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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Technology supported high intensity training at home for persons with chronic nonspecific low back pain: a pilot study

Marten Snoeks
Robbe Vranken

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

PROMOTOR :
Prof. dr. Annick TIMMERMANS

COPROMOTOR :
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Acknowledgement

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We would also like to give special thanks to first-degree master's student Tine Theysmans for helping us with setting up the practical aspects of the study. Alongside that, we are very grateful for the major part she had in the recruitment of potential participants and for all the work she put into this phase.

A debt of gratitude is also owed to our participant for taking part in the study and for the continuous effort during the rehabilitation process. The importance of this participant should not be underestimated.

Next to that, we would like to thank the research group REVAL from the Faculty of Rehabilitation Sciences (UHasselt) for the use of their premises and materials during the rehabilitation phase of our study.

Finally, many thanks should also go to our parents and partners for their continuous support. Without them none of this would have been possible.

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Research context

This master's thesis encompasses content related to the musculoskeletal rehabilitation domain. The study specifically targets persons with chronic low back pain, which means the targeted sample has complaints that are persistent for longer than 3 months. This is a major cause of the disability, pain, and reduction of quality of life and affects persons of all ages. Previous research has shown that exercise therapy can reduce these complaints and improve the quality of life of patients (Owen et al., 2020). The musculoskeletal research group of our university and their collaborators have shown that exercise intensity matters when treating chronic low back pain (Verbrugghe et al., 2019), which supports the utilization of high intensity training protocols. However, because of the multicomplex drivers (eg. motivation, practicality, education, …) adherence to these exercises is not evident for everyone (Saner, Bergman, de Bie, & Sieben, 2018). It is necessary to discuss new fields in the physical therapy which can facilitate the adherence and improve quality of life effectively.

The COVID-19 crisis made clear that an urgent change of safe alternatives is necessary to give patients the help they need. Telerehabilitation is a service that can be used to help patients at a distance by using various technologies as telephone, internet, video-conferencing or mobile/internet applications. There are still many questions about this field of rehabilitation in musculoskeletal disorders (eg. feasibility, effectivity) and mostly therapists remain skeptical about the implementation of it in daily life (Dierick, Pierre, Profeta, Telliez, & Buisseret, 2021). The goal of this trial was therefore to evaluate the feasibility/effectiveness of a technology supported high intensity training (HIT) program performed at home in persons with chronic low back pain. Outcomes as pain, physical function, physical activity, and fear avoidance were analyzed, together with the feasibility.

This was an independent study carried out by second-degree master's students Marten Snoeks and Robbe Vranken and led by promotor Prof. Dr. Annick Timmermans and co-promotor Dr. Jonas Verbrugghe. The trial design was a pilot cohort study which was conducted at REVAL, University of Hasselt (Belgium), and in the home-setting of participants. The research questions and protocol were already stated by the promotor and co-promotor and this protocol was already submitted at the Medical Ethics Committee of University of Hasselt.

Both students had an equal share in preparation, recruitment, data-acquisition, and analysis for this trial. The preparation consisted mainly of digitalizing the home program and setting up practical aspects of the intervention: translate and insert questionnaires in Qualtrics, record videos for PhysiTrack, set up PhysiTrack with individualized program for the participants, smartwatch configuration and setting up the interval protocol on the bicycle ergometer. Recruitment was done by e-mail, social media, handing out flyers at internships and word to mouth advertising. The students itself also conducted the intervention one time to experience the physical demandings of a HIT protocol and to understand what a patient would experience while following the program. The four in-center interventions were given by the students with supervision by Dr. Jonas Verbrugghe. Lastly, the academic writing process of this master's thesis was fully independent.

Abstract

Background: Telerehabilitation is a fast-growing service to assist physical therapists in giving necessary care to patients. Recent advancements of smart devices and mobile applications have made the transformation to this therapy modality even more feasible. Next to that, HIT has been shown to be feasible and effective in the rehabilitation of patients with chronic nonspecific low back pain (CNSLBP).

Objectives: To investigate the feasibility and effectivity of a HIT protocol performed in the home-setting with the support of the PhysiTrack application.

Participants: One patient with CNSLBP was included. The participant was 64 years old and had no underlying impairments. The physical function and quality of life of the patient were not much influenced by the experienced LBP. Although, the patient showed a mild level of fear avoidance.

Measurements: Clinical outcomes, feasibility outcomes, adherence and exercise capacity outcomes were assessed in the included participant with CNSLBP. This trial consisted of three measuring moments: PRE (baseline), MID (after two weeks) and POST (after six weeks). The MID-measurement moment evaluated the effect of four in-center rehabilitation sessions while the POST-measurement moment was important to analyze the effect of eight home-based rehabilitation sessions with the support of PhysiTrack.

Results: Clinical outcomes did not change significantly for lower back pain related outcome measures. However, at the POST-assessment a large improvement was observed for the fear-avoidance. Feasibility outcomes showed no difference between in-center and home-based rehabilitation and the participant reported that rehabilitating with the support of PhysiTrack was easy, useful and worth repeating.

Conclusion: It is feasible to support the rehabilitation of CNSLBP with the PhysiTrack application. Effectivity outcomes improved the most on fear-avoidance. The use of this HIT program via PhysiTrack is an interesting new kind of rehabilitation for CNSLBP and should therefore be further investigated to gain insights about the effectivity.

Keywords: chronic nonspecific low back pain, HIT, rehabilitation, feasibility, effectivity, PhysiTrack

1. Introduction

Telemedicine applications have grown in popularity over the last few years as new computer science technologies and more powerful telemedicine equipment have been available. The COVID-19 pandemic encouraged physical therapists to utilize safe alternatives, which boosted the use of telerehabilitation. Telerehabilitation is defined as "the provision of a rehabilitation service at a distance using telecommunications technology as a delivery medium" (Russell, 2007, p. 217). Recent advancements of smart devices and related mobile applications have made this transformation even more feasible. This developing service can be applied by various media and technologies such as a telephone, internet, video-conferencing systems, mobile/internet applications, and sensor technologies. However, some challenges still must be overcome such as quantifying movement remotely, the need for rehabilitation equipment and the difficulties to provide therapy without the possibility for hands-on interventions (Barton et al., 2021). A study of Tenforde et al. (2020) found that 211 patients, who received telerehabilitation sessions during the pandemic, reported healthcare still as high-quality (93%). Furthermore, according to the De Baets et al. (2021) patients in Belgium agreed on the benefits of less relocation (71%) and time saving (69%). However, therapists were more reluctant than patients in Belgium to use telerehabilitation, mainly because of the lack of hands-on-therapy (67%) (De Baets et al., 2021; Dierick et al., 2021). Still, considering these barriers, telerehabilitation permits therapists to guarantee adequate/continued services to patients with acute and chronic conditions in its home environment (Alsobayel et al., 2021; Turolla, Rossettini, Viceconti, Palese, & Geri, 2020).

According to the Global Burden of Disease Study 2019, musculoskeletal disorders (MSDs) contribute to the most important drivers of increasing burden, affecting all ages. Those burden of MSDs increased largely over the last 30 years with a Disability-Adjusted Life Years (DALYs) rate of 30,7% (Vos et al., 2020). Besides, MSDs are also contributing globally the most to Years Lived with Disability (YLDs) with approximately 149 million YLDS, accounting for 17% of all YLDs worldwide (Cieza et al., 2020). Chronic nonspecific low back pain (CNSLBP) is the main disorder of MSDs (MacKenzie & de Melo-Martin, 2015) and the leading cause of disability and productivity loss worldwide with a lifetime prevalence of up to 84% (Balagué, Mannion, Pellisé, & Cedraschi, 2012). Most episodes (80-90%) resolve within 6 weeks but 10% of

patients develop chronic symptoms. Still, 40-50% of patients deal with recurring symptoms after being symptom free for at least 12 months (da Silva et al., 2019).

Active rehabilitation, including therapeutic exercise is one of the evidence-based treatments that physical therapists can deliver for chronic low back pain using telerehabilitation (Bodes Pardo et al., 2018). Although promising results for exercise therapy were found (Kim & Yim, 2020), improvements after recovery with physical therapy were not retained over long term, neither did reduce the risk of recurrence, which may explain partially the high recurrence of LBP (da Silva et al., 2019; Ferreira et al., 2021). The low adherence of patients might affect the depicted outcomes in these clinical trials and even more in clinical practice. Adherence at the start of home rehabilitation may be high but will decrease over time which may be a consequence of low self-management (Peterson, 2018; Salo et al., 2012). Nevertheless, MSD patients adhere better when exercise programs are provided on an app with remote support compared to paper handouts (Lambert et al., 2017). Chhabra, Sharma, and Verma (2018) even found of an app for self-management of chronic LPB clinically meaningful for improvements in pain and disability. Thus, application of telerehabilitation is an adequate option to improve adherence (Dias et al., 2021; Roine et al., 2009; Russell, 2007) by assisting with longitudinal care by self-management strategies via telerehabilitation (Beattie, Silfies, & Jordon, 2016).

An increasingly used active rehabilitation mode is high-intensity training (HIT). HIT consists of short intense activities that elicit ≥90% of VO_{2max}, >75% of maximal power and periods of rest or low-intensity exercise (Atakan, Li, Kosar, Turnagol, & Yan, 2021). This intervention has shown its effectiveness in healthy populations (Atakan et al., 2021; Sadek et al., 2022). A trial of Verbrugghe et al. (2019) even found HIT to be a feasible and effective program for chronic LBP and to have greater improvements in comparison to a moderate exercise program.

As already mentioned, previous trials of recent years expanded already the investigation in telerehabilitation (Alsobayel et al., 2021; Dias et al., 2021) and HIT protocols in the management of CNSLBP (Berry et al., 2019; Helmhout, Harts, Staal, Candel, & de Bie, 2004; Verbrugghe et al., 2021). However, currently, these were always investigated separately. Therefore, the aim of this trial was to evaluate the feasibility with an additional interest for the effectivity of a HIT program consisting of a combined cardio-respiratory and core muscle training protocol in a home-setting by using a mobile application, in persons with CNSLBP.

2. Method

2.1 Study design

This pilot cohort study of which this master's thesis contributes to, aimed to include 15 participants with chronic LBP and contains a six-week HIT intervention with a total of 12 rehabilitation sessions (**Fig. 1**). The first four sessions take place at REVAL Research Center (UHasselt) and in these initial sessions the patients get educated how to execute the exercise protocol. These sessions are completely supervised. The following eight sessions are performed in the home setting with support of the PhysiTrack technology. These sessions are performed without a physically present physiotherapist but with the guidance of a mobile application. There were three measuring moments during this study: PRE, MID and POST. PRE and POST measurements were carried out at REVAL and included physical testing and questionnaires (the questionnaires of the POST-assessment were completed online at home). MID-measurements included questionnaires and were carried out online using an online survey (Qualtrics software). The purpose of the MID-measurement moment was to analyze the effect of the four in-center rehabilitation sessions. The data from the POST-measurement moment was important to compare the maximal cardiorespiratory test to the test done at PRE-measurement and to analyze the effect of the eight home-based rehabilitation sessions.

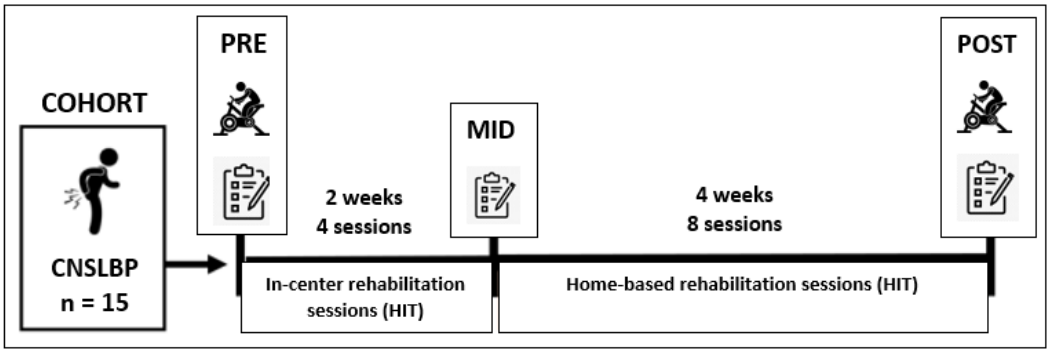


Fig. 1: study design

2.2 Participants

Persons with chronic nonspecific low back pain were recruited in the region of Limburg (Belgium). The recruitment was done via advertisement with flyers in public places and on social media (Facebook, Instagram). An e-mail with information about the study plus the flyer

was sent to companies and facilities (Cegeka Limburg, Corda Campus Hasselt and VKW Limburg), general practices and health care institutions near Diepenbeek. Lastly, verbal advertisement amongst family, friends and colleagues was also used as a recruitment strategy. The recruitment of patients started the 14th of February 2022 and will end around August 2023.

An a priori power sample size to evaluate the correct sample size was not performed because this was a feasibility study. However, guidelines to define sample size for progression criteria for pragmatic pilot studies were followed. M. Lewis et al. (2021) indicated that a minimum sample size of 10-15 is recommended for feasibility studies. Subsequently, the decision was made to include 15 participants in this pilot study.

Participants were eligible for inclusion if they met all the following criteria: chronic LBP of a nonspecific origin (medical diagnosis of pain localized below the costal margin and above the inferior gluteal folds with or without referred leg pain of a nociceptive mechanical nature, not attributable to a recognizable, known specific pathology, for example, infection, tumor, osteoporosis, fracture, structural deformity, inflammatory disorder, radicular syndrome, or cauda equina syndrome for a period of at least 12 weeks (Airaksinen et al., 2006). Patients had to be between 25 to 65 years old and speak the Dutch language. It was also important that they owned an Android or iOS smartphone and could work with it. Persons were excluded if they had a history of spinal fusion, had an acute or chronic musculoskeletal disorder aside from the chronic non-specific LBP, had comorbidities (e.g. paresis and/or sensory disturbances by neurological causes, diabetes mellitus and rheumatoid arthritis), were pregnant or tried to be, had ongoing compensation claims and/or a work disability for more than 6 months, had followed another exercise therapy program for LBP in the past 3 months and when they were not able to attend regular therapy appointments. The study was approved by CME UHasselt (Hasselt, Belgium) on the 15th of December 2021. The code of the trial is CME2021/081. All participants gave written informed consent before being included in the study.

2.3 Procedure

2.3.1 Intervention

In-center rehabilitation (session one to four, week one to two)

After the collection of PRE-measurement data, patients had to carry out four in-center rehabilitation sessions of about 1h-1.5h (twice a week). These rehabilitation sessions consisted of three main parts: a high intensity exercise protocol consisting of cardiorespiratory training, general resistance training and core muscle training. The session always started with the cardiorespiratory training consisting of a high intensity interval protocol on a cycle ergometer. After a warm-up of five minutes, patients were instructed to perform five high intensity one-minute bouts (110 RPM), followed by one minute of active recovery (75 RPM) after every one-minute bout. The 110 RPM-bouts were performed at 100% of the VO2max workload achieved during the cardiopulmonary exercise test (PRE-assessment) and the 75 RPM-bouts were performed at 50% of the same workload (Wens et al., 2015). After the HIT-session, a cooling down period of five minutes was allowed on a self-selected load and RPM. The first two in-center cardiorespiratory training sessions were performed on a Technogym (Excite 700) ergometer and the other two were performed on a Tunturi (FitCycle 50i) ergometer. The purpose of this was to let the participants get used to the Tunturi ergometer because it would be used at home.

The second part of the in-center rehabilitation session consisted of six high load general resistance training exercises on fitness devices. The exercise protocol consisted of three lower and three upper body exercises (vertical traction, leg curl, chest press, leg press, biceps curl and leg extension). During the first in-center session, patients were introduced to the fitness devices and the correct execution was taught. Patients were asked to try and perform the exercises on low loads while the therapists checked for compensations and made sure the execution was flawless. After mastering the technique, a one repetition maximum (1RM) testing was performed for every resistance exercise. In the second session, the quality of execution was checked followed by 15 repetitions at an intensity of 60% 1RM. During the third and fourth sessions patients were asked to perform ten repetitions at an intensity of 80%

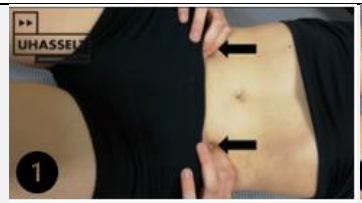
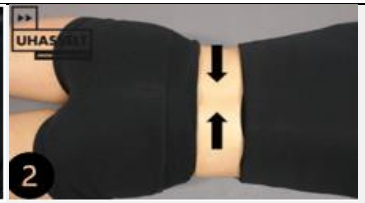
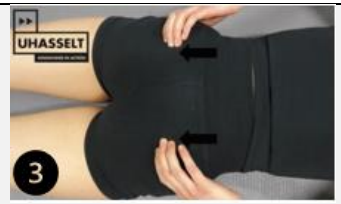
1RM. The quality of performance remained very important, and patients were encouraged to 'push their lower back' into the back seat of the fitness device while performing the exercises.

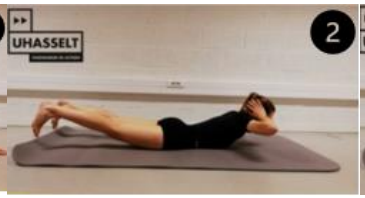
At last, patients had to complete a core strength program consisting of six static core exercises. During the first in-center session, the therapists taught the participants how to activate m. tractus abdominus, m. multifidus, mm. gluteus medius & maximus (***Table 1.***) and muscles in the thoracic region between the scapulae. The second session consisted of the quality control of the contractions followed by the demonstration on how to perform the main exercises. The six main exercises were bridging, clamming, bird dog, planking, sideplanking and rowing (***Table 1.***). The starting exercises consisted of glute bridge, resistance band glute clam, lying diagonal extension, adapted knee plank, adapted knee side plank and elastic band shoulder retraction with hip hinge. Patients had to perform one set of ten repetitions of a ten second static hold. If it wasn't possible to execute the starting exercise, patients had to start with corresponding regressions and had to try and make progression throughout the rehabilitation. Exercises were made more difficult by increasing the static hold time and, if possible, progressing to a more challenging posture when they were executed with a stable core for the indicated time on two consecutive training sessions**.** During the third and fourth in-center rehabilitation session, patients started the exercises on their level of the previous session. Therapists checked the quality of the execution and whether the participants were able to reach the static hold time that was prescribed. During these two sessions the same rules as mentioned above applied for making progression. After the fourth session, it was important that the participants knew how to perform the prescribed exercises and what aspects were important to pay attention to while exercising at home.

During the in-center rehabilitation sessions, patients were already instructed to download the PhysiApp mobile application (Physitrack, https://www.physitrack.com) on their phone. Bennell et al. (2019) used PhysiTrack already in a trial for MSDs and found that the addition of this web-based exercise programming increased the adherence and confidence to perform the prescribed exercises at home. PhysiApp is the application where patients can see their exercises while therapists use PhysiTrack to prescribe exercises. PhysiTrack is a cloud-based technology to deliver health-related content, like exercises and training programs remotely to patients. Therapists can track patient progress, provide them with feedback (via messages or

Table 1.

Exercise progressions for the home-based rehabilitation sessions

Static core exercise	Exercise level 1	Exercise level 2	Exercise level 3	Exercise level 4	Exercise level 5
Muscle activations	 *m.transverdus abdominus* (abdominal drawing in manoeuver in crook lying)	 *m. multifidus* (prone posterior pelvic tilting)	 *mm. gluteus medius & maximus* (prone isolated contraction, squeezing buttocks)	/	/
Glute bridge	 *Glute bridge* (5s & 10s) (= starting position)	 *Quadruped hip extension with knee extended* (5s & 10s)	 *Quadruped diagonal arm and hip extension with knee extension* (5s & 10s)	 *Unilateral glute bridge with bended knee* (5s & 10s)	 *Unilateral glute bridge with extended knee* (5s & 10s)
Glute clam	 *Glute clam* (5s & 10s)	 *Glute clam with resistance band* (5s & 10s) (= starting position)	 *Glute clam with resistance band* (different colour) (5s & 10s)	/	/

Bird dog	 *Lying diagonal extension* (5s & 10s) (= starting position)	 *Lying superman extension with hands on head* (5s & 10s),	 *Lying superman extension with extended arms* (5s & 10s).	/	/
Planking	 *Adapted knee plank with height* (5s & 10s)	 *Adapted knee plank* (5s & 10s) (= starting position)	 *Long lever whole body plank with height* (5s & 10s)	 *Long lever whole body plank* (5s & 10s)	/
Side planking	 *Adapted knee side plank with height* (5s & 10s),	 *Adapted knee side plank* (5s & 10s) (= starting position)	 *Whole body side plank with height* (5s & 10s)	 *Whole body side plank* (5s & 10s)	/
Rowing	 *Elastic band shoulder retraction with hip hinge* (5s & 10s) (= starting position)	 *Elastic band shoulder retraction with hip hinge and progressive resistance* (5s & 10s)	/	/	/

via video conferencing) and send reminders. PhysiTrack is GDPR and HIPPAA compliant. When patients had completed their last in-center session, therapists had to make sure that everything worked as it should, and patients fully understood how they had to use the mobile application.

Home rehabilitation (session five to 12, week three to six)

The rehabilitation sessions at home were carried out over a period of four weeks with eight sessions in total. Patients were provided with a bicycle ergometer (Tunturi FitCycle 50i), a smartwatch (Polar Ignite 2), a training mat (Tunturi NBR), four different resistance bands (Fysiosupplies) and four different elastic bands with handles (Fysiofupplies) to complete the sessions at home. The HIT protocol resembled the in-center sessions as much as possible and had a duration of about one hour. The resistance training exercises on fitness devices were not included in the home sessions because this was impossible to arrange. Researchers formulated a personalized HIT program for every patient by using the PhysiTrack program. Subsequently, patients could watch their program via PhysiApp which was already installed on their phone during the in-center sessions. The videos that were used for the home sessions were pre-recorded by the researchers and uploaded to PhysiTrack. Researchers had to make sure all six static core exercises with progressions (***Table 1.***) were recorded as well as al the progressions for the cardiorespiratory interval protocol. Once all the videos were uploaded to PhysiTrack, clear written instructions were added to every separate video to ensure that patients could rely on instructions next to the videos for completing their exercises. Instruction videos on how to set up the interval protocol on the bike as well as a video on how to adjust the saddle height of the Tunturi bike were also added to every participant's PhysiApp program.

For the cardiorespiratory interval protocol videos of a test subject (not included in the study), performing the several protocols with every progression (1'10", 1'20", 1'30" and 1'40"), were recorded. Structured videos were constructed with clear instructions, so patients were able to perform the HIT protocol without supervision by watching the prescribed video (**Fig. 2**). During the first week (two sessions) patients were instructed to perform five high intensity bouts of 1'10" at 110 RPM separated by five one-minute periods of active recovery at 75 RPM. Warming-up and cooling-down phases remained the same as during the in-center sessions.

Progression was made to 1'20" for the high intensity bouts (110 RPM) in week two, 1'30" in week three and 1'40" in week four. The active recovery phase remained one minute (75 RPM) every week. The smartwatch was used to inventory heartrate during the interval protocol. Patients were instructed to manually start and stop the activity on the smartwatch. When patients successfully finished the protocol and pressed the 'stop' button, progress was automatically saved on the watch. After four weeks, all data was retrieved by synching the smartwatch to the Polar Flow application on the computer.

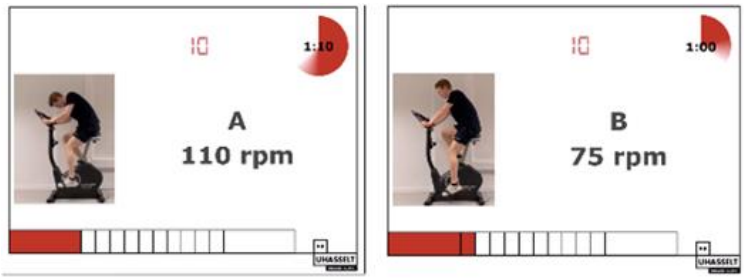


Fig. 2*: Screenshots of the HIT protocol video. Left: 1'10" bout (110 RPM), right: one minute bout (active rest, 75 RPM). The '10' in the top center is a timer to indicate the last ten seconds of a bout. The blocks with progression at the bottom turn red when a bout is finished.*

The core strength training was performed on a fitness mat at home while using visual footage (videos and photos) in PhysiApp. This footage was also pre-recorded and uploaded to PhysiTrack. Patients were instructed to execute these exercises in the same session as the cardiorespiratory interval protocol. During the last in-center rehabilitation session, therapists determined the level for the participants and assigned the corresponding exercise to their PhysiApp program. Patients performed a total of six static core exercises. Only the progression which was suitable for every individual patient was uploaded to their PhysiApp program to make clear which exercise patients were expected to perform. Progressions and regressions of the six static core exercises can be found in ***Table 1***.. Patients were always prescribed ten repetitions of five or ten seconds (depending on their progression) per exercise. The PhysiTrack system was set up to send automated reminders about exercise times, record exercise completion, track the amount of completed repetitions and it had the ability to follow-up the self-reported NPRS (pain scale from 0 to 10) per exercise. Each participant's program was reviewed and progressed weekly (i.e. every two sessions) by the researchers if needed. This was done by reviewing the self-reported NPRS and completion rate of every exercise. Core exercises were only progressed when they were executed for the indicated time

on two consecutive training sessions and when the NPRS for this exercise was not higher than three. The cardiorespiratory interval protocol was always progressed after two sessions no matter the self-reported NPRS score. The researchers checked the PhysiTrack system daily for messages from participants.

Therapy adherence to the exercise program was evaluated by counting the amount of completed therapy sessions within the four-week protocol. Therapy adherence (i.e. number of sessions, amount of exercises and repetitions completed) within each session was recorded by the PhysiTrack system (expressed as a percentage). The program was considered feasible if at least 90% of participants completed the study and if the adherence to the program was at least 75% (= six out of eight sessions performed in total) (Dimatteo, Giordani, Lepper, & Croghan, 2002). Patients were also asked to record adverse events directly into their PhysiApp by sending a message to the researchers so that they could review them. An adverse event was described as an intervention-related event that resulted in an inability to perform the exercises or modification to the exercise intervention.

2.3.2 Baseline assessment

A baseline assessment (PRE) was performed at REVAL Research Center, UHasselt. This assessment consisted of a maximal cardiopulmonary exercise test and the completion of five questionnaires which are related to the characterization of the included patients, the evaluation of the feasibility with a secondary attention to the effectiveness of the program.

The maximal cardiopulmonary exercise test was performed on a bicycle ergometer (eBike Basic, General Electric GmbH, Bitz, Germany) and a pulmonary gas exchange analysis (MetaMax 3B, Cortex BioPhysik GmbH, Leipzig, Germany) was used (Macfarlane & Wong, 2012). Maximal oxygen uptake (VO2max), maximal heart rate (HRmax), 2’ POST heartrate (HRrecup) maximal wattage (Wmax) and peak workload were measured. The heart rate of patients was monitored throughout the entire test using a heart rate chest strap (Polar Electro Inc. Finland). Patients were instructed to warm up for five minutes, whereafter a step-by-step resistance protocol (80 reps/minute starting at 30 Watts, increasing with 15 Watts every minute) was executed until the maximum wattage was reached. This maximal wattage was

equivalent to no longer being able to maintain a stable 75 revolutions per minute (RPM) (Verbrugghe et al., 2018). The load (wattage) corresponding with the VO2max of patients was used in the HIT protocol which will be addressed later in this section.

The five pre-measurement questionnaires that are related to the characterization and effectiveness were the Brief Pain Inventory short form (BPI-sf), the Modified Oswestry Disability Index (MODI), the International Physical Activity Questionnaire (IPAQ) and the Fear Avoidance Components Scale (FACS). The Motivation Visual Analogue Scale (MVAS) was related to the evaluation of feasibility.

The BPI-sf is used to evaluate the severity of the pain and its impact on the patient's daily life. The patients had to fill in the worst, lowest, mean and current pain intensity, name the several treatments they had with its effectiveness and determine what effect the pain has on their general activity, mood, walking ability, normal work, relationships, sleep and quality of life on a scale from zero to ten, whereby zero means 'no hindrance' and ten means 'complete hindrance' (Jumbo et al., 2020). Mendoza, Mayne, Rublee, and Cleeland (2006) found a good convergent validity (≥0.60) with the VAS and WOMAC pain index. Internal consistency of the subscales and the total scale were above 0.80 (Cronbach's α) and acceptable test-retest reliability was found (Yildirim et al., 2019).

The MODI evaluates the constraints patients experience in their daily life due to their chronic nonspecific LBP. It contains ten items that can be scored on a 5-point scale. The total score corresponds with a percentage of restriction for the patient. A score varying between 0% and 20% means that the patient experiences minimal disability, moderate disability (21% and 40%), severe disability (41% and 60%), very severe disability (61% and 80%) and a score varying between 81% and 100% means that patients are bed-bound or exaggerating their pain (Davidson & Keating, 2002). Baradaran, Ebrahimzadeh, Birjandinejad, and Kachooei (2016) found good reliability for the individual items (ICC: 0.43-0.80). Convergent validity between the MODI and functioning subscale of the SF-36 (r=-0.54) and between the physical component domain (r=-0.55) and good internal consistency across all items (Cronbach's α: 0.69).

For the estimation of the physical activity level ***the IPAQ*** is used. This questionnaire consists of seven questions about the intensity of physical activity during the last seven days. The higher the score the more physically demanding the activity level. The aim of this questionnaire is to find out about the types of physical activities that people perform as part of their daily lives. It includes four intensity levels: vigorous and moderate activity, walking and sitting. Patients have to report the amount of days they performed the indicated activity level followed by the amount of time per day (Lee, Macfarlane, Lam, & Stewart, 2011). A moderate criterion validity (Spearman's ρ: 0.33-0.40) was found by (Van Holle, De Bourdeaudhuij, Deforche, Van Cauwenberg, & Van Dyck, 2015) for older Belgian adults. This trial also found a test-retest reliability to moderate-to-good for work-related PA, domestic PA, MVPA and total PA (ICC: 0.52-0.81), but poorer for transportation and recreational PA (ICC 0.44 and 0.43, respectively).

The FACS is designed to evaluate fear avoidance in patients and includes pain-related catastrophic cognitions, hypervigilance, and avoidance behaviors. It includes 20 items with a score from zero (totally disagree) to five (totally agree), with a maximal score of 100. A total score corresponds with a certain anxiety avoidance severity level: subclinical (0-20), mild (21-40), moderate (41-60), severe (61-80) and extreme (81-100) (Neblett, Mayer, Hartzell, Williams, & Gatchel, 2016). Neblett et al. (2016) evaluated the psychometric values and found a high internal consistency (Cronbach's $\alpha = 0.92$) and high test/retest reliability ($r = 0.90\text{-}0.94$, $P < 0.01$) in chronic pain patients.

The MVAS evaluates how motivated participants are to start the rehabilitation program. It consists of a line indicating scores from zero to ten, whereby zero corresponds with 'no motivation' and ten corresponds with 'very high motivation'.

BPI-sf, MODI, IPAQ and FACS are all reliable and valid questionnaires for use in patients with chronic nonspecific LBP (Fairbank & Pynsent, 2000; Garg, Pathak, Churyukanov, Uppin, & Slobodin, 2020; Neblett et al., 2016; Sember et al., 2020).

2.3.3 Mid-assessment

The second phase of the study started when patients finished their last in-center session and had to fill in the MID-measurement questionnaires. Two extra questionnaires were added to the baseline questionnaires: the Satisfaction Visual Analogue Scale (SVAS) (Jacob et al., 2022) and Intrinsic Motivation Inventory (IMI) (Brunet et al., 2020). These questionnaires are both related to the evaluation of feasibility.

The SVAS is a nominal scale used to evaluate the satisfaction of the first four rehabilitation sessions whereby zero means 'no satisfaction' and ten means 'very high satisfaction'.

The IMI assesses multidimensional subjective experience while performing certain activities. It contains 35 items and is used to evaluate the motivation of participants during the four in-center sessions. This questionnaire contains six subscales: interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice. A score of one means 'not true at all' and a score of seven means 'entirely true'. The higher the score the higher the intrinsic motivation (Markland & Hardy, 1997). This questionnaire has an acceptable reliability with a coefficient alpha of 0.85 (McAuley, Duncan, & Tammen, 1989).

2.3.4 Post-assessment

After the termination of the home-based rehabilitation sessions an e-mail with the link for the Qualtrics survey was sent to the participants. Participants were instructed to fill in these questionnaires as soon and as honest as possible. The POST-assessment Qualtrics survey contained one extra questionnaire, the System Usability Scale.

The SUS assesses the perceived usability of the PhysiTrack application and is part of the evaluation of feasibility. It is a standard 10-item questionnaire which measures responses on a 5-point Likert scale. A score of 'one' means that a participant strongly disagrees with the question and a score of 'five' means that a participant strongly agrees. The total score ranges between zero (worst) and 100 (absolute best). An above average usability corresponds with a score higher than 68. A score of 81 or higher means that the usability is that high that the

participants are likely to recommend the product to others (Zhou et al., 2021). In this assessment phase, the Intrinsic Motivation Inventory assessed the intrinsic motivation for the technology supported HIT training via PhysiTrack. This is different from the IMI in the MID-assessment where it assessed the motivation for the in-center rehabilitation sessions. All the other questionnaires (MVAS, SVAS, BPI-sf, MODI, IPAQ and FACS) had the same purpose as in the baseline and MID-assessment. J. Lewis and Sauro (2009) found the SUS reasonably reliable with a coefficient alpha of 0.92 for usability and 0.70 for learnability. Martins, Rosa, Queirós, Silva, and Rocha (2015) found a high and significant correlation with other usability measures for the construct validity: Post-Study Usability System Questionnaire (r = 0 .70) and a general usability questionnaire (r = 0.48).

Participants also performed the maximal cardiopulmonary exercise test for a second time. The execution protocol was the same as the first exercise test and is described in detail in the baseline assessment section.

2.4 Data-analysis

A method for data analysis was set up to be performed in JMP Pro (14.0, SAS Institute Inc., Cary, USA). Recruiting fifteen participants was the goal for this trial, however this was not achievable during the timeframe of this master's thesis. Given the limited equipment (three home trainers), only three participants could follow the trial at the same time. On top of that due to the short timetable (February-May; 12 weeks) a maximum of six participants could be included (considering two weeks less for the pre-/post-assessment and the processing of the results). When someone started the trial after the 18th of April, not all the data could be retrieved before the deadline and data processing for writing this master's thesis. It should be noted that the estimate for six participants was the ideal script, however because of the start of recruitment on the 14th of February, this was less achievable. Therefore, the data analysis was composed for a more realistically estimated three participants. Following are the steps that were needed for this analysis.

The first part consisted of checking whether the data was normally distributed to determine whether parametric or non-parametric analyses had to be performed. If a normal distribution

was the case, then the Wilcoxon signed rank test and one sample t-test were used. Because of the dependent data, the differences of both comparisons (PRE-MID; MID-POST) were checked for normal distribution and not the outcomes on its own. The first comparison was to evaluate the initial effect of the in-center sessions and the second outcome to evaluate the feasibility of HIT at home. The Wilcoxon signed rank test was used solely if the data was not normally distributed.

Because of the small number of expected participants, a higher significance level (alpha) was used to keep a power of 80%. In the calculation for the significance level, data was used from observed therapy effects on the Modified Oswestry Disability Index (MODI) from a previously published feasibility study (Verbrugghe et al., 2018). A minimal clinically important difference (MCID) of ten points out of 100 (Ostelo et al., 2008), a standard deviation of 12 (Ostelo et al., 2008), a power of 80% and three participants gave a two-sided significance level of 0,544. This high alpha value increases the chance for a type I error (false positive). This would mean that deciding to reject the null hypothesis and concluding that the tested participants are different from each other, there is a 54,5% chance of being wrong.

3 Results

Only one participant could be included in this trial during the timeframe for this master's thesis, which didn't make it possible to run a statistic analysis. A descriptive analysis is given about the characteristics of the participant, the progression of the exercises, the adherence with the intervention, clinical outcomes, and feasibility outcomes.

3.1 Participant characteristics

Participant 01 was recruited via word-of-mouth advertising. 01 was a female of 64 years old, living in Limburg, Belgium. Her body measures were a height of 1,61 meters and 85 kilograms which corresponded to a BMI of 32,8. The pre-assessment was fulfilled on the 24th of March 2022 and consisted of questionnaires and a maximal cardiopulmonary exercise test which gained more information about the participant. Physical functioning and quality of life was not much influenced by the experienced back pain: long standing, self-care and lifting heavy objects gave more pain without affecting the activity (eg. duration and execution); sitting longer than an hour was not possible (MODI) (**Table 4.**). Pain could be tolerated well when walking, social life was normal without extra pain, sleep quality was not disrupted, and she could bear the back pain without the use of analgetics. The FACS total score of 32 implicated that she experienced a mild fear avoidance (A. Knezevic et al., 2018) with maximum scores on high concern of pain and avoiding of certain activities because of fear for worsening the pain. She also agreed with the thought that her pain would aggravate until she wouldn't function anymore (**Table 4.**). However, pain could reach 9/10 on the BPI-sf when at its worst but fluctuated between 0-2/10 and was felt at the right low back. When she experienced pain, the only treatment she used was diclofenac or ibuprofen.

3.2 Progression of exercises

During the four-week rehabilitation phase at home the participant made progression on four out of six core exercises (**Table 2.**). The planking and sideplanking were the most difficult exercises to perform because of the participants' shoulder pain during the execution. The participant started with 'adapted knee (side) plank with height 5s' and progression to '10s' for

both exercises was made in session six but this yielded pain scores of eight (planking) and nine (sideplanking). Therefore, the participant was instructed to regress to 'adapted knee (side) plank with height 5s' for the last two sessions. The HIT protocol on the bicycle ergometer was standardized for progression no matter the performance rate and pain score. In the first week it started with 'HIT protocol 1'10"' and ended with 'HIT protocol 1'40"' in week four. NPRS scores were missing for session seven and eight since the participant did not submit them into the PhysiApp after completing the exercises.

Table 2.
Exercise sessions for the home-based rehabilitation sessions by participant 01

	Exercise level	**NPRS**		**Exercise level**	**NPRS**
Session 1	Unilateral glute bridge with bended knee 5s	1	**Session 2**	Unilateral glute bridge with bended knee 5s	6
	Glute clam with resistance band 5s	0		Glute clam with resistance band 5s	0
	Lying superman extension with hands on head 10s	1		Lying superman extension with hands on head 10s	0
	Adapted knee plank with height 5s	4		Adapted knee plank with height 5s	1
	Adapted knee side plank with height 5s	5		Adapted knee side plank with height 5s	3
	Elastic band shoulder retraction with hip hinge 5s	0		Elastic band shoulder retraction with hip hinge 5s	0
	HIT protocol 1'10"	1		HIT protocol 1'10"	1
	Exercise level	**NPRS**		**Exercise level**	**NPRS**
Session 3	Unilateral glute bridge with bended knee 5s	2	**Session 4**	Unilateral glute bridge with bended knee 5s	0
	Glute clam with resistance band 10s	2		Glute clam with resistance band 10s	1
	Lying superman extension with hands on head 10s	1		Lying superman extension with hands on head 10s	1
	Adapted knee plank with height 5s	1		Adapted knee plank with height 5s	2
	Adapted knee side plank with height 5s	2		Adapted knee side plank with height 5s	3
	Elastic band shoulder retraction with hip hinge 10s	0		Elastic band shoulder retraction with hip hinge 10s	0

	HIT protocol 1’20”	3		HIT protocol 1’20”	3
	Exercise level	**NPRS**		**Exercise level**	**NPRS**
Session 5	Unilateral glute bridge with bended knee 10s	2	**Session 6**	Unilateral glute bridge with bended knee 10s	2
	Glute clam with resistance band 10s (ER)	1		Glute clam with resistance band 10s (ER)	2
	Lying superman extension with extended arms 5s	2		Lying superman extension with extended arms 5s	2
	Adapted knee plank with height 5s	2		Adapted knee plank with height 10s	8
	Adapted knee side plank with height 5s	3		Adapted knee side plank with height 10s	9
	Elastic band shoulder retraction with hip hinge 10s (ER)	1		Elastic band shoulder retraction with hip hinge 10s (ER)	2
	HIT protocol 1’30”	4		HIT protocol 1’30”	2
	Exercise level	**NPRS**		**Exercise level**	**NPRS**
Session 7	Unilateral glute bridge with extended knee 5s	-	**Session 8**	Unilateral glute bridge with extended knee 5s	-
	Glute clam with resistance band 10s (ER)	-		Glute clam with resistance band 10s (ER)	-
	Lying superman extension with extended arms 10s	-		Lying superman extension with extended arms 10s	-
	Adapted knee plank with height 5s	-		Adapted knee plank with height 5s	-
	Adapted knee side plank with height 5s	-		Adapted knee side plank with height 5s	-
	Elastic band shoulder retraction with hip hinge 10s (ER)	-		Elastic band shoulder retraction with hip hinge 10s (ER)	-
	HIT protocol 1’40”	-		HIT protocol 1’40”	-

Legend: NPRS = Numeric Pain Rating Scale (0-10), self-reported pain score; ER = extra resistance, stronger resistance band; 5s = 5 seconds; 10s = 10 seconds; HIT = High Intensity training

3.3 Adherence

The participant completed every session, four at REVAL and eight at home (**Table 3.**). Via the PhysiTrack application researchers could check whether the participant completed the session

and how many exercises were performed. PhysiTrack visualized the percentage of the number of exercises performed per session. The therapy adherence for every session was 100% which makes the average adherence also 100%. The participant contacted the researchers via PhysiTrack messages when there were difficulties with exercises, to communicate her pain score including an additional explanation or when she experienced technical difficulties. The participant contacted the researchers during a total of six sessions. The researchers made sure that they were always available via the PhysiTrack chat on the days that she performed her exercises (Tuesday and Friday) so that she didn't have to wait for an answer or for advice. Because of this, there was a minimum of two times per week contact with the participant via chat.

Table 3.
Therapy adherence

	# of completed therapy sessions (REVAL) (/4)	**# of completed therapy sessions (home) (/8)**	**Therapy adherence * (home) (%)**
Subject 01	4	8	100%**

Legend: # amount; * = number of exercises completed (expressed as a percentage in PhysiTrack); ** = average percentage of the combined sessions

3.4 Clinical outcomes

The BPI-sf, MODI, IPAQ and FACS were filled in by the participant at all three measuring moments. The pre-assessment data has already been described at section *4.1 Participant characteristics*. The MID and POST data were compared with the PRE and MID data respectively. An overview of PRE, MID and POST data is provided (**Table 4.**).

Brief Pain Inventory short form

This questionnaire which evaluated the severity of the pain and the impact of this pain on daily functioning had variable outcomes for worst pain. During the mid-assessment, after in-center rehabilitation, was worst pain considered as 3/10, while at the post-assessment this was measured as 7/10. Furthermore, least pain remained zero over all measurement moments. Average pain for the last 24 hours and impact of pain (IOP) on general activity and sleep went from 2/10 to 0/10 from MID to POST (**Table 4.***)*.

Modified Oswestry Disability Index

The MODI (**Table 4.**) evaluated the functional disability and is considered the 'gold standard' of low back functional outcome tools (Fairbank & Pynsent, 2000). The total scale went from 5/50 at PRE to 4/50 at MID and POST and corresponded to a percentage of 10% to 8% respectively. These percentages indicated mild disability which showed that this participant could cope with most living activities and usually, no treatment was indicated apart from advice on lifting, sitting and exercise (Fairbank, Couper, Davies, & O'Brien, 1980; Fairbank & Pynsent, 2000; Roland & Fairbank, 2000).

International Physical Activity Questionnaire

The IPAQ (**Table 4.**) was not filled in correctly given that our participant didn't count the HIT-sessions as a heavy activity. This will be more discussed in chapter five. During the in-center rehab our participant was less days per week active at a moderate intensity (MID), while this went back to a higher frequency during the home-sessions (POST). However, during the in-center rehab phase 190' were spend at a day to moderate activities, while this was lower at 30' a day during the home-sessions. During the in-center rehabilitation she went less for a walk than before and after where she walked 5 times/week in contrary to 3 times/week. The estimation of sitting time went from 245' to 100' per day during the home-sessions.

Fear Avoidance Components Scale

At pre-measurement the FACS (**Table 4.**) total score of 32 implicated a mild severity of fear avoidance. This score decreased over all measuring moments till 5, which was labeled as subclinical (A. Knezevic et al., 2018). During the mid-assessment a maximum score was given to avoiding certain heavy activities last week because of the pain. Other higher scored (3-4/5) elements were avoiding activities that used the painful body part, avoiding of certain activities because of fear for worsening the pain and trying to avoid activities and movements that worsen the pain. At post-assessment no high scores were given anymore with a two as the highest score for trying to avoid activities and movements that worsen the pain.

Exercise capacity outcomes

No difference in maximal oxygen uptake capacity was observed between the maximal cardiopulmonary exercise test at baseline and after six weeks. The maximal heartrate during

the test was nine beats per minute higher (148 vs 139) at baseline and two minutes after the test the heartrate was 111 at baseline and 129 after six weeks. This indicates that at baseline she was significantly better at recovering her heartrate in comparison to the POST-assessment. The maximal wattage the participant reached during the exertion was 165 at baseline and 150 after six weeks. The peak workload, expressed as the wattage divided by the weight (kg) of the participant, was subsequently 0.19 Watt/kg higher at baseline (**Table 5.**).

Table 4.
Outcomes related to characterization of the included patients and effectiveness of the program

	PRE	MID	POST	Δ PRE - MID	Δ MID - POST
BPI-sf					
Worst pain (0-10)	9	3	7	6	-4
Least pain (0-10)	0	0	0	0	0
Average pain* (0-10)	2	2	0	0	2
Pain ATM (0-10)	1	0	0	1	0
IOP on general activity* (0-10)	3	2	0	1	2
IOP on mood*	1	0	0	1	0
IOP on walking ability*	1	0	0	1	0
IOP on normal work*	1	1	0	0	1
IOP on relationships*	0	0	0	0	0
IOP on sleep*	2	2	0	0	2
IOP on enjoyment of life*	1	0	0	1	0
MODI (0-50)	**5 (10%)**	**4 (8%)**	**4 (8%)**	**1**	**0**
Pain intensity	0	0	0	0	0
Personal care	1	1	0	0	1
Lifting	1	1	1	0	0
Walking	0	0	0	0	0
Sitting	2	1	1	1	0
Standing	1	1	2	0	-1
Sleeping	0	0	0	0	0
Sex life	0	0	0	0	0
Social life	0	0	0	0	0
Travelling	0	0	0	0	0
IPAQ					
# HA days **	1	0	0	1	0
# time of HA (average/day)	150’	-	-	-	-
# MA days **	7	3	6	4	-3
# time of MA (average/day)	150’	190’	30’	-40’	160’
# 10’ walking days **	5	3	5	2	-2

# walking time in walking days	70’	30’	40’	40’	10’
# time sitting **	245’	245’	100’	0’	145’
FACS (0-100)	**34**	**21**	**5**	**13**	**16**

Legend: values are visualized as reported outcome scores on the several questionnaires (Qualtrics); PRE = baseline assessment; MID = assessment after two weeks; POST = assessment after six weeks; Δ = total difference; BPI-sf = Brief Pain Inventory short form; MODI = Modified Oswestry Disability Index; IPAQ = International Physical Activity Questionnaire; FACS = Fear Avoidance Components Scale; * = during past 24 hours; ATM = at the moment; IOP = impact of pain; # = amount of; HA = heavy activity; MA = moderate activity; ‘ = minute(s); ** = in the past seven days; Q1-Q20 = questions of the FACS, found in the appendix

Table 5.
Exercise capacity outcomes

	PRE	POST	Δ PRE - POST
VO2max (ml/kg/min)	16	16	0
HRmax (bpm)	148	139	9
HRrecup (bpm)	111	129	-18
Wmax (Watt)	165	150	15
Peak WL (Watt/kg)	1.94	1.75	0.19

Legend: PRE = baseline assessment; POST = assessment after six weeks; Δ = total difference; VO2max = maximal oxygen uptake capacity; HRmax = maximal heart rate; HRrecup: heartrate 2’ after test; Wmax = maximal wattage; WL = workload; l = liter; kg = kilogram; min = minute; bpm = beats per minute

3.5 Feasibility outcomes

The MVAS, SVAS, IMI and SUS (**Table 6.**) evaluated the feasibility of the in-center rehabilitation sessions and the home-based rehabilitation sessions. The MVAS was filled in at the PRE, MID and POST-assessment, the SVAS and IMI at the MID and POST-assessment. The SUS was only filled in at the POST-assessment to assess the perceived feasibility of PhysiTrack (PhysiApp).

Motivation Visual Analogue Scale and Satisfaction Visual Analogue Scale

The participant’s motivation for the execution of the exercise program (MVAS) dropped by one point from PRE to MID as well as from MID to POST. The score on the satisfaction for the exercise program (SVAS) remained the same in the MID and POST-assessment. This indicates that the participant was equally satisfied with the in-center and the home-based sessions.

Intrinsic Motivation Inventory

The IMI was filled in at MID and POST. The combined result at the MID-assessment (after two weeks) was 179, for the POST-assessment (after six weeks) it was 176. A small difference of three points in favor of the in-center rehabilitation sessions. The first subscale,

interest/enjoyment, scores 5.14 after two weeks and 5.42 after six weeks. This small difference of 0.28 points indicates that the home-based rehabilitation was a little more interesting and enjoyable for the participant. The perceived competence of the participant was 0.50 points higher for the in-center rehabilitation compared to home-based rehabilitation indicating a better capability of 01 during the in-center sessions. The effort the participant put into the in-center rehabilitation and home-based rehabilitation was 6.80 out of 7 for both groups. The pressure she felt during the home-based rehabilitation was slightly higher compared to the in-center rehabilitation. 01 scored the subscale value/usefulness of the in-center rehabilitation slightly better than the home-based rehabilitation (5.60 vs 5.42) with a small difference of 0.18 points. She also indicated that she felt more related to the in-center rehabilitation than to the home-based rehabilitation (difference of 0.20 points). Three subscales were in favor of the in-center rehabilitation, two in favor of the home-based rehabilitation and one subscale is equal for both rehabilitation modalities.

System Usability Scale

After converting the scores from the questionnaire to a number between zero and four, a total score of 40 was achieved. This score was multiplied by 2.5 which means that 01 gave the usability of PhysiApp a maximal score of 100.

Table 6.
Feasibility related outcomes

	PRE	MID	POST	Δ PRE - MID	Δ MID - POST
MVAS (score from 0 to 10)	**9**	**8**	**7**	**1**	**1**
SVAS (0-10)	-	**9**	**9**	-	**0**
IMI (35-245)		**179**	**176**	-	**3**
Interest/enjoyment (7 questions)	-	5.14	5.42	-	-0.28
Percieved competence (6)	-	5.33	4.83	-	0.50
Effort/importance (5)	-	6.80	6.80	-	0.00
Pressure/tension (5)	-	1.40	1.60	-	-0.20
Value/usefulness (7)	-	5.60	5.42	-	0.18
Relatedness (5)	-	6.00	5.80	-	0.20
SUS (0-100)	-	-	**100**	-	-

Legend: values are visualized as reported outcome scores on the several questionnaires (Qualtrics); PRE = baseline assessment; MID = assessment after two weeks; POST = assessment after six weeks; Δ = total difference; MVAS = Motivation Visual Analogue Scale; SVAS = Satisfaction Visual Analogue Scale; IMI = Intrinsic Motivation Inventory; SUS = System Usability Scale

4 Discussion

4.1 Findings related to research questions

Participant 01 was a vital CNSLBP patient with only mild symptoms. However, at the start of the trial she scored a mild severity of fear avoidance which also emphasizes the importance of a biopsychosocial approach (N. N. Knezevic, Candido, Vlaeyen, Van Zundert, & Cohen, 2021). Most progress of all clinical outcomes was made on the FACS with a score from 32 at the start to five at the end. It is important to emphasize that despite her higher fear-avoidance score, she completed every session. This could mean that the addition of HIT and home-based training with an app improves the self-management and self-efficacy by making the patient realize of what he/she still capable is, gaining more autonomy of its treatment and thereby facilitating a behavior change (Du, Liu, Cai, Hu, & Dong, 2020). Thereby can be hypothesized that a HIT-program may be more effective for patients with yellow flags (eg. pain behavior, appraisals, beliefs, …) (Nicholas, Linton, Watson, Main, & Group, 2011). This improvement of outcome also corresponds to an earlier stated hypotheses that HIT does not only influence the physiological/biomechanical aspects, but also the psychosocial aspects like self-efficacy (Verbrugghe et al., 2019). This implies important considerations to be considered for further research (*5.4 Recommendations for further studies*). Verbrugghe et al. (2021) even found that abdominal muscle strength and back strength did not improve after HIT, however the aerobic capacity did improve significantly and was still significant at six months follow-up. This is in contrast with the participant of this trial whom the results made a decline on the maximal cardiopulmonary exercise test. A possible explanation may be the duration of this trial. Six weeks may be too short to gain beneficial physiological effects. Milanovic, Sporis, and Weston (2015) investigated the effect of HIT in 28 trials and found HIT to have a small beneficial effect on VO_2max when compared to endurance training. However, included trials' duration ranged from three weeks to 24 weeks and greater effects were found for less fit older adults. So, a longer duration of this feasibility study, like the 12 weeks lasting trial of Verbrugghe et al. (2021), may have resulted in some improvement on the physiological markers. Furthermore, feasibility was more emphasized than effectiveness in this trial.

However, next to the effectivity of a technology supported HIT program, this trial was mostly interested in the feasibility to perform HIT at home and to use PhysiTrack as a supportive technology application. The results of the questionnaires made clear that participant 01 had no preference according to in-center vs home-based rehabilitation. The observed differences of the IMI were minimal, and it is not possible to draw conclusions about which rehabilitation mode was more motivating. However, she felt more related to in-center rehabilitation and scored its usefulness slightly better. This might be because of the face-to-face therapy, which was often preferred in earlier trials (De Baets et al., 2021; Fridler et al., 2012; Kerschke & Hux, 2021). This participant scored the patient oriented PhysiTrack app (PhysiApp) with a maximal score of 100, which showed the high feasibility for her of using this app. She indicated that everything was very clear and simple in use, that she felt confident using the system and that she would like to use the system again in the future. She also reported that she does not need the support of a technical person to be able to use PhysiApp and that the various functions in the application were well integrated. It is clear that a home-based rehabilitation was feasible for participant 01 and that the utilization of an app did not cause many problems to fulfill the rehabilitation sessions.

Post-trial conversation with participant 01

After 01 completed the rehabilitation sessions and the POST-assessment, the researchers had an online meeting with her. The conversation was about the general feelings of the participant in relation to the rehabilitation at home, the experienced difficulties, the contact with the researchers and the general improvements of her complaints. Subsequently, some additional questions about the perception of the technology (PhysiTrack) were asked.

01 reported that the four weeks of home-based rehabilitation went really well. Every Tuesday and Friday morning she performed the sessions and she indicated that she always felt motivated to complete every exercise. When asked about any difficulties she reported that the bicycle ergometer once turned off without a reason and that the PhysiTrack application once shut down (may have been due to her internet connection). She also reported that she fell during walking in her spare time but that this fall did not have a consequence on the exercise performance. She experienced the contact with the researchers as very fluent and the communication via the PhysiTrack chat was also very easy. She really enjoyed the

motivation of the researchers and indicated that this made her do the exercises even better. The videos and instructions in PhysiTrack were clear and the video of the HIT protocol on the bicycle ergometer was very helpful and motivating. When asked about her general well-being she reported that she felt better. Sitting on a chair while playing cards is no longer painful and getting up after sitting for some time is no problem anymore.

When asked about her user experience with PhysiTrack, she responded that it was clear, understandable, and easy to use. She thought it was also useful for exercising in the home setting and working with PhysiTrack made the home-based rehabilitation for her more interesting. She did not feel apprehensive at all about using PhysiTrack, but it scared her a bit to think that information could be lost if she did something wrong in the application. She also indicated that the built-in help facility (PhysiTrack chat) was helpful to ask the researchers for advice. She found PhysiTrack useful for the rehabilitation of chronic nonspecific low back pain and she would use PhysiTrack again in the future when necessary. To finish of the conversation, she reported that rehabilitation via technology was fine, but a real-life therapy session in combination with one home-session every week would have been more ideal on the long term.

4.2 Strengths of this trial

The strength of this study is that everything is set up and ready to immediately start the protocol with future participants. A lot of things can be learned from the steps subject 01 went through and the difficulties researchers faced during this rehabilitation protocol. For example, by guiding the patient through PhysiTrack it became clear that the PhysiTrack messages are very useful to follow-up patients. It is very easy for patients to send the researchers questions or communicate which exercises went well and even a pain score could be added in the chat to an exercise which was more difficult to perform. An example of something that is learned is that due to some inconsistencies in the results of the questionnaires, it is now known that in the future more explanation could be given to participants about the several questionnaires. For the MID and POST-assessment questionnaires (which the participants must fill in by themselves) an additional document with information could be provided to patients. After the elaboration of this descriptive study researchers are now aware what they

must consider while guiding future participants through this protocol and what can be done better. The acquired knowledge of the researchers and the development of this descriptive study, with a comprehensive description of the method and results, can play an important role in optimizing the rehabilitation process for future participants. Furthermore, the post-trial conservation with the participant can give a perspective about the practical experience of a patient who experienced a telerehabilitation HIT program. This study is the first of its genre to evaluate the feasibility and the effectivity of a HIT program consisting of a combined cardio-respiratory and core muscle training protocol in the home-setting by using PhysiTrack, in persons with CNSLBP. Feasibility testing was the main purpose of this trial and consisted of a comprehensive method including four questionnaires. By analyzing the results on the feasibility outcomes of the included participant, a conclusion can be made that the use of PhysiTrack was feasible in the rehabilitation of chronic nonspecific low back pain for subject 01. These results are in concordance with earlier research for telerehabilitation in low back pain population. Geraghty et al. (2018) did the first feasibility trial for this topic and demonstrated an internet intervention of six weeks to be feasible. Amorim et al. (2019) also conducted a feasible and well accepted trial by using an internet-based application and activity tracker, while also receiving 12 based telephone-based sessions. This positive outcome needs to be confirmed by including more participants to corroborate, but a good foundation has been laid for further research. Moreover, the implementation of this home-based rehabilitation method via PhysiTrack is clinically applicable in the treatment of patients with CNSLBP.

4.3 Limitations of this trial

Given the fact that only one participant could be included in this trial during the proposed timeframe for this master's thesis, the results may have been biased. Therefore, it is important to keep in mind that these results are less generalizable to a broad CNSLBP patient group. The inclusion of five participants would have been ideal but unfortunately this did not happen, and a decision was made to visualize the results in a descriptive way to make everything as clear as possible so it can be of help for the rehabilitation of future participants. Secondly, the psychological aspect which has found to be important in patients with chronic pain was not integrated in the treatment plan. This is a difficult aspect to incorporate into PhysiTrack

because the application mainly focusses on the physiological aspects of rehabilitation and because of the lack of face-to-face sessions (Mohr et al., 2010). Thirdly, therapy adherence is difficult to measure objectively via PhysiTrack, participants have the possibility to report the completion of exercises without truly completing them. This remains a stumbling block for the concept of tele-rehabilitation and especially for the rehabilitation via platforms on which therapists have no control of checking actual performance. Fourthly, the participant reported no NPRS scores for the prescribed exercises on PhysiTrack for the last two home-based rehabilitation sessions. This makes that progression for the last session could not be made because the NPRS was an important requirement in making exercise progression. The consequence of these missing pain scores is that the participant could have undertrained for maximally one training session. However, this is not considered as a serious drawback because, if the participant did make progression for the two exercises progression could be made for, it is unlikely that it would have influenced the clinical outcome measures. Fifthly, the clinical outcome measures and the measures of feasibility are both completely reliable on patient reported outcomes. These are not always as reliable for standardized results and participants could fill them in without really paying attention which can have a big impact on the reported results (Richardson & Meyer, 2021). When the participant had a bad day at the time of filling in the questionnaires, it could be the reason for survey bias, and this can have a big impact on the interpretation of results. For example, the maximal score on the System Usability Scale is remarkable because it indicates that everything was very clear and easy in use. However, researchers thought that not everything was perfect, and some things could have been visualized a little better.

4.4 Recommendations for further studies

Health- and rehabilitations-oriented applications are still in an early phase, but a rapidly evolving and expanding array of applications can be found (Howard & Kaufman, 2018). Although, the rapid development for utilization of technological aspects, they are still not accepted as something usual in the musculoskeletal setting. However, for cardiac rehabilitation this new field of management is more and more commonplace, where barriers for center-based rehabilitation can be solved by monitoring devices and remote communication (Batalik, Filakova, Batalikova, & Dosbaba, 2020; Brouwers et al., 2020). In this

setting telerehabilitation has already showed its effectivity and cost-efficiency as a complement to existing services (Maddison et al., 2019). Acceptability was even higher for interventions that were simple to access, easy to use, reliable and delivered through smartphone and/or web technologies (Subedi, Rawstorn, Gao, Koorts, & Maddison, 2020). However, for telehealth to become effective in general, it first must become a routinely used part of our telehealth system (Smith et al., 2020). Hence, Mohr et al. (2010) examined the acceptability of face-to-face, internet and telephone treatments and found the highest level of interest for face-to-face treatment. Nevertheless, this study suggests that there is openness to try newer treatment deliveries but with no substantial demand yet. Given that these are still seen as comparatively new treatment delivery media, this level of interest is notable (Mohr et al., 2010). De Baets et al. (2021) investigated the use of telerehabilitation during COVID-19 in Belgium. Physiotherapists (62.4%) and patients (57%) reported that remote physical therapy can only be possible if the patient is also treated in real life with face-to-face sessions. The main barrier for patients (46%) to use technology for physical therapy was the lack of hands-on therapy. Therefore, more research is needed for a blended care approach, which is a combination of telerehabilitation and face-to-face therapy, which can be integrated in patient's lifestyle without being an intrusive alternative. Patients would hereby still be able to receive hands-on therapy and in-person contact. This will need a trial lasting a minimum of 12 weeks to give enough time for physiological adaptations when doing HIT-training. Lastly, because of the multifactorial origin of CNSLBP, a program which implies other therapy modalities such as pain neuroscience education and cognition-targeted exercise therapy should be considered (Malfliet et al., 2017).

5 Conclusion

Results of participant 01 with CNSLBP do support the utilization of a HIT program to be feasible in a home-setting by using a mobile application (PhysiTrack). Effectivity was an additional interest and showed the most improvement on fear-avoidance (FACS), which emphasizes the multi-factorial origin of CNSLBP. This HIT program consisting of a combined cardio-respiratory and core muscle training protocol, is an interesting new kind of rehabilitation for CNSLBP and should therefore be further investigated in the future to gain insights about the effectivity. The implementation of blended care proactively combined with face-to-face therapy is more credible to generate greater profits in long-term and assist with the contemporary challenges of healthcare.

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Verbrugghe, J., Hansen, D., Demoulin, C., Verbunt, J., Roussel, N. A., & Timmermans, A. (2021). High Intensity Training Is an Effective Modality to Improve Long-Term Disability and Exercise Capacity in Chronic Nonspecific Low Back Pain: A Randomized Controlled Trial. *Int J Environ Res Public Health, 18*(20). doi:10.3390/ijerph182010779

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Attachment 1: Declaration of Honor (RV)

Verklaring op Eer

Ondergetekende, student aan de Universiteit Hasselt (UHasselt), faculteit Revalidatiewetenschappen aanvaardt de volgende voorwaarden en bepalingen van deze verklaring:

1. Ik ben ingeschreven als student aan de UHasselt in de opleiding Revalidatiewetenschappen en kinesitherapie, waarbij ik de kans krijg om in het kader van mijn opleiding mee te werken aan onderzoek van de faculteit Revalidatiewetenschappen aan de UHasselt. Dit onderzoek wordt beleid door Prof. dr. Annick Timmermans & dr. Jonas Verbrugghe en kadert binnen het opleidingsonderdeel Wetenschappelijke stage/ masterproef deel 2. Ik zal in het kader van dit onderzoek creaties, schetsen, ontwerpen, prototypes en/of onderzoeksresultaten tot stand brengen in het domein van Technology supported high intensity training at home for persons with chronic nonspecific low back pain: a pilot study. (hierna: "De Onderzoeksresultaten").

2. Bij de creatie van De Onderzoeksresultaten doe ik beroep op de achtergrondkennis, vertrouwelijke informatie[1], universitaire middelen en faciliteiten van UHasselt (hierna: de "Expertise").

3. Ik zal de Expertise, met inbegrip van vertrouwelijke informatie, uitsluitend aanwenden voor het uitvoeren van hogergenoemd onderzoek binnen UHasselt. Ik zal hierbij steeds de toepasselijke regelgeving, in het bijzonder de Algemene Verordening Gegevensbescherming (EU 2016-679), in acht nemen.

4. Ik zal de Expertise (i) voor geen enkele andere doelstelling gebruiken, en (ii) niet zonder voorafgaande schriftelijke toestemming van UHasselt op directe of indirecte wijze publiek maken.

5. Aangezien ik in het kader van mijn onderzoek beroep doe op de Expertise van de UHasselt, draag ik hierbij alle bestaande en toekomstige intellectuele eigendomsrechten op De Onderzoeksresultaten over aan de UHasselt. Deze overdracht omvat alle vormen van intellectuele eigendomsrechten, zoals onder meer – zonder daartoe beperkt te zijn – het auteursrecht, octrooirecht, merkenrecht, modellenrecht en knowhow. De overdracht geschiedt in de meest volledige omvang, voor de gehele wereld en voor de gehele beschermingsduur van de betrokken rechten.

6. In zoverre De Onderzoeksresultaten auteursrechtelijk beschermd zijn, omvat bovenstaande overdracht onder meer de volgende exploitatiewijzen, en dit steeds voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding:

   - het recht om De Onderzoeksresultaten vast te (laten) leggen door alle technieken en op alle dragers;

[1] Vertrouwelijke informatie betekent alle informatie en data door de UHasselt meegedeeld aan de student voor de uitvoering van deze overeenkomst, inclusief alle persoonsgegevens in de zin van de Algemene Verordening Gegevensbescherming (EU 2016/679), met uitzondering van de informatie die (a) reeds algemeen bekend is; (b) reeds in het bezit was van de student voor de mededeling ervan door de UHasselt; (c) de student verkregen heeft van een derde zonder enige geheimhoudingsplicht; (d) de student onafhankelijk heeft ontwikkeld zonder gebruik te maken van de vertrouwelijke informatie van de UHasselt; (e) wettelijk of als gevolg van een rechterlijke beslissing moet worden bekendgemaakt, op voorwaarde dat de student de UHasselt hiervan schriftelijk en zo snel mogelijk op de hoogte brengt.

- het recht om De Onderzoeksresultaten geheel of gedeeltelijk te (laten) reproduceren, openbaar te (laten) maken, uit te (laten) geven, te (laten) exploiteren en te (laten) verspreiden in eender welke vorm, in een onbeperkt aantal exemplaren;
- het recht om De Onderzoeksresultaten te (laten) verspreiden en mee te (laten) delen aan het publiek door alle technieken met inbegrip van de kabel, de satelliet, het internet en alle vormen van computernetwerken;
- het recht De Onderzoeksresultaten geheel of gedeeltelijk te (laten) bewerken of te (laten) vertalen en het (laten) reproduceren van die bewerkingen of vertalingen;
- het recht De Onderzoeksresultaten te (laten) bewerken of (laten) wijzigen, onder meer door het reproduceren van bepaalde elementen door alle technieken en/of door het wijzigen van bepaalde parameters (zoals de kleuren en de afmetingen).

De overdracht van rechten voor deze exploitatiewijzen heeft ook betrekking op toekomstige onderzoeksresultaten tot stand gekomen tijdens het onderzoek aan UHasselt, eveneens voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding.

Ik behoud daarbij steeds het recht op naamvermelding als (mede)auteur van de betreffende Onderzoeksresultaten.

7. Ik zal alle onderzoeksdata, ideeën en uitvoeringen neerschrijven in een "laboratory notebook" en deze gegevens niet vrijgeven, tenzij met uitdrukkelijke toestemming van mijn UHasseltbegeleiders Prof. dr. Annick Timmermans & dr. Jonas Verbrugghe.

8. Na de eindevaluatie van mijn onderzoek aan de UHasselt zal ik alle verkregen vertrouwelijke informatie, materialen, en kopieën daarvan, die nog in mijn bezit zouden zijn, aan UHasselt terugbezorgen.

Gelezen voor akkoord en goedgekeurd,

Naam: Robbe Vranken

Adres: Paalsteenlaan 53, 3620, Lanaken

Geboortedatum en –plaats : 24 juni 1999, Tongeren

Datum: 5 juni 2022

Handtekening: 

Attachment 2: Declaration of Honor (MS)

Verklaring op Eer

Ondergetekende, student aan de Universiteit Hasselt (UHasselt), faculteit Revalidatiewetenschappen aanvaardt de volgende voorwaarden en bepalingen van deze verklaring:

1. Ik ben ingeschreven als student aan de UHasselt in de opleiding Revalidatiewetenschappen en kinesitherapie, waarbij ik de kans krijg om in het kader van mijn opleiding mee te werken aan onderzoek van de faculteit Revalidatiewetenschappen aan de UHasselt. Dit onderzoek wordt beleid door Prof. dr. Annick Timmermans & dr. Jonas Verbrugghe en kadert binnen het opleidingsonderdeel Wetenschappelijke stage/ masterproef deel 2. Ik zal in het kader van dit onderzoek creaties, schetsen, ontwerpen, prototypes en/of onderzoeksresultaten tot stand brengen in het domein van Technology supported high intensity training at home for persons with chronic nonspecific low back pain: a pilot study. (hierna: "De Onderzoeksresultaten").

2. Bij de creatie van De Onderzoeksresultaten doe ik beroep op de achtergrondkennis, vertrouwelijke informatie[1], universitaire middelen en faciliteiten van UHasselt (hierna: de "Expertise").

3. Ik zal de Expertise, met inbegrip van vertrouwelijke informatie, uitsluitend aanwenden voor het uitvoeren van hogergenoemd onderzoek binnen UHasselt. Ik zal hierbij steeds de toepasselijke regelgeving, in het bijzonder de Algemene Verordening Gegevensbescherming (EU 2016-679), in acht nemen.

4. Ik zal de Expertise (i) voor geen enkele andere doelstelling gebruiken, en (ii) niet zonder voorafgaande schriftelijke toestemming van UHasselt op directe of indirecte wijze publiek maken.

5. Aangezien ik in het kader van mijn onderzoek beroep doe op de Expertise van de UHasselt, draag ik hierbij alle bestaande en toekomstige intellectuele eigendomsrechten op De Onderzoeksresultaten over aan de UHasselt. Deze overdracht omvat alle vormen van intellectuele eigendomsrechten, zoals onder meer – zonder daartoe beperkt te zijn – het auteursrecht, octrooirecht, merkenrecht, modellenrecht en knowhow. De overdracht geschiedt in de meest volledige omvang, voor de gehele wereld en voor de gehele beschermingsduur van de betrokken rechten.

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[1] Vertrouwelijke informatie betekent alle informatie en data door de UHasselt meegedeeld aan de student voor de uitvoering van deze overeenkomst, inclusief alle persoonsgegevens in de zin van de Algemene Verordening Gegevensbescherming (EU 2016/679), met uitzondering van de informatie die (a) reeds algemeen bekend is; (b) reeds in het bezit was van de student voor de mededeling ervan door de UHasselt; (c) de student verkregen heeft van een derde zonder enige geheimhoudingsplicht; (d) de student onafhankelijk heeft ontwikkeld zonder gebruik te maken van de vertrouwelijke informatie van de UHasselt; (e) wettelijk of als gevolg van een rechterlijke beslissing moet worden bekendgemaakt, op voorwaarde dat de student de UHasselt hiervan schriftelijk en zo snel mogelijk op de hoogte brengt.

- het recht om De Onderzoeksresultaten geheel of gedeeltelijk te (laten) reproduceren, openbaar te (laten) maken, uit te (laten) geven, te (laten) exploiteren en te (laten) verspreiden in eender welke vorm, in een onbeperkt aantal exemplaren;
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7. Ik zal alle onderzoeksdata, ideeën en uitvoeringen neerschrijven in een "laboratory notebook" en deze gegevens niet vrijgeven, tenzij met uitdrukkelijke toestemming van mijn UHasseltbegeleiders Prof. dr. Annick Timmermans & dr. Jonas Verbrugghe.

8. Na de eindevaluatie van mijn onderzoek aan de UHasselt zal ik alle verkregen vertrouwelijke informatie, materialen, en kopieën daarvan, die nog in mijn bezit zouden zijn, aan UHasselt terugbezorgen.

Gelezen voor akkoord en goedgekeurd,

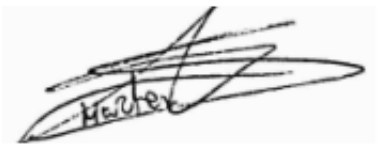
Naam: Marten Snoeks

Adres: Bovenlinde 28, 3990 Peer

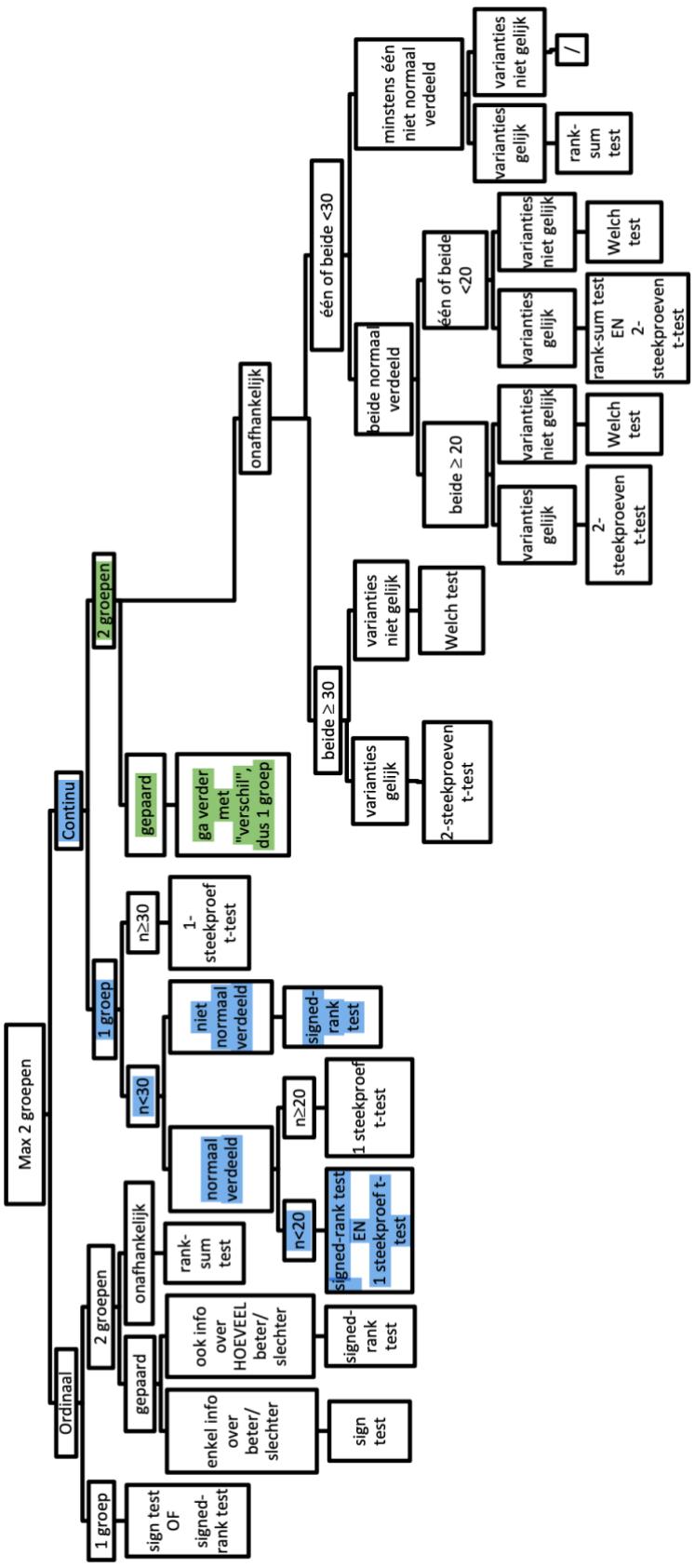
Geboortedatum en –plaats : 20/05/1998, Hasselt

Datum: 05/06/2022

Handtekening:



Attachment 3: Statistical Flowchart



Attachment 4: Registration form jury Master's Thesis

UHASSELT
KNOWLEDGE IN ACTION

Inschrijvingsformulier verdediging masterproef academiejaar 2021-2022,
Registration form jury Master's thesis academic year 2021-2022,

GEGEVENS STUDENT - *INFORMATION STUDENT*

Faculteit/School: **Faculteit Revalidatiewetenschappen**
Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1745648 Vranken Robbe**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine musc.**

INSTRUCTIES - *INSTRUCTIONS*

Neem onderstaande informatie grondig door.

Print dit document en vul het aan met DRUKLETTERS.

In tijden van van online onderwijs door COVID-19 verstuur je het document (scan of leesbare foto) ingevuld via mail naar je promotor. Je promotor bezorgt het aan de juiste dienst voor verdere afhandeling.

Vul luik A aan. Bezorg het formulier aan je promotoren voor de aanvullingen in luik B. Zorg dat het formulier ondertekend en gedateerd wordt door jezelf en je promotoren in luik D en dien het in bij de juiste dienst volgens de afspraken in jouw opleiding.
Zonder dit inschrijvingsformulier krijg je geen toegang tot upload/verdediging van je masterproef.

Please read the information below carefully.

Print this document and complete it by hand writing, using CAPITAL LETTERS.

In times of COVID-19 and during the online courses you send the document (scan or readable photo) by email to your supervisor. Your supervisor delivers the document to the appropriate department.

Fill out part A. Send the form to your supervisors for the additions in part B. Make sure that the form is signed and dated by yourself and your supervisors in part D and submit it to the appropriate department in accordance with the agreements in your study programme.
Without this registration form, you will not have access to the upload/defense of your master's thesis.

LUIK A - VERPLICHT - IN TE VULLEN DOOR DE STUDENT
PART A - MANDATORY - TO BE FILLED OUT BY THE STUDENT

Titel van Masterproef/*Title of Master's thesis:*

● behouden - *keep* TECHNOLOGY SUPPORTED HIGH INTENSITY TRAINING AT HOME FOR PERSONS WITH CHRONIC NON-SPECIFIC LOW BACK PAIN: A PILOT STUDY

○ wijzigen - *change to*:

UHvoorlev5 23/05/2022

/:

O behouden - *keep*

O wijzigen - *change to*:

In geval van samenwerking tussen studenten, naam van de medestudent(en)/*In case of group work, name of fellow student(s)*:

● behouden - *keep* MARTEN SNOEKS

O wijzigen - *change to:*

LUIK B - VERPLICHT - IN TE VULLEN DOOR DE PROMOTOR(EN)
PART B - MANDATORY - TO BE FILLED OUT BY THE SUPERVISOR(S)

Wijziging gegevens masterproef in luik A/*Change information Master's thesis in part A:*

● goedgekeurd - *approved*

O goedgekeurd mits wijziging van - *approved if modification of:*

Scriptie/Thesis:

● openbaar (beschikbaar in de document server van de universiteit)- *public (available in document server of university)*

O vertrouwelijk (niet beschikbaar in de document server van de universiteit) - *confidential (not available in document server of university)*

Juryverdediging/*Jury Defense:*

De promotor(en) geeft (geven) de student(en) het niet-bindend advies om de bovenvermelde masterproef in de bovenvermelde periode/*The supervisor(s) give(s) the student(s) the non-binding advice:*

● te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

● de verdediging is openbaar/*in public*

O de verdediging is niet openbaar/*not in public*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK C - OPTIONEEL - IN TE VULLEN DOOR STUDENT, alleen als hij luik B wil overrulen
PART C - OPTIONAL - TO BE FILLED OUT BY THE STUDENT, only if he wants to overrule part B

In tegenstelling tot het niet-bindend advies van de promotor(en) wenst de student de bovenvermelde masterproef in de bovenvermelde periode/*In contrast to the non-binding advice put forward by the supervisor(s), the student wishes:*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK D - VERPLICHT - IN TE VULLEN DOOR DE STUDENT EN DE PROMOTOR(EN)
PART D - MANDATORY - TO BE FILLED OUT BY THE STUDENT AND THE SUPERVISOR(S)

Datum en handtekening student(en)
Date and signature student(s)

24/05/2022

Datum en handtekening promotor(en)
Date and signature supervisor(s)

27/05/2022

UHASSELT
KNOWLEDGE IN ACTION

Inschrijvingsformulier verdediging masterproef academiejaar 2021-2022,
Registration form jury Master's thesis academic year 2021-2022,

GEGEVENS STUDENT - *INFORMATION STUDENT*

Faculteit/School: **Faculteit Revalidatiewetenschappen**
Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1644353 Snoeks Marten**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine musc.**

INSTRUCTIES - *INSTRUCTIONS*

Neem onderstaande informatie grondig door.

Print dit document en vul het aan met DRUKLETTERS.

In tijden van van online onderwijs door COVID-19 verstuur je het document (scan of leesbare foto) ingevuld via mail naar je promotor. Je promotor bezorgt het aan de juiste dienst voor verdere afhandeling.

Vul luik A aan. Bezorg het formulier aan je promotoren voor de aanvullingen in luik B. Zorg dat het formulier ondertekend en gedateerd wordt door jezelf en je promotoren in luik D en dien het in bij de juiste dienst volgens de afspraken in jouw opleiding.
Zonder dit inschrijvingsformulier krijg je geen toegang tot upload/verdediging van je masterproef.

Please read the information below carefully.

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Fill out part A. Send the form to your supervisors for the additions in part B. Make sure that the form is signed and dated by yourself and your supervisors in part D and submit it to the appropriate department in accordance with the agreements in your study programme.
Without this registration form, you will not have access to the upload/defense of your master's thesis.

LUIK A - VERPLICHT - IN TE VULLEN DOOR DE STUDENT
PART A - MANDATORY - TO BE FILLED OUT BY THE STUDENT

Titel van Masterproef/*Title of Master's thesis:* TECHNOLOGY SUPPORTED HIGH INTENSITY TRAINING AT HOME FOR PERSONS WITH CHRONIC LOW BACK PAIN: A PILOT STUDY

● behouden - *keep*

○ wijzigen - *change to*:

/:

O behouden - *keep*

O wijzigen - *change to*:

In geval van samenwerking tussen studenten, naam van de medestudent(en)/*In case of group work, name of fellow student(s)*: ROBBE VRANKEN

● behouden - *keep*

O wijzigen - *change to:*

LUIK B - VERPLICHT - IN TE VULLEN DOOR DE PROMOTOR(EN)
PART B - MANDATORY - TO BE FILLED OUT BY THE SUPERVISOR(S)

Wijziging gegevens masterproef in luik A/*Change information Master's thesis in part A:*

● goedgekeurd - *approved*

O goedgekeurd mits wijziging van - *approved if modification of:*

Scriptie/*Thesis:*

● openbaar (beschikbaar in de document server van de universiteit)- *public (available in document server of university)*

O vertrouwelijk (niet beschikbaar in de document server van de universiteit) - *confidential (not available in document server of university)*

Juryverdediging/*Jury Defense:*

De promotor(en) geeft (geven) de student(en) het niet-bindend advies om de bovenvermelde masterproef in de bovenvermelde periode/*The supervisor(s) give(s) the student(s) the non-binding advice:*

● te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

● de verdediging is openbaar/*in public*

O de verdediging is niet openbaar/*not in public*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK C - OPTIONEEL - IN TE VULLEN DOOR STUDENT, alleen als hij luik B wil overrulen
PART C - OPTIONAL - TO BE FILLED OUT BY THE STUDENT, only if he wants to overrule part B

In tegenstelling tot het niet-bindend advies van de promotor(en) wenst de student de bovenvermelde masterproef in de bovenvermelde periode/*In contrast to the non-binding advice put forward by the supervisor(s), the student wishes:*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

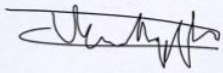
O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

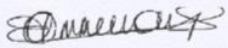
LUIK D - VERPLICHT - IN TE VULLEN DOOR DE STUDENT EN DE PROMOTOR(EN)
PART D - MANDATORY - TO BE FILLED OUT BY THE STUDENT AND THE SUPERVISOR(S)

Datum en handtekening student(en)
Date and signature student(s)

24/05/2022

Datum en handtekening promotor(en)
Date and signature supervisor(s)





27/05/2022

Attachment 4: mail reply – positive advice

Jonas VERBRUGGHE
aan mij, Annick, Marten

27 mei 2022 19:41 (3 dagen geleden)

Hallo Robbe en Marten

Ik heb jullie thesis doorgenomen. Zie bijgevoegd voor feedback. Jullie hebben zeker nog wel wat werk voor de boeg in de komende week om het geheel sterk genoeg te maken, maar de basis is er en ik geloof dat jullie dit klaar kunnen krijgen.

Enkele van de belangrijkste opmerkingen:
- focus meer op de positieve elementen die in deze studie zitten, zowel methodologisch als de hypotheses die je kan maken gebaseerd op je case. Momenteel ligt de focus nog te veel/vaak (en zelfs herhaaldelijk identiek) op de missing data. Verkoop jezelf!
- pas op met persoonlijke data weergave. Kwalitatieve analyse moet kunnen binnen de uitkomsten van je vragenlijsten en feedback die de participant gaf waarmee anderen op geen enkele manier kunnen terughalen wie dit was. Hier wordt (terecht) fel op afgestraft!
- probeer je discussie nog voller te maken door terug te grijpen naar enkele andere gelijkaardige studies. Je kan je case dan gebruiken als een bepaald profiel binnen deze pilot en afloetsen ten opzichte van andere profielen die je kan verwachten.
- let op met langdradige weergave van methodes/resultaten

In bijlage sturen we jullie onze aanbeveling tot indiening eerste zit. Hopelijk kunnen jullie nog een mooie iteratie verzorgen. Veel succes!

Mvg

Op di 24 mei 2022 om 23:45 schreef Robbe Vranken <robbe.vranken@student.uhasselt.be>:

Attachment 6: Progress Form

www.uhasselt.be
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UHASSELT
KNOWLEDGE IN ACTION

INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
04/11/2021	MP2 opstart, algemene informatie over opzet MP2 (online)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
14/12/2021	MP2 overleg, informatie over protocol (online)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
16/12/2021	Weergave HIT protocollen MP2 (REVAL)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
21/01/2022	MP2 overleg – praktische opzet HIT-HOME studie (A108)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
11/02/2022	Overleg opvolging MP2 – start rekrutering (online)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
16/05/2022	MP2 overleg – update over studie en overleg over resultaten (online)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student: Marten Snoeks **Datum:** 05/06/2022

Titel Masterproef: Technology supported high intensity training at home for persons with chronic nonspecific low back pain: a pilot study

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
   - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	NVT	1	2	3	4	5
Opstelling onderzoeksvraag	O	O	O	O	O	O
Methodologische uitwerking	O	O	O	O	O	O
Data acquisitie	O	O	O	O	O	O
Data management	O	O	O	O	O	O
Dataverwerking/Statistiek	O	O	O	O	O	O
Rapportage	O	O	O	O	O	O

2) Niet-bindend advies: Student(e) krijgt toelating/geen toelating (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student: Robbe Vranken **Datum:** 05/06/2022

Titel Masterproef: Technology supported high intensity training at home for persons with chronic nonspecific low back pain: a pilot study

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
   - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	**NVT**	**1**	**2**	**3**	**4**	**5**
Opstelling onderzoeksvraag	O	O	O	O	O	O
Methodologische uitwerking	O	O	O	O	O	O
Data acquisitie	O	O	O	O	O	O
Data management	O	O	O	O	O	O
Dataverwerking/Statistiek	O	O	O	O	O	O
Rapportage	O	O	O	O	O	O

2) Niet-bindend advies: Student(e) krijgt toelating/geen toelating (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)