more about the possible difficulties and requirements of the assistive technologies. The most important user-requirements that occurred were; the device needs to be easy to use; clear in use, the device should not be too small, the device needs to have audio-feedback or should be voice controlled, the use of color needs and vividness of screens needs to be adjustable.

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Appendix

A. Information letter.

Proefpersonen informatie ten behoeve van wetenschappelijk onderzoek getiteld:
Improving physical exercise in people with visual impairment using technology. Exploratory study

Geachte heer/mevrouw,

Ik zal me even voorstellen. Ik ben Hilde Jansen, student aan de Universiteit Twente. Momenteel ben ik bezig met afstuderen voor mijn master Health Psychology and Technology waarvoor ik stageloop bij Koninklijke Visio. Binnen Visio doe ik onderzoek naar bewegen bij ouderen met een visuele beperking.

Achtergrond van dit onderzoek
Uit onderzoek blijkt dat het voor mensen met een visuele beperking lastig is om voldoende te bewegen. Zij lopen tegen meer barrières aan wanneer zij willen gaan bewegen dan mensen zonder een visuele beperking. Toch is bewegen belangrijk en nog meer voor mensen met een visuele beperking omdat met bewegen het evenwichtsorgaan wordt gestimuleerd waardoor de kans op val incidenten en bijbehorende botbreuken wordt verminderd. In dit onderzoek wil ik erachter komen wat de meest voorkomende dingen zijn die het voor mensen met een visuele beperking lastig maken om te gaan bewegen en welke dingen juist helpen om te gaan bewegen.

Huidig onderzoek
Ik wil u daarom graag uitnodigen deel te nemen aan een interview om meer inzicht te krijgen in het bewegen met een visuele beperking. Hierbij gaat het voornamelijk om uw mening over bewegen, uw mening over technologie, de belemmeringen die het voor u lastig maken om te bewegen en de mogelijke invloed van de sociale omgeving op het bewegen. Ook zal ik u een aantal verschillende situaties voorleggen waarbij u enkele vragen krijgt over mogelijk gebruik van een technologisch hulpmiddel, wat uw mening is over technologische hulpmiddelen en waar een technologisch hulpmiddel volgens u aan moet voldoen om het makkelijk te kunnen gebruiken.

Wat houdt deelname in?
Wanneer u besluit deel te nemen aan het interview zal ik contact met u opnemen voor het maken van een afspraak. Het interview zal afgenomen worden via telefoon of skype. Van het interview zullen audio opnamen worden gemaakt. Dit zal nodig zijn voor de latere uitwerking van het interview. Deze audio opnamen worden na uitwerking vernietigd.
Het interview zal ongeveer 45 minuten van uw tijd in beslag nemen. Eventueel is er de mogelijkheid dat de onderzoeker bij u thuis langs komt voor het afnemen van het interview mocht dit gewenst zijn.

Vertrouwelijkheid

De gegevens die tijdens het interview over u verzameld worden zullen vertrouwelijk behandeld worden volgens nationale regels en wetten, waaronder de Wet Bescherming Persoonsgegevens.

Als u besluit deel te nemen aan dit interview geeft u toestemming voor het volgende:

- De hoofdonderzoeker en toezichthouders hebben toegang tot uw dossier. Zij zijn verplicht deze geheim te houden.
- Indien u zou beslissen om uw deelname aan het onderzoek te stoppen dan worden de tot dan toe verzamelde gegevens niet gebruikt in het onderzoek.

Vrijwillige deelname

Deelname aan dit interview is geheel vrijwillig. Als u niet wil deelnemen hoeft u daarvoor geen reden op te geven. Ook wanneer u nu toezegt deel te nemen aan het onderzoek kunt u dit ten alle tijden zonder opgave van reden weer intrekken.

Vragen

Mocht u vragen hebben over dit onderzoek alvorens te beslissen of u wil deelnemen dan kunt u terecht bij Hilde Jansen.
U kunt mailen naar: h.jansen-2@student.utwente.nl, ik zal zo spoedig mogelijk contact opnemen met u, desgewenst kan dit telefonisch. Vermeld dan uw telefoonnummer zodat ik contact op kan nemen met u.

B. Informed consent.

Toestemmingsverklaring

Improving physical exercise in people with visual impairment using persuasive technology.

Doel van het onderzoek:

Dit onderzoek wordt geleid door Hilde Jansen. U bent van harte uitgenodigd om deel te nemen aan dit onderzoek. Het doel van dit onderzoek is het in kaart brengen van factoren die bijdragen aan het in standhouden van een zittende levensstijl en het opstellen van mogelijke randvoorwaarden voor technische hulpmiddelen voor volwassenen met een visuele beperking.

Vertrouwelijkheid van gegevens:

Uw privacy is en blijft maximaal beschermd. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegeven van of over u naar buiten gebracht, waardoor iemand u zal kunnen herkennen.
Voordat gegevens worden gebruikt worden uw gegevens anoniem gemaakt. Uw naam zal worden vervangen door een combinatie van getallen.

Verklaring respondent:

Met mijn ondertekening bevestig ik dat ik de informatiebrief voor deelname aan dit interview in verband met het onderzoek naar bewegen bij mensen met een visuele beperking heb gelezen en dat ik deze informatie begrijp. Ik heb voldoende tijd gehad om over mijn deelname na te denken en ben in de gelegenheid geweest om vragen te stellen. Deze vragen zijn naar tevredenheid beantwoord.

1. Ik geef toestemming voor deelname aan bovengenoemd interview.
2. Ik weet dat mijn deelname geheel vrijwillig is en dat ik mijn toestemming op ieder moment kan intrekken zonder dat ik daarvoor een reden hoef op te geven.
3. Ik geef toestemming dat bevoegde personen van het onderzoeksteam, leden van de toetsingscommissie en toezichthoudende autoriteiten inzage kunnen krijgen in mijn gegevens.
4. Ik geef toestemming om audio opnamen te maken van het interview zodat dit later ad-verbum kan worden uitgewerkt.
5. Ik geef toestemming om de gegevens te verwerken voor het doeleinde zoals beschreven in de informatiebrief.

Naam proefpersoon:	Handtekening:	Datum:
……	……..	……

C. Interviewguide and cases.
Themalijst

1. Gebruiker
    a. Attitude tegen over bewegen
    b. Vernomen barrières bij bewegen
    c. Sociale omgeving
2. Casus
    a. Casus
        i. Wearable
        ii. Google Home Fitness workout
        iii. Fitness
    b. Bruikbaarheid van het besproken systeem
    c. Mogelijk gebruik van het systeem
    d. Mogelijke verbeteringen van het systeem
    e. Randvoorwaarden van systemen

Voorbereiding en introductie

Voorbereiding

- Zorg dat je alleen zit in een kamer.
- Zorg dat de respondent goed te verstaan is, telefonisch en via skype extra goed.
- Geef aan dat je het interview gaat opnemen en dat de opname alleen wordt gebruikt om een gespreksverslag te maken en dat de opname na afloop van het onderzoek wordt vernietigd.
- Vraag aan de respondent of hij/zij het goed vindt dat het gesprek wordt opgenomen.
- Pak de nodige materialen en zet het opnameapparatuur klaar.
- Laat de respondent de toestemmingsverklaring in tweevoud ondertekenen en doe dat zelf ook.
- Geef één van de exemplaren aan de respondent, het andere exemplaar dient gearchiveerd te worden.
- Geef aan dat je, voordat je van start gaat met het interview een test wild oen met het opnameapparaat.
- Schakel het apparaat in en spreek: “Test, datum van de dag en tijdstip”
- Vraag aan de respondent of hij dit wil herhalen.
- Spoel de opname terug en verzeker jezelf ervan dat de geluidsopname goed is. Pas zo nodig het geluidsniveau of de opstelling aan en herhaal de test totdat de opname goed is.
- Kondig aan dat je klaar bent om met het interview te beginnen.

Introductie

"Nogmaals hartelijk dank dat u wil mee werken aan dit interview. Door het afnemen van interviews proberen we inzicht te krijgen het dagelijks bewegen van mensen met een visuele beperking. Ook proberen we samen met u een aantal randvoorwaarden te ontdekken waar een technologisch hulpmiddel aan zou moeten voldoen."

"Uw persoonsgegevens worden strikt vertrouwelijk behandeld en de gegevens die u tijdens het interview verstrekt worden anoniem verwerkt en zijn op geen enkele manier tot u te herleiden."

"U heeft de mogelijkheid achteraf de uitgetypte versie van dit interview te ontvangen, hiervoor kunt u contact op nemen met mij."

"Ik wil u vragen om zo uitgebreid mogelijk te antwoorden, ik hoor graag al uw ervaringen met betrekking tot bewegen. Ik beschouw u als expert op dit gebied en wil graag van u leren en samen met u kijken naar mogelijkheden om bewegen makkelijker of leuker te maken."

"Wanneer u iets niet snapt of u kunt het niet volgen, laat dit alstublieft weten zodat ik helderheid kan verschaffen."

"Geeft u alstublieft aan wanneer u vragen niet snapt, of niet wil beantwoorden. Neemt u alle tijd die u nodig heeft, ik snap dat dit een confronterend onderwerp kan zijn"

"Heeft u nog vragen vooraf?"

Leeftijd:

Geslacht:

Hoogst afgeronde opleidingsniveau:

Hoe lang bent u al slechtziend?:

Aard van de aandoening:

Vragenlijst

1. **Bewegen**

1.1 Attitude tegenover gedrag

Wat betekend bewegen voor u?

In hoeverre vindt u het persoonlijk belangrijk om in beweging te blijven?

- □ **Helemaal niet belangrijk**
- □ **Niet belangrijk**
- □ **Geen mening**
- □ **Enigszins belangrijk**
- □ **Heel belangrijk**

Wat motiveert u of motiveert u juist niet om te bewegen?

Waarom motiveert dit u?
Waarom motiveert dit u juist niet?

Vind u bewegen leuk om te doen? Wat vindt u er leuk aan?

Waarom is dit leuk?

Wat vindt u niet leuk aan bewegen/Waarom vindt u bewegen niet leuk?

Wat zijn dingen waardoor bewegen misschien weer leuker wordt?

Wat houdt u tegen om te bewegen?

Wat zijn voordelen van bewegen?

1.2 **Gedrag**

"De overheid heeft een zogenaamde norm gezond bewegen opgesteld. Volgens deze norm zouden volwassenen 5 dagen in de week minstens een half uur matig intensief moeten bewegen. Een stuk wandelen of fietsen wordt gezien als matig intensieve beweging. Ongeveer 50% van de mensen met een visuele beperking haalt deze norm. Bij mensen zonder visuele beperking is dit 63%."

Wat vindt u van deze richtlijn?

Op welke manier probeert u zelf in beweging te blijven?

Welke manieren?

Hoe vaak doet u dit per week?
Hoe lang doet u dit ongeveer per x?

In hoeverre voldoet u aan deze richtlijn?

- □ **Ik voldoe volledig aan deze richtlijn**
- □ **Ik voldoe enigszins aan deze richtlijn**
- □ **Ik voldoe niet aan deze richtlijn**

Wat zijn de grootste veranderingen in beweging sinds u slechtziend bent?

1.3 Sociale norm (Normative influence)

Wat denkt uw omgeving over het belang van bewegen?

- □ **Heel belangrijk**
- □ **Enigszins belangrijk**
- □ **Geen mening**
- □ **Niet belangrijk**
- □ **Helemaal niet belangrijk**

Ontvangt u vanuit uw omgeving wel eens aanmoediging om te bewegen?

Ontvangt u vanuit uw omgeving ook wel eens ontmoediging om te bewegen?
Waarom is dit voornamelijk?

Wie zijn de mensen die u aanmoedigen of ontmoedigen?

Trekt u zich iets aan van deze aanmoediging of ontmoedigingen?

Zijn er mensen in uw omgeving die u zouden kunnen helpen om meer te bewegen?
Op welke manier zouden ze kunnen helpen?
Zouden anderen uit uw niet directe omgeving hier ook mee kunnen helpen?

1.4 Perceived behavioral control + self-efficacy

Vind u het lastig om voldoende te bewegen? (Volgens de eerder genoemde norm)

Wanneer ik wil bewegen ben ik er zeker van dat ik dit zelfstandig kan.

- □ **Helemaal niet zeker**
- □ **Niet zeker**
- □ **Geen mening**
- □ **Enigszins zeker**
- □ **Heel zeker**

Ik heb er vertrouwen in dat ik een half uur per dag, 5 dagen in de week matig intensief actief kan zijn.

- □ **Helemaal niet waar**
- □ **Niet waar**

□ **Geen mening**
□ **Enigszins waar**
□ **Waar**

Waarom is dit?

Welke factoren maken het soms lastig om voldoende te bewegen? Denk hierbij aan alle soorten van beweging die u zou willen uitvoeren.

Zijn er nog andere factoren?
Zijn er nog factoren op ander gebied? (Bijv. persoonlijk, vervoer etc.)
Waarom zijn dit belemmeringen voor u?

1.5 Intentie

In hoeverre heeft u motivatie om te gaan bewegen?

□ **Ik heb voldoende motivatie om te bewegen**
□ **Ik heb enigszins motivatie om te bewegen**
□ **Ik heb te weinig motivatie om te bewegen**
□ **Ik heb helemaal geen motivatie om te bewegen**

Over het algemeen genomen, zou u dan meer willen bewegen in het dagelijks leven?

2. Technologie

2.1 Gedrag en technologie

Maakt u in het dagelijks leven gebruik van een smartphone of tablet/Ipad?

Hoe staat u tegenover het gebruik van technologie in het algemeen?

Is er naar uw mening voldoende technologie beschikbaar voor uw doelgroep?

Heeft u interesse in een technologie die zou kunnen helpen om bewegen makkelijker te maken?

3. Casussen

Casus 1: Wearable

Een stappenteller die u om uw pols draagt. Deze houd bij hoeveel u loopt. Wanneer u te weinig beweegt geeft het horloge een signaaltje door middel van een korte trilling of een geluidje. Dit zal ieder uur gebeuren wanneer u geen 250 stappen per uur dreigt te halen. Het tijdsbestek kunt u zelf instellen, u kunt bijv. de meldingen laten starten na 10 uur s ochtends en laten doorlopen tot 20 uur s avonds. Binnen deze uren zal het horloge een melding geven. Wanneer u uw dagelijkse aantal stappen hebt gehaald zal het horloge een langere trilling geven om u ervan op de hoogte te stellen dat uw doel is bereikt.

Casus 2: Google Home Fitness workout

Google Home is een technologie die u kan helpen in huis met simpele handelingen. Zo kan het op het moment de temperatuur van uw thermosstaat aanpassen. Google home is spraakgestuurd, dit betekend dat u kunt praten tegen het apparaat en deze kunt vragen om bijvoorbeeld een app te openen op uw smartphone. In de Google Home is een standaard

fitness programma, deze kunt u gebruiken om thuis te bewegen. U kunt uw apparaat vragen de app te openen, de app zal u vervolgens via spraak door verschillende oefeningen heen helpen. Als eerst geeft het de mogelijkheid om een oefening uit te leggen, of om direct te starten wanneer u bekend bent met de oefening. Ook moedigt het systeem je aan om door te gaan, geeft aan welke spieren belangrijk zijn voor de verschillende oefeningen en telt af wanneer je bijna klaar bent met de oefening.

Casus 3: Fitness voor visueel beperkte mensen

Een reguliere fitness is vaak lastig te betreden voor visueel beperkte mensen. In deze fitness werken de toestellen echter hydraulisch en met een kaart lezer. Ieder lid krijgt een persoonlijke pas waarop de gegevens staan van deze persoon. De eerste keer fitness wordt samen met de cliënt een ronde gemaakt op alle toestellen, de begeleiding legt uit en stelt een gewicht in. Dit gewicht wordt opgeslagen op de persoonlijke kaart van de cliënt. Een volgende keer hoeft de client alleen de kaart in de kaartlezer te doen en de machine stelt zelf het juiste gewicht in. Eventueel kan het gewicht aangepast worden door middel van een toetsen systeem naast de kaartlezer. Het aangepaste gewicht wordt via audiofeedback benoemt zodat de cliënt weet met welk gewicht er gewerkt wordt. De gegevens worden opgeslagen op de persoonlijke kaart, deze kan verbonden worden met een app waardoor de client zelf de gegevens terug kan halen en eventueel vergelijken met vorige trainingen.

Heeft u ervaring met soortgelijke technologie?

Wat vindt u goed/nuttig/zinvol aan deze technologie?

Zou deze technologie u motiveren om te gaan bewegen?
Waarom wel/niet?

Zijn er ook dingen aan deze technologie welke lastig voor u zijn?
Zou dit verbeterd kunnen worden? Op welke manier?

Wat zou u hinderen om zoiets te gebruiken?
Waarom zou dit u hinderen

Denkt u dat u in de toekomst zoiets zou gebruiken?

- □ **Helemaal niet**
- □ **Niet**
- □ **Geen mening**
- □ **Mogelijke wel**
- □ **Zeker**

Waarom wel/niet?

Welke voorwaarden zou een technologie moeten hebben voor mensen met een visuele beperking om bruikbaar te zijn?