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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

The Feasibility and Efficacy of Technology-Supported High-Intensity Training at Home for Persons With Chronic Nonspecific Low Back Pain

Nienke Hollands
Yenthe Rens

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

PROMOTOR :

dr. Jonas VERBRUGGHE

Prof. dr. Annick TIMMERMANS

BEGELEIDER :

De heer Timo MEUS

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2024

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www.uhasselt.be
Universiteit Hasselt
Campus Hasselt:
Martelarenlaan 42 | 3500 Hasselt
Campus Diepenbeek:
Agoralaan Gebouw D | 3590 Diepenbeek

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Situating

This pilot cohort study is part of a larger, ongoing project that evaluates the effects of training intensity and training mode in chronic nonspecific low back pain (CNSLBP) rehabilitation through a prospectively registered, five-arm, randomised controlled trial (RCT) at REVAL Research Center (Hasselt University, Diepenbeek, Belgium, identifier: NCT05234008). Led by Prof. Dr. Annick Timmermans and Dr. Jonas Verbrugghe, the project is titled as follows: 'Technology-Supported High Intensity Training at Home for Persons With Chronic Low Back Pain (HIT-HOME)' This study is related to the domain of technology-supported rehabilitation, while this master thesis will examine:

1. To what extent is a technology-supported high-intensity training (HIT) programme at home, regarding system usability, a feasible therapeutic modality in people with CNSLBP?
2. To what extent is a technology-supported HIT programme at home an effective therapeutic modality to improve pain and disability in people with CNSLBP?
3. To what extent does a technology-supported HIT programme at home, for persons with CNSLBP, support adherence concerning motivation and satisfaction?

These research questions arose while conversing about the pilot study with our promoter, Prof. Dr. Jonas Verbrugghe, and Drs. student Timo Meus. It came to light that therapy adherence was not as high as it should be, and therapy at home had become an increasing variant of traditional physical therapy during the COVID-19 lockdown. Additionally, HIT has become an increasingly studied modality for chronic low back pain, with promising results thus far. Therefore, this thesis and pilot study aim to provide the impetus for an RCT on a larger scale with a larger sample size. This thesis was authored by Nienke Hollands and Yenthe Rens. Both authors were not directly involved in the implementation and data collection of the HIT-home intervention; this was executed by Dr. Jonas Verbrugghe and Drs. Timo Meus. Both Nienke and Yenthe were, however, involved in the recruitment of participants. The writing of the thesis—abstract, introduction, methods, results, and discussion—was mainly done by Nienke Hollands. The data analysis, with associated statistics, and the creation of tables and figures were mainly performed by Yenthe Rens.

Abstract

Background. Chronic low back pain (CLBP) is a considerable problem among musculoskeletal disorders with extremely high costs. High-intensity training (HIT) has shown promising results as a therapy modality, yet adherence to training at home remains low. However, it has been shown that technology can have a positive impact on therapy adherence.

Objectives. The aim is to evaluate to what extent a technology-supported HIT programme at home is a feasible and effective therapeutic modality to treat persons with CNSLBP and to investigate whether the support of technology during HIT at-home exercises supports therapy adherence in persons with CNSLBP.

Methods. This pilot cohort study, which lasted six weeks, entailed an intervention group that performed a HIT programme at home, supported by Physitrack. Every week had two training sessions, each lasting 1.5 hours/session of cardiovascular, core muscle training and general resistance training all at high intensity. The outcome measures consisted of feasibility- and adherence-related measures (System Usability Scale [SUS], Motivation Visual Analogue Scale [MVAS], Satisfaction Visual Analogue Scale [SVAS], Intrinsic Motivation Inventory [IMI]) and disease-related measures (Brief Pain Inventory [BPI-SF], Fear Avoidance Components Scale [FACS]). The MVAS, the BPI-SF and the FACS had before (PRE) and after (POST) measurements, whereas the others only had one measurement.

Results. At POST, the MVAS showed no significant improvements (-1.5 ± 1.7, P = .9961). The FACS did have significant improvements (-11.1 ± 12.8, P = .0042), likewise, the BPI-SF revealed significant results on the evolution of pain during the last 24 hours and the influence of pain. Regarding the SUS, eight out of 13 participants gave the app an above-average usability score. Participants scored a high mean score on the SVAS (8 ± 1.9). Lastly regarding the IMI, the majority of participants were satisfied with the therapy and enjoyed the training.

Conclusion. A technology-supported HIT at-home programme seems to be a feasible and effective therapeutic modality. The majority of outcome measures improved following the protocol, thus proving that a more elaborate study needs to be performed with a control and intervention group along with a larger sample size compared to this study.

Keywords. Low back pain, therapy adherence, HIT, technology, exercise, rehabilitation

Introduction

Chronic low back pain (CLBP) is a considerable problem in musculoskeletal disorders, as it is the most disabling one worldwide (Hoy et al., 2014). Models in the report of Ferreira et al. (2023) reveal that the total number of prevalent cases is expected to increase to more than 800 million by 2050. CLBP leads to a considerable burden on working-age people, an increase in absenteeism, and even early retirement (Ferreira et al., 2023). Furthermore, the costs of treating low back pain (LBP) are extremely high, whereas indirect costs represent the majority of the overall costs associated with LBP (Dagenais et al., 2008). Owen et al. (2020) previously observed that it is unlikely that one kind of exercise training is the single best approach to treating chronic non-specific low back pain (CNSLBP) and that active therapy is superior, perhaps in a multidimensional setting. Keeping this in mind, another study from 2019 suggests that high-intensity training (HIT) is a suitable therapy modality to improve exercise capacity and disability in persons with CLBP compared to a similar programme at moderate intensity (Verbrugghe et al., 2019).

Adherence is defined by the WHO as the extent to which a person's behaviour—taking medication, following a diet, and/or executing lifestyle changes—concords with agreed-upon recommendations from a healthcare provider (Sabaté, 2003). Despite the proven efficacy of exercise therapy, people with CLBP often do not adhere to exercise therapy after discharge, which in turn can lead to a decline in therapy results, which in turn shows the importance of exercise therapy (Babatunde et al., 2017; Jordan et al., 2010). Albergoni et al. (2019) also expressed that, despite evidence of the importance of physical activity (PA) in preventing and treating patients with chronic diseases, adherence to guidelines is still rather low. Boutevillain et al. (2017) argue that there are three broad categories of facilitators and barriers for PA, which are: physical, psychological, and socio-environmental. The main barriers were, respectively, pain, lack of motivation, kinesiophobia, and demanding work. The main facilitators were the will to engage in PA and supervised physical sessions (Boutevillain et al., 2017). Even during COVID-19, home-based exercise programmes have been researched, and it has been shown that adherence to therapy was not high (Sieczkowska et al., 2022). Despite therapy adherence being a proven and necessary component of physical therapy, Kenny et al. (2023) showed that it is assessed among less

than half the randomised controlled trials investigating exercise as an intervention for LBP and stated that more assessment is needed.

Lambert et al. (2017) showed that technology can provide better adherence to therapy when compared to paper handouts. The participants of this study found the app to be very useful and said they would use it again. This was measured through interviews and online surveys (Lambert et al., 2017). The study by Du et al. (2020) also mentioned that findings suggest that e-health-based self-management programmes may positively improve pain intensity and disability within a short-term period for CLBP patients. Therefore, a technology-supported home programme, which assists with the needed effort to further improve, could enhance the retention of acquired training effects (Lambert et al., 2017). This could indicate that technology-supported home-based programmes should be considered as a treatment option. As mentioned before, the costs of treating LBP are extremely high; thus, a therapy programme at home would pose less substantial costs to both the healthcare system and patients individually (Dagenais et al., 2008). In regards to this, Fatoye et al. (2020) concluded that telerehabilitation was associated with greater health benefits and lower costs, suggesting that it was a cost-saving therapy compared to a clinic-based therapy.

This study used Physitrack to support the patient with home exercises, a mobile application for participants, and a software platform for researchers. Recently, Arensman et al. (2022) investigated patient perspectives on using Physitrack and stated: “Physitrack is well suited to support treatment but not to replace a physical therapist” (Arensman et al., 2022). Interestingly, despite the previously displayed importance of therapy adherence, there is still a lack of research regarding this phenomenon (Kenny et al., 2023).

Therefore, this paper aims to evaluate to what extent a technology-supported HIT programme at home, regarding system usability, is a feasible and effective therapeutic modality to improve pain and disability in people with CNSLBP and to investigate whether the support of technology during HIT at-home exercises supports therapy adherence concerning motivation and satisfaction for persons with CNSLBP.

Methods

Trial design

This pilot cohort study is part of a larger project that evaluates the effects of training intensity and training mode in CNSLBP rehabilitation through a prospectively registered, five-arm, randomised controlled trial at REVAL Research Center (Hasselt University, Diepenbeek, Belgium). This master thesis mainly focuses on the feasibility and effectiveness of a technology-supported HIT programme at home and whether the support of technology during HIT at home supports adherence to therapy.

Participants and recruitment

For this study, there were certain inclusion and exclusion criteria. Inclusion criteria were 1) speak Dutch, 2) be 25 to 60 years old, 3) have CLBP of a nonspecific origin (meaning, a medical diagnosis of pain localised 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 recognisable, known specific pathology, for example, infection, tumour, osteoporosis, fracture, structural deformity, an inflammatory disorder, radicular syndrome, or cauda equina syndrome for at least 12 weeks), of which participants had to provide proof of, and 4) must have an android or iOS smartphone. Exclusion criteria were 1) a history of spinal fusion, 2) suffering from any cardiac disease, 3) having an acute or chronic musculoskeletal disorder aside from CNSLBP that could affect the correct execution of the therapy programme, 4) having comorbidities (meaning, paresis and/or sensory disturbances by neurological causes, diabetes mellitus, rheumatoid arthritis), 5) being pregnant or trying to be pregnant, 6) having ongoing compensation claims and/or a work disability >6 months, 7) having followed an exercise therapy programme for LBP in the past 3 months, and 8) not able to attend regular therapy appointments.

Flyers containing information regarding the study were distributed regionally (Vlaams Brabant and Limburg, Belgium), and on top of that, master students looked for eligible participants as well. The master students handed out flyers in two physical therapy practices, in Tongeren and Lummen. Patient organisations were contacted via social media as well as other posts on the personal accounts of said students. Possible participants who contacted the researchers and met the inclusion criteria were informed about the details of the study by one of the researchers via either telephone or mail. In case the participant was still

interested after receiving the more detailed description, the study protocol, information, and consent form were provided via hardcopy or email, depending on the participant's preference. Within seven days, the researcher then contacted the participants to answer final questions and to determine whether or not they were willing to participate. The recruitment phase lasted for 1.5 years and started in January 2022.

Randomization and blinding

These items were not relevant as there was only one intervention group and no control group. Therefore, randomization and blinding of participants were not possible.

Intervention

The intervention entailed both an in-centre programme and an at-home programme. In total, the intervention had a duration of six weeks with a total of 12 sessions. Two of the first weeks were done in-centre, with a frequency of two sessions per week. The remaining four weeks were performed at home, with a frequency of two sessions per week as well. The sessions performed at home were supported by an app called Physitrack. Before the start of the intervention, maximal cardiopulmonary exercise testing (CPET) took place to determine the VO2 max workload.

The in-centre programme had a duration of two weeks with four sessions in total (twice a week). Participants executed an exercise protocol of about 1h–1.5h at the rehabilitation facility on campus, including cardiorespiratory training, general resistance training, and core muscle training, all of which were to be performed at high intensity. The goal of the in-centre sessions was to explain and show all exercises to the participants and to make sure they knew how to perform them. On top of that, the used app, Physitrack, was also explained more elaborately during these sessions.

The cardiorespiratory training entailed an interval protocol on a cycle ergometer consisting of five high-intensity one-minute bouts (110 revolutions per minute (RPM) at 100% of the VO_{2max} workload achieved during the previously mentioned maximal CPET); this was separated by one minute of active recovery (75 RPM at 50% of the same VO2max workload). The recovery time between bouts remained the same for the entire trial.

General resistance training entailed three upper and three lower body exercises performed on fitness devices. The one-repetition maximum (1RM) will be measured for each exercise

prior. In the first session, one set of a maximum of 12 repetitions was executed at 80% 1RM for each exercise. The exercise weight was progressively increased by researchers when the participant was able to perform more than ten repetitions on two consecutive training sessions.

Core strength training entailed six static core exercises. These exercises were chosen in function of their ability to load the core muscles at an intensity of a minimum of 40–60% of the maximum voluntary contraction. One set of ten repetitions of a ten-second static hold was performed each time. Participants were encouraged to hold the last repetition as long as possible. By increasing the static hold time, exercises were made more difficult. On top of that, they progressed to a more demanding posture when they were performed with a stable core posture for the holding time on two consecutive training sessions.

During the in-centre phase, participants were instructed to download the Physitrack app on their phones. The application was free for the participants. Physitrack is a digital platform that is cloud-based. It allows health professionals to give exercises and programmes (with training dosage) to people remotely, track progress, provide feedback in real-time, and send reminders. The app is GDPR and HIPPAA-compliant. The researchers were able to check whether the app worked correctly and were able to provide information on how to use it, which was necessary for the at-home phase.

The at-home programme had a duration of four weeks with a total of eight sessions, two each week. Participants were provided with a fitness bike, a smartwatch (Polar M200), and a training mat during the execution of the at-home sessions. With Physitrack, researchers created a personalised HIT programme to perform at home on the bike and training mat for each participant by selecting from a battery of >3500 exercises that included narrated videos and descriptions about how to perform each exercise or insert a new exercise to add to the library. The HIT programme done at home resembled the one performed during the in-centre phase as much as possible; it also had a duration of one hour and entailed a cardiorespiratory interval protocol combined with a core strength protocol. However, the strengthening exercises performed on fitness devices were not done at home.

Physitrack would also send reminders about exercise times and record exercise completion, including sets, repetitions, and rate of perceived exertion (RPE) for each exercise, as well as

include feedback or messages that are sent (in real-time) to the researcher (or to participants) for monitoring and reviewing. Participants have been prescribed a specific training dose for every exercise (frequency, sets, and repetitions) and asked to report their RPE using the 10-point scale that the app provides. Each participant's programme was reviewed and progressed every two sessions by the researchers, if needed, by reviewing the self-reported RPE and sets/repetitions for every exercise completed via the web-based Physitrack platform. On top of that, Physitrack was also checked daily by researchers for any urgent alerts or messages from participants. The smartwatch was used to inventory heart rate during the cardiorespiratory interval protocol. Participants were asked to fill in their training values on the Physitrack platform.

Testing procedure and outcomes

Participants were assessed via Qualtrics at baseline, after two weeks, and at the end of the six-week intervention period. To answer our research questions, only the PRE and POST measurements are important.

Outcome measures

Feasibility- and adherence-related measures

Regarding the usability of technology within a HIT at-home programme, the System Usability Scale (SUS) was used. The SUS demonstrates high reliability and validity with strong internal consistency (Lewis & Sauro, 2009). The SUS is a standard 10-item questionnaire in which responses are measured on a 5-point Likert scale ranging from one (strongly disagree) to five (strongly agree). Questions 1, 3, 5, 7, and 9 are positive, and questions 2, 4, 6, 8, and 10 are negative. A total SUS score is derived by summing the individual scores and multiplying by 2.5, which yields a score ranging between zero (worst) and 100 (absolute best). A score > 68 is considered above-average usability, and a score > 80 is considered high usability and a level at which participants are likely to recommend the product to peers. The SUS was measured once at the end of the trial.

The Motivational Visual Analogue Scale (MVAS) was used to measure participants' motivation for following the protocol. The VAS is an outcome measure with good validity (Kuhlmann et al., 2016). This nominal scale consists of a line indicating eleven successive

scores (0–10), whereby zero means 'no motivation' and ten means 'very high motivation'. The MVAS was assessed at baseline and the end of the six-week intervention period.

The Satisfaction Visual Analogue Scale (SVAS) was used to measure participants' level of satisfaction related to following the protocol. The VAS is an outcome measure with good validity (Kuhlmann et al., 2016). This nominal scale uses the same line as the MVAS, indicating eleven successive scores as the MVAS, whereby zero means 'no satisfaction' and ten means 'very high satisfaction'. The SVAS was measured once at the end of the trial.

The Intrinsic Motivation Intervention Scale (IMI) measured participants' levels of intrinsic motivation. The authors of the mentioned study highlight that the IMI has demonstrated strong construct validity. Regarding reliability, it demonstrates high internal consistency (Markland & Hardy, 1997). The IMI is a nominal 35-item questionnaire that assesses the multidimensional subjective experience while performing a certain activity (i.e. the HIT protocol). It yields six subscales (interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice), with the possibility of independent scoring for each scale and a general scoring. The scoring goes from one to seven, with one being 'not true at all' and seven 'being very true'. A higher score correlates to higher intrinsic motivation (total range: 35–245). To be able to formulate an answer to the research questions, the subscale interest/enjoyment was used, as this is the most direct measure of intrinsic motivation (Monteiro et al., 2015). The IMI was assessed once at the end of the trial.

Therapy adherence to the exercise programme is evaluated by counting the number of completed therapy sessions within the six-week protocol. Therapy adherence (i.e. the number of sessions completed, number of exercises, and sets and repetitions completed (all expressed as a percentage) within each session) was recorded within the Physitrack system. The programme will be considered feasible if at least 90% of the participants complete the trial and if adherence to the programme is at least 75% (equivalent to at least six out of eight sessions in total performed). As part of measuring therapy adherence, the IMI, SVAS, and MVAS can also be considered valuable outcome measures.

Outcome measures regarding effectivity in relation to disease-related measures

The severity of a patient's pain and the impact of this pain on the patient's daily functioning was evaluated by the Brief Pain Inventory Short Form (BPI-SF). The BPI demonstrates sufficient structural validity and internal consistency. Its reliability is supported in this study as well (Chiarotto et al., 2019). This is a 9-item questionnaire, whereby the patient is asked to rate the worst, lowest, mean, and current pain intensity, list current treatments and their perceived effectiveness, and judge the degree to which pain interferes with general activity, mood, walking ability, normal work, relationships with other individuals, sleep, and quality of life on a 10-point scale. The BPI-SF was assessed at baseline and after finalising the protocol. For this outcome measure, the data from questions 3, 4, 5, 6, and the entirety of question 9 were examined and analysed, as these were most relevant to the research question. The BPI-SF was assessed at baseline and the end of the six-week intervention period.

Fear-avoidance behaviour was measured with the Fear Avoidance Components Scale (FACS). The FACS is a valid and reliable tool for assessing fear avoidance in chronic pain patients (Neblett et al., 2015). This questionnaire is designed to evaluate fear avoidance in patients with painful medical conditions and includes constructs such as pain-related catastrophic cognitions, hypervigilance, and avoidance behaviors. The FACS consists of 20 items with a score from zero (totally disagree) to five (totally agree), for a total possible score of 100. The following anxiety avoidance severity levels are recommended for clinical interpretation: subclinical (0–20), mild (21–40), moderate (41–60), severe (61–80), and extreme (81–100). This questionnaire was assessed at baseline and the end of the six-week intervention period.

Data analysis

When data was analysed, nonparametric and parametric statistics (JMP Pro 17, SAS, Institute Inc, Cary, USA) were used. PRE-POST test comparisons were performed using the Wilcoxon signed ranks test. When normality was checked and cleared, a t-test was used. During the statistical analysis, a 5% confidence interval for all data was used meaning that data will be rejected at a 0.05 significance level. Descriptive statistics were used for outcome measures, which only had one measurement throughout the entire study. For the remainder of the outcome measures, a decision tree provided by the University of Hasselt (Appendix 1) was used.

Results

Subject characteristics

Table 1 summarizes the sociodemographic characteristics (gender, BMI, age) of our 15 participants at baseline. These subject characteristics were used to explain more about the participant population.

Table 1

Sociodemographic Characteristics of Participants at Baseline

Sociodemographic variables	Total (n = 15)
Gender	
Male	7
Female	8
Age (y)	45.5 (12.0)
BMI (kg/m²)	25.5 (4.3)

Note. Categorical variables are expressed as numbers; continuous variables are expressed as mean (SD); Abbreviations: y: years; BMI: Body-Mass Index; kg: kilograms; m: meters.

Feasibility- and adherence-related measures

System usability scale.

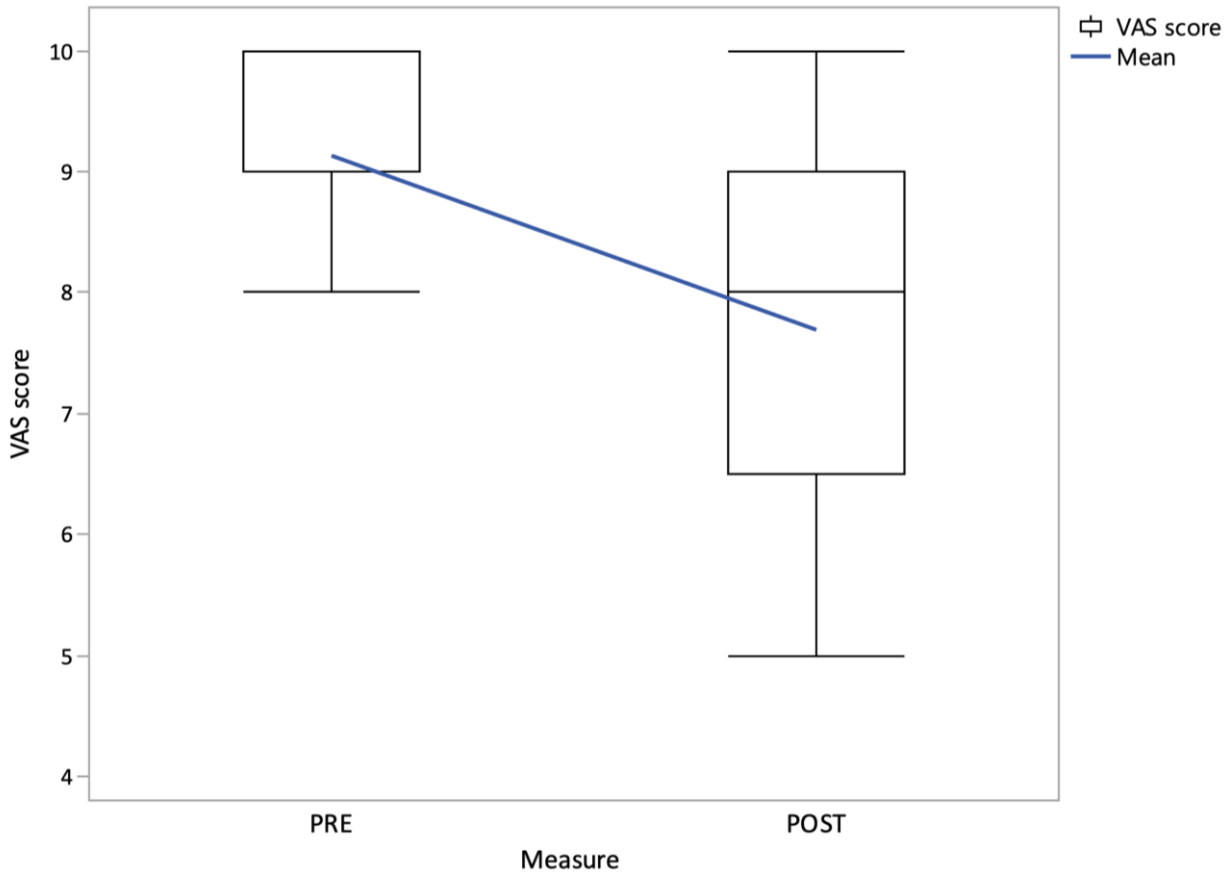
The evaluation of system usability using the SUS revealed predominantly high total scores (min. 60, max. 77) among participants as detailed in Table 2. Regarding the positive theorems, the participants mostly agreed whereas with the negative theorems, the participants mostly disagreed. Generally, participants demonstrated comfort in utilising the Physitrack application. Analysis of the average SUS total scores, where a value exceeding 68 signifies above-average usability, corroborated these observations (70.1 ± 6.7). It was found that eight out of 13 participants achieved scores surpassing this threshold.

Motivation for rehabilitation.

The data did not have a normal distribution, so nonparametric tests were used. After using the signed-rank test, the results turned out to be not significant (-1.5 ± 1.7, P = .9961), as shown in Table 3. When looking further at this table, one can see a decrease in the scores on the MVAS when comparing the PRE (9.1 ± 0.7) and POST (7.7 ± 1.7) measurements. Figure 1 shows a clear representation of said decrease in scoring.

Figure 1

Box Plots of Motivational Visual Analogue Scale for PRE and POST Measurements



Note. PRE measurement was assessed at baseline, and POST measurement was assessed after finalising the protocol.

Satisfaction with rehabilitation.

The maximum score was 10/10, whereas the lowest score was 5/10. When looking at the mean, a score of 8/10 was found, accompanied by a standard deviation (SD) of 1.9.

Intrinsic Motivation.

The highest mean score (5.5 ± 1.3) represented in Table 2 pertained to participants finding the training interesting. Additionally, the lowest mean score (1.8 ± 1.3) concerned the inability to maintain attention during training. For a more detailed analysis, see Table 2**.**

Therapy adherence.

For this outcome measure, the MVAS, SVAS, and IMI were examined. The MVAS showed no significant results as described above, with Figure 1 showing visual support for these

statistical results. Regarding the SVAS, participants had a high mean score (8.0 ± 1.9), as mentioned before.

Effectivity in relation to disease-related measures

BPI-SF.

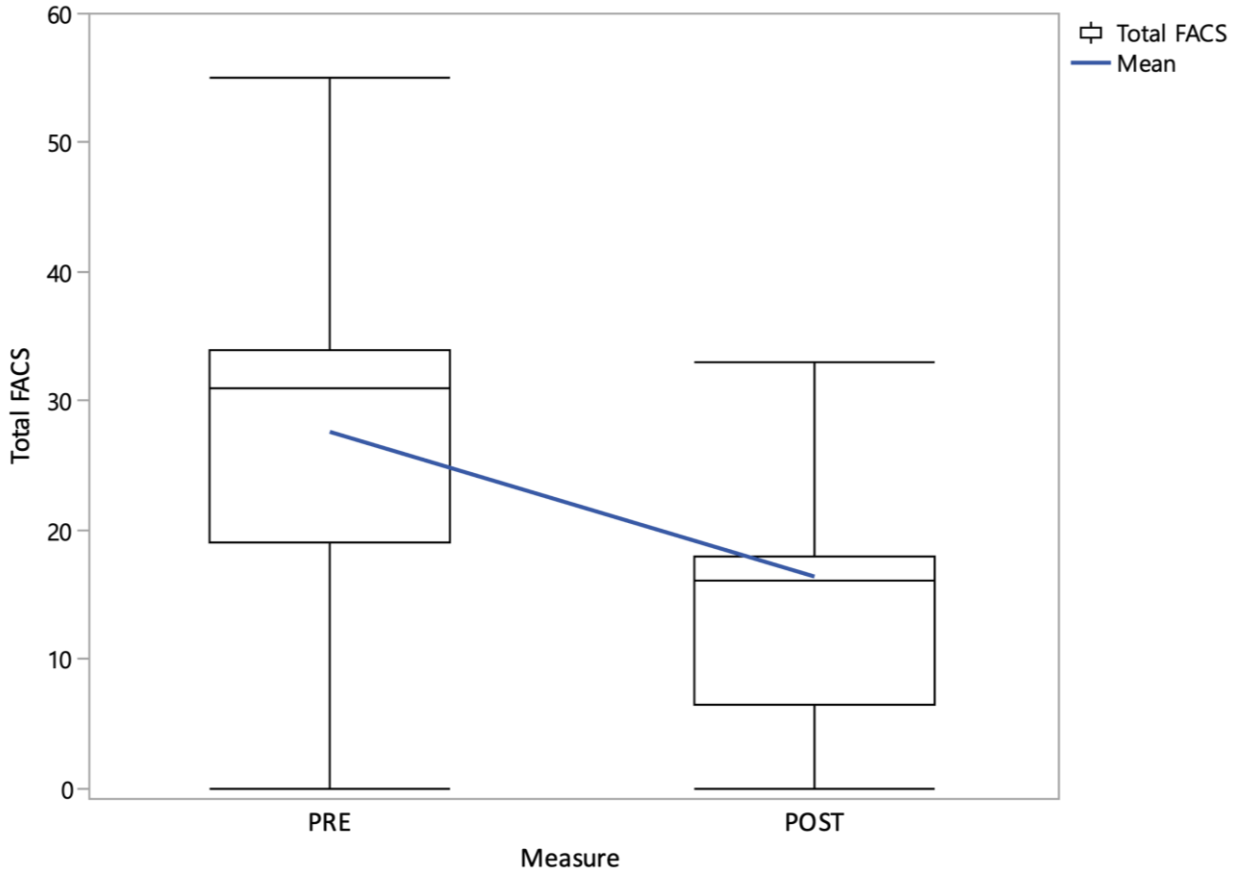
After the statistical analysis was executed, all of the data aside from questions 4 and 9d followed a normal distribution (P = .0087 and .0292) as per Table 3. Only the data from questions 6, 9c, and 9d did not present significant results (P = .1403, .4641, and .0625) when the comparison was made between the PRE and POST results. The data related to the other questions did give significant results. These pertained to questions 3, 4, 5, 9a, 9b, 9e, 9f, and 9g (respective P-values: .0061, .0039, .0111, .0254, .0079, .0235, .0349, and .0383). A more detailed description can be found in Table 3.

FACS.

After checking for normality (P = .3315), analysis was carried out using the total score of the questionnaire. Compared to the scores before their participation, the intervention significantly improved participants' level of fear avoidance related to pain (-11.1 ± 12.8, P = .0042). Figure 2 depicts a representation of the decrease in score.

Figure 2

Box Plots of Total score of the Fear Avoidance Components Scale for PRE and POST Measurements



Note. PRE measurement was assessed at baseline, and POST measurement was assessed after finalising the protocol.

Discussion

The first aim was to investigate to what extent a technology-supported HIT programme at home, regarding system usability, is a feasible therapeutic modality in people with CNSLBP.

The outcome measure that will be discussed regarding this research question is the SUS. As discussed in the results section, eight out of 13 participants exceeded the 68 score threshold. This indicates that for the majority of participants, Physitrack was an above-average technology tool to use at home. Based on the results, Physitrack received above-average scores, indicating that it is a feasible technology for at-home exercise programmes. When comparing these results with those from Arensman et al. (2022), who also used the SUS, it was found that both studies concluded the app received above-average scores on this outcome measure. However, they did not work with total scores as was done in this paper (Arensman et al., 2022).

The second aim of the study was to investigate to what extent a technology-supported HIT programme at home is an effective therapeutic modality to improve pain and disability in people with CNSLBP.

To answer this research question, outcome measures (FACS, BPI-SF) that corresponded with effectivity in relation to disease were assessed. The FACS revealed that within the intervention group, the levels of fear avoidance related to pain had reduced significantly. This showed that for these participants, the intervention did have a positive effect related to fear. This corresponds with the pilot study of Chatzitheodorou et al. (2007), stating that aerobic training at high intensity can have a positive influence on psychological distress. Psychological distress in this study, however, was measured using the Hospital Anxiety and Depression Scale, which differs from the FACS employed in our measurement of fear and anxiety. However, Klaps et al. (2022) reported improvements related to anxiety with HIT in CLBP. This was measured via the Fear Avoidance Beliefs Questionnaire. Regarding the BPI-SF, studies have shown that high-intensity aerobic training and PA can reduce pain and physical disability in persons with LBP (Verbrugghe et al., 2018; Vuori, 2001). Several results of the BPI-SF were examined and showed that within the intervention group, there was a significant reduction in pain related to certain situations, such as average pain, after completing the entire trial, which corresponds with the study of Vuori (2001). However, it is important to note that they did not consider HIT training programmes but general PA.

The third aim was to investigate to what extent a technology-supported high-intensity training (HIT) programme at home, for persons with CNSLBP, supports adherence concerning motivation and satisfaction.

Regarding this research question, the IMI, SVAS, and MVAS were assessed. The IMI showed that participants found the training to be interesting and that, for the majority of participants, their attention could be retained during the exercise programme. This suggests that the HIT program may have enhanced participants' self-confidence in performing high-intensity (heavy) daily activities. Schunk (1995) states that intrinsic motivation could enhance self-efficacy. Additionally, they assert that self-efficacy is beneficial as it motivates individuals to improve their competence, thereby aiding in the prediction of motivation and performance. Furthermore, Jack et al. (2010) demonstrated that self-efficacy is associated with adherence, noting that poor treatment adherence was linked to low levels of self-efficacy. This implies that the HIT programme had a positive effect on therapy adherence when looking at intrinsic motivation. Following the examination of the mean and median scores related to the SVAS, it can be observed that the majority of participants were satisfied with this therapeutic modality, which in turn has a positive influence on therapy adherence. This last interpretation is supported by the feasibility study of Verbrugghe et al. (2018) who found that therapy satisfaction remained high with their participants as well after they completed their trial. After examining these results and looking at comparable studies, a technology-supported HIT programme at home seems to be an effective therapeutic modality to enhance therapy adherence in persons with CNSLBP. Regarding the MVAS, no significant differences were found between the PRE and POST measurements. When looking at Figure 1, a decrease can be seen in motivation, however, in the statistical analysis, this turned out not to be significant. This is in contrast to the study of Thum et al. (2017), which states that individuals reported greater enjoyment when following a high-intensity interval training programme compared to a moderate-intensity interval training programme. It is important to note that the individuals in the study of Thum et al. (2017), were all healthy, non-obese, recreationally active men and their outcome measure for enjoyment differed from the one used in this study, necessitating caution when comparing results. Specifically, they employed the Physical Activity Enjoyment Scale. These three outcome measures influence therapy adherence as they form an important foundation related to this aspect of

therapy (Jack et al., 2010; Schunk, 1995). Based solely on the IMI, SVAS, and MVAS, it can be stated that these received positive results aside from the MVAS.

Strengths and Limitations

One of the strengths of this pilot cohort study is the used protocol. It was a standardized protocol with standardized methods of measurements which makes it possible for other researchers to replicate or reproduce this study design and protocol. On top of that, all of the training sessions were individualised based on the CPET and measured 1RM. Moreover, another strength of this study is that it establishes a baseline for future comparative studies, and it can provide insights into possible limitations that can be prevented in future research. Overall, it offers valuable insights into the feasibility, acceptability, and potential effectiveness of this topic, laying the groundwork for future research and clinical implementation.

While this study provides valuable insights into the use of technology in the rehabilitation of CNSLBP, several limitations need to be acknowledged. First of all, it is important to mention that this study is solely a pilot study with just one intervention group and no control group. This study intends to be the impetus for a larger-scale RCT with a control group and an intervention group. Secondly, two participants were missing different outcome measures which could affect statistical analyses and interpretation. Thirdly, the majority of the data is skewed, as determined by Pearson's median skewness formula (Appendix 2). This limitation influenced the results, necessitating a cautious interpretation of the presented data. The mean is particularly susceptible to the influence of outliers and skewed data, and this must be considered when interpreting the findings (Bhandari, 2023; Doane, 2011). Furthermore, in order to statistically analyse the BPI-SF, the choice was made to study the questions of the subscale pain and disability separately. This method has both advantages and disadvantages. The statistical analysis is more nuanced when the questions are considered separately, and one gets a more detailed picture of the evolution. However, the disadvantage is that more statistical tests were performed, and thus the probability of a significant result automatically increases. A solution for this disadvantage and a recommendation for future research would be to use the Bonferroni correction or Tukey's HSD Test. On top of that, the sample size in this study is small, which makes generalisation to the general population difficult. In this pilot study, during the first four sessions at the REVAL Research Centre, the participants

executed a general resistance training protocol on fitness devices. This however could not be executed during their at-home sessions and therefore is a limitation to this study. Future research should try to find solutions to the current limitations, that were noticed during this trial, of performing strength training at home. Lastly, in the methods section it was explained that after the first two weeks of the trial, the participants had to undergo assessments again. However, this data was not available when writing this paper. Future research should make use of all the data collected throughout the entire trial when performing their analyses.

Conclusion

Under the conditions of the presented pilot cohort study, a technology-supported HIT programme at home for persons with CNSLBP seems to be feasible in terms of the use of technology, effective concerning pain and disability, and supportive of adherence. It may improve fear avoidance related to pain, pain and disability, and intrinsic motivation. On top of that, Physitrack seems to be a usable technology modality to support HIT at-home training programmes. On the other hand, the MVAS did not demonstrate significant improvements when comparing PRE and POST measurements; in fact, it showed a decrease in scores, although this decrease was not statistically significant.

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Attachments

Table 2

Descriptive Statistics of Outcomes with Only One Measurement

Outcomes	Mean (SD)	Min.	Max.
SUS			
1. I think that I would like to use this system frequently	3.8 (1.2)	2	5
2. I found the system unnecessarily complex	1.1 (0.3)	1	2
3. I thought the system was easy to use	4.8 (0.4)	4	5
4. I think that I would need the support of a technical person to be able to use this system	1.2 (0.4)	1	2
5. I found the various functions in this system were well integrated	4.3 (1.0)	2	5
6. I thought there was too much inconsistency in this system	1.2 (0.6)	1	3
7. I would imagine that most people would learn to use this system very quickly	4.5 (0.5)	4	5
8. I found the system very cumbersome to use	1.0 (0.0)	1	1
9. I felt very confident using the system	4.7 (0.6)	3	5
10. I needed to learn a lot of things before I could get going with this system	1.0 (0.0)	1	1
Total score	70.1 (6.7)	60	78
SVAS	8.0 (1.9)	5	10
IMI			
1. I enjoyed doing this activity very much	4.4 (1.4)	2	6
2. This activity was fun to do	4.4 (1.4)	2	7
3. I thought this was a boring activity	2.0 (1.4)	1	5
4. This activity did not hold my attention at all	1.8 (1.3)	1	5
5. I would describe this activity as very interesting	5.5 (1.3)	3	7
6. I thought this activity was quite enjoyable	4.8 (1.1)	3	7
7. While I was doing this activity, I was thinking about how much I enjoyed it	3.2 (1.7)	1	6

Note. Abbreviations: SUS: System Usability Scale; SVAS: Satisfaction Visual Analogue Scale; IMI: Intrinsic Motivation Inventory; (SD): Standard Deviation; Min.: Minimum score; Max.: Maximum score.

Table 3

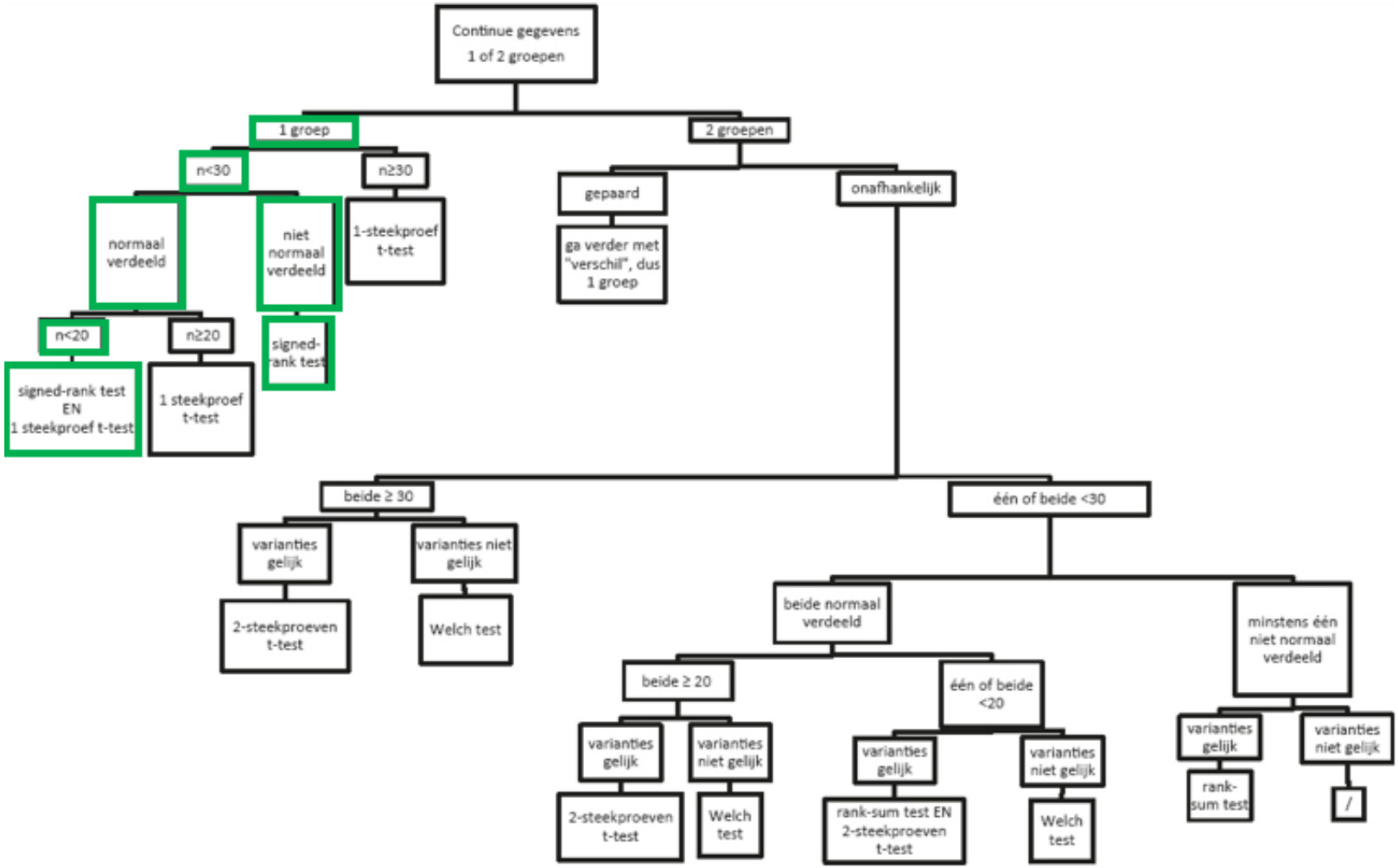
Statistical Analysis of Outcomes with PRE and POST Measurements

	Outcomes	Mean PRE (SD)	Mean POST (SD)	Mean Δ (SD)	Normal distibution (P-value)	P-value t-test	P-value signed-rank
BPI-SF							
	3. Worst pain past 24h	7.4 (1.6)	6.2 (2.2)	-1.3 (1.6)	Yes (.2775)	.0061*	.0078*
	4. Least pain past 24h	1.6 (1.2)	0.9 (1.0)	-0.8 (0.7)	No (.0087*)	/	.0039*
	5. Average pain	3.9 (2.0)	2.3 (1.8)	-1.6 (2.2)	Yes (.4875)	.0111*	.0107*
	6. Pain right now	2.5 (2.2)	1.8 (1.9)	-0.8 (2.5)	Yes (.9482)	.1403	.1523
	9a. Pain interfered with general activity	3.7 (1.7)	1.3 (2.2)	-2.1 (2.8)	Yes (.1277)	.0254*	.0332*
	9b. Pain interfered with mood	4.2 (2.9)	1.2 (1.0)	-3.1 (3.1)	Yes (.7574)	.0079*	.0098*
	9c. Pain interfered with walking ability	4.5 (2.9)	2.7 (4.1)	-0.2 (4.7)	Yes (.8001)	.4641	.5000
	9d. Pain interfered with normal work	3.3 (2.5)	1.5 (2.1)	-1.8 (3.7)	No (.0292*)	/	.0625
	9e. Pain interfered with relations	3.6 (2.8)	0.4 (0.9)	-3.1 (3.3)	Yes (.5212)	.0235*	.0313*
	9f. Pain interfered with sleep	3.2 (2.2)	1.1 (1.6)	-1.8 (2.3)	Yes (.8846)	.0349*	.0625
	9g. Pain interfered with enjoyment of life	4.1 (3.0)	1.0 (1.4)	-3.3 (3.7)	Yes (.9177)	.0383*	.0625
FACS							
	Total score	27.6 (13.7)	16.4 (13.8)	-11.1 (12.8)	Yes (.3315)	.0042*	.0024*
MVAS		9.1 (0.7)	7.7 (1.7)	-1.5 (1.7)	No (.0235*)	/	.9961

Note. Abbreviations: BPI-SF: Brief Pain Inventory Short-Form; FACS: Fear Avoidance Components Scale; MVAS: Motivational Visual Analogue Scale; (SD): Standard Deviation; Δ: delta displays the post-pre difference; *$p < 0.05$.

Appendix 1

Decision Tree of Continuous Data



Note. The green path to use the signed-rank test and/or signed-rank test plus t-test, depending on normality.

Appendix 2

Calculation of Pearson's Median Skewness

Outcomes	Pearson's median skewness
BPI-SF	
Question 3	-0.6
Question 4	0.9
Question 5	0.5
Question 6	-0.9
Question 9a	-0.1
Question 9b	-0.1
Question 9c	-0.1
Question 9d	0.2
Question 9e	-0.1
Question 9f	0.3
Question 9g	0.6
FACS	-0.5
MVAS	-0.9
SUS	
Question 1	-0.5
Question 2	1
Question 3	-1.5
Question 4	1.5
Question 5	-2.1
Question 6	1
Question 7	-3
Question 8	/
Question 9	-1.5
Question 10	/
SVAS	0
IMI	
Question 1	0.9
Question 2	0.9
Question 3	2.1
Question 4	1.8
Question 5	-1.2
Question 6	-0.5
Question 7	0.4

Note. Calculations were done by applying the formula of Pearson's median skewness $= 3 \times \frac{(Mean - Median)}{Standard\ deviation}$