The use of virtual reality in patients with rheumatoid arthritis suffering from chronic pain

Master thesis

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Abstract

Background.
Patients with rheumatoid arthritis (RA) are often suffering from pain. Most of the time treatment with disease-modifying anti-rheumatic drugs (DMARDs) is effective in reducing nociceptive pain, however, some patients experience nociplastic pain and are still suffering from chronic pain. Since this treatment is ineffective in reducing this chronic pain, another treatment is necessary. Therefore, virtual reality (VR) can be a solution, since VR focuses on distraction, education and visualisation of how pain works, which can help patients manage their pain. Several studies showed that VR treatment has promising effects on reducing chronic pain. However, its efficacy for RA patients is still unclear.

Objective.
The primary aim of this pilot study is to investigate the feasibility and applicability of using virtual reality at home in patients with RA suffering from chronic pain. The secondary aim was to get indications of VR treatment's possible efficacy in reducing pain intensity, which can be used for the upcoming randomized controlled trial (RCT). This RCT will further examine the effects of VR on chronic pain.

Methods.
A longitudinal pilot study was conducted involving the Reducept intervention at the rheumatology department of Medisch Spectrum Twente (MST). For this study, a mixed-methods approach is used. Seven patients with RA suffering from chronic pain participated in this study. Pico VR goggles with the Reducept application were used. Reducept is a digital training program designed for people suffering from chronic pain. Participants used the VR goggles for 8 weeks at home. The primary outcome variables were technical difficulties, satisfaction and cybersickness. These variables are necessary to determine the feasibility. The secondary outcome variables were the type of pain, pain intensity, quality of life and self-efficacy. These variables are necessary to determine the applicability. These variables were measured using the virtual reality sickness questionnaire (VRSQ), generalized pain questionnaire (GPQ), numerical pain rating scale (NRS), arthritis self-efficacy scale (ASES) and 36-item short-from health survey (SF-36) respectively. The VRSQ results are displayed in a heatmap, to see the differences before and after VR use. The GPQ results were summed up to check if the score is higher than ten. The NRS results were presented in a graph, to show the progress in 8 weeks. The SF-36 and ASES results were divided into different categories, to determine each independent score.

Results.
Seven patients participated in the study, with three of them having been part of an earlier cross-sectional pilot study. One patient dropped out due to cybersickness, while another completed the study without using the VR goggles. The remaining five participants completed the study as intended. Most participants did not experience deterioration of virtual reality sickness symptoms, except for one participant whose symptoms worsened. Fatigue was the most reported symptom, but its severity remained the same or even improved after VR use. Overall, VR did not worsen the participants' symptoms. Besides, the VR goggles were fun and easy to use. With regard to the exercises, it can be made more challenging. There were no unsolvable problems that occurred by using VR at home. Three of the five participants are experiencing less pain after using VR, however, the pain scores fluctuate a lot. The scores for quality of life and self-efficacy are some points higher after the VR treatment.

Conclusion.
This study demonstrated good feasibility of the VR treatment at home. To keep users engaged, challenging and diverse exercises are recommended. The applicability of the treatment remains limited, only small improvements are measured. However, these results give promising indications for further research, including a longer study period and investigation of different VR applications.

Contents

1 Introduction

Given the complexity of chronic pain in rheumatoid arthritis (RA) patients and the limitations of existing treatments, alternative treatments are necessary to treat chronic pain and improve the patient's quality of life.
RA is an inflammatory and chronic autoimmune disease, which causes inflammation of the joints [1]. Autoimmune diseases are caused by an unwarranted immune response of an organism against its own normal body constituents, often resulting in an imbalance between pro-inflammatory and anti-inflammatory cytokines. RA is the most prevalent inflammatory joint disease in adults, with a worldwide prevalence of 0.3% to 1% [1]. The typical symptoms of RA patients are pain, stiffness, and warm and swollen joints [2]. One of the primary consequences of RA is pain, which often goes along with morning stiffness, sleep disturbance and fatigue, which is called pain interference [3]. Pain interference refers to the impact that pain has on different aspects of a person's life. It describes how pain can hinder the self-efficacy of a person to engage in daily activities. This leads to lower health status and a worse quality of life [4]. Another major consequence of pain in RA patients is work disability, which affects 20% to 30% of the patients [5]. This can have a negative effect on psychological and emotional well-being [6]. For many patients, pain is the main reason to have a consultation with a rheumatologist. They mostly rate their pain as one of the highest priorities for improvement [7]. There are differences in pain over time between men and women [3]. At the beginning of the disease, men experience worse pain. However, women have less improvement in pain during the first year of treatment. So, women are identified with worse pain over time than men. In conclusion, the treatment for improving pain needs more attention in research.

The treatment of RA patients is a continuous process, their disease activity should be evaluated multiple times per year [2]. The current medication consists of disease-modifying anti-rheumatic drugs (DMARDs) to suppress the inflammation of the joints, and thus the disease activity [8]. Another commonly used class of medication are non-steroidal anti-inflammatory drugs (NSAIDs), which effectively control pain, inflammation and stiffness [9]. NSAIDs should always be used in combination with other medications because only NSAIDs do not slow down the progression of the disease. The use of DMARDs in the early stage of the disease slows down the progression of the disease and strongly improves the prognosis. These DMARDs ensure that an increasing number of patients experience low disease activity [8]. The disease activity of RA patients is measured with the disease activity 28-joint count score (DAS28) [10]. This score consists of four different measures; tender joint counts (TJC), swollen joint counts (SJC), erythrocyte sedimentation rate (ESR) and patients' general health. A higher DAS28 score means a higher disease activity. A DAS28 score lower than 2.6 means that the patient is in remission [4]. The level of disease activity is low for a score lower than 3.2, moderate for a score between 3.2 and 5.1 and high for a score higher than 5.1.
In most cases the medication treatment is effective, because of its effectiveness in reducing inflammatory symptoms [7]. However, more than 75% of the RA patients continue to suffer from pain, even when having a low disease activity following the DAS28 criteria [11]. Another situation can occur where the DAS28 is high and the pain complaints are still present, but medication does not have any effect on the disease activity. This is the case when patients have a lot of tender joints, a few or no swollen joints, a low ESR and low general health, which also leads to a high DAS score. So, the DAS28 score is not always representative and pain can be present even when there is no clinical evidence of disease activity. Medication treatment is often used in combination with physiotherapy. Physiotherapy is useful in helping patients manage their diseases. Physiotherapists use different strategies to help patients reduce pain intensity. Education is an important aspect that is often used to explain to patients about their disease and condition and give options to improve their quality of life. However, physiotherapy is not effective for all patients to reduce their pain intensity [12].

The pain complaints in RA patients are challenging to treat effectively. Therefore, the mechanisms behind this pain are important to understand, to choose the right treatment. RA patients experience musculoskeletal pain, this pain can be classified into three types of pain; nociceptive pain, neuropathic pain and nociplastic pain [11]. The first type of pain is nociceptive pain, which is an adaptive and high-threshold pain [13]. Nociceptive pain is the early-warning protective system of the body. It is essential to detect and minimize contact with damaging or noxious stimuli, and thus prevent damage to the body. Therefore this type of pain is essential for maintaining bodily integrity. Nociception is the process in which nociceptors detect stimuli produced in case of tissue damage or inflammation [14]. These nociceptors convert the stimuli into an electrical signal, that is sent to the peripheral nerves. If the electrical signal is high enough, it will reach the threshold. In that case, the transmission of the electrical signal towards the brain will start, which travels along the ascending pathway. The brain will signal this as pain. However, via the inhibitory descending pathway, the nociceptive information is suppressed [15]. This type of pain can be treated with NSAIDs, these drugs cause pain relief by decreasing the sensitivity of nociceptors. Due to this type of medication, patients with nociceptive pain often experience less pain after treatment.
The second type of pain is neuropathic pain which is caused by a lesion or disease of the somatosensory nervous system, in other words, nerve damage [16]. So, the pain persists in the absence of harmful stimuli. Patients suffering from neuropathic pain often report a lower quality of life and used pain medication more often. RA patients experience symptoms that look like symptoms of neuropathic pain, however, there is no nerve damage, which means it is not neuropathic pain. RA patients experience these symptoms, because of deregulation of pain mechanisms. These symptoms may represent central sensitisation, which is a form of nociplastic pain. This third type of pain is defined as pain that arises from altered nociception although no clear evidence of actual or threatened tissue damage causing the activation of peripheral nociceptors or evidence for disease or lesion of the somatosensory system causing pain [11]. Central sensitisation is the increased responsiveness of nociceptive neurons, this hypersensitivity lies in the central nervous system. Altered nociception causes hyperalgesia, which means that the pain sensitivity is increased [17]. A stimulus that usually provokes pain now provokes increased pain sensitivity. Another problem that is caused by nociplastic pain is allodynia, which causes pain due to a non-painful stimulus. In this case, people often experience pain from softly touching their skin. This nociplastic pain could be the reason for chronic pain in RA patients, where chronic pain lasts longer than 6 months. This is mainly caused by the imbalance between the pain stimulus and the pain suppression. If the pain stimulus input is larger than the pain suppression, this results in pain perception [18]. This nociplastic pain perception also depends on past cognitive activities [19]. In conclusion, nociceptive pain and neuropathic pain can be treated with medication. For nociplastic pain and thus chronic pain, medication is not effective and another treatment is necessary.

Chronic pain is not only affected by stimuli and sensitisation but also by previous experiences of pain, neuroplasticity, pain memory and stress [19]. This makes it difficult to treat chronic pain in the right way since pain is different for each person, because of the different biological and psychological factors that influence pain. Medication often reduces the disease activity of RA patients as well as nociceptive pain complaints. However, the pain intensity of people experiencing nociplastic pain is not reduced. So, several treatments like medication and physiotherapy, are not always effective in reducing all types of pain. Therefore, additional treatment is needed to reduce nociplastic pain, like behavioural treatment.
Virtual reality (VR) can be a good solution since it uses different types of behavioural treatment. Virtual reality is a system that creates a computer-generated world. This world can be reached by using VR goggles. When wearing these VR goggles, the user will be fully immersed in the vision field of the VR environment and can also interact with it [20]. Immersion in a VR system refers to the level of sensory input generated by the system through visual, auditory, tactile, and olfactory stimuli [21]. It determines the extent to which users feel deeply engaged in the virtual environment.

On the other hand, presence in a VR system is the user's subjective sense of being present within the virtual world while using the system. It reflects the feeling of "being there" in the virtual environment. Both immersion and presence contribute to the overall VR experience, with immersion directly influencing presence by enhancing the user's sense of being present in the virtual world [21]. The immersion and presence ensure that the user gets distracted from the normal world and has less attention to process incoming pain signals [22]. Distraction is one of the reasons that VR can reduce acute pain [21]. However, distraction on its own can not reduce chronic pain, therefore types of behavioural treatments need to be involved. like behavioural therapy, visualisation, stress relief and education. These aspects are often processed in different VR environments. These behavioural treatments are important to treat the other factors that influence chronic pain, like psychological and cognitive factors.
Virtual reality interventions need to meet five characteristics to be effective for acute pain management [23]. When all these criteria are met, a good VR environment is reached, which is fully focused on the immersion and presence of the environment. In that way, the VR environment gets users distracted from the normal world and the VR seemed to be perfect for reducing acute pain complaints. To be effective in chronic pain reduction, types of behavioural treatment need to be added. So, the VR environment needs to meet the following criteria:

- The user needs to feel present in the virtual world, when this is the case, the user is distracted from adverse stimuli. Increased presence is associated with a VR that is more effective in pain management.
- Interactivity between the virtual world and the user is important. It supports physical involvement and pain tolerance.
- Social interaction in the virtual world can help the user with distraction from the real world.
- Personalization of the virtual world can be effective, users can decide what works best for them.
- The embodiment of the avatar in the virtual world can help the user to feel fully immersed.

Several studies showed that the use of VR could be a solution to help people manage their chronic pain [24, 25, 26, 27]. These studies did however not focus on VR treatment at home in RA patients, which is why this still needs to be investigated. However, looking at the results of these studies can shape expectations for RA patients. These studies focus on the feasibility and applicability of VR, which need to be defined first. Feasibility in this context refers to whether or not the treatment of RA with VR from home is practical. Applicability, on the other hand, evaluates the effectiveness and relevance of reducing chronic pain.
Participants who participated in earlier studies including VR treatment did not report any technical difficulties [24]. They also not reported any adverse effects when using the VR device [25]. Participants reported that the VR device was enjoyable and comfortable to use [26]. They rated the VR device with high levels of satisfaction. They were involved in the treatment and considered VR as a useful treatment [27]. The use of VR causes cybersickness on a low level, which has no negative effect on the VR use [24]. Besides, the high engagement of participants and their satisfaction combined with few adverse effects support the feasibility of VR for chronic pain [24]. As well as the positive and comfortable experiences with VR [26]. All studies showed positive outcomes in pain reduction and self-reported disability, which give promising effects for the applicability of the treatment. However, they also acknowledged the need for further research with larger study populations [24, 25, 26, 27]. Given the good feasibility and applicability of using VR at home, there are potential benefits to further research [24].

While there is a variety of VR applications available at the moment, this research focuses on VR goggles with the Reducept application installed. Nowadays, Reducept is used by over 200 chronic pain professionals in the Netherlands [28], who discovered the benefits of adding Reducept to their treatment program. Reducept was developed specifically for patients with chronic pain and is based on scientific research [29, 30, 31]. Different studies are performed with the Reducept application, which gives promising effects on reducing chronic pain [32]. However, the VR treatment for RA patients at home is not investigated yet.
Reducept is an exercise program that uses VR to reduce chronic pain [28]. It uses different aspects of behavioural treatments. Behavioural treatments focus on changing behaviour [33]. In this case, it is used to change maladaptive thoughts, feelings and behaviours, such as the experience of pain. Previous studies showed that behavioural treatment reduces the severity of chronic pain [24, 25]. Reducept distracts patients from their pain, which makes them experience it less. The different aspects of behavioural treatment that Reducept uses are cognitive-behavioural therapy, acceptance and commitment therapy, eye movement desensitization and reprocessing, pain education, mindfulness techniques, and gamification. All different aspects were processed in the different games in Reducept. These games represent a journey through the nervous system, to learn how pain works in the body. The goal of Reducept is to train the brain to deal with pain in a different way with different behavioural treatments [28]. This is important to treat nociplastic pain since the brain has a big influence on the pain intensity.

The different aspects behind Reducept need a better explanation to understand the working mechanisms for improving pain complaints. First, cognitive-behavioural therapy (CBT) focuses on changing behaviour, which indicates pain, disability and catastrophic thinking [34]. It is a skill-based treatment, which encourages patients to apply learned skills to overcome health problems [20]. CBT consists of different mechanisms to change behaviour such as increasing self-efficacy as well as learning to decrease negative emotional responses which are also related to mindfulness [35]. CBT is effective in helping patients decrease the severity of pain.
Second, acceptance and commitment therapy (ACT) prioritises helping people accept pain to improve function [36]. ACT focuses on psychological flexibility as the main goal of the treatment. Psychological flexibility is the ability to change a behaviour pattern depending on one's goal and the situation [37]. Changing behaviour will focus on realizing valued goals instead of pain control.
Third, eye movement desensitization and reprocessing (EMDR) is a therapy that can be used to treat negative life experiences, such as pain [38]. EMDR aims to reduce stress and strengthen adaptive cognition. EMDR seems to have an effect on the treatment of pain [39]. It is proving its value in decreasing negative associations in chronic pain.
Fourth, the gate control theory is processed in some exercise of Reducept [19]. This theory suggests that pain is not a direct result of sensory input but is also influenced by cognitive factors. Overall, it means that cognitive factors can modify the transmission of pain signals in the spinal cord.
Last, some aspects are processed in the different exercises in the Reducept application, such as education and gamification. Education is used to improve patients' understanding and control of their pain. Gamification is using game design principles like points, achievements and levels [20]. This is used to support user engagement. User engagement refers to the level of interest and involvement of the users with the application. All these aspects are necessary for this application to effectively reduce pain.

Earlier, a cross-sectional pilot study was performed to assess the applicability of the Reducept application in patients with RA and chronic pain [40]. The study explored the feasibility and applicability of using VR goggles, focusing on user experience, pain intensity, virtual reality sickness symptoms, and the working mechanisms of the VR system. However, this study only involved participants using VR goggles once. The results showed that participants barely experienced VR sickness symptoms. Overall, participants reported a good user experience and a positive attitude towards VR. Although this study provided indications into usability, further research is needed to investigate the usability and applicability for a longer period. The overall goal of this pilot study is to set up a randomised controlled trial (RCT) where the VR system is used by the patients for a longer period at home. The patients need to use the VR headset at home, that way, patients can integrate the VR treatment into their daily life without the need for frequent hospital visits.

To conclude, there were multiple studies performed on the VR treatment in patient groups with chronic pain other than RA. These studies showed that VR can have a possible effect on managing chronic pain. The goal of Reducept is to train the brain to deal with pain in a different way [28]. While this treatment is used in multiple chronic pain conditions, its efficacy in RA has not been investigated yet. Therefore, this research assesses the feasibility and applicability of VR use at home in RA patients. Feasibility in this context refers to whether or not the treatment of RA with VR from home is practical. Applicability, on the other hand, evaluates the effectiveness and relevance of reducing chronic pain.
A longitudinal study is set up to study the VR use at home in RA patients for 8 weeks. This 8 weeks period allows patients to become familiar with the VR headset and enables the collection of sufficient data points to determine the long-term effects. If the feasibility and applicability of VR use present promising results, an RCT can be conducted to further examine the effects of VR on chronic pain.

1.1 Objectives

For this study, the following research question has been set up to investigate if VR can be a possible treatment for RA patients suffering from chronic pain.

- What is the feasibility and applicability of using VR at home for 8 weeks in patients with RA suffering from chronic pain?

This research question is divided into three sub-questions. These three sub-questions are necessary to determine the feasibility of using VR as a possible treatment for RA patients.

- Do patients experience any technical difficulties with using the VR headset at home during 8 weeks?
- Are patients satisfied with the VR treatment?
- Do patients get cybersickness from using the VR headset for 8 weeks?

Four other questions are set up about the possible efficacy of VR treatment in reducing pain intensity. These questions are necessary to determine the applicability and to give possible indications for the RCT study. This research can not give explicit answers, because of the small sample size. However, it is useful for the RCT study.

- What are the possible positive and negative effects of VR use?
- Are there any possible effects on the pain intensity of the patients after using the VR headset?
- Are there any possible effects on the patient's quality of life after VR use?
- Are there any possible effects on the patient's self-efficacy after using the VR headset?

Hypothesis
Since different studies showed that VR can reduce chronic pain, it is expected that in this study it will also reduce the chronic pain of RA patients [24, 25, 26, 27]. The earlier cross-sectional pilot study showed that patients did not experience a lot of virtual reality sickness symptoms [40]. For this study, it is expected that the period of 8 weeks of VR use, will not have any effect on this outcome. No big, unsolvable problems are expected to occur since different longitudinal studies showed no adverse effects [24, 25, 26, 27]. Internet connectivity issues and problems with running the application will probably occur with the use of VR at home, but this can all be solved by contacting the researcher. The satisfaction of the VR treatment will be good if the user engagement is good, based on an earlier study [24]. Concluded, it is expected that the use of VR for 8 weeks has good feasibility and applicability.

2 Methods

2.1 Design

This was a longitudinal pilot study involving the Reducept intervention applied in a patient group diagnosed with RA suffering from chronic pain. All questionnaires were in Dutch because all participants are Dutch. For this study, different questionnaires were administered. This study was conducted between January 2023 and May 2023. For this study, a mixed-methods approach is used. The study was approved by Wetenschapsbureau Medisch Spectrum Twente (MST) (K20-17).

2.2 Setting

This pilot study is conducted at the rheumatology department of MST. Earlier a cross-sectional pilot study is conducted about the applicability of VR in reducing pain. After the completion of this study, a randomized controlled trial (RCT) will be set up. The goal of this RCT is to investigate if VR causes a significant pain reduction over a longer period.

2.3 Study population

The population for this study consisted of patients with RA suffering from chronic pain. For the recruitment of these patients, multiple inclusion and exclusion criteria were applied. All patients were recruited from the rheumatology department of MST. There was checked if the patients participated in the cross-sectional part of this study. The goal was to include at least four patients who participated in the cross-sectional study.

Inclusion criteria:

- Aged 18 and over.
- Diagnosed with rheumatoid arthritis.
- Disease duration 2 years or more.
- Chronic pain: visual analogue scale (VAS) ≥ 4 [8].
- Low disease activity: DAS28 < 3.2 on 2 moments with minimal 6 months in between or DAS28 < 3.2 on 1 moment + opinion of the rheumatologist or a difference between tender joint count (TJC) and swollen joint count (SJC) ≥ 4 on 2 or more moments with minimal 6 months in between [4].
- Sufficient level of Dutch.
- Informed consent given.

Exclusion criteria:

- Active RA.
- No pain complaints at the moment of inclusion (VAS < 4).
- Severe audiovisual limitations, which make it impossible to use the VR headset.
- One of the following comorbidities: dizziness, limited cognition, visual complaints, balance disorder or claustrophobia in such a manner that VR use is impossible.
- Other causes for tender joints such as severe joint damage or osteoarthritis.
- Diagnosed with psychotic disorders.
- Diagnosed with dementia.
- No access to the internet.

Patients who met all the criteria were called for interest and received the informed consent form (see appendix A) with more information about the study. A week later, patients were called and if interested, invited for a first appointment at the MST.

2.4 Intervention

For this study, VR goggles (PICO G2 4K, Android OS 8.1.0) were used with the application Reducept (version 1.12.5) [28]. Reducept is a digital training program designed for people suffering from chronic pain. This program teaches patients to deal with their pain in a different way. This

is done by a virtual journey through the nervous system, in which the patient is provided with an explanation of how pain works. During the journey, the patient is offered different exercises that cover a part of the nervous system. These different parts are; the nerves, the spinal cord, the brain, the alarm centre and the control room.
The exercise about the nerves (appendix M.1) focuses on visualization and pain education. In this exercise, the patient is in their nervous system, it is a visualization of how to take control of threat-related stimuli in the nervous system. In this exercise, the patient destroys the stimuli, these threat-related stimuli protect the body against danger and can cause pain. People with chronic pain can have active stimuli even if there is no damage. This visualization allows the brain to respond with less pain.
The spinal cord exercise (appendix M.2) focuses on CBT, gate control theory and education. The main learning point is that positive thoughts and relaxation can help the patient to get a better grip on pain complaints. In this exercise, they see that all nerves, and thus threat-related stimuli, come together in their spinal cord. Before the stimuli enter the spinal cord, they must pass through a gate. This gate allows fewer stimuli if they feel positive and relaxed, which is based on the gate control theory.
The brain exercise (appendix M.3) focuses on EMDR and pain education. The most important educational principle is the fact that when the more often the patient has pain, the stronger the brain responds to pain, which is called central sensitisation. The key takeaway is that the brain is flexible and can become less effective in creating reactions that cause pain.
The alarm centre exercise (appendix M.4) focuses on ACT, visualization and pain education. The alarm centre in the brain is where all stimuli arrive, it determines how many stimuli go on to the brain. The alarm centre can react more sensitively and pass on many stimuli, but it can also decide not to. The way people direct their attention affects the sensitivity of our alert centre. Before the stimuli can enter the alarm centre, users can destroy the negative stimuli. This is based on psychological flexibility.
The control room exercise (appendix M.5) focuses on CBT, mindfulness and pain education. In this exercise, patients learn how to stay in touch with their bodies, as well as how to recognize and let go of negative thoughts. Every time patients play this exercise, they train their brains and create new connections in their brains, these new connections are different from the connections that cause pain.

2.5 Data collection

The data collection consisted of two digital questionnaires in Qualtrics and one on-paper questionnaire. These questionnaires are based on the different outcome variables. The primary outcome variables are technical difficulties, satisfaction and cybersickness of VR. These are measured using the evaluation questionnaire and the virtual reality sickness questionnaire (VRSQ) [41]. These variables are necessary to determine the feasibility of the VR treatment. The secondary outcome variables were the type of pain, pain intensity, quality of life and self-efficacy. These variables were measured using the generalized pain questionnaire (GPQ) [42], numerical pain rating scale (NRS) [43], 36-item short-form health survey (SF-36) [44] and arthritis self-efficacy scale (ASES) [45] respectively. These variables are necessary to determine the applicability of the VR treatment. The digital questionnaires included also questions about patient characteristics and comorbidities. The questionnaires about characteristics and comorbidities, the VRSQ, GPQ, SF-36 and ASES were administered in week 0 before VR use. In week 0 the VRSQ is also administered after VR use. The NRS questionnaire was administered twice a week, for a period of eight weeks. In week 8 the VRSQ, SF-36 and ASES were administered after VR use. All questionnaires were validated and translated into Dutch because all the participants speak Dutch at a sufficient level. All these questionnaires were used in earlier research at the MST.

2.5.1 Characteristics and comorbidities

The first questionnaire contains some questions about the characteristics of the participants as well as possible comorbidities. The characteristics questions (see appendix F) were about age, gender, educational level, use of analgesics and other diseases than RA. The use of medication was gathered from the electronic patient dossier. The comorbidities questions (see appendix G) were about possible comorbidities that have a negative influence on using VR goggles, especially focused on cybersickness. These two questionnaires were administered in week 0 before using the VR goggles.

2.5.2 Virtual reality sickness questionnaire

The first outcome variable, cybersickness of VR use, was measured by the virtual reality sickness questionnaire (VRSQ) [41]. The cross-sectional pilot study did forward-backwards translation for this questionnaire [40]. This questionnaire contains ten items, which incorporate symptoms that often occur in virtual reality sickness. The question is 'To what extent do you currently experience…' ('In welke mate heeft u nu last van…'). Each item can be rated by 'none' ('niet'), 'slight', ('licht'), 'moderate' ('matig'), and 'severe' ('ernstig'). The total questionnaire can be found in appendix H. This questionnaire was administered at the first appointment in week 0, before and after using the VR goggles and in week 8 after using the VR goggles.

2.5.3 Generalized pain questionnaire

The second outcome variable, pain experience, was measured by the generalized pain questionnaire (GPQ) [42]. The GPQ is specially developed for generalized pain sensitivity, which is frequently observed in chronic pain conditions. This questionnaire can divide the different pain phenotypes, a score higher than 10 suggest that the patient experience chronic pain due to hyper-sensitization, or in other words nociplastic pain [42]. The GPQ consists of 7 items. Each item can be rated by a 5-point Likert-scale by 0='never' ('niet'), 1='hardly noticed' ('nauwelijks'), 2='moderate' ('matig'), 3='strongly' ('hevig'), 4='very strongly' ('zeer hevig'). All answers were transformed into numbers like the 5-point Likert scale. The total questionnaire can be found in appendix I. This questionnaire was administered at the first appointment in week 0 before using the VR goggles.

2.5.4 Numerical pain rating scale

The third outcome variable, pain intensity, was measured by the numerical rating scale (NRS) [43]. This scale was used for the question 'How much pain do you experience at this moment?' ('Hoeveel pijn heeft u op dit moment?'). The scale ranged from 0 to 10, where 0 represents 'no pain at all' ('geen pijn') and 10 represents 'worst pain ever possible' ('ergst denkbare pijn'). The total questionnaire can be found in appendix D. This on-paper questionnaire was administered during the eight weeks of patients using the VR goggles. The questionnaire was filled in twice a week.

2.5.5 36-item Short form health survey

The fourth outcome variable, quality of life, was measured by the 36-item short-form health survey (SF-36) [44]. This questionnaire measures eight different categories; physical functioning, role limitations due to physical health problems, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems and emotional well-being. It contains also one question about the change in health in the last year. All items were rated differently however, every item was scored in a 0 to 100 range. A higher score indicates a more favourable health state. The total questionnaire can be found in appendix J. This questionnaire was administered in week 0 and week 8.

2.5.6 Arthritis self-efficacy scale

The fifth outcome variable, self-efficacy, was measured by the Arthritis self-efficacy scale (ASES) [45]. This questionnaire was translated and validated by Taal et al. [46]. This questionnaire consists of twenty items about how certain people are to perform an activity or achieve any results. The twenty items were divided into three categories; managing pain, physical function and controlling other symptoms. Each item can be rated by 'strongly agree' ('volkomen juist'), 'agree' ('grotendeels juist'), 'neutral' ('neutraal'), 'disagree' ('grotendeels onjuist'), 'strongly disagree' ('volkomen onjuist'). This rating can be changed to scores, a higher score indicates a greater self-efficacy in managing pain. The total questionnaire can be found in appendix K. This questionnaire was administered in week 0 and week 8.

2.5.7 Questions for evaluation

At last, some questions for evaluation were processed in the questionnaire in week 8. These questions are about how the participants experienced the study and how they performed the study. These questions were selected from the questionnaire about measuring user experience in virtual immersive environments [47]. These questions are about technical difficulties and satisfaction with the VR treatment experienced by the participants. The answers are also used for the strengths and limitations of this research. These aspects can be used for the RCT later on. All evaluation questions can be found in appendix L.

2.6 Procedure

At the start of the experiment, the participants had a first appointment at the MST. At this first appointment, the participants were asked to sign the informed consent form (see appendix A) and the receipt of the VR goggles (see appendix B). After that, the participants were asked to fill in the first questionnaires on a tablet. These questionnaires are characteristics, comorbidities, VRSQ, GPQ, SF-36 and ASES. Next, they get an instruction about how to use the VR goggles. Then they were asked to use the VR goggles and play the introduction exercise and the nerves exercise of the application. Afterwards, participants were asked if they fully understood it and knows how to use it at home. The participants needed to connect the VR headset to the WiFi network at home, which is important for the researcher to see the progress of the participant. Therefore, this is explained very precisely. Finally, they answered again the VRSQ on the tablet. A new appointment was made after eight weeks. After the appointment, the participants took the VR goggles, a manual for the VR goggles (appendix C), the NRS questionnaire (appendix D) and an explanatory letter home (appendix E) as well as a copy of the signed forms. The participants were asked to use the VR goggles a minimum of three times a week. The goal was to use the VR goggles for approximately 15 minutes. They used the VR goggles for 8 weeks. During these eight weeks, they filled in the NRS questionnaire twice a week. If the participants had any questions regarding the study, they were able to contact the researcher by telephone or email. In week 1 the patients were called if they were able to use the VR goggles and fill in the questionnaire. After 8 weeks, the participants came back for their last appointment. At this appointment, they used the VR goggles one more time and filled in the last questionnaires. They were also asked about their experience. The procedure is also presented in figure 1 for a schematic overview.

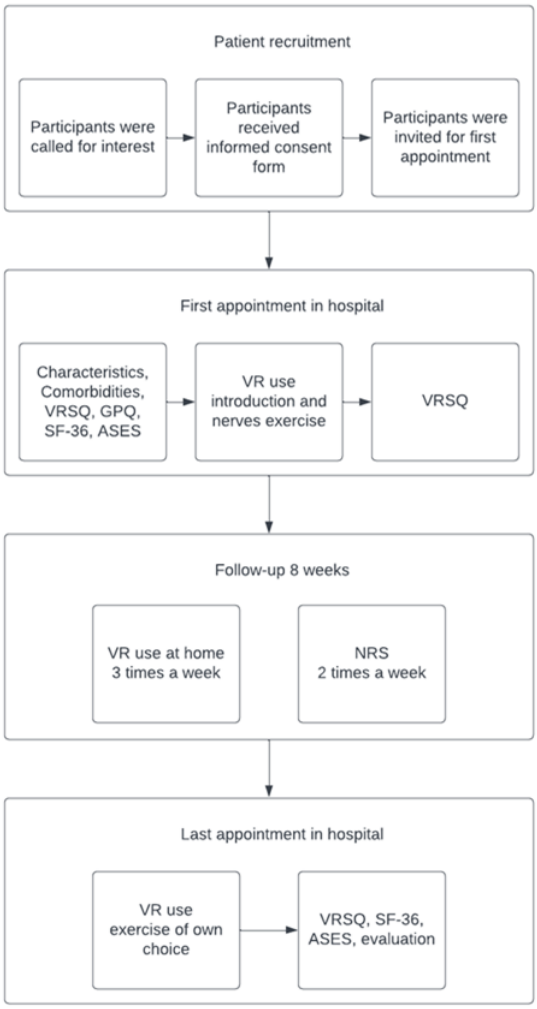


Figure 1: Flowchart of the procedure.

2.7 Data analysis

All responses to the questionnaire were exported from Qualtrics to Excel. All questions were sorted per questionnaire and irrelevant data is removed. This irrelevant data consists of the time and date the questionnaire was filled in, which is not important for the results. In Excel different analyses were executed. The characteristics and comorbidities of the participants were sorted in a demographic table, to get directly an overview of the study population. The results of the VRSQ were presented in a heat map. Each item was indicated with a colour, which presents the severity of the symptom. This is a good visualization to directly see the severity of the symptoms. The results of the VRSQ before VR use and after VR use were compared. With this comparison can be checked if the symptom appeared due to VR use or not.
The GPQ results were transformed into numbers like the 5-point Likert scale, where 0 means never and 4 means very strongly. All items of the GPQ questionnaire were summed up, the total score varies between 0 and 28. These scores were presented in a table.
The NRS results were copied to Excel as well. From these NRS pain scores a graphic can be made. This graphic shows the progress of the pain score in 8 weeks.
The results of the SF-36 questionnaire were transformed into scores from 0 to 100. This was done by following the scoring rules for the SF-36 [44]. After scoring all questions, the eight different categories can be averaged. The scoring rules tell which item belongs to which category. In this way, for each different category, an average score can be determined. These scores were presented in a table. A higher score means a better quality of life. The results of the ASES were changed into scores from 1 to 5. The ASES consists of 3 different categories, the scores from the categories are

added to each other and divided by the number of items. So for each category, an average score is determined. These scores were presented in a table. A higher score means a more favourable health state. The questions about user experience are presented in a heat map. The answers to the other evaluation questions are explained in the result section. Furthermore, no statistical tests were performed since there were only seven participants included in the study. Therefore, all analyses are exploratory.

The feasibility depends on three different aspects; technical difficulties, satisfaction and cybersickness. Feasibility refers to whether or not VR treatment at home for RA patients with chronic pain is practical. A high feasibility is observed when the VR headset is easy to use by patients and no unsolvable problems occurred when using VR goggles. If the headset is enjoyable and the users are engaged, feasibility improves. When this is not the case, patients will not use the VR, which means they are not following the treatment. The reduction in pain complaints leads to good satisfaction, and thus also affects the feasibility. Lastly, a low or manageable level of cybersickness indicates good feasibility. When there are no technical difficulties and high satisfaction, but the symptoms of cybersickness are moderate, the feasibility is not good.

The applicability depends on the pain intensity, quality of life and self-efficacy. Applicability evaluates the effectiveness and relevance of reducing chronic pain. The intervention needs to be relevant to the problem, therefore the applicability is important. A positive evaluation of applicability can be achieved if any one of these aspects improves while the others remain unchanged. This indicates that the treatment is beneficial. However, great applicability is reached when all three aspects show improvement. This shows the effectiveness of VR use.

3 Results

In the end, seven patients participated in the study, whereof three patients participated in the earlier cross-sectional pilot study. One patient dropped out after the first appointment due to cybersickness, this patient was not able to wear the VR goggles for a longer time. Another patient completed the 8 weeks follow-up but had not used the VR goggles at all and did not fill in the NRS questionnaire, because this patient was not feeling well and did not feel like using the VR headset. The other 5 participants completed the study as intended.

3.1 Patient characteristics and comorbidities

The characteristics and the comorbidities of the participants are presented in the demographic table 1. This gives an overview of the study population that participated in this study. The study group consist of five women and two men. Three participants use only DMARDs and the other four participants use DMARDs in combination with NSAIDs. Six of the seven people use analgesics in combination with DMARDs. Two participants reported that they have balance problems and one of them reported dizziness. These comorbidities had no negative effect on VR use for these participants. One participant reported a fear of heights and was not able to use the VR device and resulting in their withdrawal from the study.

Table 1: Participant characteristics.

Gender, n	
Male	2
Female	5
Age group (years), n	
50-60	4
60-70	2
70-80	1
Educational level, n	
Primary	1
Secondary	2
MBO	2
HBO	2
WO	0
Medication use, n	
DMARD only	3
DMARD and NSAID	4
Analgesic use, n	
Yes	6
No	1
Comorbidities, n	
Balance problems	2
Dizziness	1
Fear of heights	1
No comorbidities	4

3.2 Virtual reality sickness questionnaire

The results of the VRSQ are presented in three different heat maps. The heat map in figure 2 shows the results of week 0 before using the VR goggles, and figure 3 the results of week 0 after using the VR goggles. The difference between these two figures shows the effect of VR on the severity of the symptoms. There can be seen if the symptom was already reported before using the VR goggles or if it appeared after using the VR goggles.

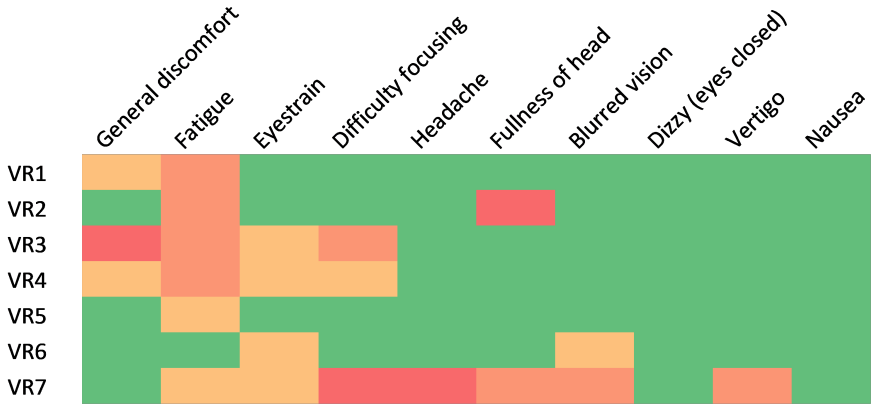


Figure 2: Heat map of the results of virtual reality sickness questionnaire before VR use at week 0. The different colours present the severity of the symptoms, where green means none, yellow means slight, orange means moderate and red means severe. The results of VR2 are not shown.

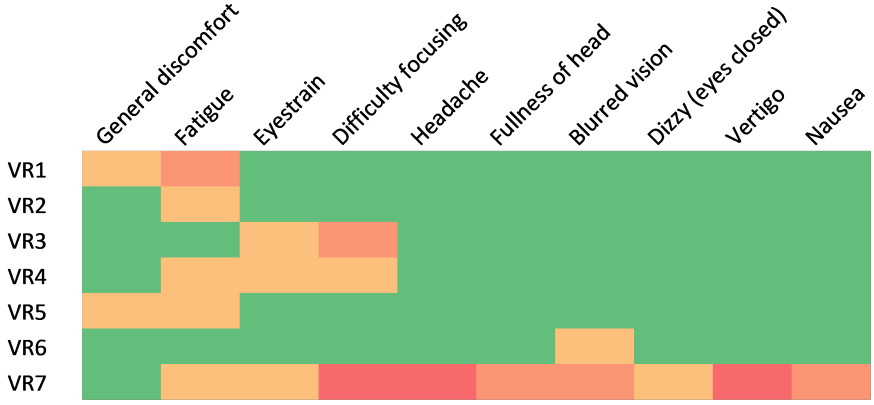


Figure 3: Heat map of the results of virtual reality sickness questionnaire after VR use at week 0. The different colours present the severity of the symptoms, where green means none, yellow means slight, orange means moderate and red means severe.

When looking at figure 2 and figure 3, there can be seen that the majority of the patients did not experience any virtual reality sickness symptoms or only reported slight symptoms. Participant VR3 is suffering from severe general discomfort before VR use. However, after VR use general discomfort has been reduced to no suffering. Participant VR5 is slightly suffering from general discomfort after VR use and was not suffering from this before VR use. So, except for one participant slightly suffering from general discomfort, VR use did not provoke general discomfort. Fatigue is the most reported symptom. Comparing before and after VR use, the severity of the symptoms is equal or less after VR use. This means that VR use did not worsen fatigue.
Three participants indicated to be slightly suffering from eyestrain after VR use, all these three patients were also slightly suffering from eyestrain before VR use. Participant VR6 indicated to be slightly suffering from eyestrain before VR use, however, after VR use suffering from eyestrain has been reduced. This means that VR use did not cause eyestrain. Three participants indicate to be slightly, moderately and severely suffering from difficulty focusing after VR use. However, all these three patients indicate the same severity of the symptom before VR use. This means that VR use did not provoke difficulty focusing.
Participant VR7 indicates to be severely suffering from a headache before and after VR use. All other participants are not suffering from a headache. This means that VR did not cause a headache. Besides, participant VR7 is moderately suffering from the fullness of the head before and after VR use. Participant VR2 is suffering from severe fullness of the head before VR use, and after VR use suffering from this symptom has been reduced. So, this means that fullness of the head is not

caused by VR use.
Two participants indicated having slightly or moderately blurred vision. They indicated the same severity before and after VR use. All other patients have no blurred vision. This means that VR use did not cause blurred vision. All participants indicated to be not suffering from dizziness before VR use. After VR use, participant VR7 indicated to have slight dizziness. Dizziness is not caused by VR use, except for one participant.
Participant VR7 is moderately suffering from vertigo before VR use. After VR use suffering from vertigo is increased to severe. So, for this participant, the VR use makes the severity of the symptom worse. All other patients are not suffering from vertigo before and after VR use. Overall, VR use did not provoke vertigo. All participants indicated not suffering from nausea before VR use. After VR use participant VR7 indicated to be moderately suffering from nausea, this patient was dropped out of the study, because of this symptom. The other patients were not suffering from nausea at all. So, except for one participant, VR did not cause nausea.
To summarize, four out of seven participants did not notice any increase in symptoms after VR use. Two other participants experienced a symptom that they did not have before VR use. Participant VR7 already had vertigo, but after VR use it get worse and even experienced two new symptoms. The most reported symptom before VR use was fatigue, however, VR use did not impact the severity of this symptom.

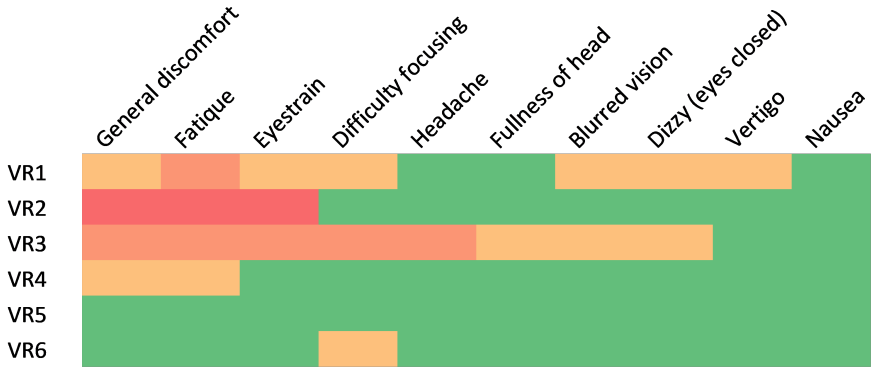


Figure 4: Heat map of the results of virtual reality sickness questionnaire after VR use at week 8. The different colours present the severity of the symptoms, where green means none, yellow means slight, orange means moderate and red means severe.

When looking at figure 4, still most reported severity of the symptoms is none or slight. Comparing these results with the results in figure 3, there is a lot of difference between the severity of the symptoms. Participants VR1 and VR2 experienced a lot of slight or moderate symptoms, while after VR use in week 0, they reported suffering from two symptoms. Participant VR2 reported severe general discomfort, fatigue and eyestrain. In week 0 they reported only slight fatigue. Two other participants reported one less symptom in week 8 compared to week 0. Participant VR6 is still slightly suffering from one symptom, however, this symptom differs between the different measurements. To summarize, three participants experienced more cybersickness symptoms at week 8 and three experienced fewer symptoms.

3.3 Generalized pain questionnaire

The total scores of the GPQ are presented in figure 5. A score higher than ten represents hypersensitization, a symptom of nociplastic pain. Nociplastic pain is most of the time the reason that RA patients suffer from chronic pain. So, the four participants with a score higher than ten, probably have nociplastic pain. Two patients have a score of almost ten. One patient has a score of two, indicating minimal symptoms of nociplastic pain.

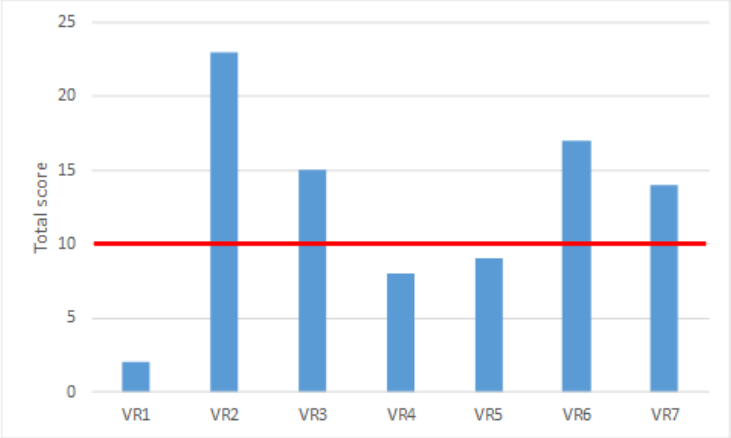
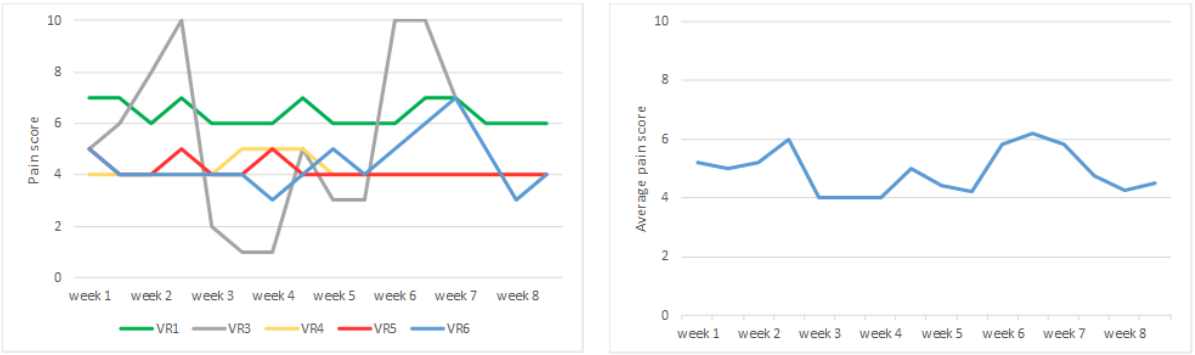


Figure 5: Total scores of the GPQ per patient. The red line is the threshold hyper-sensitization.

3.4 Numerical pain rating scale

Figure 6a presents the results of the NRS questionnaire, which show the pain scores of each patient over a period of 8 weeks. The results of participant VR2 are not displayed, because the NRS questionnaire was not filled in by this participant. While some participants reported nearly similar pain scores over this period, participant VR3 reported varying pain scores, ranging between one and ten. In the end, three participants scored lower after 8 weeks, one participant remained the same and one scored higher. Figure 6b displays the average pain score of all patients, the pain score fluctuates between four and six. There is no reduction in pain complaints over time.



(a) Pain scores per patient over 8 weeks.

(b) Average pain score over 8 weeks.

Figure 6: The pain scores administered from the NRS questionnaire.

3.5 36-item Short form health survey

The results of the SF-36 are presented in table 2. The table shows the scores for every different category of the questionnaire. A higher score means a better quality of life. In the bottom row, the average of all participants is calculated. It shows that the category pain has the lowest score, which means that pain has the worst influence on the quality of life. Two participants reported a score of 0, which means that their pain is at its worst. The category with the highest score is emotional well-being. The emotional well-being of the participants is good and did not affect their quality of life that much. The category health change scores 33, which means that most participants are feeling worse than a year ago. Looking at the results of week 8, the average pain score improved by 14 points. When looking at individual scores, the scores of four participants improved. The score of participant VR3 stays the same and the score of participant VR4 decreased by 13 points. Most categories are improved over 8 weeks, except for emotional well-being and social functioning. The category emotional well-being still has the highest score, but it is lower than in week 0. Three

participants scored lower after 8 weeks.
The averages for weeks 0 and 8 are also visually presented in figure 7, to have an overview of the comparison between the two moments.

Table 2: Results of the 36-item short form health survey in week 0 and week 8.

Participant number	Physical functioning		Role limitations due to physical health		Role limitations due to emotional problems		Energy/fatigue		Emotional well-being		Social functioning		Pain		General health		Health change	
	T0	T8	T0	T8	T0	T8	T0	T8	T0	T8	T0	T8	T0	T8	T0	T8	T0	T8
VR1	45	60	100	75	100	100	80	70	88	88	88	75	35	68	55	55	50	50
VR2	40	30	0	0	0	33	25	30	68	76	50	25	0	13	10	10	0	0
VR3	45	50	0	0	33	0	40	50	60	40	50	13	23	23	60	45	0	25
VR4	20	20	50	50	100	100	50	55	92	88	63	63	58	45	75	70	75	50
VR5	65	80	100	100	100	100	50	55	96	100	75	88	58	80	80	85	50	50
VR6	30	75	0	50	0	33	30	50	84	60	50	50	0	30	25	40	25	50
Average	41	53	42	46	56	61	46	52	81	75	63	52	29	43	51	51	33	38

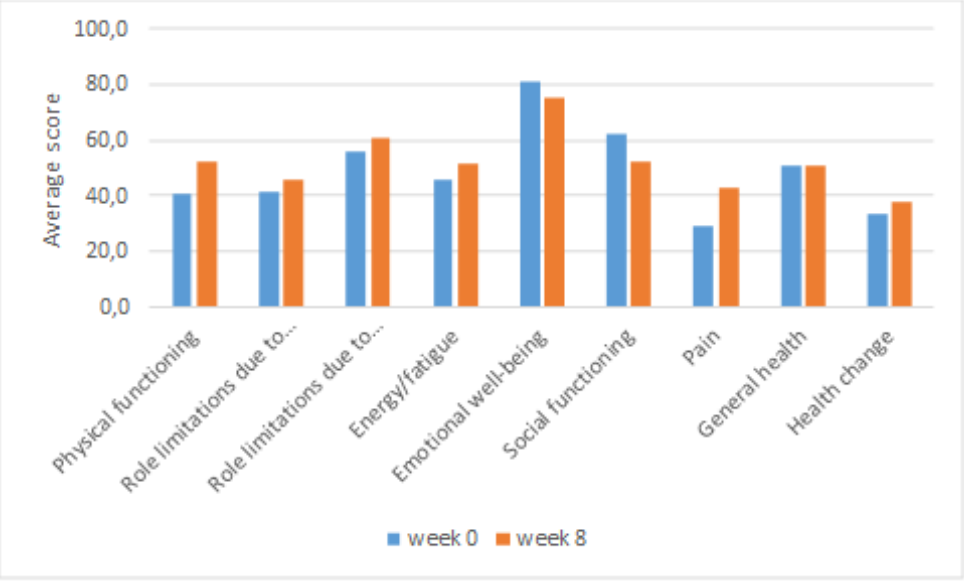


Figure 7: Total scores of the 36-item short form health survey per patient for week 0 in blue and week 8 in orange.

3.6 Arthritis self-efficacy scale

The results of the ASES are presented in table 3. The tables show the scores for the three different categories. At the bottom row, the average score of all participants is calculated. A higher score means better self-efficacy. The category managing pain has the lowest score at week 0. The

categories of physical function and controlling other symptoms have the same score of 3.6. This means that the participants are not that satisfied with their capability in managing their pain. They are more satisfied with their capability to physical functioning and control other symptoms. At week 8, the category of managing pain improved, except for participant VR6, who scored lower, and for participant VR3 who scored the same. The category of physical function scores a bit lower after 8 weeks. Two participants scored higher and the other four participants scored lower. In the category controlling other symptoms, three participants scored higher, participants VR4 and VR6 scored the same and participant VR3 scored lower. The averages of weeks 0 and 8 are also visually presented in figure 8, to have an overview.

Table 3: Total scores of the arthritis self-efficacy scale per patient in week 0 and week 8.

Participant number	Managing pain		Physical function		Controlling other symptoms	
	T0	T8	T0	T8	T0	T8
VR1	3.8	4.0	4.2	4.3	4.0	4.3
VR2	1.2	2.0	3.3	2.9	1.5	2.2
VR3	1.8	1.8	4.0	3.6	4.2	3.7
VR4	3.0	3.4	2.7	2.3	4.3	4.3
VR5	4.2	4.6	3.8	4.6	4.7	4.8
VR6	3.4	2.6	3.4	3.0	3.0	3.0
Average	2.9	3.1	3.6	3.4	3.6	3.7

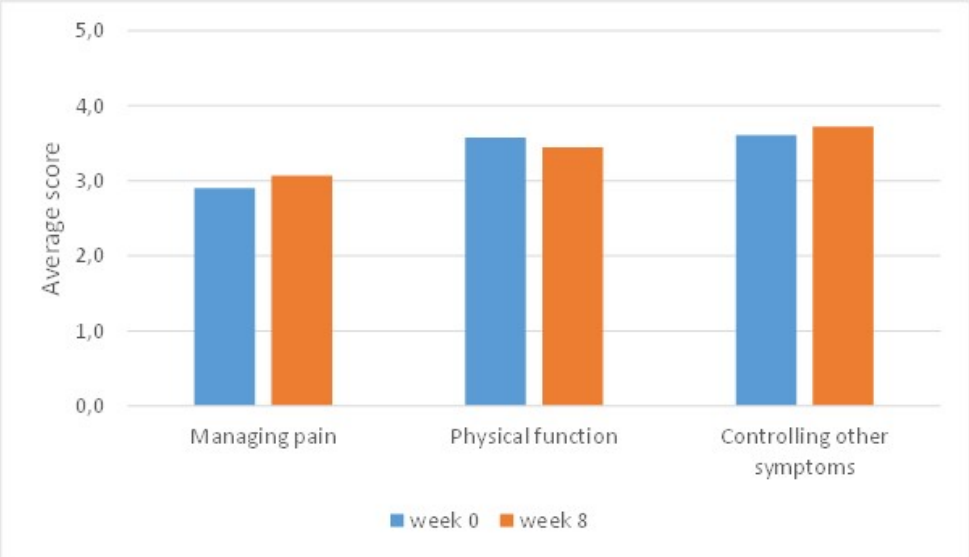


Figure 8: Total scores of the ASES per patient for week 0 in blue and week 8 in orange.

3.7 Evaluation questions

Participants were asked to rate five questions about the user experience with the VR goggles. The results of these questions are presented in a heat map in figure 9. The results of participant VR2 are not displayed, because this participant did not use the VR goggles.

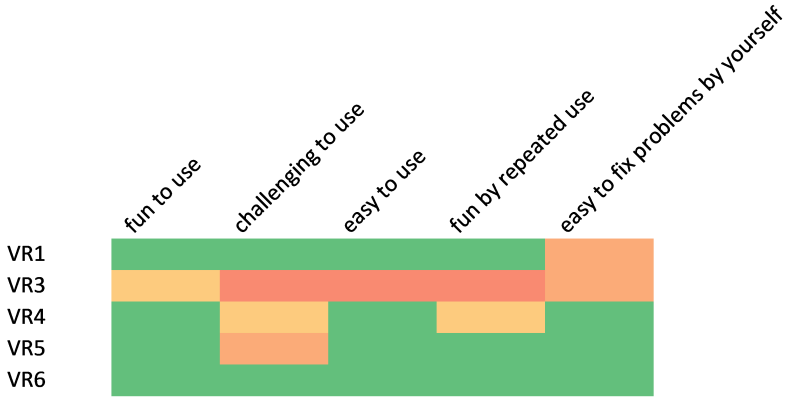


Figure 9: Heat map of the user experience. The heat map consists of five colours, where green means totally agree, yellow means agree, light orange means neutral, orange means disagree and red means totally disagree.

The heat map in figure 9 shows that four of the five participants had fun using the VR goggles. Participant VR3 agreed also with the statement about fun to use, but not totally agreed. The statement challenging to use scored much lower and differed among the participants. They stated that after doing all exercises, it was not challenging anymore, because it was the same routine every time. Four of the five participants stated that the VR goggles were easy to use. Participant VR3 stated disagreed with this statement, because of some problems that occurred. Three participants stated that the VR goggles were fun by repeated use. Two participants did not totally agree herewith. Fun by repeated use depends on the statement challenging to use. When the headset is not challenging enough, after a while, it is not fun anymore. Regarding the statement about fixing problems, it was rated neutral two times and totally agree three times.

Participants were asked to use the VR goggles a minimum of three times a week. Participant VR2 did not use the VR goggles at all. Two other participants used the VR goggles two times a week. They did not enjoy the exercises that much, which is why they found it hard to use the VR goggles multiple times. Two other participants used the VR goggles 3 times a week. Participant VR6 used the VR goggles sometimes 5 times a week. They stated that when they have a lot of pain, they used VR goggles. All participants used the VR goggles not at a fixed time. They used it when having a lot of pain.

Participants were asked if they had any problems with using the goggles. Participant VR1 was stuck on one problem, they accidentally removed the Reducept application and were not able to reinstall the application. After informing the researcher, they were able again to reinstall the application and go further with using the VR goggles. Two participants stated that the VR goggles sometimes went off, but when they started up the VR goggles again, the problem was fixed. Another participant indicated that the middle of the screen sometimes moved to the side. The VR goggles have a button to fix this, but the participant forgot this function and accepted it for that exercise and turned it off afterwards. Overall, there were no problems that can not be solved.

Participants were asked if they recommended the treatment to other people. Participant VR1 indicated that they would recommend it to other people because it was easy to use and it was fun. They think it could help other people unless it does not help them. Participant VR4 stated that it helps to get insight and control over your pain complaints, which is why they would recommend it to other people. Participant VR5 would recommend it to other people because due to using the VR goggles, you will come to rest and in that way, you get distracted from your pain. Participant VR6 also recommend it to other users, since it helped them to have less pain at that moment. Overall, it is recommended for other users get insight and control over pain complaints.
The most important aspect of improvement of the treatment is to make it more challenging to

use. Participants indicated that after performing the five different exercises multiple times, it gets a little bit boring. When the exercises are more challenging, they will use the VR goggles more frequently. They recommend using different levels for each exercise, so if you completed one level you go to the next, more challenging level.

When talking about the effect of VR on pain complaints, participants stated that it helps sometimes. At the moment, when using VR, they experience less pain. However, after VR use the pain is back. Participant VR6 stated that the pain is less for a couple of hours and after that, the pain is back.
Participants also provided feedback on the number and the length of the questionnaires. Two participants indicated that the questionnaires were too long and the questions were sometimes difficult to answer. However, the number of questionnaires was acceptable for every participant. So, the majority of the participants had no trouble with the questionnaires.
So when looking at the user experience, the main point is that it was easy to use and unsolvable problems were not found. It is recommended for other users, however when the different exercises get more challenging the use of VR would be even better.

3.8 Feasibility and applicability

The feasibility depends on if the participants had any technical difficulties, their satisfaction with using the goggles and whether or not they experienced cybersickness. Although there were some technical difficulties, all participants were able to solve these problems. Three out of five participants indicated that it was easy to fix problems on their own. The other two participants indicated finding it more hard, but their problem was fixed after contacting the researcher.
All participants were satisfied with the treatment but noticed some points for improvement. Overall the participants find it fun to use the VR headset, but it became quite repetitive so there was a desire for more challenging exercises. They were satisfied with the use of the VR goggles.
Four out of seven participants did not notice any increase in cybersickness symptoms after VR use. Moreover, the severity of the cybersickness symptoms was reported to be relatively low.

The applicability depends on the pain intensity, quality of life and self-efficacy. The pain intensity fluctuates a lot for all participants. They reported less pain during the exercises with VR, but after putting down the goggles the pain returned to normal levels. So overall, there was no improvement in pain intensity. The quality of life increases in different categories, but not for every participant. The self-efficacy in managing pain is improved a bit, but the self-efficacy in physical function and controlling other symptoms are not improved.

4 Discussion

In this section, the results of the longitudinal pilot study are discussed. The main goal is to evaluate the feasibility and applicability of VR treatment at home in a population of RA patients with chronic pain. This is done by interpreting the research findings obtained from the study. After the interpretation of the results, an exploration of the strengths and limitations are given in chapter 4.1. Chapter 4.2 provides recommendations for further research.

The feasibility of the VR treatment is determined by the results of the technical difficulties, satisfaction of the participants and cybersickness.
On the topic of technical difficulties, none of the participants experienced unsolvable problems with using the VR goggles at home. They were able to fix the problems that they did have by contacting the researcher. Earlier research stated that people were able to understand and use VR goggles [26]. Therefore, the results of this study align with the outcomes of earlier studies. These findings suggest that VR treatment has good feasibility.
The satisfaction of the participants with the treatment is also an aspect of determining the feasibility. Participants were satisfied with the number of times they used the VR goggles. The VR goggles helped distract patients from their severe pain. This means that the Reducept application meets the five criteria of an effective VR treatment for acute pain reduction, presence, interactivity, interaction, personalization and embodiment. They indicated enjoying using the VR goggles, however after using them multiple times it gets quite repetitive. If the application had more diverse and challenging exercises, participants stated they would use the VR headset more often. After the 8 weeks, the participants were overall satisfied with the treatment, but using it for a longer period would become a little bit boring. For now, the feasibility seems to be satisfactory, however, to keep the participants engaged, the inclusion of more challenging exercises is essential. Another aspect that can be improved is the criteria for personalization. When the treatment is more personal, the patients will be more satisfied. Earlier research also supports this, highlighting the positive satisfaction levels associated with VR treatment [32, 24].

The results of the VRSQ showed that in general, the VR headset did not induce cybersickness symptoms. Several participants experienced some symptoms after VR use, however, they already experienced these symptoms before using the headset. The most reported symptom was fatigue, but also this symptom did not get worse after VR use. Fatigue is often correlated with pain in RA patients, therefore it is logical that it is the most reported symptom [48]. The cybersickness symptoms that get worse after VR are general discomfort, dizziness, vertigo and nausea. These are all reported once. Earlier research also indicated that the majority of the participants did not experience severe cybersickness that could have hindered the use of the VR goggles [24]. So, the findings from this study correspond to the expectations retrieved from earlier research [24, 40]. The low levels of cybersickness observed in the majority of participants contribute to the overall positive feasibility of the study. However, it is worth noting that one participant was unable to complete the study due to severe cybersickness. This participant had a fear of heights, which contributes to the severe cybersickness symptoms.
To conclude, the findings suggest that VR treatment had good feasibility, with none of the participants experiencing unsolvable problems and expressing satisfaction with its usage. However, to maintain its effectiveness, the inclusion of more challenging and diverse exercises is recommended. It is crucial to address cybersickness symptoms and consider excluding individuals with a fear of heights, to ensure successful implementation in future studies and randomized controlled trials.

The applicability of the VR treatment is based on the results of the pain intensity, quality of life and self-efficacy questionnaires. The applicability is good when the treatment is effective in reducing pain complaints, enhancing the patient's quality of life and improving their self-efficacy. For the pain intensity, participants needed to rate their pain two times a week during the follow-

up period. Earlier studies involving participants with chronic pain other than RA resulted in a decrease in pain scores. Therefore, this was the expectation for participants with RA as well [24, 25, 26, 27]. However, the study population of these studies were patients with chronic pain and not especially patients with RA. The earlier cross-sectional pilot study also concluded that there was pain reduction in RA patients after using the VR goggles [40]. During this research, however, the pain scores of the participants fluctuated a lot. Three of the five participants scored one point lower than at the beginning of the follow-up period. One participant scored two points higher and the other participant scored the same. When asked about their pain complaints, most of the patients had either no pain or only slight pain during the VR exercises. The reason for this was the distraction the VR goggles provided. However, when turning off the VR goggles, they were experiencing pain again. One participant mentioned that they were experiencing no pain for a couple of hours and after the use of VR, it slowly got worse. Different behavioural treatments are used in the application with the intent to have a long-term effect on pain reduction. However, after 8 weeks, no improvements were observed. This does not correspond to the expectations and earlier research that indicated a pain reduction [26]. An earlier study with Reducept concluded that only two out of eight participants had pain reduction, but a larger study population is needed [32]. The period of 8 weeks may be too short to see pain reduction.
Two participants mentioned the mindfulness and educational part that was used in the exercises. These mindfulness exercises helped them to relax and have less pain. So, different working mechanisms of the application led to pain reduction, although this did not last for long periods of time. Therefore, the applicability of the VR treatment is not as sufficient as possible. However, the small improvements give promising implications for the RCT, this corresponds to the results of an earlier study about Reducept [32]. The treatment, for now, can be used for a longer period of time to see if the working mechanisms affect the pain complaints.

The SF-36 questionnaire about the quality of life showed improvements in some categories. When looking at the pain category, four participants scored higher than before the treatment. One participant scores the same and the other scored lower. In general, each category scored better after 8 weeks, however, each category scored lower by one or more participants compared to their scores at week 0. The category general health scores are approximately the same for each participant between the two measurements. These results correspond to the results of previous studies and to the expectations [24, 25]. The period of 8 weeks was too short to see statistical improvements in the quality of life. However, these results are promising for the following RCT. These small improvements indicate good applicability.
The ASES questionnaire was administered to determine the self-efficacy of the participants. This was divided into three categories, managing pain, physical function and controlling other symptoms. In both measurements, the category managing pain scored the lowest. However, after 8 weeks, four out of the six participants scored higher, one participant the same and the other scored lower. The category physical function scored a bit lower and the category controlling other symptoms scored a bit higher. So, the effect after 8 weeks is small, but it is promising for further research over a longer period. A previous study about VR treatment stated that self-efficacy about managing pain was improved, but not substantively [24]. This small improvement in self-efficacy in managing pain indicates good applicability.
Overall, the VR treatment is applicable when looking at quality of life, since the pain is reduced during VR exercises.

The GPQ about the different pain types was administered to check if the participants had chronic pain due to hyper-sensitization. The GPQ can distinguish between different pain phenotypes. If the total score of the GPQ is ten or higher, the pain is probably caused by hyper-sensitization. This means that they are suffering from nociplastic pain, which is hard to treat with medication [42]. Four out of the seven participants scored higher than this threshold and thus are probably suffering from nociplastic pain. So, these participants are a good target audience for this study.

Two participants have nearly a score of ten, and participant VR1 scored only 2 points. This participant hardly has any symptoms of nociplastic pain. The distraction-working mechanism will probably work for this patient. For the other participants, the other working mechanisms can have a better effect. Since they are experiencing nociplastic pain, which can be treated best with behavioural treatments.

4.1 Strengths and limitations

There are some strengths and limitations in this research that need careful attention and possible solutions for these limitations need to be given.
The main strength of this research is the design of the study. It was a longitudinal study which is combined with a mixed-methods approach. Due to the longitudinal study, the long-term effects of VR use could be measured. The participants were followed for a longer period of time, which gives multiple measurements. Through this long follow-up period, the changes in different variables were observed. Whether the 8 weeks period of this study, was long enough, is unclear. Therefore, further research is important, to check if the results will change.
The mixed-methods approach allows researchers to combine quantitative data with qualitative data. In this study, the different questionnaires are quantitative data and the evaluation questions are qualitative data. This approach allows a better understanding of the feasibility and applicability of the VR treatment. The quantitative and qualitative results are combined to have a good insight into the feasibility and applicability of the VR treatment.

Some limitations in this research need attention, so they can be avoided for further research.
Not all participants were able to connect to the WiFi network at home. As a result, the researcher was not able to see the progress of the participants. Moreover, one participant did not use the VR goggles and thus the researcher was not able to monitor this. To avoid this situation next time, all participants need to connect to the WiFi network at home. So, a very clear instruction is needed about how to connect to the WiFi network. This instruction is already in the Reducept manual but can be improved. This way, the use of VR goggles can be monitored multiple times a week.

The goal for the study population was to include eight participants, however, only 5 participants completed the study. One participant did not use the VR goggles during the eight-week follow-up. Another participant dropped out after the first appointment due to cybersickness. Participant number eight was called for interest and was interested in participating. However, after receiving the informed consent form, they did not answer the phone to make an appointment. This means that the study population was smaller than expected, however, since it is a pilot study, the study population was big enough to make some recommendations for further research.
The recruitment of patients was difficult. A lot of patients did not meet the inclusion and exclusion criteria. This is due to worse documentation of the VAS scores of the patients. When there was no documentation of the VAS score, the patients were excluded. Therefore, it is important that the rheumatologists write down the VAS score at each consultation. Some participants were able to be included but did not want to spend 8 weeks on a study. For further research, more inflammation diseases can be included, such as psoriatic arthritis or spondyloarthritis. In that way, the recruitment of patients would be more easy.

One participant accidentally removed the Reducept application and was not able to install it on their own. The researcher explained how to reinstall it and the participant succeeded in installing it again. To avoid this situation in the future, the Reducept application can be blocked from removal.
After this removal, the newest version of the application was installed. Therefore, there were two VR goggles with a different version of the Reducept application. The researcher has gone through both versions to check if there were any differences, but this was not the case. Therefore, all participants had the same exercises.

One final limitation is that the results of the VRSQ, which measures the cybersickness, in week 8 are not representative, since the VRSQ was only administered after VR use. Therefore, it is important for the following study, to administer the VRSQ in week 8 also before VR use. In that case, the same comparison can be done in week 0. Now, there are only results after VR use, and there is no idea how the participants were feeling before VR use. So, it is hard to draw conclusions from these results.

4.2 Recommendations

For further research, different VR applications or an improved Reducept application can be investigated since participants stated that repeated use of the VR headset was boring. They expect more challenging exercises. There are five exercises that can be done, and they are the same every time they are played. Therefore, Reducept can be improved, by making different challenges or levels within an exercise. Since VR is quite new for treatment options, there can be a lot of improvements. This can be helpful for participants to use VR goggles more often, which leads to better feasibility.

Another aspect that can be improved to execute the RCT as well as possible, is the communication between the participants and the researcher. The researcher had contact with the participants during the appointments in the hospital and during one appointment by phone. For the remaining time, participants were able to contact the researcher for questions. When all participants are connected at home to their WiFi network, the researcher can follow the progress of the participant. In that way, the researcher can contact the participant when they obtain that the participant is not using the goggles as much as necessary.

Some participants found it hard to fill in all questionnaires because their pain complaints differed each day. It is important to tell the participants that it is necessary to fill in the questions about what they are feeling at that moment. This can be added to the questionnaire, to make it extra clear.
Besides, some participants noticed that some questions were difficult to understand. So for the next studies, the questions can be formulated more easily, so that everyone can understand them.

5 Conclusion

The feasibility of the VR treatment is good. There were no unsolvable problems that occurred with using the VR goggles at home. The problems that occurred can be avoided next time. The satisfaction of the participants is good but can be improved. Not all participants are satisfied with the pain reduction after eight weeks. However, the pain was less at the moment of wearing the VR goggles, which was a relief. The participants are satisfied using the VR goggles since they liked doing the exercises and do not experience any problems. The exercises should be more challenging, so the participants will use the headset more often and the user engagement keeps good.
The majority of the participants experienced no cybersickness symptoms. One participant, with a fear of heights, experienced a lot of cybersickness symptoms, which leads to the withdrawal of the study. Five out of seven participants indicated fatigue after VR use, however, this was the same before VR use. This means that VR use does not cause fatigue. To conclude, the feasibility of the VR treatment is good but can be improved with more challenging exercises in Reducept.

The applicability of the VR treatment is not sufficient at this moment. The results for the pain intensity, quality of life and self-efficacy give some promising effects, however, the improvement was less than expected. Out of all the participants, only one participant reported a decrease in pain intensity. There was a lot of fluctuation in pain scores over eight weeks. However, four participants had an improved score in quality of life about pain. This indicates that the pain complaints had reduced and the quality of life was improved. The self-efficacy in managing pain improved for four participants. All these results give promising indications to execute an RCT. Therefore, the RCT have to be performed for a longer period, to check whether the results improve.

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Appendices

A Informed consent form

Longitudinale studie Virtual Reality bij chronische pijnklachten

Titel van het onderzoek

Longitudinale studie Virtual Reality bij chronische pijnklachten

Inleiding

Geachte heer/mevrouw,

Wij vragen u vriendelijk om mee te doen aan een wetenschappelijk onderzoek in het MST getiteld "Virtual Reality bij chronische pijnklachten". Wij zijn bezig met een onderzoek waarbij we kijken naar het effect van het herhaaldelijk gebruiken van Virtual Reality op pijnklachten. In deze brief kunt u meer informatie over dit onderzoek vinden. Lees deze informatiebrief rustig door. Heeft u na het lezen van deze informatie nog vragen? Dan kunt u terecht bij de onderzoeker. Op pagina 3 vindt u de contactgegevens.

1. Wat is het doel van het onderzoek?

Er is een grote groep patiënten die chronische pijnklachten ervaren, ondanks dat zij pijnstillende medicatie gebruiken. Daarom zijn behandelaars steeds op zoek naar manieren om deze pijnklachten te verminderen. Virtual Reality (VR) is een nieuwe manier die mogelijk kan bijdragen aan de behandeling van deze pijnklachten. Virtual Reality bestaat uit een digitale wereld waar u in terecht komt door middel van het opzetten van een VR-bril. VR lijkt mogelijk effectief te zijn voor chronische pijn, maar het precieze werkingsmechanisme van VR op chronische pijn is nog niet helemaal bekend. We willen onderzoeken of het meerdere keren per week gebruik van VR een positief effect heeft op chronische pijn.

2. Hoe wordt het onderzoek uitgevoerd?

Dit onderzoek bestaat uit een aantal VR trainingen van ongeveer 15 minuten per keer. Gedurende 8 weken voert u deze trainingen minimaal 3 keer per week thuis uit. Voor de eerste training komt u naar het ziekenhuis. U krijgt dan uitleg over het onderzoek en de VR-bril en u neemt vervolgens de VR bril in bruikleen mee naar huis. Vervolgens voert u minimaal 3 keer per week de trainingen zelfstandig uit. Na 8 weken komt u terug naar het ziekenhuis om de VR-bril in te leveren. De onderzoeker stelt u dan nog een aantal vragen over uw ervaringen.

3. Wat wordt er van u verwacht?

Wanneer u meedoet aan dit onderzoek wordt u benaderd voor het inplannen van de eerste afspraak. U krijgt dan uitleg over het gebruik van de VR-bril en u vult een aantal vragenlijsten in. Daarna kunt u de trainingen zelfstandig thuis uitvoeren. Twee keer per week vult u een korte vragenlijst in over uw pijnscore. Na 8 weken komt u terug naar het ziekenhuis om de VR-bril in te leveren en om een korte vragenlijst in te vullen.

4. Wat gebeurt er als u niet wenst deel te nemen aan dit onderzoek?

U beslist zelf of u meedoet aan het onderzoek. Deelname is geheel vrijwillig. Als u besluit niet mee te doen, hoeft u verder niets te doen. U hoeft ook niet te zeggen waarom u niet wilt meedoen.
Als u wel meedoet, kunt u zich altijd bedenken en toch stoppen, ook tijdens het onderzoek. U hoeft geen reden te geven waarom u wilt stoppen.

5. Wat gebeurt er met uw gegevens?

Voor dit onderzoek worden uw persoonsgegevens gebruikt en bewaard. Het gaat om gegevens zoals uw naam, geboortedatum en om gegevens over uw gezondheid. Het verzamelen, gebruiken en bewaren van uw gegevens is nodig om de vragen die in dit onderzoek worden gesteld te kunnen beantwoorden en de resultaten te kunnen publiceren. Wij vragen voor het gebruik van uw gegevens uw toestemming.

Vertrouwelijkheid van uw gegevens

Om uw privacy en identiteit te beschermen krijgen uw gegevens een anonieme code. Uw naam en andere gegevens die u direct kunnen identificeren worden daarbij weggelaten. Nergens wordt uw naam gekoppeld aan uw onderzoeksgegevens. Alleen de hoofdonderzoeker heeft toegang tot deze codelijst. Alleen met de sleutel van de code zijn gegevens tot u te herleiden. De sleutel van de code blijft veilig opgeborgen in de lokale onderzoeksinstelling. De gegevens in rapporten en publicaties over het onderzoek zijn eveneens niet naar u te herleiden.

Toegang tot uw gegevens voor controle

Sommige personen kunnen in het ziekenhuis toegang krijgen tot al uw gegevens. Ook tot de gegevens zonder code. Dit is nodig om te kunnen controleren of het onderzoek goed en betrouwbaar is uitgevoerd. Personen die ter controle inzage krijgen in uw gegevens zijn prof. dr. H.E. Vonkeman, bevoegde medewerkers van dit onderzoek, de Inspectie voor de Gezondheidszorg en controleurs van de Raad van Bestuur van de instelling waar het onderzoek wordt uitgevoerd, nationale en internationale toezichthoudende autoriteiten, bijvoorbeeld de Inspectie Gezondheidszorg en Jeugd. Zij houden uw gegevens geheim. Wij vragen u voor deze inzage toestemming te geven.

Bewaartermijn gegevens

Volgens wettelijke bepalingen zullen uw gegevens 5 jaar worden bewaard in het ziekenhuis. Hierna worden de gegevens vernietigd.

Intrekken toestemming

U kunt uw toestemming voor gebruik van uw persoonsgegevens altijd weer intrekken. De onderzoeksgegevens die zijn verzameld tot het moment dat u uw toestemming intrekt worden nog wel gebruikt in het onderzoek.

Meer informatie over uw rechten bij verwerking van gegevens

Voor algemene informatie over uw rechten bij verwerking van uw persoonsgegevens kunt u de website van de Autoriteit Persoonsgegevens raadplegen.

Bij vragen of klachten over de verwerking van uw persoonsgegevens raden we u aan eerst contact op te nemen met het ziekenhuis. U kunt ook contact opnemen met de Functionaris voor de Gegevensbescherming van de instelling [zie bijlage A].

6. Zijn er extra kosten of krijgt u een vergoeding wanneer u besluit aan dit onderzoek mee te doen?

U krijgt geen vergoeding voor deelname aan het onderzoek.

7. Door wie is dit onderzoek goedgekeurd?

De Raad van Bestuur van Medisch Spectrum Twente heeft goedkeuring gegeven om dit onderzoek uit te voeren.

8. Wilt u verder nog iets weten?

Wanneer u na het lezen van deze informatie of tijdens deelname aan dit onderzoek vragen heeft kunt u contact opnemen met:

Dr. H.E. Vonkeman, reumatoloog-onderzoeker
Telefoonnummer: 053-4872450

Indien u na zorgvuldige overweging besluit deel te nemen aan dit wetenschappelijk onderzoek, dan vragen we u om het toestemmingsformulier te ondertekenen en van een datum te voorzien.

Met vriendelijke groet,
dr. H.E. Vonkeman, reumatoloog-onderzoeker

Bijlage A: Contactgegevens
Bijlage B: Toestemmingsformulier

Bijlage A: Contactgegevens voor Medisch Spectrum Twente

Dr. H.E. Vonkeman, reumatoloog-onderzoeker
Koningsplein 1
7512 KZ Enschede
Te bereiken: maandag t/m vrijdag (8.00-17.00 uur) via telefoonnummer: 053 487 24 50

Klachten: Patiënten service centrum
Te bereiken: maandag t/m vrijdag (8.30-17.00 uur) via telefoonnummer: 053-487 20 45

Functionaris voor de Gegevensbescherming van de instelling:
Mw. P. van Paridon
Te bereiken maandag t/m vrijdag (8.30-17.00 uur) via telefoonnummer: 06-317 513 87

Bijlage B: Toestemmingsformulier
Verdiepend onderzoek Virtual Reality bij chronische pijnklachten.
Versie 1.2, datum: 14 november 2022

- ✓ Ik heb de informatiebrief voor deelname aan het onderzoek gelezen. Ik kon aanvullende vragen stellen. Mijn vragen zijn genoeg beantwoord. Ik had genoeg tijd om te beslissen of ik meedoe.

- ✓ Ik weet dat meedoen helemaal vrijwillig is. Ik weet dat ik op ieder moment kan beslissen om toch niet mee te doen. Daarvoor hoef ik geen reden te geven.

- ✓ Ik weet dat sommige mensen mijn gegevens kunnen zien. Die mensen staan vermeld in de informatiebrief.

- ✓ Ik geef toestemming om mijn gegevens te gebruiken, voor de doelen die in de informatiebrief staan.

- ✓ Ik geef toestemming om mijn onderzoeksgegevens 5 jaar na afloop van dit onderzoek te bewaren.

- ✓ Ik wil meedoen aan dit onderzoek.

- ✓ **Ik lever de VR-bril na het einde van deze studie weer in**

Naam deelnemer:
Handtekening: Datum : __ / __ / __

Ik verklaar hierbij dat ik deze deelnemer volledig heb geïnformeerd over het genoemde onderzoek. Als er tijdens het onderzoek informatie bekend wordt die de toestemming van de deelnemer zou kunnen beïnvloeden, dan breng ik hem/haar daarvan tijdig op de hoogte.

Naam onderzoeker (of diens vertegenwoordiger):
Handtekening: Datum: __ / __ / __

Aanvullende informatie is gegeven door (indien van toepassing):
Naam:
Functie:
Handtekening: Datum: __ / __ / __
---

* Doorhalen wat niet van toepassing is.

B Receipt

Ontvangstbewijs

Ik verklaar dat ik de volgende dingen heb ontvangen en ook weer in zal leveren na 8 weken.

- De VR bril, waarop Reducept geïnstalleerd is
- Een oplader
- Een afstandsbediening
- Een opberghoes
- De handleiding van de VR bril
- De NRS vragenlijst
- Inloggegevens

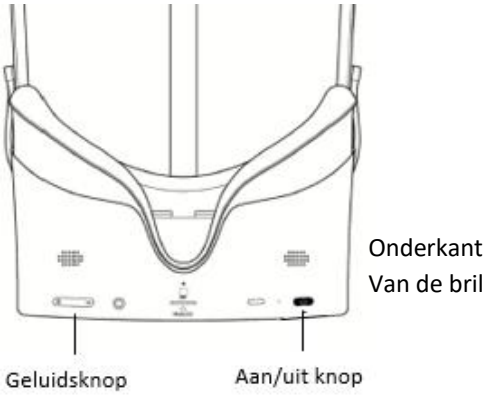
Daarnaast verklaar ik dat ik de VR-bril niet voor andere doeleinden zal gebruiken.

Naam deelnemer:

Handtekening: Datum:

Deelnemershandleiding Applicatie – VR bij chronische pijn

Uitleg van de knoppen op de VR bril



Terug knop: Hiermee gaat u terug naar het vorige scherm.
Selecteer knop: Hiermee kunt u bepaalde knoppen op het scherm selecteren.
Pico knop: Hiermee gaat u op elke gewenst moment terug naar het beginscherm. Wanneer het zicht niet meer gecentreerd is, kunt u dat ook herstellen met deze knop.
Geluidsknop: Hiermee kunt het geluid harder en zachter zetten.
Aan/uit knop: Hiermee kunt het apparaat aan en uit zetten.

Wi-Fi inschakelen

Om te kunnen inloggen bij Reducept heeft u verbinding nodig met internet.
Daarvoor gaat u naar het Wi-Fi symbool in de balk onderin het scherm.
Richt met uw vizier op het Wi-Fi symbool en druk op de 'selecteer' knop.
U krijgt nu de verschillende netwerken te zien, selecteer de juiste en vul het wachtwoord in.
Druk hierna op verbinden. Als het goed is, is de VR bril nu verbonden met internet.

Reducept applicatie opstarten

De Reducept applicatie kunt u vinden onder de knop 'App Library', onderin de menubalk. Daarna klikt u op de Reducept applicatie (zie afbeelding hieronder). Hierna verschijnt het opstartscherm van Reducept, zolang u dit ziet hoeft u niks te doen.

Reducept applicatie.

In het beeld ziet u een wit rondje, dit rondje is uw vizier. In Reducept reageren dingen als u er een paar tellen met uw vizier op richt. Hou het vizier vast tot het rondje rondom het vizier volledig is volgelopen.

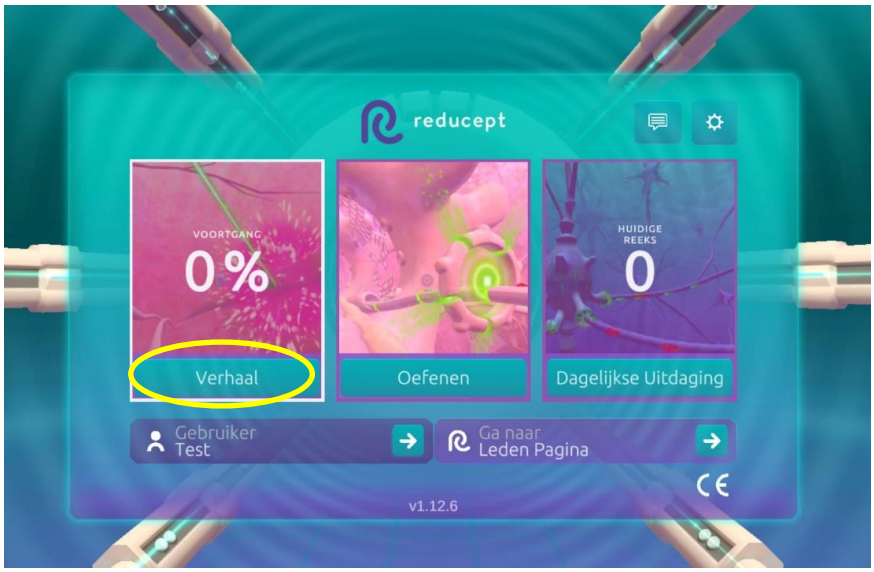
Inloggen Reducept

Wanneer u nog niet bent ingelogd, kunt u met de gegevens die u van ons hebt gekregen inloggen in Reducept. Dit doet u met het verkregen e-mailadres en het bijbehorende wachtwoord.

Inloggegevens	
Email:	mstvr0001@gmail.com
Wachtwoord:	ReumaVR1!

Wanneer het inloggen is gelukt, verschijnt het onderstaande beeld, dit het startscherm.

U bevindt zich in het startscherm. Richt uw vizier op ‘Verhaal’, zoals weergegeven in de afbeelding hieronder.



Daarna verschijnt het volgende beeld en kunt u de introductie starten, door met uw vizier op start te richten.

Vervolgens krijgt u een introductie van Reducept te zien. Tijdens deze introductie krijgt u meer uitleg over het besturen van Reducept.

Menu

Onderin het scherm ziet u de menubalk, zoals hiernaast weergegeven.
Wanneer u uw vizier op ‘Menu’ richt, opent het menu.

Wanneer u het menu opent, pauzeert het spel altijd.
Vanuit hier kunt u doorgaan met waar u mee bezig was.
U kunt het level herstarten.
U kunt naar de opties.
U kunt terug naar het hoofdmenu.

Navigeren in Reducept

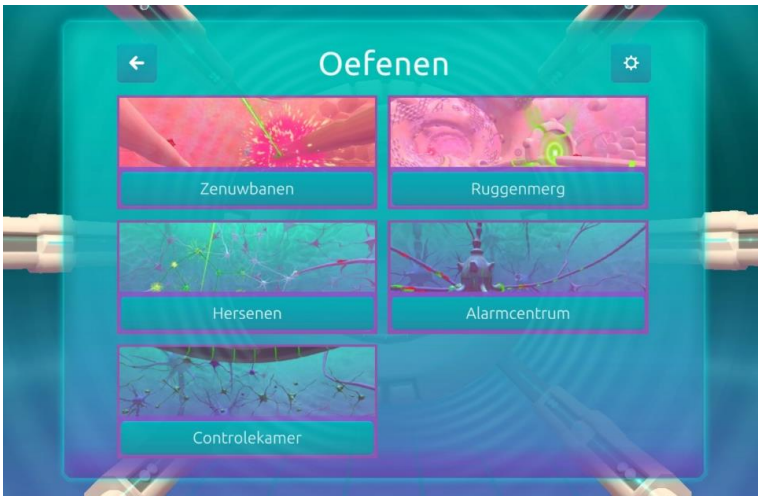
Naast de introductie, zijn er 3 verschillende trainingen die u kunt doen; Verhaal, Oefenen en Dagelijkse uitdaging.
In deze trainingen zijn 5 verschillende levels die u kunt spelen; Zenuwbanen, Ruggenmerg, Hersenen, Alarmcentrum en Controlekamer.
Wij adviseren u om met het verhaal te beginnen en deze eerst helemaal te doorlopen. Gedurende de weken, kunt u afwisselen tussen de verschillende trainingen en levels.

Training starten

Richt uw vizier op bijvoorbeeld ‘Verhaal’, hier kunt wisselen tussen de verschillende levels door middel van de pijltjes, zie afbeelding hieronder. Daarna kunt het level starten door naar start te gaan.

Wanneer het level is afgelopen komt u weer terecht in het Startscherm.

Voor de training oefenen, ziet u in het scherm de verschillende levels, die u kunt kiezen door naar het level te gaan van uw keuze. Het level zal vanzelf starten als u het aanklikt.



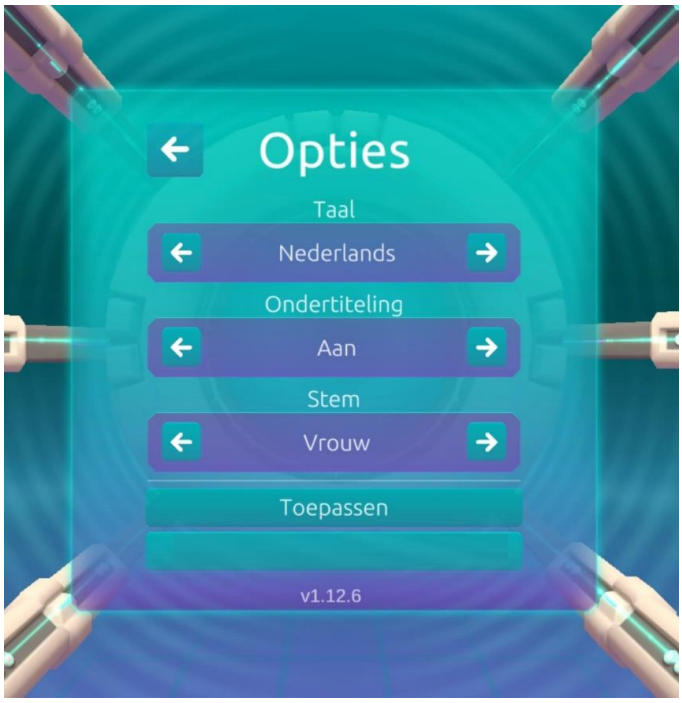
Zo kunt u iedere keer het level spelen van uw keuze. Probeer gedurende de 8 weken te variëren met de verschillende levels.

Applicatie afsluiten

Richt uw vizier op het kruisje linksboven in het Startscherm. Reducept zal vervolgens worden afgesloten.
De VR-bril kunt u uitzetten door de Aan/uit knop een paar seconden ingedrukt te houden.

Instellingen wijzigen

Wanneer u de taal, ondertiteling of stem van de applicatie wilt veranderen gaat u naar de instellingen (rechts bovenin). Dan krijgt het u volgende scherm te zien:



Hier kunt u kiezen om de taal te wijzigen, de ondertiteling aan of uit te zetten en het wijzigen naar een mannen- of vrouwenstem.

D Numerical pain rating scale

NRS vragenlijst **Deelnamenummer:**

Datum	**Tijd**	**Hoeveel pijn heeft u op dit moment?** (1 = geen pijn, 10 = ergst denkbare pijn)
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10
		1 2 3 4 5 6 7 8 9 10

E Explanatory letter

Begeleidende brief bij handleiding Reducept

Geachte heer/mevrouw,

Allereerst willen wij u nogmaals bedanken voor uw deelname aan dit onderzoek. In deze brief staat wat er van u wordt verwacht tijdens het onderzoek. Daarnaast staan er ook contactgegevens waar u contact mee kan op nemen, wanneer u tegen problemen aanloopt. Onderaan de brief staan de inloggegevens voor uw Reducept account.

Wat heeft u meegekregen naar huis:

- De VR bril, waarop Reducept geïnstalleerd is
- Een oplader
- Een afstandsbediening
- Een opberghoes
- De handleiding van de VR bril
- De NRS vragenlijst

In de eerste week van het onderzoek wordt u gebeld, om even kort te bespreken hoe de eerste week verloopt. Mochten er problemen zijn, dan kunt u deze dan bespreken.
Wanneer er daarna nog problemen zijn, of mocht u er niet uitkomen, dan kunt u contact opnemen met Femke.deGreef@mst.nl.
Tijdens werkdagen tussen 9.00 en 16.00 kunt u ook contact opnemen met 06-11722595

Plan voor de komende 8 weken:
2x per week vult u de NRS vragenlijst in. Deze schaalt loopt van 0 (=geen pijn) tot 10 (=meest voorstelbare pijn). Het makkelijkste is als u deze vragenlijst op een vast moment invult. Bijvoorbeeld net na het opstaan, of na het avondeten.
Iedere week voert u minstens **3** trainingssessies uit van 10-15 minuten. U kunt kiezen uit het verhaal, oefeningen, of de dagelijkse oefening. Probeer te variëren met de verschillende levels.
Probeer eerst het verhaal te doorlopen, nadat u deze helemaal hebt doorlopen kunt u variëren met de verschillende trainingen.
U mag er natuurlijk altijd voor kiezen om de VR-bril vaker te gebruiken.

Na 8 weken komt u weer terug in het ziekenhuis, dan neemt u alles weer mee naar het ziekenhuis. Hierover zult u ook nog een bericht ontvangen.

Om gebruik te kunnen maken van de VR bril heeft u de volgende inloggegevens nodig:
Deelnamenummer: 1
E-mailadres: mstvr0001@gmail.com
Wachtwoord: ReumaVR1!

F Questions about characteristics

Wat is uw deelname nummer?

Wat is uw leeftijd?

Wat is uw geslacht?

- ○ Man
- ○ Vrouw

Gebruikt u pijnstillers?

- ○ Ja, namelijk:
- ○ Nee

Heeft u andere aandoeningen / ziektes?

- ○ Psychiatrische ziekte
- ○ Artrose
- ○ Schade aan gewrichten
- ○ Aandoening met chronische pijn
- ○ Anders, namelijk:
- ○ Nee

Wat is uw hoogst genoten opleiding?

- ○ Lager onderwijs
- ○ Middelbaar onderwijs
- ○ MBO
- ○ HBO
- ○ Wetenschappelijk onderwijs

G Questions about comorbidities

Heeft u (ondanks het dragen van een gehoorapparaat nog) problemen met het horen?

- ◯ Ja, namelijk omdat:
- ◯ Nee

Heeft u (ondanks het dragen van een bril / lenzen nog) problemen met het zien?

- ◯ Ja, namelijk omdat:
- ◯ Nee

Heeft u last van angst in kleine ruimtes (claustrofobie)?

- ◯ Ja
- ◯ Nee

Heeft u last van evenwichtsproblemen?

- ◯ Ja
- ◯ Nee

Heeft u last van duizeligheid?

- ◯ Ja
- ◯ Nee

Heeft u last van epilepsie?

- ◯ Ja
- ◯ Nee

Heeft u last van reisziekte?

- ◯ Ja
- ◯ Nee

Heeft u last van hoogtevrees?

- ◯ Ja
- ◯ Nee

Heeft u last van migraine?

- ◯ Ja
- ◯ Nee

Heeft u een andere medische aandoening die slecht samen gaat met VR?

- ◯ Ja, namelijk:
- ◯ Nee

← →

H Virtual reality sickness questionnaire

In dit deel van de vragenlijst wordt naar uw klachten met betrekking tot het gebruik van virtual reality gevraagd. Wilt u elke vraag beantwoorden door het juiste hokje aan te kruisen. Wanneer u twijfelt over het antwoord op een vraag, probeer dan het antwoord te geven dat het meest van toepassing is.

In welke mate heeft u nu last van:

	Niet	Licht	Matig	Ernstig
Algeheel oncomfortabel	○	○	○	○
Vermoeid	○	○	○	○
Vermoeide ogen	○	○	○	○
Moeite om scherp te zien	○	○	○	○
Hoofdpijn	○	○	○	○
Vol gevoel in het hoofd	○	○	○	○
Wazig zien	○	○	○	○
Licht in het hoofd (ogen dicht)	○	○	○	○
Draaiduizeligheid	○	○	○	○
Misselijkheid	○	○	○	○

I Generalized pain questionnaire

UNIVERSITY OF TWENTE.

In dit deel van de vragenlijst wordt naar uw pijnervaringen gevraagd. Wilt u elke vraag beantwoorden door het juiste hokje aan te kruisen. Wanneer u twijfelt over het antwoord op een vraag, probeer dan het antwoord te geven dat het meest van toepassing is.

Geef aan in welke mate u de volgende klachten heeft.

	Niet	Nauwelijks	Matig	Hevig	Zeer hevig
Pijn door lichte aanrakingen (bijvoorbeeld door een schouderklopje of een handdruk)	○	○	○	○	○
Pijn door wrijving over uw huid (bijvoorbeeld door kleding of de wind)	○	○	○	○	○
Pijn door warmte of kou die de meeste mensen niet als pijnlijk zouden ervaren	○	○	○	○	○
Pijn die langer aanhoudt dan bij de meeste andere mensen	○	○	○	○	○
Pijn die pas later optreedt en die bij de meeste andere mensen niet optreedt (bijvoorbeeld uren later of de volgende dag na inspanning zoals wandelen)	○	○	○	○	○
Ongebruikelijke intense ervaringen van pijn (bijvoorbeeld misselijkheid of naar lucht happen)	○	○	○	○	○
Pijn die zich ook verspreidt naar andere lichaamsdelen (bijvoorbeeld pijn in de hand verspreidt zich naar de onderarm)	○	○	○	○	○

← →

J 36-item Short form health survey

In dit deel van de vragenlijst wordt naar uw gezondheid gevraagd. Wilt u elke vraag beantwoorden door het juiste hokje aan te kruisen. Wanneer u twijfelt over het antwoord op een vraag, probeer dan het antwoord te geven dat het meest van toepassing is.

Wat vindt u, over het algemeen genomen, van uw gezondheid ?

- ◯ Uitstekend
- ◯ Zeer goed
- ◯ Goed
- ◯ Matig
- ◯ Slecht

In vergelijking met een jaar geleden, hoe zou u nu uw gezondheid in het algemeen beoordelen ?

- ◯ Veel beter dan een jaar geleden
- ◯ Iets beter dan een jaar geleden
- ◯ Ongeveer hetzelfde als een jaar geleden
- ◯ Iets slechter dan een jaar geleden
- ◯ Veel slechter dan een jaar geleden

De volgende vragen gaan over dagelijks bezigheden. Wordt u door uw gezondheid op dit moment beperkt bij deze bezigheden ? Zo ja, in welke mate ?

	Ja, ernstig beperkt	Ja, een beetje beperkt	Nee, helemaal niet beperkt
Forse inspanning zoals hardlopen, zware voorwerpen tillen, inspannend sporten	○	○	○
Matige inspanning zoals het verplaatsen van een tafel, stofzuigen, bowlen	○	○	○
Tillen of boodschappen dragen	○	○	○
Een paar trappen oplopen	○	○	○
Eén trap oplopen	○	○	○
Buigen, knielen of bukken	○	○	○
Meer dan een kilometer lopen	○	○	○
Een halve kilometer lopen	○	○	○
Honderd meter lopen	○	○	○
Uzelf wassen of aankleden	○	○	○

Had u, ten gevolge van uw lichamelijke gezondheid, de afgelopen 4 weken één van de volgende problemen bij uw werk of andere dagelijkse bezigheden ?

	Ja	Nee
U heeft minder tijd kunnen besteden aan werk of andere bezigheden	○	○
U heeft minder bereikt dan u zou willen	○	○
U was beperkt in het soort werk of soort bezigheden	○	○
U had moeite met het werk of andere bezigheden (het kostte u bijvoorbeeld extra inspanning)	○	○

Had u, ten gevolge van een emotioneel probleem (bijvoorbeeld doordat u zich depressief of angstig voelde), de afgelopen 4 weken één van de volgende problemen bij uw werk of andere dagelijkse bezigheden ?

	Ja	Nee
U heeft minder tijd kunnen besteden aan werk of andere bezigheden	○	○
U heeft minder bereikt dan u zou willen	○	○
U heeft het werk of andere bezigheden niet zo zorgvuldig gedaan als u gewend bent	○	○

In hoeverre heeft uw lichamelijke gezondheid of hebben uw emotionele problemen u de afgelopen 4 weken belemmerd in uw normale sociale bezigheden met gezin, vrienden, buren of anderen ?

- ◯ Helemaal niet
- ◯ Enigzins
- ◯ Nogal
- ◯ Veel
- ◯ Heel erg veel

Hoeveel pijn had u de afgelopen 4 weken?

- ◯ Geen
- ◯ Heel licht
- ◯ Licht
- ◯ Nogal
- ◯ Ernstig
- ◯ Heel ernstig

In welke mate heeft pijn u de afgelopen vier weken belemmerd bij uw normale werkzaamheden (zowel werk buitenshuis als huishoudelijk werk) ?

- ◯ Helemaal niet
- ◯ Een klein beetje
- ◯ Nogal
- ◯ Veel
- ◯ Heel erg veel

Deze vragen gaan over hoe u zich de afgelopen 4 weken heeft gevoeld. Wilt u bij elke vraag het antwoord aankruisen dat het beste aansluit bij hoe u zich heeft gevoeld. Hoe vaak gedurende de afgelopen 4 weken :

	Voortdurend	Meestal	Vaak	Soms	Zelden	Nooit
Voelde u zich levenslustig?	○	○	○	○	○	○
Voelde u zich erg zenuwachtig?	○	○	○	○	○	○
Zat u zo erg in de put dat niet u zich kon opvrolijken?	○	○	○	○	○	○
Voelde u zich kalm en rustig?	○	○	○	○	○	○
Voelde u zich energiek?	○	○	○	○	○	○
Voelde u zich neerslachtig en somber?	○	○	○	○	○	○
Voelde u zich uitgeblust?	○	○	○	○	○	○
Voelde u zich gelukkig?	○	○	○	○	○	○
Voelde u zich moe?	○	○	○	○	○	○

Hoe vaak hebben uw lichamelijke gezondheid of emotionele problemen gedurende de afgelopen 4 weken uw sociale activiteiten (zoals bezoek aan vrienden of naaste familieleden) belemmerd ?

- ◯ Voortdurend
- ◯ Meestal
- ◯ Soms
- ◯ Zelden
- ◯ Nooit

Wilt u het antwoord kiezen dat het beste weergeeft hoe juist of onjuist u elk van de volgende uitspraken voor uzelf vindt.

	Volkomen juist	Grotendeels juist	Weet ik niet	Grotendeels onjuist	Volkomen onjuist
Ik lijk gemakkelijker ziek te worden dan andere mensen	◯	◯	◯	◯	◯
Ik ben net zo gezond als andere mensen die ik ken	◯	◯	◯	◯	◯
Ik verwacht dat mijn gezondheid achteruit zal gaan	◯	◯	◯	◯	◯
Mijn gezondheid is uitstekend	◯	◯	◯	◯	◯

←

→

K Arthritis self-efficacy scale

Uitvoerbaarheidsverwachtingen met betrekking tot pijn.
Wilt u het antwoord kiezen dat het beste weergeeft hoe juist of onjuist u elk van de volgende uitspraken voor uzelf vindt.

	Volkomen juist	Grotendeels juist	Neutraal	Grotendeels onjuist	Volkomen onjuist
Ik ben tevreden over mijn eigen mogelijkheden om de pijn van mijn reumatische aandoening te beheersen.	○	○	○	○	○
Bij pijn en stijfheid door mijn reumatische aandoening kan ik mijn dagelijkse bezigheden gewoon blijven uitvoeren.	○	○	○	○	○
Ik ben er zeker van dat ik kan slapen ondanks de pijn van mijn reumatische aandoening.	○	○	○	○	○
Ik ben er zeker van dat ik de pijn als gevolg van mijn reumatische aandoening behoorlijk kan verminderen zonder extra medicijnen te gebruiken.	○	○	○	○	○
Ik ben er zeker van dat ik de pijn door mijn reumatische aandoening tijdens mijn dagelijkse bezigheden goed aankan.	○	○	○	○	○

Uitvoerbaarheidsverwachtingen met betrekking tot functie.
Wilt u het antwoord kiezen dat het beste weergeeft hoe juist of onjuist u elk van de volgende uitspraken voor uzelf vindt.

	Volkomen juist	Grotendeels juist	Neutraal	Grotendeels onjuist	Volkomen onjuist
Ik ben er zeker van dat ik dertig meter kan lopen in 20 seconden.	○	○	○	○	○
Ik ben er zeker van dat ik tien treden naar beneden kan lopen in 7 seconden.	○	○	○	○	○
Ik ben er zeker van dat ik uit een stoel zonder armleuningen kan opstaan zonder mijn handen te gebruiken.	○	○	○	○	○
Ik ben er zeker van dat ik drie middelgrote knopen dicht en open kan maken in 12 seconden.	○	○	○	○	○
Ik ben er zeker van dat ik zonder hulp een stuk vlees kan snijden.	○	○	○	○	○
Ik ben er zeker van dat ik een kraan volledig open en dicht kan draaien (geen zwenkkraan).	○	○	○	○	○
Ik ben er zeker van dat ik mijn schouderbladen kan krabben zowel met mijn rechter- als met mijn linkerhand.	○	○	○	○	○
Ik ben er zeker van dat ik in en uit een auto kan stappen zonder hulp(middelen).	○	○	○	○	○
Ik ben er zeker van dat ik een overhemd met lange mouwen (of soortgelijke blouse) aan kan trekken in 8 seconden (zonder de knopen dicht te doen).	○	○	○	○	○

Uitvoerbaarheidsverwachtingen met betrekking tot functie.
Wilt u het antwoord kiezen dat het beste weergeeft hoe juist of onjuist u elk van de volgende uitspraken voor uzelf vindt.

	Volkomen juist	Grotendeels juist	Neutraal	Grotendeels onjuist	Volkomen onjuist
Ik ben tevreden over mijn eigen mogelijkheden om zelf dagelijkse bezigheden uit te voeren.	○	○	○	○	○
Ik ben er zeker van dat ik mijn vermoeidheid kan beheersen.	○	○	○	○	○
Ik ben er zeker van dat ik mijn bezigheden zo kan regelen dat mijn reumatische aandoening er niet door wordt verergerd.	○	○	○	○	○
Ik ben er zeker van dat ik me er zelf weer bovenop kan helpen als ik me een beetje somber voel.	○	○	○	○	○
Ik ben er zeker van dat ik mijn reumatische aandoening zodanig kan beheersen dat ik kan doen wat ik leuk vindt.	○	○	○	○	○
Ik ben er zeker van dat ik de frustraties die ik door mijn reumatische aandoening ondervindt aankan.	○	○	○	○	○

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L Questions about evaluation

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In hoeverre bent u het eens met onderstaande stellingen:

	Helemaal mee eens	Mee eens	Neutraal	Oneens	Helemaal oneens
Ik vond het leuk om de trainingen uit te voeren.	○	○	○	○	○
De trainingen waren genoeg uitdagend voor mij.	○	○	○	○	○
De trainingen waren makkelijk zelfstandig uit te voeren.	○	○	○	○	○
De trainingen bleven ook bij herhaaldelijk gebruik leuk genoeg.	○	○	○	○	○
Het lukte goed om problemen met de bril zelfstandig op te lossen.	○	○	○	○	○

Tegen welke problemen bent u aangelopen bij het thuis gebruiken van de bril?

Gebruikte u de bril op een vast moment?

- ○ Ja
- ○ Nee

Op welke vaste momenten gebruikte u de bril?

Hoe vaak gebruikte u de bril? (aantal keer per week)

Zou u deze behandeling aanraden aan anderen?

- ○ Ja, omdat...
- ○ Nee, omdat...

Heeft u tips om de behandeling te verbeteren?

Wat vond u van de lengte van de vragenlijsten?

Wat vond u van het aantal vragenlijsten?

M Different exercises of Reducept

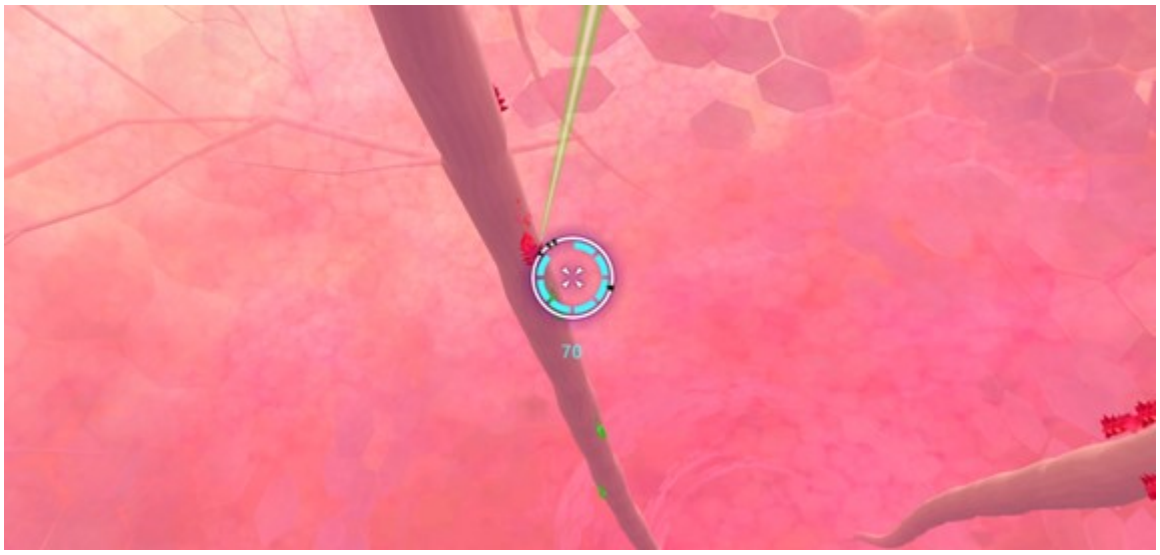

Figure 1: Nerves exercise

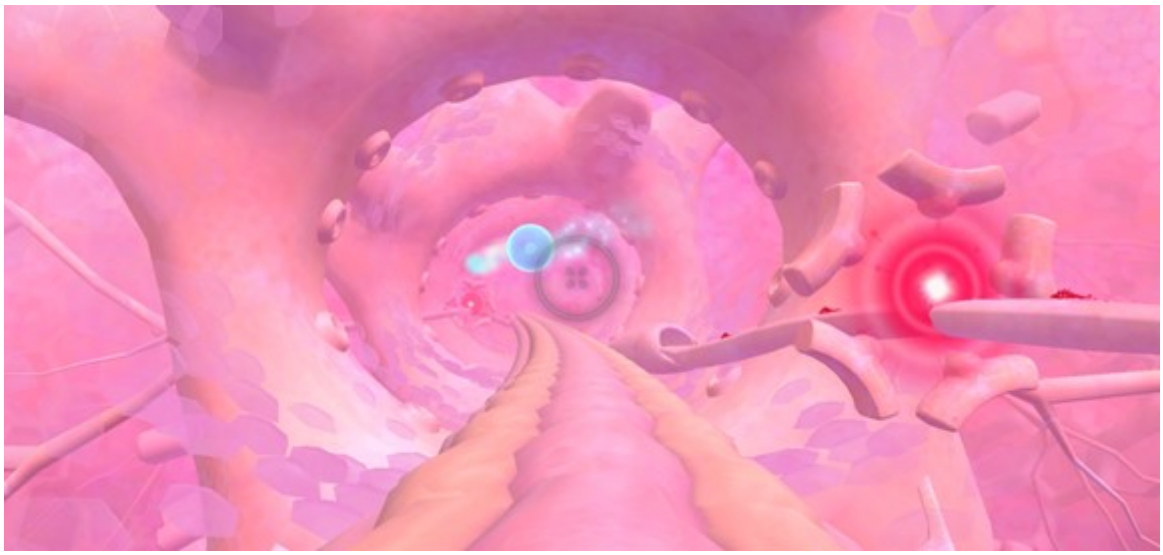

Figure 2: Spinal cord exercise

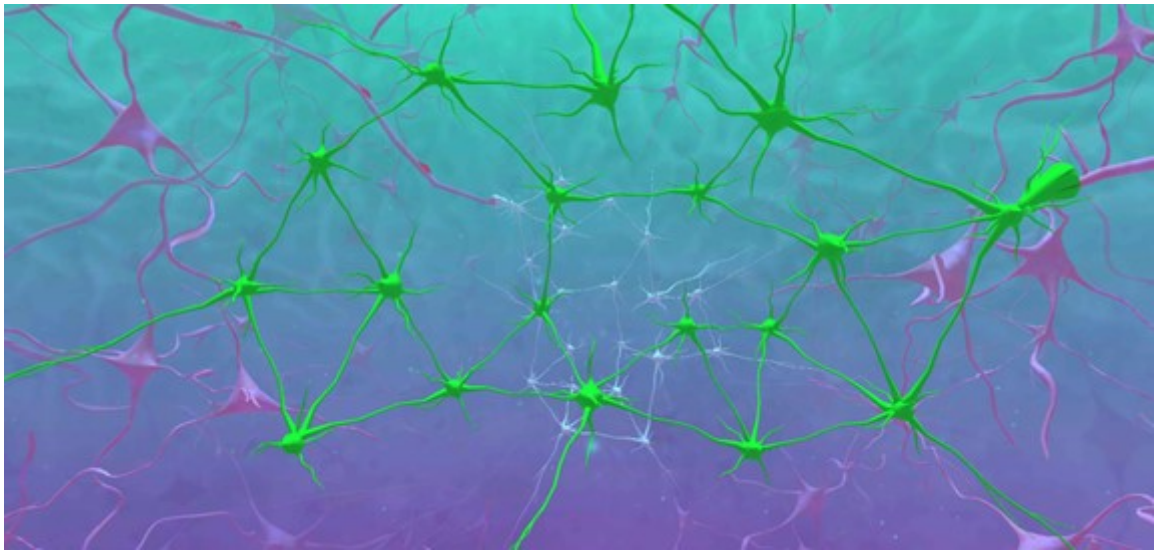

Figure 3: Brain exercise

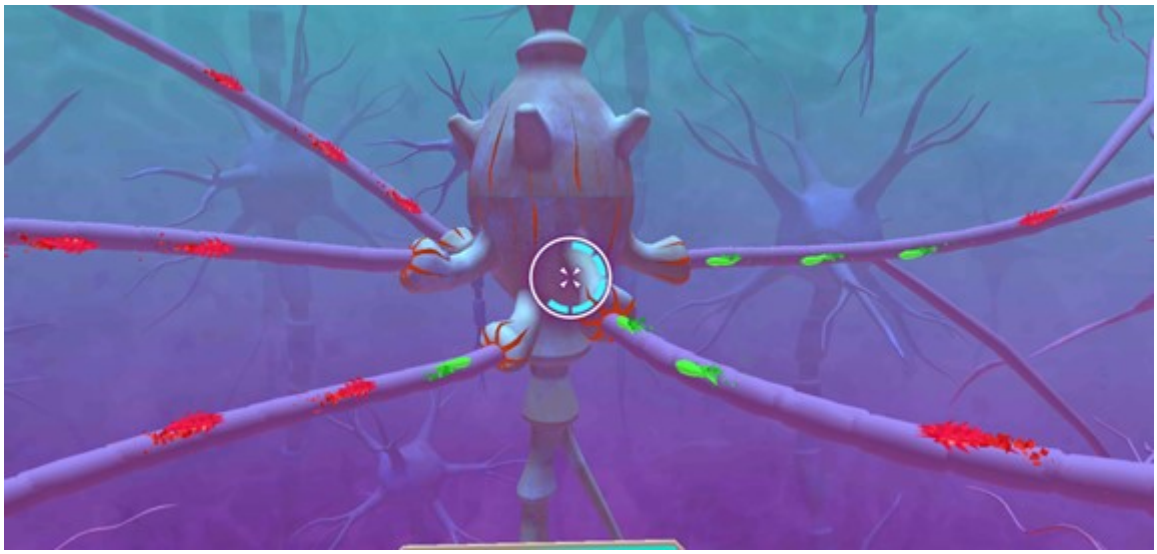

Figure 4: Alarm centre exercise

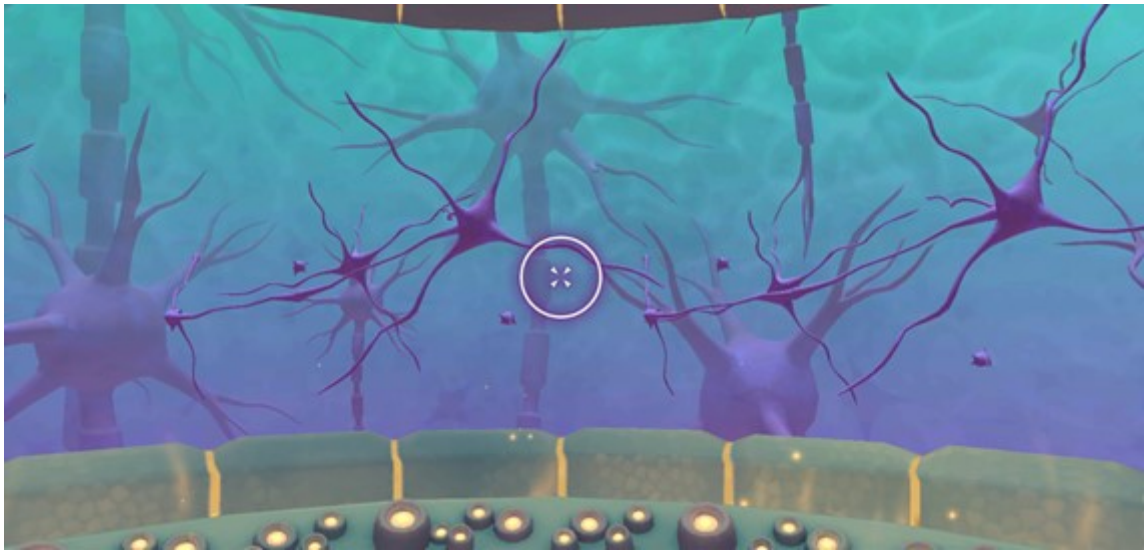

Figure 5: Control room exercise