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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

The difference between low and moderate intense resistance training, combined with aerobic endurance training, on exercise tolerance and functional capacity in patients with heart failure

Lieze Nouwen
Lore Timmers

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. Dominique HANSEN

BEGELEIDER :

Mevrouw Natalia TURRI DA SILVA

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Acknowledgement

The present study was written by Nouwen Lieze and Timmers Lore during their Master of Rehabilitation Sciences and Physiotherapy at the University of Hasselt, Belgium. The supervisor for the students was Prof. dr. Hansen Dominique. For this Master's thesis, a collaboration with 'Ziekenhuis Oost-Limburg, Genk' was set up.

The students want to thank Prof. dr. Hansen Dominique, from the University of Hasselt, for the interesting subject and to guide them through the study. Furthermore, they want to thank Dra. Turri Da Silva Natalia for giving suggestions and Dra. Marinus Nastastia to help coordinating the study. The physiotherapists, Duchateau Anneleen, Geladé Kristof, Jacobs Guy and Tulleneers Bart, and the cardiologist, Dr. Mullens Wilfried, of 'Ziekenhuis Oost-Limburg, Genk' get a special thank for their commitment to the study. The students want to thank the members of the study team for guiding the intervention when both students were unavailable at 'Ziekenhuis Oost-Limburg, Genk'. The comments and advices the students got from everyone were implemented in this Randomized Controlled pilot Trial (RCT).

Vrenenstraat 39, 3900 Pelt; 7 juni 2021 N.L.

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Research context

The present study fits in the domain 'Rehabilitation sciences and physiotherapy'. The specific subject of the present study is 'Rehabilitation of patients with heart failure (HF)'. According to evidence, an exercise training program is important to improve the quality of life, prognosis and anatomic function in patients with HF (Cornelis, Beckers, Taeymans, Vrints, & Vissers, 2016). A combined training method, with aerobic endurance training and resistance training is more effective for patients with HF than aerobic endurance or resistance training alone (Marzolini, Oh, & Brooks, 2012). For the rehabilitation of patients with HF, the optimal intensity of resistance training, when combining with aerobic endurance training, is not defined yet.

The subject of this Master's thesis consists of different resistance training intensity's (low or moderate) combined with aerobic endurance training. The results of the present study may be interesting for physiotherapists who are in charge of rehabilitation of cardiac patients. Based on this study, further research with larger sample sizes and longer duration (training sessions and follow-up) will be executed.

The students, Nouwen Lieze and Timmers Lore, got offered the subject of this Master's thesis from Prof. dr. Hansen Dominique. The intervention to examine the subject took place in the cardiac rehabilitation unit of 'Ziekenhuis Oost-Limburg, Genk'. The students determined together a research design and the methods based on this subject. These were in consensus with Prof. dr. Hansen Dominique, the physical therapists of 'Ziekenhuis Oost-Limburg, Genk' and two other students (Machiels Lise Jetske and Verdonck Lennert). The other students describe the outcomes of a combined training program on resistance parameters. The present study is a Randomized Controlled pilot Trial (RCT). The students prepared all documents needed for the ethical commission from the University of Hasselt and from 'Ziekenhuis Oost-Limburg, Genk'. The students went together or separately (at different moments) to the cardiac rehabilitation unit of 'Ziekenhuis Oost-Limburg, Genk' to train the included participants of the study. In the hospital, they were guided by physiotherapists: Duchateau Anneleen, Geladé Kristof, Jacobs Guy and Tulleneers Bart. Data recruitment was performed by the students, together with other members of the study team. Both students worked independently performing the statistical analyses. Results were compared, complemented and corrected to avoid mistakes and imperfections. The study is a product of a cooperation between both students, having an equal contribution. Dra. Turri Da Silva Natalia improved the written version of the study by giving suggestions.

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The difference between low and moderate intense resistance training, combined with aerobic endurance training, on exercise tolerance and functional capacity in patients with heart failure

1 Abstract

Background: The cardiac disease heart failure (HF) has a multidisciplinary approach among which exercise rehabilitation. Conflicting evidence exists about the training intensities and its outcomes. However, when combining with moderate aerobic endurance training, the optimal intensity of resistance training still needs to be explored.

Objectives: This pilot study will clarify which intensity of resistance training, combined with aerobic endurance training, will maximize the effects of aerobic endurance training in patients with HF.

Participants: Patients with HF who rehabilitated in 'Ziekenhuis Oost-Limburg, Genk' were included in the study. Seven participants, randomized into two intervention groups, completed at least 80% of the 20-session training intervention.

Measurements: The primary and secondary outcomes are the measurements of the six minute walk test (6MWT), cardiopulmonary exercise test (CPET), blood pressure (BP) and heart rate (HR). At baseline, a descriptive questionnaire, the Minnesota Living with Heart Failure Questionnaire (MLwHF) and a one-repetition maximum (1RM) test were executed.

Results: A significant positive trend is seen for $VO_{2\ peak}$ in the moderate intensity training group. No significant differences were found for the 6MWT, HR, BP and other parameters of the CPET.

Conclusion: Combined with aerobic endurance training, moderate intensity resistance training tends to be superior to low intensity resistance training to maximize the effects of aerobic endurance training in patients with HF. Further research, with larger sample sizes, longer training intervention and/or longer follow-up period, is necessary to optimize the intensity of resistance training, when combined with aerobic endurance training.

Keywords: Heart Failure, Resistance training, Aerobic endurance training, Concurrent training

2 Introduction

Worldwide, above 37.7 million people live with heart failure (HF) (Vos et al., 2012). HF is a complex clinical syndrome, caused by a cardiac dysfunction, leading to increases in intracardiac pressures and/or a decrease in cardiac output (Ponikowski et al., 2016). The heart has a reduced capacity of filling and/or ventricular ejecting (Gebreegziabher, Makaryus, Makaryus, & McFarlane, 2007). Therefore, the heart cannot pump sufficient blood, needed for normal activity, to the tissues (Gebreegziabher et al., 2007).

The prevalence of HF increases progressively in people older than 50 years (Mosterd & Hoes, 2007). The incidence of HF is higher in men than in women (Mosterd & Hoes, 2007). Individuals who were diagnosed with a cardiovascular disease before (particularly a myocardial infarction), are more plausible to develop HF (Ponikowski et al., 2016).

The symptoms of HF consist out of: (a) abdominal swelling, (b) dyspnea on exertion (after exercise), (c) (pulmonary) edema, (d) exercise intolerance, (e) fatigue, (f) lung crepitations, (g) orthopnea, (h) paroxysmal nocturnal dyspnea, and (i) recent weight gain (King, Kingery, & Casey, 2012; Mosterd & Hoes, 2007; Ponikowski et al., 2016; Verhestraeten et al., 2020). The diagnosis of HF is based on: (a) symptoms and signs, (b) medical history, (c) physical examination, (d) echocardiography, (e) (rest) electrocardiography (ECG), (f) natriuretic peptide (BNP and NT-proBNP), (g) and left ventricular ejection fraction (LVEF) (Ponikowski et al., 2016). LVEF is assessed by using an echocardiography (Li, Wei, Cong, Hong, & Li, 2020; Mosterd & Hoes, 2007). HF can be classified into three phenotypes: (a) HF with reduced ejection fraction (HFrEF; LVEF ≤ 40%), (b) HF with preserved ejection fraction (HFpEF; LVEF ≥ 50%), and (c) HF with midrange ejection fraction (HFmrEF; LVEF 41-49%) (Ponikowski et al., 2016). Independently of the HF phenotypes, exercise intolerance is seen in patients with HF (Gebreegziabher et al., 2007) and needs to be addressed in such population in order to increase quality of life (QoL) and reduce hospitalization rates (Ponikowski et al., 2016).

HF has a multidisciplinary approach by: a physician, a physiotherapist, a dietician and a psychologist. Rehabilitation improves QoL, prognosis and anatomic function in patients with HF (Cornelis, Beckers, Taeymans, Vrints, & Vissers, 2016). Exercise therapy based on aerobic endurance and resistance training modalities is a safe approach to improve left ventricular function, physical function, exercise capacity, peak oxygen consumption, independency and QoL in patients with HF (Delagardelle et al., 2002; Gary, Cress, Higgins, Smith, & Dunbar, 2011; Gomes-Neto et al., 2019). To

increase the chronotropic reserve in patients with HF, exercise training can be used to decrease the heart rate (HR) at rest (Adams, Carr, Ozonoff, Lauer, & Balady, 2008; Conraads et al., 2004). Otherwise, other studies claim that performing combined aerobic endurance training and resistance training may not lead to significant changes in HR (Chrysohoou et al., 2015; Laoutaris et al., 2013). No studies examined the difference in blood pressure (BP) between the training sessions doing combined aerobic endurance and resistance training. More effective effects are seen when combining aerobic endurance and resistance training, compared with aerobic endurance or resistance training alone (Marzolini et al., 2012; Spruit et al., 2009). However, the most effective intensity of resistance training, when combining with moderate aerobic endurance training, still needs to be explored.

Previous studies, who indicate improvements on peak oxygen uptake capacity ($VO_{2\ peak}$) (by cardiopulmonary exercise test (CPET)) and six minute walk test (6MWT), showed different intensities of resistance training ranging from 30% of one-repetition maximum (1RM) up until 90% of 1RM (Chrysohoou et al., 2015; Laoutaris et al., 2013; Safiyari-Hafizi, Taunton, Ignaszewski, & Warburton, 2016). Therefore, the primary aim of this study was to clarify which type of resistance training (low or moderate intensity), when combined with aerobic endurance training, will maximize the effects of aerobic endurance training in patients with HF. The following hypothesis can be stated: the addition of resistance training at a greater intensity on top of aerobic endurance training will lead to clinical benefits in functionality and exercise tolerance in HF patients, when compared with the addition of resistance training at a lower intensity, without being hemodynamically aggressive. The outcomes in 6MWT, CPET, HR and BP will be checked to evaluate this hypothesis.

3 Methods

3.1 Study design

The study was a prospective Randomized Clinical pilot Trial (RCT) in the context of rehabilitation of patients with HF. This single centre study consisted of two intervention groups. Another RCT will be executed based on this pilot trial.

3.2 Participants

Recruited participants were diagnosed with HF according to the ESC guidelines (Ponikowski et al., 2016) and followed a rehabilitation program at the cardiac rehabilitation unit of 'Ziekenhuis Oost-Limburg, Genk' in Belgium. Patients were included when they met all the inclusion criteria: (a) a diagnosis of HF, determined by a physician according to the ESC guidelines of 2016 (Ponikowski et al., 2016), (b) older than 18 years, and (c) started rehabilitation in 'Ziekenhuis Oost-Limburg, Genk'. Patients were excluded when they met one of the exclusion criteria: (a) presence of orthopaedic or neurological comorbidities causing an inability for the resistance training, (b) cognitive impairment or being unable to understand the exercises, (c) measurements cannot be performed correctly, (d) undergoing other physiotherapeutic interventions during the study period, and (e) completed less than 80% of the training intervention.

3.3 Sample characterization

Patients were described according to the following parameters: (a) LVEF, (b) type of HF (HFrEF, HFmrEF or HFpEF), (c) New York Heart Association (NYHA) classification, (d) etiology, (e) risk factors, (f) medication use, (g) age, (h) gender, (i) Body Mass Index (BMI), (j) QoL, (k) functional capacity by the 6MWT, (l) 1RM leg press at start, (m) 1RM dips at start, (n) 1RM pulldown at start, (o) number of sessions followed by the participant, (p) number of sessions a week, (q) walking aids, (r) previous surgery, (s) heart and/or vascular surgery in the last year, (t) other conditions (u) date of HF diagnosis, and (v) extra information. The information was obtained by medical files, tests and questionnaires.

3.4 Procedure

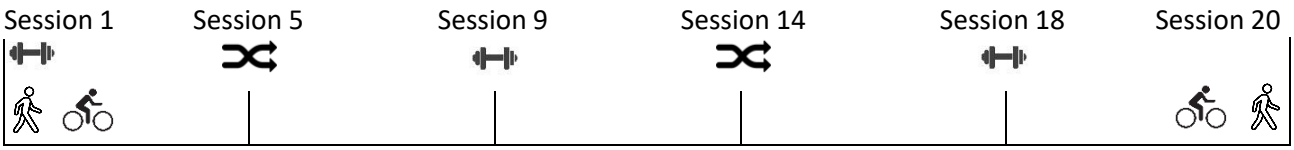
The principal investigator determined the eligibility of the patients to participate in the study. Patients were screened for inclusion and exclusion criteria by a member of the study team. Participants were randomized into one of the intervention groups: resistance training at low intensity (35-40% 1RM) or moderate intensity (55-70% 1RM), both combined with aerobic

endurance exercises. Randomization was done by opaque sealed envelopes, using block randomization (blocks consisting of six randomizations: three in each group).

All patients performed a CPET before starting the intervention and at the end of 20 sessions. The CPET (protocol appendix A) was executed by a member of the research team and supervised by a blind principal investigator (Prof. dr. W. Mullens). Participants underwent a 6MWT (protocol appendix B) before the start and at the end of the intervention protocol. A 1RM test (protocol appendix C) was executed at the start of the intervention and repeated each nine sessions. The participants filled in the Minnesota Living with HF questionnaire (MLwHF) and a descriptive questionnaire (appendix D). The BP and HR measurements were taken each session before executing the resistance exercises (protocol appendix E) using a blood pressure monitor (M3 (HEM-7154-E), Omron, Kyoto, Japan).

3.5 Training interventions

Figure 1 shows an overview of the interventions. The 1RM test was repeated each nine sessions to ensure the correct training load of resistance training. All participants underwent a multidisciplinary intervention at the hospital consisting of guidance by a rehabilitation doctor, dietician, psychologist, physical therapist and social worker. Participants randomized in the low intensity training group executed the resistance training at an intensity of 35-40% of 1RM. These participants did three sets of 21-22 repetitions for the leg press, with a one-minute break in between. The dips and pulldown consisted of three sets of 18-19 repetitions, with a one-minute break in between. When training at 35% of 1RM (the first three to four sessions after 1RM measurement), the participants did 22 repetitions with the lower extremities (LE) and 19 repetitions with the upper extremities (UE). The participants did 21 (LE) and 18 (UE) repetitions at 40% of 1RM (the last four sessions before a new 1RM measurement). Participants randomized in the moderate intensity training group executed the resistance training at an intensity of 65-70% of 1RM for the LE and 55-60% of 1RM for the UE. The resistance training in this group consisted of three sets of 12 repetitions for all three exercises, with a one-minute break in between. The number of repetitions in the low intensity training group changed to provide an equal training volume between both training groups.



UE:	UE:	UE:	UE:	UE:
35% 1RM 3x 19 reps	40% 1RM 3x 18 reps	35% 1RM 3x 19 reps	40% 1RM 3x 18 reps	35% 1RM 3x 19 reps
55% 1RM 3x 12 reps	60% 1RM 3x 12 reps	55% 1RM 3x 12 reps	60% 1RM 3x 12 reps	55% 1RM 3x 12 reps
LE:	LE:	LE:	LE:	LE:
35% 1RM 3x 22 reps	40% 1RM 3x 21 reps	35% 1RM 3x 22 reps	40% 1RM 3x 21 reps	35% 1RM 3x 22 reps
65% 1RM 3x 12 reps	70% 1RM 3x 12 reps	65% 1RM 3x 12 reps	70% 1RM 3x 12 reps	65% 1RM 3x 12 reps

% = percentage; 1RM = One-Repetition Maximum; LE = Lower Extremities; reps = repetitions; UE = Upper Extremities; x = times.

Figure 1. Overview of the intervention

The groups executed each one-hour session both aerobic endurance and resistance exercises. Aerobic endurance training was executed following the standard protocol of the hospital. Aerobic endurance training was executed using: (a) treadmill, (b) cycle ergometer, (c) arm ergometer, (d) stepper, and (e) crosstrainer. The intensity of the aerobic endurance exercises varied between 50% and 80% of $VO_{2\ peak}$, starting above the first ventilatory threshold (VT1) progressing to the second ventilatory threshold (VT2) (determined by CPET). Aerobic endurance training was executed for at least 30 minutes per session.

3.6 Outcome measurements

The primary outcome measurements were: (a) $VO_{2\ peak}$ (by CPET), (b) functional capacity (distance by 6MWT), (c) BP between sessions (by blood pressure monitor), and (d) HR between sessions (by blood pressure monitor).

The secondary outcomes were: (a) W_{max} (by CPET), (b) HR rest (by CPET), (c) difference in BORG legs score (by 6MWT), (d) difference in BORG breathing score (by 6MWT), (e) HR rest (by 6MWT) (f) HR after (by 6MWT), and (g) difference in saturation (by 6MWT).

3.7 Data analysis

Data analysis was performed using the software JMP (Version: Pro 15.2.0, JMP, USA). Data were checked for normality (Shapiro-Wilk test) and homoscedasticity (Brown-Forsythe test). Baseline characteristics were compared between the two intervention groups using t-tests, the Wilcoxon Signed-rank exact tests and/or the Welch tests for continuous data and the Fisher's exact tests for

categorical data. Differences between the test at the beginning and at the end of the intervention were used to determine effects in HR rest, $VO_{2\ peak}$ and W_{max} of the CPET. This method was also performed to determine effects in distance, %predicted, HR rest and HR after by the 6MWT. The BORG legs, BORG breathing and saturation of the 6MWT were compared using the changes of score during a test. These changes were compared using between and within analysis, at the beginning and at the end of the intervention, and between both groups. Effects were determined using the same statistical methods as used by the baseline characteristics. HR and BP were grouped per five sessions and means per patient were compared. A mixed model was used to compare the means. A p-value of ≤ 0.05 was determined as a significant difference.

3.8 Medical ethics

The study was approved by the medical ethical committee of the University of Hasselt and 'Ziekenhuis Oost-Limburg, Genk'. The number of the present study is 20/0090U, given by the ethical commission of 'Ziekenhuis Oost-Limburg, Genk'. Preliminary approval was given on December 21, 2020. Final approval was received in May, 2021. All participants signed a written informed consent with clear information about the study protocol.

4 Results

4.1 Participants

A total of 16 patients with HF were assessed for eligibility between February 2021 and March 2021. Four patients were randomized into the low intensity training group and six patients into the moderate intensity training group (figure 2). Thirty percent of the participants dropped-out during the intervention period.

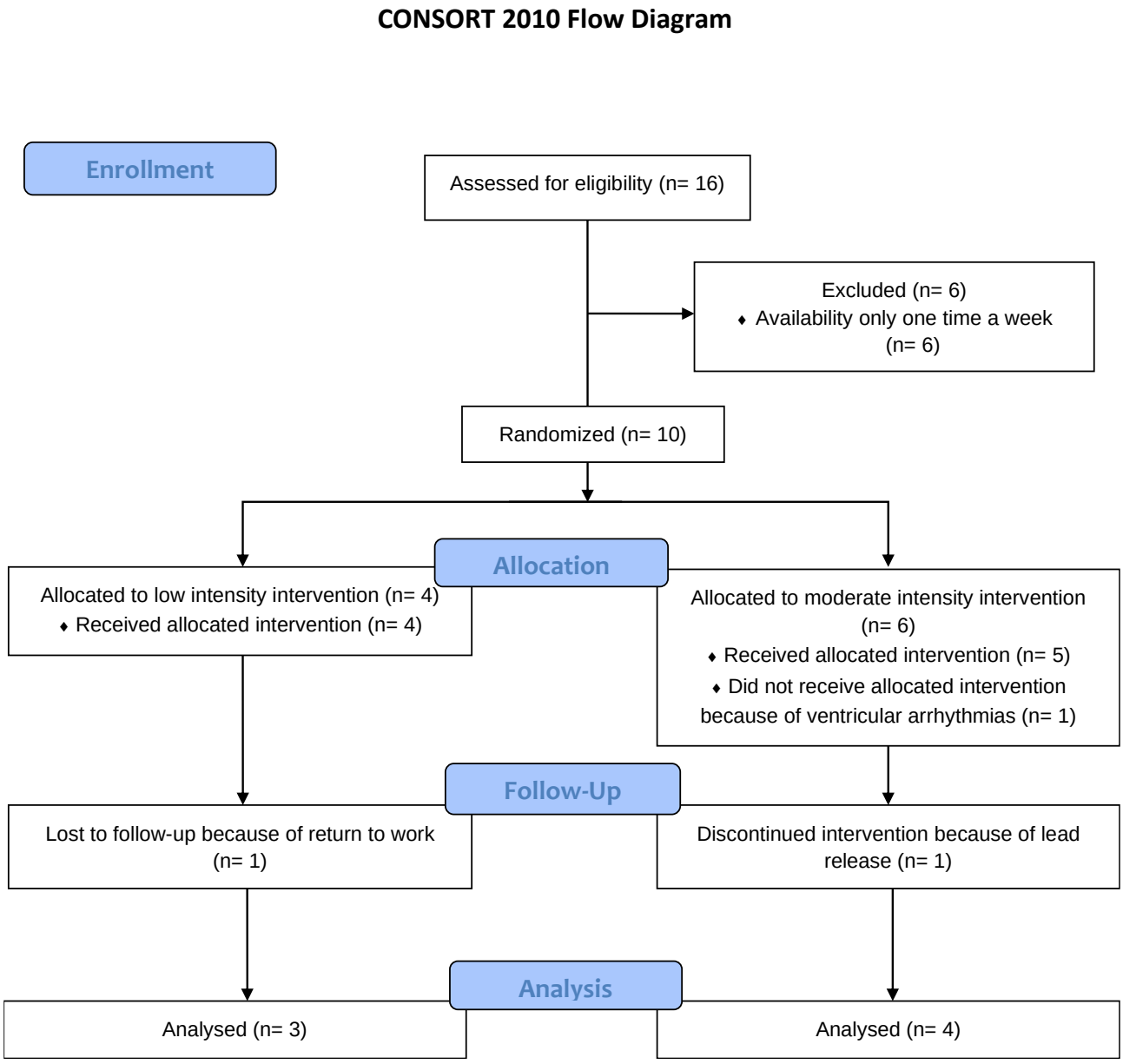


Figure 2. Flowchart

4.2 Sample characterization

The participants underwent 20 rehabilitation sessions, except one participant in the moderate intensity training group who underwent 17 rehabilitation sessions (85.00%). One participant (low intensity training group) underwent two rehabilitation sessions a week, while the others received three sessions a week. This participant defined previous heart surgery more than one year ago (ablation and placement of a Cardiac Resynchronization Therapy pacemaker (CRT-p)) and had low back pain. The two other participants in the low intensity training group had sleep apnea, whereof one participant also had lumbago and hip arthrosis. The participant with only 17 rehabilitation sessions in the moderate intensity training group had oedema in the lungs and fibromyalgia. This participant was not able to perform the CPET after intervention because of hospitalisation in the context of the thyroid gland. None of the patients used a walking aid in daily life. An overview of the characteristics per patient is given in the tables in the supplemental material.

Baseline characteristics of the included participants are shown in Table 1. This table gives an overview of the p-values with the associated statistical methods. There was a significant difference between both groups in heart and/or vascular surgery in the last year ($p = 0.0286$). There were no significant differences between the other baseline characteristics.

Comparing the baseline percentage of LVEF between both training groups was not possible. The medical file of three participants with HFpEF did not reflect the percentage of LVEF, resulting in only one participant in the low intensity training group with a given percentage of LVEF (45%).

Table 1. Sample characteristics

	Low intensity training group (n = 3)	Moderate intensity training group (n = 4)	p-value
Male (n, %)	2 (66.67)	3 (75.00)	1.0000[a]
Age (years)	66.33 ± 6.81	62.50 ± 5.92	0.4609[b] 0.4000[c]
Weight (kg)	93.83 ± 26.11	78.00 ± 9.42	0.3028[b] 0.6286[c]
Height (m)	1.74 ± 0.14	1.69 ± 0.03	0.4893[b] 0.7143[c]
BMI (kg/m²)	30.61 ± 5.97	27.45 ± 3.96	0.4344[b] 0.6286[c]
MLwHF	21.00 ± 13.08	24.50 ± 36.79	0.8833[b] 0.6286[c]
1RM Leg press (kg)	143.33 ± 56.86	106.00 ± 45.96	0.3784[b] 0.3429[c]
1RM Dips (kg)	66.67 ± 21.94	55.00 ± 18.71	0.4808[b] 0.6286[c]
1RM Pull down (kg)	55.00 ± 21.79	55.00 ± 17.80	1.0000[b] 0.9714[c]
Previous heart and/or vascular surgery in the last year			
No (n, %)	3 (100.00)	0 (0.00)	0.0286[a*]
Yes (n, %)	0 (0.00)	4 (100.00)	
Classification			
NYHA I (n, %)	1 (33.33)	2 (50.00)	
NYHA II (n, %)	2 (66.67)	1 (25.00)	1.0000[a]
NYHA III (n, %)	0 (0.00)	1 (25.00)	
HFrEF (n, %)	0 (0.00)	1 (25.00)	
HFmrEF (n, %)	1 (33.33)	3 (75.00)	0.2571[a]
HFpEF (n, %)	2 (66.67)	0 (0.00)	
Etiology for HF			
Idiophatic (n, %)	2 (66.67)	1 (25.00)	0.4857[a]
Hypertension (n, %)	1 (33.33)	0 (0.00)	0.4286[a]
Myocard infarction (n, %)	0 (0.00)	3 (75.00)	0.1429[a]
Risk factors			
Hypertension (n, %)	3 (100.00)	3 (75.00)	1.0000[a]
Hypercholesterolemia (n, %)	3 (100.00)	2 (50.00)	0.4286[a]

Overweight/obesity (n, %)	2 (66.67)	2 (50.00)	1.0000[a]
History of smoking (n, %)	3 (100.00)	1 (25.00)	0.1429[a]
Smoker (n, %)	0 (0.00)	1 (25.00)	1.0000[a]
Renal insufficiention (n, %)	1 (33.33)	0 (0.00)	0.4286[a]
Diabetic (n, %)	1 (33.33)	0 (0.00)	0.4286[a]
Drugs			
Beta-blocker (n, %)	2 (66.67)	4 (100.00)	0.4286[a]
Statins (n, %)	3 (100.00)	3 (75.00)	1.0000[a]
Diuretics (n, %)	3 (100.00)	3 (75.00)	1.0000[a]
Antithrombotica (n, %)	2 (66.67)	3 (75.00)	1.0000[a]
Anti-aritmica (n, %)	1 (33.33)	0 (0.00)	0.4286[a]
ACE-inhibitors (n, %)	1 (33.33)	2 (50.00)	1.0000[a]
Angiotensin Receptor Blockers (n, %)	2 (66.67)	2 (50.00)	1.0000[a]
Calcium-antagonist (n, %)	2 (66.67)	0 (0.00)	0.1429[a]

Values are expressed as mean ± standard deviation (SD) or frequencies (%). Comparisons between groups were analysed by [a] Fisher's Exact Test; [b] T-test; [c] Wilcoxon Signed-rank exact Test. *p ≤ 0.05.

% = percentage; ± = plus minus; 1RM = One-Repetition Maximum; ACE-inhibitors = Angiotensin-Converting Enzyme inhibitors; BMI = Body Mass Index; HF = Heart Failure; HFmrEF = Heart Failure with mid-range Ejection Fraction; HFpEF = Heart Failure with preserved Ejection Fraction; HFrEF = Heart Failure with reduced Ejection Fraction; kg = kilogram; kg/m² = kilogram per square meter; m = meter; MLwHF = Minnesota Living with Heart Failure; n = number; NYHA = New York Heart Association Functional Classification.

4.3 Outcomes

4.3.1 Six minute walk test

The exercise tolerance and functionality of the participants are summarized in Table 2. No significant differences were seen by analysing the 6MWT variables between and within groups.

4.3.2 Cardiopulmonary exercise test

Between group analysis indicates a trend of an increased $VO_{2\ peak}$ (t-test: p = 0.0174; Wilcoxon Signed-rank exact test: p = 0.1000). Within group analysis in the moderate intensity training group indicates a trend of an increased $VO_{2\ peak}$ (t-test: p = 0.0112; Wilcoxon Signed-rank exact test: p = 0.2500). In the low intensity training group, no significant difference was found in $VO_{2\ peak}$ (t-test: p = 0.1125; Wilcoxon Signed-rank test: p = 0.2500). No other significant differences were found in between and within group analysis.

Table 2. Impact of exercise training interventions on exercise tolerance and functionality in heart failure patients

Parameters	Low intensity training group (n = 3)		Moderate intensity training group (n = 4)		p-value	
	pre	post	pre	post		
6MWT						
Distance (m)	503.67 ± 35.84	524.84 ± 59.92	419.63 ± 67.22	481.75 ± 64.88	0.3081[d]	
%pred (%)	99.75 ± 11.27	102.98 ± 9.16	81.49 ± 8.49	93.93 ± 7.48	0.2382[d]	
Δ Sat (%)	-0.67 [-5.84-4.50]	-0.33 [-3.20-2.54]	-0.75 [-3.14-1.64]	-1.75 [-6.50-3.00]	0.4987[b]	0.8000[c]
HR rest (bpm)	71.67 [39.34-103.99]	63.00 [40.92-85.08]	69.00 [45.43-92.57]	66.00 [47.95-84.05]	0.5362[b]	0.8571[c]
HR after (bpm)	98.00 [85.09-110.91]	90.00 [37.66-142.34]	84.50 [60.92-108.08]	88.25 [68.06-108.44]	0.3754[b]	0.6286[c]
Δ BORG legs (n, %)						
-2	0 (0.00)	0 (0.00)	1 (25.00)	0 (0.00)		
-1	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
0	1 (33.33)	1 (33.33)	1 (25.00)	1 (25.00)		
1	1 (33.33)	1 (33.33)	1 (25.00)	1 (25.00)	1.0000[a]	
2	1 (33.33)	0 (0.00)	1 (25.00)	1 (25.00)		
3	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)		
4	0 (0.00)	0 (0.00)	0 (0.00)	1 (25.00)		
Δ BORG breathing (n, %)						
0	0 (0.00)	1 (33.33)	1 (25.00)	1 (25.00)		
1	3 (100.00)	0 (0.00)	3 (75.00)	1 (25.00)	0.4857[a]	
2	0 (0.00)	2 (66.67)	0 (0.00)	1 (25.00)		
3	0 (0.00)	0 (0.00)	0 (0.00)	1 (25.00)		
CPET						
HR rest (bpm)	76.00 ± 10.82	72.33 ± 13.05	78.50 ± 17.14	77.67 ± 11.68	1.0000[c]	
W_{max} (W)	123.33 ± 42.52	147.00 ± 49.93	116.00 ± 54.13	154.33 ± 47.61	0.5457[b]	0.4000[c]
$VO_{2\ peak}$ (ml/kg/min)	17.27 ± 3.10	18.77 ± 3.25	17.70 ± 6.36[$]	24.77 ± 4.36[$]	0.0174[b*]	0.1000[c]

Values are expressed as mean ± standard deviation (SD), mean [95% confidence interval] or frequencies (%). Comparisons between and within groups were analysed by [a] Fisher's Exact Test; [b] T-test; [c] Wilcoxon Signed-rank exact Test; [d] Welch test. [*]$p \leq 0.05$ for the comparison between pre and post between groups. [$]$p = 0.0112$ according to t-test and $p = 0.2500$ according to Wilcoxon Signed-rank exact test in the moderate intensity training group.

Δ = Difference in; % = percentage; %pred = percentage of the predicted value; ± = plus minus; 6MWT = Six Minute Walk Test; bpm = beats per minute; CPET = Cardiopulmonary Exercise Test; HF = Heart Failure; HR = Heart Rate; ml/kg/min = milliliter per kilogram per minute; m = meter; n = number; pre = before intervention; post = after intervention; Sat = Saturation; $VO_{2\ peak}$ = peak Oxygen Uptake Capacity; W = Wattage; W_{max} = maximal Work Capacity.

4.3.3 Blood pressure

The impact of exercise training on BP and HR in the participants is summarized in Table 3. No mixed models could be used to analyse the systolic blood pressure (SBP) since the data was not normally distributed. To try to normalize the data of the SBP, the logarithm was used. However, the logarithm had no normal distribution. The Friedman test was used to determine the p-value for session*group, using the software SPSS (Version: IBM SPSS 26, SPSS, Chicago, USA). Wilcoxon Signed-rank exact tests and t-tests were used to analyse within and between group values in SBP. No significant differences were found.

For the diastolic blood pressure (DBP) no significant differences were found between groups, sessions and session*group. No further between and within analysis were necessary because of the use of mixed models.

4.3.4 Heart Rate

No significant differences were found in HR between groups, sessions and session*group. No further between and within analysis were necessary because of the use of mixed models.

BP and HR per session per patient are shown in a table in the supplemental material. Figures that represent the course of the mean HR and BP (over each five sessions) per patient are shown in the supplemental material.

Table 3. Impact of exercise training sessions on blood pressure and heart rate in heart failure patients

Parameters	**Low intensity training group (n = 3)**				**Moderate intensity training group (n = 4)**				**p-value**	**p-value**	**p-value**
Session range	1-5	6-10	11-15	16-20	1-5	6-10	11-15	16-20	Session*group	Session	Group
SBP (mmHg)[b,c]	131.00 ± 21.07	132.33 ± 20.55	126.00 ± 7.00	129.00 ± 10.00	118.50 ± 25.38	120.75 ± 26.75	127.25 ± 30.48	128.50 ± 30.82	0.543[d]		
DBP (mmHg)	71.33 [59.86-82.81]	72.33 [56.36-88.30]	70.00 [59.17-80.83]	69.33 [50.69-87.98]	71.75 [59.13-84.37]	71.25 [59.75-82.75]	77.25 [70.09-84.41]	72.25 [56.69-87.81]	0.2442[a]	0.7864[a]	0.6232[a]
HR (bpm)	79.33 ± 11.59	78.00 ± 11.36	72.67 ± 6.51	70.67 ± 3.51	81.75 ± 13.57	83.00 ± 11.02	81.00 ± 16.23	79.00 ± 13.95	0.6568[a]	0.1396[a]	0.5155[a]

Values are expressed as mean ± standard deviation (SD) or mean [95% confidence interval]. Comparisons were analysed by [a] Mixed models; [b] T-test; [c] Wilcoxon Signed-rank exact Test; [d] Friedman test.
*$p \leq 0.05$.

± = plus minus; bpm = beats per minute; DBP = Diastolic Blood Pressure; HR = Heart Rate; mmHg = millimeters of Mercury; SBP = Systolic Blood Pressure.

5 Discussion

The novelty of this study is the comparison of two intensities of resistance training protocols associated with aerobic endurance training in patients with HF. This pilot study tends to indicate that moderate intense resistance training promotes a superior effect compared with low intense resistance training for the $VO_{2\ peak}$ by CPET. No significant differences in 6MWT, BP and HR were found.

The present study can be the baseline for further research using different intensities of resistance training with larger sample sizes and longer duration of intervention and/or follow-up. Exercise prescription in the field of cardiovascular rehabilitation is under intense debate, making the present study interesting. The present study is a keystone to optimize the rehabilitation of patients with HF. The effects on functional capacity and exercise tolerance show promising results for future studies.

The increase in $VO_{2\ peak}$ (in the moderate intensity training group) can possibly be explained by the amount of aerobic endurance training, which potentially differed between the training groups. Participants who performed the moderate intensity resistance training spent less time doing the resistance exercises because of the lower number of repetitions. Due to the limited time of one hour per session, less time could be spent on the aerobic endurance exercises in the low intensity training group. Another possible explanatory factor is the number of participants with a previous heart and/or vascular surgery in the past year (none in the low intensity training group and all participants in the moderate intensity training group). Within analysis in the moderate intensity training group showed a trend to an increased $VO_{2\ peak}$. This is comparable with the studies of Feiereisen, Delagardelle, Vaillant, Lasar, and Beissel (2007) and Jewiss, Ostman, and Smart (2016), who indicate an increase in $VO_{2\ peak}$ using combined aerobic endurance and resistance training at 60-80% of 1RM. However, conflicting evidence exists about the improvement in $VO_{2\ peak}$ by training. Another study indicates no significant differences in this parameter after combined training using 70% of 1RM (Degache et al., 2007). No significant difference in $VO_{2\ peak}$ was shown between combined aerobic endurance and resistance training at an intensity of 50-80% 1RM and aerobic endurance training alone (Gomes-Neto et al., 2019; Jewiss et al., 2016).

In the present study, no significant differences were found in the parameters of the 6MWT, just like Jewiss et al. (2016). Other studies showed an improvement in HR rest by training (Conraads et al.,

2004; Jewiss et al., 2016). The study of Aslanger et al. (2015) used 20 rehabilitation sessions and showed no significant difference in HR rest, just like the present study.

The moderate intensity training group had a greater improvement in distance by 6MWT. The moderate intensity training group's distance deviated more from the predicted values than the distance of the low intensity training group. Being closer to the predicted value possibly leads to a ceiling effect during the 6MWT. Height, weight and age at baseline are non-significantly higher in the low intensity training group. The predicted value is based on these parameters, combined with gender. The HR rest (post intervention - before intervention) decreased more in the low intensity training group than in the moderate intensity training group. The HR after the test decreased in the low intensity training group and increased in the moderate intensity training group. Baseline strength characteristics of the legs show that the moderate intensity training group has a lower 1RM measurement on the leg press (not significant). Less strength at baseline can lead to relatively bigger improvements during training. The W_{max} by CPET improved more in the moderate intensity training group than in the low intensity training group. Although these differences in distance by 6MWT, HR and W_{max} by CPET were not significant.

The SBP, measured each session, increased non-significantly in the moderate intensity training group. The HR, measured each session, decreased in the low intensity training group in a non-significant way.

According to recommendations (Meka, Katragadda, Cherian, & Arora, 2008), the training intervention in the present study was executed using machines and was supervised by well-trained physical therapists. The duration of the aerobic endurance training was based on the guideline of Lindenfeld et al. (2010). This guideline recommends patients with HF to do 30 minutes of moderate intense exercise five days a week (Lindenfeld et al., 2010).

The aerobic endurance training program was different for every single participant. All participants started with continuous aerobic endurance training. Aerobic endurance exercise training improves ventilatory capacities in patients with chronic HF (Tabet et al., 2009). This diminishes the increase in the slope relating ventilation to carbon dioxide production (VE/VCO_2slope) that is seen as a potent prognostic factor (Tabet et al., 2009). After some sessions, some participants switched to cycle interval training. Since it was dependent on patient motivation and individualized prescription, not all participants had made that transition during the sessions. The possibility exists that participants

in the moderate intensity training group executed interval training earlier in the rehabilitation. Tabet et al. (2009) showed that the increase in $VO_{2\ peak}$ is greater with interval training. When training at an intensity of at least 70% of the $VO_{2\ peak}$, a significant reshift to type 1 muscle fiber is seen (Tabet et al., 2009).

During the training period, some participants switched from double leg to single leg training on the leg press. This was due to more than ten repetitions at the maximal weight of the device during the 1RM measurement. Researchers thought it would be more correct to train at the percentages of 1RM with single leg instead of calculating the 1RM by a formula (((1+(0.0333*reps))*applied weight)) described by Epley (cited in Hansen et al., 2021) in 1985.

Most of the participants (in both groups) rested only 30 to 45 seconds between the sets. Participants indicated that recuperation had already occurred and that 60 seconds of rest was a long period of time when performing the resistance training.

Not all baseline characteristics (parameters applicable to only one patient or irrelevant parameters) were taken into account when doing the statistical analysis. Date of HF diagnosis was asked using the questionnaire, however it was not included in the description of the present study.

One patient in the moderate intensity training group dropped-out because of lead release, which could be indicated as an adverse event. Caution should be paid when generalizing the protocol of the present study to patients with HF.

5.1 Limitations

The biggest limitation of the present study is the low number of participants, which was a consequence of the COVID-pandemic. According to that, the power of the study is low and analyzed data is described as a trend. Other results (for example distance by 6MWT or SBP) could be significantly different if more participants were included. Influencing factors on HR and BP were not taken into account. The dropout-rate was high (30% of the participants). Selection bias could not be excluded; starting a rehabilitation program at the hospital asks for some motivation from the patient. Participants could not be blinded because of the intervention protocol, leading to a risk of performance bias. Researchers doing the tests were not blinded, leading to a risk of detection bias. Not all tests were executed at the same moment of the day which can influence the outcomes. Weight and height were asked by the descriptive questionnaire and not measured objectively. When doing the statistical analysis, changes in medication during the intervention period were not

taken into account. However, it is known that one patient changed medication during the rehabilitation period. Differences between aerobic endurance training (interval or continuous training) and resistance training (double or single leg) were not taken into account either. The statistics of the SBP were executed using t-tests and Wilcoxon Signed-rank exact tests which increases the risk of type I errors, leading to a lower specificity. The p-value of session*group was determined using the Friedman test, showing no significant result with a lower risk of type I errors.

5.2 Strong points

The strongest point of the present study is the block randomization by which the researchers excluded the risk of allocation bias. Protocols for the tests were written, which lower the risk of information bias and improve the interrater reliability. This was important because the tests were executed by different researchers. When executing the resistance exercises and 1RM measurements, participants were learned to breathe out in the concentric phase of the contraction to avoid high intrathoracic pressure and as such to avoid a reduction in cardiac output. To avoid the Valsalva maneuver, the breathing pattern was closely checked by the researchers. Both training intervention groups did receive the same amount of attention, leading to a lower risk of performance bias. Researchers obtained an equal training volume by adjusting the amount of repetitions to one other. A lot of potentially effective variables were asked using a descriptive questionnaire to achieve a broad view of the participants. The medication was taken into account at baseline, which can affect the outcomes of the study. To analyze the data, two independent researchers worked separately. Results were compared, completed and corrected to avoid mistakes and imperfections. A moderate intensity resistance training, combined with aerobic endurance training, is a training method that can be implemented in the rehabilitation of patients with HF when the correct equipment is available.

6 Conclusion

Combined with aerobic endurance training, moderate intensity resistance training seems to be superior to low intensity resistance training to maximize the effects of aerobic endurance training in patients with HF. A positive trend in favor of moderate intensity resistance training is seen in CPET for $VO_{2\ peak}$. No other significant effects were seen between the low and moderate intensity training interventions. Further research with a larger sample size and a longer training intervention and/or follow-up is indicated.

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Appendix A
Protocol cardiopulmonary exercise test

The cardiopulmonary exercise test (CPET) is performed up to volitional exhaustion using an electronically braked cycle ergometer (eBike, GE Medical systems, Milwaukee, Wisconsin, USA), controlled by the Cardiosoft electrocardiography software (Cardiosoft 6.6, GE Medical systems, Freiburg, Germany). At the beginning of each test day, a gas and volume calibration is performed according to manufacturer's instructions. During the test, environmental temperature is kept stable at 19-21 °C. The exercise test (ramp protocol) includes a 30-second pre-exercise resting period sitting upright on bike, a one to two minutes unloaded warm-up cycling phase, followed by an incremental exercise cycling period with an initial workload of ten to 60 Watt (W), and an increasing workload of five to 40 W per minute, dependent on the patient's clinical status (with the aim to complete the CPET within six to 12 minutes). During warm-up cycling and incremental exercise, a cycling frequency of 60-70 revolutions per minute (rpm) has to be maintained. The test is ended when the patient fails to maintain a pedal frequency of at least 60 rpm. All patients are verbally encouraged during exercise testing to achieve maximal effort, based on a respiratory exchange ratio (RER) ≥ 1.10 and subjective opinion of an experienced tester who confirms whether a maximal exercise test is executed, based on subjective features (e.g. dyspnea, sweating, facial flushing, clear unwillingness to continue, and/or a sustained drop in the patient's pedalling frequency from 60 rpm despite verbal encouragement). With the aid of continuous pulmonary gas exchange analysis (Jaeger MasterScreen CPX Metabolic Cart, CareFusion Germany GmbH, Hoechberg, Germany) oxygen uptake (VO_2), carbon dioxide output (VCO_2), minute ventilation (VE), equivalents for oxygen uptake (VE/VO_2) and carbon dioxide production (VE/VCO_2) and the RER are collected breath-by-breath and averaged every ten seconds. Using a 12-lead electrocardiography device (KISS™ Multilead, GE Medical systems, Freiburg, Germany) heart rate (HR) is monitored and averaged every ten seconds. Exercise tolerance is also assessed by the peak workload (W_{peak}). The first ventilatory threshold (VT1) is determined using the V-slope method, and this threshold is double-checked by establishing the nadir of the VE/VO_2 versus work rate relationship. The VT1 marks the limit between the light-to-moderate and the moderate-to-high intensity effort domains. Next, the second ventilatory threshold (VT2) is determined, using the VE vs. VCO_2 plot, on the point where VE increases out of proportion to VCO_2, and this threshold is double-checked by establishing the nadir of the VE/VCO_2 versus W relationship. The VT2 is considered to be related to the critical power, which is the upper intensity limit for prolonged aerobic endurance exercise. These ventilatory

thresholds are determined by two independent observers who cross-checked each other's work. A third independent observer then reviews these thresholds in a random subsample of patients. For every patient, consensus on VT1 and VT2 is achieved. The CPET has a strong prognostic value and is valid for patients with HF (Myers et al., 2013).

Appendix B
Protocol six minute walk test

The six minute walk test (6MWT) is used to determine the gait, walking speed and functional endurance capacity of the patient. The maximal distance a patient can walk in six minutes is measured. During the test a walking aid can be used. For patients with HF, this test is reliable and valid (Uszko-Lencer et al., 2017).

Necessities:

- A corridor (with a hard, flat surface) of at least 30 meters (m)
    - Two cones to set the pivot points.
    - Every five meter is designated with a colored stripe on the ground.
- BORG-scale
- Stopwatch
- Pulse oximeter

Test:

- Always give standardized instructions/encouragements to the patient.
    - Explanation:
        - In this test you need to attempt to walk the greatest possible distance in six minutes. You need to walk back and forth in this corridor. Behind the cone (the pivot point) you can turn around and walk the other way. Six minutes is a long time to walk, it requires an effort. You may become breathless or exhausted during the test. You can slow down or stop and rest if necessary. You can lean against the wall, but you need to continue walking as soon as possible. The time keeps running.
          So again: the purpose of this test is to walk as far as you can in 6 minutes, but you should not jog or run.

- Encouragements:
  - After one minute: It goes well; five minutes to go.
  - After two minutes: Keep on going; another four minutes to go.
  - After three minutes: It goes well; you are halfway through the test.
  - After four minutes: Keep on going; only two more minutes to go.
  - After five minutes: You're doing well; one more minute to go.
  - After five minutes 45 seconds: In a few seconds I will tell you to stop. When said, you need to stop where you are at that moment.
  - After six minutes: Stop.
    Mark the point where the patient is standing at this moment. Now you can calculate the meters your patient has walked.

- The pulse oximeter is placed on the finger of the patient during the whole test. Check the heart rate (HR) and saturation before, during and after the test.
- At the beginning and at the end of the test you check symptoms of fatigue and dyspnea based on the BORG-scale.
- For safety, keep close to the patient during the test. Walk diagonally behind him/her so you do not influence the gait speed he/she prefers. Do not walk beside or in front of the patient, because then you can influence the gait speed.

<u>Test results:</u>

Calculate how many meters the patient walked during the test. Compare that value with the predicted distance for this patient, based on height, weight and age.

- Men: (7.57 * height in cm) – (5.02 * age) – (1.76 * weight in kg) – 309m
- Women: (2.11 * height in cm) – (5.78 * age) – (2.29 * weight in kg) + 667m

Advantage/disadvantage:

This test is especially applicable to patients and elderly. With young, healthy persons you will be dealing with a ceiling effect. You are not allowed to run during the test. Young, healthy persons are going to reach a point where they want to start running in order to go faster. It is better to choose another test to measure endurance capacity with this patient population (for example the cooper test).

The test is easy to perform and gives a clear overview of the patient's functional endurance capacity. It gives an impression of which activities of daily living the patient is still able to perform.

Appendix C
Protocol one-repetition maximum test

The one-repetition maximum (1RM) test is used to determine the maximal voluntary muscle strength of a patient. The maximal load by which the movement can be performed only once (in full range of motion) by the patient is the maximal strength. The test is simple to implement and is reliable in untrained middle-aged individuals (Levinger et al., 2009).

Devices:

1. Dips
2. Leg press
3. Pulldown

Positioning:

Dips:

- The patient is seated on the chair with shoulders in 90 degrees of abduction and elbows in 90 degrees of flexion. The patient holds the handles.
- PAY ATTENTION: no lumbar hyperextension and no trunk flexion are allowed during the movement.

Leg press:

- The patient is seated on the chair with the back of the seat reclined backward.
- The feet are placed in the center of the vertical plank (reference point: the circles in the plank).
- The hips and knees are placed at an angle of 90 degrees of flexion.
- The therapist puts a hand in the knee pit of the patient, preventing hyperextension of the knee.

Pulldown:

- The patient is seated on the chair with the shoulders in 180 degrees of abduction and elbows in a small flexion. The patient holds the handles.
- PAY ATTENTION: Do not start in lumbar hyperextension.

Test:

To warm up and to get to know the movement, the patient needs to do five repetitions with low load. Thereafter the 1RM will be measured. The physiotherapist sets a weight and gives the instruction to perform the movement one time.

- If the movement cannot be performed, the therapist will reduce some weight until the patient can perform the movement just one time.
- If the movement can be performed, the therapist will increase the weight until the patient can perform the movement just one time.
    - When the movement went smoothly, the weight can be increased more (for instance 20-30 kilogram (kg))
    - If the movement was quite difficult, the weight can only be slightly increased (for instance two to six kilogram)

The break the patient gets between two attempts is the time needed to change the weight. Two minutes of rest will be scheduled between the different 1RM measurement devices.

During the performance, attention is paid to the breathing pattern (no Valsalva maneuver): breathing out with the concentric part of the movement and breathing in with the eccentric part of the movement. The movement is performed with a slow eccentric phase (three seconds).

The therapist can encourage the patient to go maximal.

Test results:

The result of this test is the maximal weight by which the patient can perform the movement only once.

Appendix D

Descriptive questionnaire

1. What is your name?

   ……

2. Which figure did you get from us?

   ……

3. Age (number of years):

   ……

4. Gender:
   a. M
   b. F
   c. X

5. Height (in meter):

   ……

6. Weight (in kilogram):

   ……

7. Do you smoke?
   a. Yes
   b. No
   c. Occasionally

   If so, how many cigarettes do you smoke a day? (average)

   ……

8. Since when have you been diagnosed with heart failure?

   ……

9. What medication are you taking? (both for heart failure and for other conditions)

   ……

10. Do you have other conditions as well? (for instance: neurological disorders, lung disorders, prosthesis, diabetes ...)
    a. Yes
    b. No

    If so, which disorder(s)?

    ……

11. Do you use walking aid(s)? (for instance: walker, wheelchair, walking stick, crutches ...)
    a. Yes, only outside
    b. Yes, only inside
    c. Yes, both inside and outside
    d. No
    e. Only when doing long distances

    When using (a) walking aid(s), which one do you use?

    ……

12. Have you ever had surgery?
    a. Yes
    b. No

    If so, which surgery?

    ……

13. Did you have a heart and/or vascular surgery in the past year?
    a. Yes
    b. No

    If so, which heart and/or vascular surgery?

    ……

14. Is there something else you think we should know about as well?

    ……

Appendix E
Protocol Blood Pressure and Heart Rate

The heart rate (HR) measurement is used to check how much oxygenated blood travels to the body every minute. A blood pressure (BP) measurement is used to check the pressure in the blood vessels by every heartbeat. The heart generates two different pressures by every heartbeat, the systolic and diastolic blood pressure (SBP and DBP). During contraction, the blood flows with the highest pressure through the vessels (SBP). After a contraction, the heart relaxes and generates a lower pressure through the vessels (DBP).

Necessities:

- Blood pressure monitor (M3 (HEM-7154-E), Omron, Kyoto, Japan)
- A chair

Positioning:

The patient is seated on a chair with both feet placed flat on the ground. The therapist places the cuff of the BP monitor around the left upper arm of the patient, just like explained on the cuff. Avoid thick clothes under the cuff; placement on bare skin is preferred. The arrow on the cuff is placed near the radial artery (inner side of the upper arm, just above the elbow). The arm of the patient needs to be relaxed during the measurement by placing it on the lap of the patient.

Instructions:

- The cuff is going to inflate on your arm.
- The cuff will gently deflate afterwards.
- Please sit still on the chair during the measurement.

Test results:

The BP monitor displays the results of the measurement. The SBP and the DBP are given separately in millimeters of Mercury (mmHg). The HR is shown in beats per minute (bpm).

A normal BP is 120-129 mmHg (SBP) by 80-84 mmHg (DBP) (Williams et al., 2018). Hypertension is defined as the SBP routinely higher than 140 mmHg and/or DBP higher than 90 mmHg (Williams et al., 2018).

A normal HR is 60-100 bpm (Thaler, 2015). Tachycardia is defined as a rapid HR, above 100 bpm (Thaler, 2015). Bradycardia is defined as a slow HR, beneath 60 bpm (Thaler, 2015).

Supplemental material

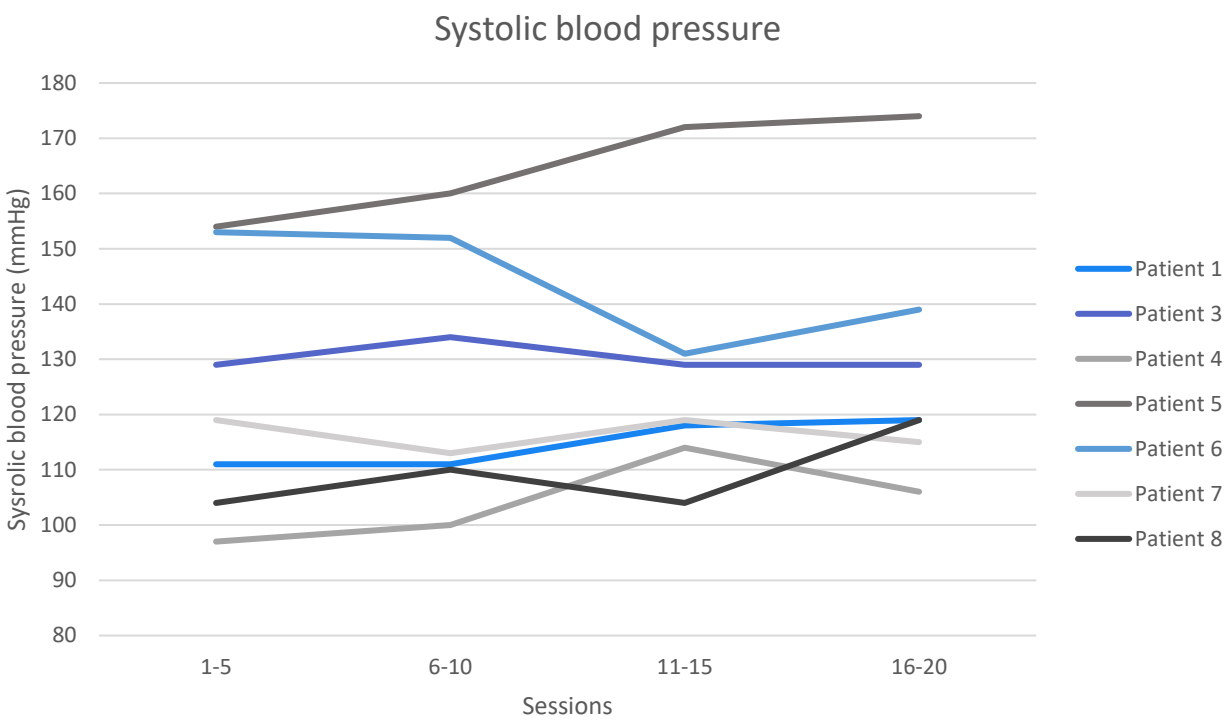

Figure a. Overview systolic blood pressure

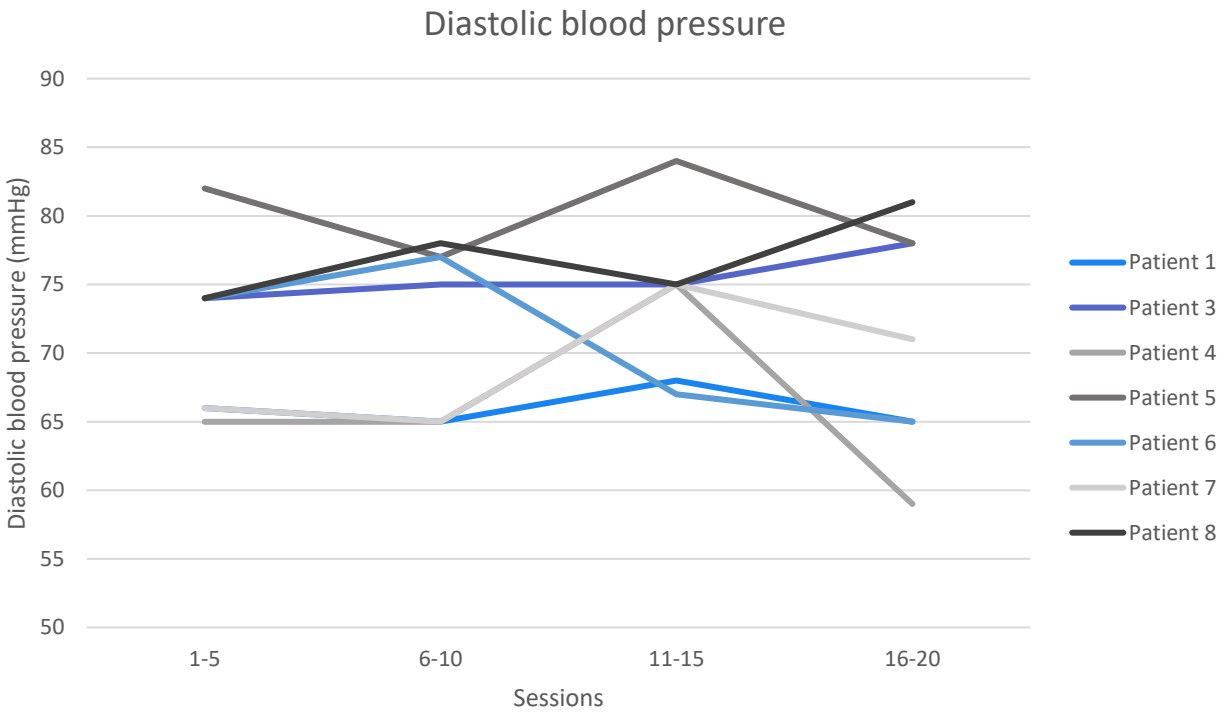

Figure b. Overview diastolic blood pressure

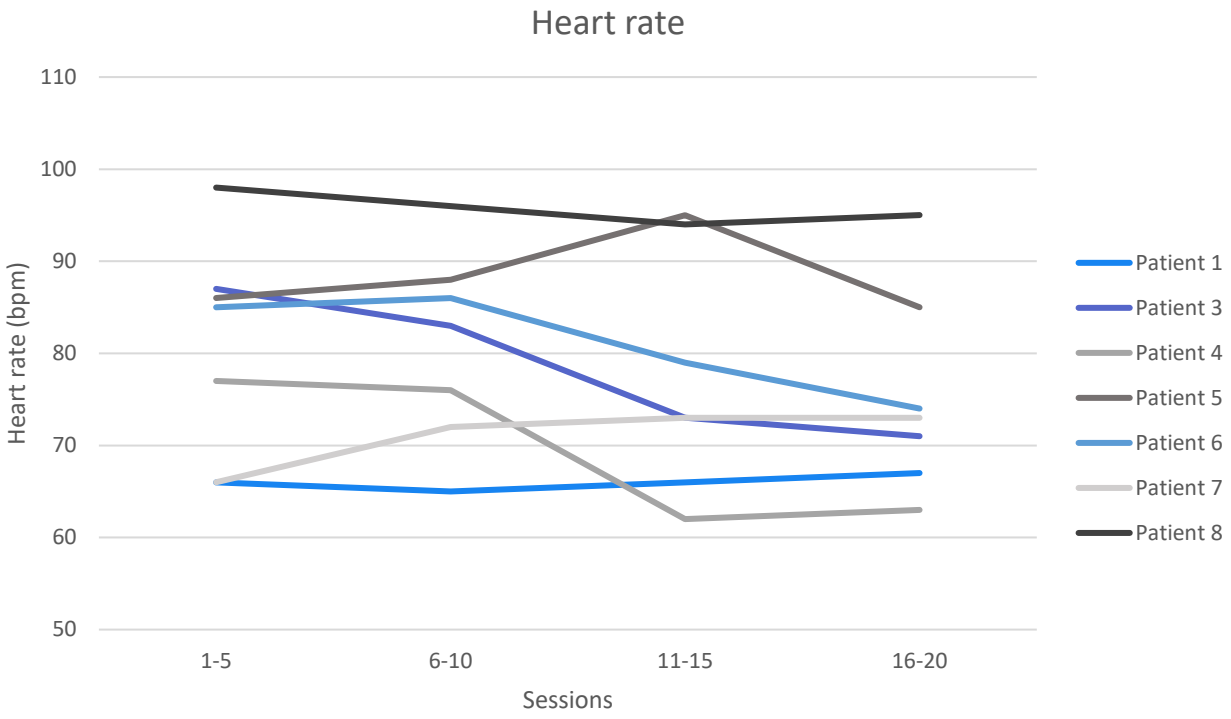

Figure c. Overview heart rate

Table 1

Outcomes endurance parameters

	First measurement	Second measurement	First measurement	Second measurement	First measurement	Second measurement
Patient number	1		2		3	
Intensity resistance training	Low intensity		Moderate intensity		Low intensity	
6MWT						
Height (m)	1.89	1.89	1.80	/	1.72	1.72
Weight (kg)	109.8	106.0	118.3	/	108.0	107.0
Predicted distance (m)	622.26	628.95	639.57	/	481.68	483.44
Distance (m)	542.0	582.0	430.0	/	498.0	530.0
%predicted (%)	87.102	92.535	67.232	/	103.388	109.631
HR rest (bpm)	59	53	68	/	85	70
Sat rest (%)	99	96	97	/	95	97
BORG legs rest	0	0	1	/	1	1
BORG breathing rest	0	0	1	/	1	1
HR after (bpm)	95	68	101	/	95	92
Sat after (%)	96	97	95	/	96	96
BORG legs after	0	0	3	/	3	4
BORG breathing after	1	0	5	/	2	3
CPET						
HR rest (bpm)	67	60	92	/	73	71
W_{max} (W)	155	168	168	/	140	183
$VO_{2\ peak}$ (ml/kg/min)	18.8	21.3	16.3	/	19.3	19.9
VT1	90	77	68	/	/	87
VT2	149	162	137	/	/	167

% = percentage; 6MWT = Six Minute Walk Test; bpm = beats per minute; CPET = Cardiopulmonary Exercise Test; HR = Heart Rate; kg = kilogram; m = meter; ml/kg/min = milliliter per kilogram per minute; Sat = Saturation; $VO_{2\ peak}$ = peak Oxygen Uptake Capacity; VT1 = first Ventilatory Threshold; VT2 = second Ventilatory Threshold; W = Wattage; W_{max} = maximal Work Capacity.

Table 1

Outcomes endurance parameters

	First measurement	**Second measurement**	**First measurement**	**Second measurement**	**First measurement**	**Second measurement**
Patient number	4		5		6	
Intensity resistance training	Moderate intensity		Moderate intensity		Low intensity	
6MWT						
Height (m)	1.72	1.72	1.68	1.68	1.61	1.61
Weight (kg)	78.0	78.0	67.0	68.0	63.7	63.7
Predicted distance (m)	544.52	544.52	488.42	486.66	433.12	433.12
Distance (m)	429.5	547.0	358.0	475.0	471.0	462.5
%predicted (%)	78.877	100.455	73.298	97.604	108.747	106.784
HR rest (bpm)	62	50	64	66	71	66
Sat rest (%)	99	98	98	98	98	99
BORG legs rest	2	1	4	3	3	3
BORG breathing rest	2	1	4	3	3	3
HR after (bpm)	77	71	85	101	104	110
Sat after (%)	99	99	95	92	98	98
BORG legs after	3	2	6	7	4	4
BORG breathing after	3	2	5	6	4	5
CPET						
HR rest (bpm)	71	65	100	80	88	86
W_{max} (W)	170	200	99	105	75	90
$VO_{2\ peak}$ (ml/kg/min)	24.7	29.3	17.2	20.6	13.7	15.1
VT1	57	80	/	68	44	62
VT2	143	170	/	/	69	90

% = percentage; 6MWT = Six Minute Walk Test; bpm = beats per minute; CPET = Cardiopulmonary Exercise Test; HR = Heart Rate; kg = kilogram; m = meter; ml/kg/min = milliliter per kilogram per minute; Sat = Saturation; $VO_{2\ peak}$ = peak Oxygen Uptake Capacity; VT1 = first Ventilatory Threshold; VT2 = second Ventilatory Threshold; W = Wattage; W_{max} = maximal Work Capacity.

Table 1

Outcomes endurance parameters

	First measurement	Second measurement	First measurement	Second measurement	First measurement	Second measurement
Patient number	7		8		9	
Intensity resistance training	Moderate intensity		Moderate intensity		Low intensity	
6MWT						
Height (m)	1.65	1.65	1.70	1.70	1.69	/
Weight (kg)	90.0	90.0	77.0	80.0	98.0	/
Predicted distance (m)	473.81	473.81	546.20	540.92	501.67	/
Distance (m)	381.0	395.0	510.0	510.0	543.0	/
%predicted (%)	80.412	83.367	93.372	94.284	108.239	/
HR rest (bpm)	59	73	91	75	62	/
Sat rest (%)	99	98	98	99	97	/
BORG legs rest	3	4	3	2	0	/
BORG breathing rest	8	5	3	2	1	/
HR after (bpm)	71	88	105	93	94	/
Sat after (%)	99	97	98	98	94	/
BORG legs after	1	6	3	2	1	/
BORG breathing after	9	7	3	2	3	/
CPET						
HR rest (bpm)	60	/	83	88	/	/
W_{max} (W)	48	/	147	158	/	/
$VO_{2\ peak}$ (ml/kg/min)	9.4	/	19.5	24.4	/	/
VT1	44	/	47	57	/	/
VT2	/	/	126	143	/	/

% = percentage; 6MWT = Six Minute Walk Test; bpm = beats per minute; CPET = Cardiopulmonary Exercise Test; HR = Heart Rate; kg = kilogram; m = meter; ml/kg/min = milliliter per kilogram per minute; Sat = Saturation; $VO_{2\ peak}$ = peak Oxygen Uptake Capacity; VT1 = first Ventilatory Threshold; VT2 = second Ventilatory Threshold; W = Wattage; W_{max} = maximal Work Capacity.

Table 2

Outcomes blood pressure

Patient number	1	2	3	4	5
Intensity resistance training	Low	Moderate	Low	Moderate	Moderate
Blood pressure (systolic/diastolic) (mmHg)					
Session 1	113/74	98/72	120/70	97/67	117/76
Session 2	108/58	107/74	137/78	102/62	186/102
Session 3	112/70	/	131/72	/	160/80
Session 4	124/62	95/68	114/70	96/68	146/76
Session 5	99/67	/	144/79	94/64	159/77
Session 6	111/66	100/73	137/85	/	159/83
Session 7	110/59	125/99	137/69	98/68	157/71
Session 8	115/64	/	135/75	107/60	159/80
Session 9	102/64	/	120/76	101/68	168/72
Session 10	117/70	103/80	142/70	92/63	159/81
Session 11	106/67	120/75	/	127/73	151/85
Session 12	118/68	/	136/79	97/63	190/97
Session 13	110/62	112/80	127/70	135/115	171/75
Session 14	124/71	105/84	126/79	99/58	163/76
Session 15	130/73	116/84	126/71	110/64	183/86
Session 16	130/70	/	128/78	115/57	174/78
Session 17	114/69	/	122/66	84/51	202/89
Session 18	115/69	110/71	134/76	98/59	149/69
Session 19	97/43	107/63	139/85	112/61	170/71
Session 20	139/73	84/60	124/84	120/65	173/85

mmHg = millimeters of Mercury.

Table 2

Outcomes blood pressure

Patient number	6	7	8	9	10
Intensity resistance training	Low	Moderate	Moderate	Low	Moderate
Blood pressure (systolic/diastolic) (mmHg)					
Session 1	171/73	121/70	88/68	163/92	102/78
Session 2	129/72	/	119/78	142/83	/
Session 3	/	118/56	103/73	159/98	82/62
Session 4	139/73	119/71	104/77	/	/
Session 5	172/78	/	/	/	/
Session 6	/	117/70	98/65	145/90	/
Session 7	180/84	119/69	107/87	134/76	/
Session 8	/	94/53	127/85	/	/
Session 9	142/73	/	/	/	/
Session 10	133/73	121/69	107/76	/	/
Session 11	115/72	119/72	114/80	/	/
Session 12	165/68	/	/	/	/
Session 13	/	114/79	92/72	/	/
Session 14	110/59	113/76	/	/	/
Session 15	132/69	129/72	105/73	/	/
Session 16	148/62	115/75	119/74	/	/
Session 17	128/59	115/66	101/73	/	/
Session 18	/	/	122/86	/	/
Session 19	143/69	/	126/84	/	/
Session 20	137/68	/	125/88	/	/

mmHg = millimeters of Mercury.

Table 3

Outcomes heart rate

Patient number	1	2	3	4	5
Intensity resistance training	Low	Moderate	Low	Moderate	Moderate
Heart rate (bpm)					
Session 1	63	87	91	72	90
Session 2	66	57	84	76	84
Session 3	70	/	83	/	94
Session 4	66	75	85	87	85
Session 5	66	/	92	71	79
Session 6	66	59	85	/	91
Session 7	62	71	87	86	92
Session 8	66	/	92	78	82
Session 9	68	/	66	59	85
Session 10	64	73	84	79	90
Session 11	67	64	/	63	86
Session 12	66	/	83	53	99
Session 13	61	60	77	76	86
Session 14	69	71	69	56	102
Session 15	69	74	64	64	104
Session 16	68	/	68	66	89
Session 17	70	/	68	77	90
Session 18	65	85	81	57	81
Session 19	67	75	75	54	75
Session 20	63	64	64	60	88

bpm = beats per minute.

Table 3

Outcomes heart rate

Patient number	6	7	8	9	10
Intensity resistance training	Low	Moderate	Moderate	Low	Moderate
Heart rate (bpm)					
Session 1	83	63	92	68	74
Session 2	94	/	101	69	/
Session 3	/	62	105	68	72
Session 4	86	72	93	/	/
Session 5	78	/	/	/	/
Session 6	/	70	92	84	/
Session 7	101	74	102	69	/
Session 8	/	73	96	/	/
Session 9	79	/	/	/	/
Session 10	78	71	92	/	/
Session 11	84	73	95	/	/
Session 12	78	/	/	/	/
Session 13	/	76	94	/	/
Session 14	79	70	/	/	/
Session 15	73	74	92	/	/
Session 16	75	74	94	/	/
Session 17	69	72	95	/	/
Session 18	/	/	103	/	/
Session 19	75	/	99	/	/
Session 20	78	/	86	/	/

bpm = beats per minute.

Table 4

Patient characteristics

Patient number	1	2	3	4	5
Intensity resistance training	Low	Moderate	Low	Moderate	Moderate
Patient characteristics					
LVEF (HFrEF/HFmrEF/HFpEF)	HFmrEF	HFrEF	HFpEF	HFrEF	HFmrEF
% EF	45	13	n.i.	35	40
Systolic/diastolic	Diastolic	Systolic	Diastolic	Systolic	Diastolic
Etiology	Idiopathic	Cardiac sarcoidosis	Arterial hypertension	Myocardial infarction	Myocardial infarction
NYHA	II	III	II	I	II
Number of sessions followed	20	20	20	20	20
Number of sessions a week	3	3	3	3	3
Age (years)	61	41	64	62	71
Gender (M/F)	M	M	M	M	M
Height (m)	1.89	1.80	1.72	1.72	1.68
Weight (kg)	110	118	108	78	67
BMI (kg/m^2)	30.794	36.420	36.506	26.366	23.739
Smoker	No	No	No	No	Yes, 25 cigarettes a day
When diagnosed with HF?	15/03/1998	04/02/2021	24/04/2014	27/01/2021	04/01/2016

Patient number	1	2	3	4	5
Intensity resistance training	Low	Moderate	Low	Moderate	Moderate
Patient characteristics					
Medication	Bisoprolol, Atorvastatine, Allopurinol, Imonogas, Mometason neusspray, Trust druppels, Sediplus druppels, Cogniton Focus, Sulpiride, Aldactone and Entresto	Bisoprolol, Bumetanide, Calciumcarb/colecalc, Dapagliflozine, Spironolactone, Pantoprazol, Folavit, Medrol A, Ledertrexate, Entresto, Burinex, Pantomed, Steovit and Forxiga	Aldactone, Nobiten, Sevikar hct, Acetylsalicylzuur, Atorvastatine and Asaflow	Bisoprolol, Losartan, Pantoprazol, Ticagrelor, Asaflow, Atorvastatine, Sostilar, Inspra and Spirolonactone	Clopidogrel, Paracetamol, Asaflow, Lipitor, Bisoprolol/perindopril-arginine, Bipressil and Atorvastatine
Risk factors	Hypertension, hypercholesterolemia, history of smoking, overweight	Obesity	Obesity, hypertension, hypercholesterolemia, history of smoking	Hypercholesterolemia	Hypertension, hypercholesterolemia, smoker
Other conditions (which?)	Yes, dental prosthesis and sleep apnea	No	No	No	No
Walking aid(s) (which)?	No	No	No	No	No
Previous surgery (which)?	Yes	Yes, shoulder	Yes, gall and nose	Yes, PCI	Yes
Heart and/or vascular operation(s) in previous year (which)?	No	No	No	Yes, PCI	Yes
Extra information	Lumbago 2020, sleep apnea and arthrosis right hip	Cardiac sarcoidosis	Sleep apnea	/	/
MLwHF	12/105	61/105	15/105	0/105	5/105

Patient number	1	2	3	4	5
Intensity resistance training	Low	Moderate	Low	Moderate	Moderate
Patient characteristics					
1RM leg press (kg)	160	150	190	110	110
1RM dips (kg)	74	65	84	60	55
1RM pulldown (kg)	70	70	65	65	55

% = percentage; 1RM = One-Repetition Maximum; BMI = Body Mass Index; EF = Ejection Fraction; F = Female; HF = Heart Failure; HFmrEF = Heart Failure with mid-range Ejection Fraction; HFpEF = Heart Failure with preserved Ejection Fraction; HFrEF = Heart Failure with reduced Ejection Fraction; kg = kilogram; kg/m² = kilogram per square meter; LVEF = Left Ventricular Ejection Fraction; M = Male; m = meter; MLwHF = Minnesota Living with Heart Failure questionnaire; n.i. = not indicated; NYHA = New York Heart Association Functional Classification; PCI = Percutaneous Coronary Intervention.

Table 4

Patient characteristics

Patient number	6	7	8	9	10
Intensity resistance training	Low	Moderate	Moderate	Low	Moderate
Patient characteristics					
LVEF (HFrEF/HFmrEF/HFpEF)	HFpEF	HFmrEF	HFmrEF	HFpEF	HFrEF
% EF	n.i.	40	40	n.i.	25
Systolic/diastolic	Diastolic	Diastolic	Diastolic	Diastolic	Systolic
Etiology	Idiopathic	Idiopathic	Myocardial infarction	Cardiomyopathy	Cardiomyopathy
NYHA	I	III	I	I	III
Number of sessions followed	20	17	20	11	4
Number of sessions a week	2	3	3	3	2
Age (years)	74	58	59	59	50
Gender (M/F)	F	F	M	M	F
Height (m)	1.63	1.63	1.70	1.69	1.57
Weight (kg)	63.5	90.3	80.0	98.0	120.0
BMI (kg/m²)	23.900	33.987	27.682	34.313	48.684
Smoker	No	No	No	No	No
When diagnosed with HF?	06/11/2013	12/03/2021	08/03/2021	25/12/2016	17/10/2020
Medication	Atorvastatine, D-cure, Glucosamine Pharma Nord, Flecainide Retard EG, Lixiana, Actonel, Magistrale bereiding Natriumbicarbonaat, Lodixal, Coversyl arg, Burinex, Aldactone and Atorstatineg	Vista D3, Tramadol/paracetamol, Buscopan Dragee, Mictonorm, Bipressil, Spironolactone, Pantoprazol, Calciumcarbonaat, Ibuprofen, Paracetamol and Calciumcarbonaat	Ticagrelor, Atorvastatine, Acetylsalicylzuur, Bisoprolol, Valsartan, Spironolactone, Colchicine, Asaflow, Lipitor and Brilique	Rivaroxaban, Bisoprolol, Pantoprazol, Bisoprolol, Perindopril Sandoz, Spironolactone, Allopurinol, Amiodaron, Amiodarone and Xarelto	Spironolactone, Atorvastatine, Ticagrelor, Bisoprolol, Edoxaban, Sacubitril/valsartan and Bumetanide

Patient number	6	7	8	9	10
Intensity of resistance training	Low	Moderate	Moderate	Low	Moderate
Patient characteristics					
Risk factors	Hypertension, diabetic, hypercholesterolemia, renal insufficiency, history of smoking	Obesity, overweight, hypertension	Hypertension, overweight	Obesity, hypertension	Obesity, history of smoking, hypercholesterolemia, overweight
Other conditions (which?)	No	Yes, edema lungs and fibromyalgia	No	No	No
Walking aid(s) (which)?	No	No	No	No	No
Previous surgery (which)?	Yes, chest, shoulder, CRT-P and ablation	Yes, gallstones, umbilical hernia, kidney stones, tummy tuck and tonsils	Yes, eyes	No	Yes, pacemaker
Heart and/or vascular operation(s) in previous year (which)?	No	Yes, keyhole surgery through a. femoralis	Yes	No	Yes, pacemaker
Extra information	Backpain	/	/	/	/
MLwHF	36/105	79/105	14/105	6/105	84/105
1RM leg press (kg)	80	46	158	168	90
1RM dips (kg)	42	30	75	84	40
1RM pulldown (kg)	30	30	70	84	60

% = percentage; 1RM = One-Repetition Maximum; a. = artery; BMI = Body Mass Index; CRT-P = Cardiac Resynchronization Therapy Pacemaker; EF = Ejection Fraction; F = Female; HF = Heart Failure; HFmrEF = Heart Failure with mid-range Ejection Fraction; HFpEF = Heart Failure with preserved Ejection Fraction; HFrEF = Heart Failure with reduced Ejection Fraction; kg = kilogram; kg/m² = kilogram per square meter; LVEF = Left Ventricular Ejection Fraction; M = Male; m = meter; MLwHF = Minnesota Living with Heart Failure questionnaire; n.i. = not indicated; NYHA = New York Heart Association Functional Classification.

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UHASSELT
KNOWLEDGE IN ACTION

INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
26/01/2021	Online meeting + mail: overzicht van werking metingen en interventie Ziekenhuis Oost-Limburg, Genk (in overleg met kinesitherapeuten ZOL).	Promotor: Prof. dr. Hansen Dominique Copromotor/Begeleider: / Student(e): Lieze Nouwen Student(e): Lore Timmers
05/02/2021	Online meeting: overzicht van werking en verloop metingen en interventie Ziekenhuis Oost-Limburg, Genk (in overleg met kinesitherapeuten ZOL)	Promotor: Prof. dr. Hansen Dominique Copromotor/Begeleider:/ Student(e): Lieze Nouwen Student(e): Lore Timmers
21/02/2021	Online meeting + mail: overzicht van verloop van metingen en interventie ZOL + overlopen vragen over inleiding en methode	Promotor: Prof. dr. Hansen Dominique Copromotor/Begeleider:/ Student(e): Lieze Nouwen Student(e): Lore Timmers
03/03/2021	Online meeting: overzicht van verdere verloop metingen en interventie ZOL + overlopen vragen over methode	Promotor: Prof. dr. Hansen Dominique Copromotor/Begeleider:/ Student(e): Lieze Nouwen Student(e): Lore Timmers
23/04/2021	Online meeting: aanpassing van onderzoeksuitkomsten omwille van latere opstart door COVID-19	Promotor: Prof. dr. Hansen Dominique Copromotor/Begeleider:/ Student(e): Lieze Nouwen Student(e): Lore Timmers
21/05/2021	Online meeting: Overlopen tabellen en methode	Promotor: Prof. dr. Hansen Dominique Copromotor/Begeleider:Natalia Turri Da Silva Student(e): Lieze Nouwen Student(e): Lore Timmers
25/05/2021	Online meeting: bespreking statistische methode	Promotor: / Copromotor/Begeleider:Natalia Turri Da Silva Student(e): Lieze Nouwen Student(e): Lore Timmers
26/05/2021	Online meeting: voorleggen statistische methode + ontvangen van goedkeuring ter verdediging	Promotor: Prof. dr. Hansen Dominique Copromotor/Begeleider:Natalia Turri Da Silva Student(e): Lieze Nouwen Student(e): Lore Timmers

UHASSELT
KNOWLEDGE IN ACTION

Inschrijvingsformulier verdediging masterproef academiejaar 2020-2021,
Registration form jury Master's thesis academic year 2020-2021,

GEGEVENS STUDENT - *INFORMATION STUDENT*

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

Stamnummer + naam: **1642953 Nouwen Lieze**
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:*

O behouden - *keep*

● wijzigen - *change to*: THE DIFFERENCE BETWEEN LOW AND MODERATE INTENSE RESISTANCE TRAINING, COMBINED WITH AEROBIC ENDURANCE TRAINING, ON EXERCISE TOLERANCE AND FUNCTIONAL CAPACITY IN PATIENTS WITH HEART FAILURE

/:

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)*:

O 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:*

O goedgekeurd - *approved*

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

Scriptie/*Thesis:*

O 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:*

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

O 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)

29/05/2021

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

Lore Timmers <lore.timmers@student.uhasselt.be>

20/0090U is nummer van studie bij ETC ZOL

1 bericht

Dominique HANSEN <dominique.hansen@uhasselt.be> 26 mei 2021 om 13:20
Aan: Lore Timmers <lore.timmers@student.uhasselt.be>

21/12/2020 preliminaire goedkeuring
mei 2021 finale goedkeuring (muv DTA)

Bij deze ook mijn finale goedkeuring voor indiening van jullie masterproef ter verdediging.

mvg,

D

Prof. dr. Dominique Hansen

Full Professor, Rehabilitation and Exercise Physiology in Cardiometabolic Diseases
Vice Dean, Faculty of Rehabilitation Sciences
Head, Rehabilitation of Cardiorespiratory and Internal Diseases (CRI) research group
Vice-Chair, REVAL Research group
Chair, EAPC Secondary Prevention and Rehabilitation Section
Board member, European Association of Preventive Cardiology
Fellow of the European Society of Cardiology

BIOMED/REVAL

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