Patient-specific predictors of physical recovery after LVAD implantation

Masterthesis

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Name student:	R.C.J. (Romeo) van Schaik
Student number:	6878644
Date:	21-7-2023
Internship supervisor(s):	Dr. K. (Karin) Valkenet
Internship institute:	Department of Rehabilitation, Physiotherapy Science and Sport, Brain Center UMC Utrecht, Utrecht University, The Netherlands
Lecturer/supervisor Utrecht University:	M.F. Pisters

“ONDERGETEKENDE

Romeo Cornelis Jacobus van Schaik

bevestigt hierbij dat de onderhavige verhandeling mag worden geraadpleegd en vrij mag worden gefotokopieerd. Bij het citeren moet steeds de titel en de auteur van de verhandeling worden vermeld.”

Examiner

Dr. M.F. Pisters

Assessors:

Dr. K. Valkenet

Dr. M.A. Timmer

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ABSTRACT

Background

Improvement of physical capacity is one of the primary goals after Left Ventricular Assistant Device (LVAD) placement in heart failure patients. Although LVAD placement is effective at regaining physical capacity and quality of life in some patients, others do not benefit. Identifying factors related to a lack of physical improvement at discharge may help personalize care after implantation.

Aim

This study aims to determine if physical fitness and patient characteristics can predict a lack of physical improvement in LVAD patients measured with the six-minute walk test (6MWT).

Methods

Data of patients with an LVAD implanted at the University Medical Center Utrecht between November 2014 and January 2023 were collected. The difference in walking distance on 6MWT in the short term (three months) and long term (first year) after implantation was calculated. Patients with an improvement in walking distance of less than 45 meters in the first three months were considered to have a lack of physical improvement. Patients with a walking distance more than 45 meters were considered improvers. Odds ratios were calculated using logistic regression.

Results

The total cohort consisted of 214 patients (mean age 52.4). There were 49 patients with a lack of physical improvement (mean walking difference: -54,9 ±26.6), and 165 improvers (mean walking difference: 195.2 ±15.7). The physical capacity of the total cohort increased significantly in the short-term (138.0 ±33.3, p: < 0.001), and in the long-term (188.7 ±39.9, p: < 0.001). Walking distance > 300 meters at discharge is a significant predictor (OR 5.701, 95% C.I, 2.044 – 15.899) for a lack of physical improvement.

Conclusion and key findings

Patients walking more than 300 meters on a 6MWT at discharge are more likely to have a lack of physical improvement after LVAD implantation. Physical capacity increases after LVAD implantation, these results give more certainty to patients relying on an LVAD to be alive. To predict physical improvement personalized care is needed to identify those with a lack of physical improvement. It seems to be important to repeatedly monitor the physical capacity of LVAD patients.

Keywords: Heart-Assist Devices, LVAD, Cardiac Rehabilitation, Functional Capacity, prognosis.

INTRODUCTION

According to the Dutch Heart Foundation 238.700 people in the Netherlands were diagnosed with heart failure, in 2020(1,2). Due to the aging population, this number is expected to increase, with a yearly incidence of 38.000. In the Netherlands, 29.440 hospital admissions with heart failure as the primary discharge diagnosis were registered in 2020(2). Complaints of heart failure will progressively increase over time. The five-year survival time of advanced heart failure after the initial diagnosis ranges from approximately 25 to 35%(1–3).

Advanced heart failure is a major cause of morbidity and mortality, and contributes significantly to healthcare costs(4,5). When medical treatment fails, a Left Ventricular Assist Device (LVAD) becomes a therapeutic option for patients with advanced heart failure(6). An LVAD is a mechanical continuous flow device consisting of eighter an internal axial-flow blood pump or a centrifugal pump device with a percutaneous lead that connects the pump to an external system controller and power source(6–8). This way an LVAD supports pumping blood in the heart's left ventricle. Due to the limited availability of donor hearts, the number of patients receiving an LVAD is anticipated to increase(4,9,10). The placement of an LVAD is not a suitable solution for every patient with heart failure. Only a small proportion is found eligible to receive an LVAD due to the high physical, cognitive, and mental demands of recovery, and compliance of patients(10). LVADs are employed as a bridge to transplantation but can also be a final treatment option for patients who are not eligible for heart transplantation(9,11,12). In the case of a bridge to transplantation, an LVAD supports patients to stay active in their daily living until a donor heart for transplantation comes available(4,9).

One of the physical therapeutic goals after LVAD placement is to improve physical capacity. The six-minute walk test (6MWT) is a valid measurement to test physical capacity(13,14). After placing an LVAD, physical capacity increases significantly(4,5,9,11,12,15). On the other hand, prior studies have demonstrated that 20 – 30% of LVAD patients fail to improve their physical capacity(13,16). At this point, there is limited knowledge of the characteristics of these patients(9,13,16). Several factors are indicated to influence the course of physical capacity, e.g., older age, patients that suffer adverse events, and higher prevalence of comorbidities but no evidence is collected on their contribution to physical recovery(5,13,15,16).

Insight into the characteristics of these poor improving patients is important because low physical capacity scores in chronic heart failure patients are associated with higher morbidity and mortality rates(16,17). Subsequently, higher morbidity rates come with higher healthcare costs. If certain characteristics can be identified that predict a lack of physical improvement in an early stage, medical staff gains better insight into patients with a risk of a lack of physical improvement, and care can be optimized by providing patients with personal and tailored care.

Recent studies investigated the risk of survival rate after LVAD placement in the Netherlands, but until this point, no evidence is collected on the course of physical capacity after LVAD placement in the Netherlands(18–20). Other trials on the physical course either took place within the first six months(5,9,12,15) or involved a particularly small group of participants(11). Following a higher number of participants within the first year after discharge, with multiple measurements will provide a constructive guideline for LVAD patients and their physical improvement.

Therefore, the aim of this study is to determine if physical fitness and patient characteristics can predict a lack of physical improvement in LVAD patients in the first three months after discharge. Additionally, this study describes the course of physical capacity in the first year after discharge in LVAD patients.

METHODS

Study design

A monocenter retrospective cohort study was conducted at the University Medical Center Utrecht (UMCU) in the Netherlands. This study performed dossier research and the medical ethics committee determined that this study is not subject to the Medical Research Involving Human Subjects Act (WMO) (protocol no. 18-242). Therefore, informed consent is not applicable in this study.

Study population

Data of all patients suffering from severe heart failure (New York Heart Association: ≥ 3) in whom the HeartMate-II (HM), HM-3, or the Heartware Ventricular Assist Device (HVAD) was implanted at the UMCU between November 2014 and January 2023 were collected. The clinical profile of patients was classified with the American Society of Anesthesiologists (ASA) score. All subjects had to be 18 years or older and have an LVAD implanted to bridge for transplantation or destination therapy. Patients were excluded if they had died within the first three months and/or no physical measurement was present after implantation.

Measurements

Patient demographics, comorbidities, and physical fitness were extracted from electronic patient files by researchers not involved in patient care. To investigate the course of physical capacity data was obtained from the 6MWT, at discharge (T0), at three months after discharge (T1), and at twelve months after discharge (T2). The 6MWT is a valid and reliable measurement tool to measure physical capacity(14). The reliability varies from good to excellent, with interclass correlation coefficients ranging from 0.75 to 0.97(14,21).

Independent variables were collected at different moments in time. Preimplantation collected independent variables included sex, ASA score, comorbidities (calculated using the Charlson Comorbidity Index), age, BMI, and hospital days. Two physical tests are performed at T0, T1, and T2; 6MWT and handgrip strength (HGS) measured with a Jamar. There are no LVAD-specific rates for the HGS, but it is stated that measuring HGS appears to be a simple and reliable measure to correlate clinical outcomes in patients receiving or awaiting LVADs(22). In elderly patients, HGS is a valid and reliable screening or diagnosis of sarcopenia and muscle strength(23). At T1 patients were asked whether they followed physical therapy in the first three months regarding rehabilitation after LVAD implantation.

Outcome

The outcome of the study was physical improvement or a lack of physical improvement after LVAD implantation. Physical improvement was measured through the difference in walking distance on the 6MWT at T0 and T1. Based on the minimal clinical important difference (MCID) for heart failure patients on the 6MWT, of 45 meters, patients were divided into two groups(24). Improvers were defined as patients with a physical capacity improvement of more than 45 meters walked on a 6MWT from discharge to three months. On the other hand, there were patients with a lack of physical improvement. Patients with a lack of physical improvement did not reach the MCID of 45 meters walked on a 6MWT from discharge to three months. Additionally, the distance walked on the 6MWT in the short term (T1), and long term (T2) after implantation was described.

Statistical analysis

SPSS software (IBM version 28) is used for statistical analysis.

Descriptive analyses of several baseline characteristics were performed. This contains categorical data (sex, ASA score, comorbidities, number of cases without comorbidities, and smoking status) and continuous data (age and BMI). Categorical data were presented as a percentage of the total cohort and for both groups. Continuous data were presented with the mean ±Standard Error of the Mean (SEM) of the total cohort and for both groups. Assessment of normality for continuous data was performed by using the Shapiro-Wilk method, Q-Q plot, skewness, and kurtosis. Comparisons between groups were performed by chi-square, paired T-test, or Wilcoxon's test as appropriate.

The mean scores of 6MWT were calculated. The normality of walking distance at each measurement moment was checked by the Shapiro-Wilk method Q-Q plot, skewness, and kurtosis. In case of normality, the difference over time was analyzed with a paired T-test comparing T0 with T1 and T1 with T2. If normality was not met a Wilcoxon test was performed.

To analyze independent determinants for physical improvement, odds ratios (OR) with 95% confidence interval (C.I.) are presented based on a logistic regression performed with univariate and multivariate analysis. In this logistic regression a lack of improvement was the dependent variable, and the different patient characteristics and physical fitness were the independent variables. An overview of independent variables is provided in Appendix 1.

Characteristics associated with a lack of physical improvement in univariate analysis ($p < 0.20$) were entered into the multivariate model and then selected using an enter method. Variables with a significance level below 0.20 in the multivariate regression were included in the final model. To check on the calibration of the model a Hosmer and Lemeshow Test for Goodness of fit was performed. A significant Goodness of fit ($p < 0.05$) indicates that the model is not well calibrated(25,26).

Missing data were first checked on the nature of the missing value, using Little's test. It was expected that data was missing completely at random (MCAR), in case of MCAR multiple imputation was performed. By using multiple imputation, the chance of bias will be decreased(27). Early recommendations were that five imputation sets would be sufficient(27,28).

RESULTS

Baseline

From November 2014 until January 2023, 297 patients underwent an LVAD implantation in the UMCU (65.3% male, mean age 52,8 (±12.55) years). Within the first three months, 25 patients died after LVAD placement (8.4%), and 42 had died in the first twelve months (14.1%). Two patients were below 18 years and were therefore excluded. From the remaining 270 patients, the testing data of 56 patients were not available and were excluded from this study (Figure 1).

Data from 6MWT of 50 patients (23.4%) at both discharge and three months is present, 48 improvers, and two patients with a lack of improvement. Little's test showed no significance (p: 0.985) for this reason data is approached as data MCAR and multiple imputation was used. The missing data is imputed with five datasets.

After imputation, the total cohort consisted of 214 patients, 165 patients (77.1%) were improvers, and 49 patients (22.9%) had a lack of physical improvement. In the group of improvers, the mean age was 51.3 (±1.4), and 66.1% were male. In the group with a lack of improvement, the mean age was 56.4 (±3.7), and 63.3% were male. There is a significant difference in walking distance between the improvers and lack of improvement (p: 0.000) and a significant difference in the number of patients walking more than 300 meters at discharge (p: >0.004).

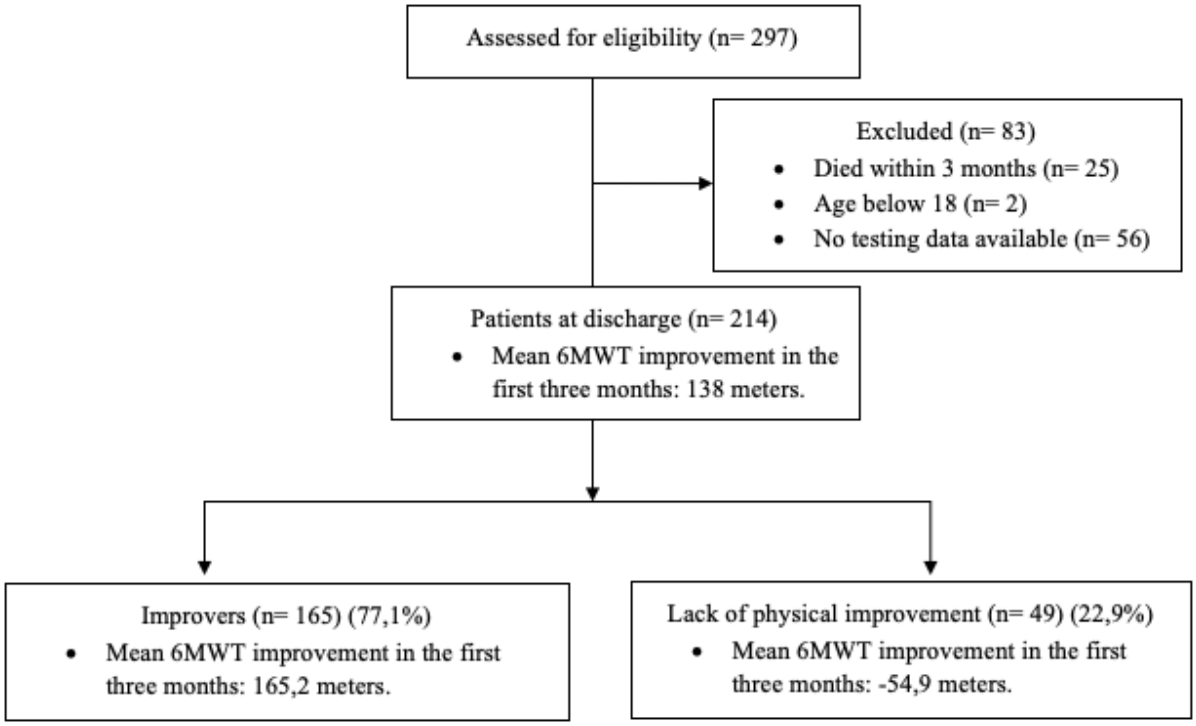

Figure 1: Study groups after imputation.

6MWT = 6-minute walk test. N = number of participants

The majority (79.9%) of the total cohort was classified with an ASA score four. Most cases had one or more known comorbidities (73.4%). The HM3 was implanted most frequently (67.3%), followed by HVAD (23.8%), and HM-II in nineteen patients (8.9%). The majority of patients received physical therapy within the first three months after discharge (77.6%). Baseline characteristics are summarized in Table 1.

Table 1: Baseline characteristics

	Total cohort (N = 214)	Improvers (N = 165)	Lack of improvement (N = 49)
Device			
HM-II	19 (8.9%)	16 (9.7%)	3 (6.1%)
HM-3	144 (67.3%)	107 (64.8%)	37 (75.5%)
HVAD	51 (23.8%)	42 (25.5%)	9 (18.4%)
Gender (male)	140 (65.4%)	109 (66.1%)	31 (63.3)
Age (years) (SD)	52.4 (0.8)	51.3 (1.4)	56.4 (3.7)
BMI (kg/m^2) (SD)	24.6 (0.3)	24.5 (0.4)	25.3 (0.8)
ASA Score			
3	37 (17.3%)	29 (17.6%)	8 (16.3%)
4	171 (79.9%)	132 (80.0%)	39 (79.6)
5	6 (2.8%)	4 (2.4%)	2 (4.1%)
Charlson Comorbidity Index			
No (0)	4 (1.9%)	4 (2.4%)	0 (0.0%)
Mild (1-2)	78 (36.5%)	63 (38.2%)	15 (30.6%)
Moderate (3-4)	86 (40.2%)	67 (40.6%)	19 (38.8%)
Severe (≥ 5)	46 (21.5%)	31 (18.8%)	15 (30.6%)
Cases without comorbidities (yes)	57 (26.6%)	45 (27.3%)	12 (24.5%)
Smoking status (yes)	19 (8.9%)	13 (7.9%)	4 (8.2%)
Mean 6MWT distance (SEM)*	287.1 (30.6)	256.0 (22.2)	391.7 (32.9)
6MWT distance > 300m at discharge (yes)*	101 (47.2%)	66 (40.0%)	35 (71.4%)
HGS, > 80% pred (yes)	43 (20.1%)	33 (20.0%)	10 (20.4%)
Physical therapy (yes)	166 (77.6%)	126 (76.4%)	40 (81.6%)
Hospital days (SEM)	45.0 (1.4)	43.6 (1.7)	49.7 (5.9)

* = Significant Group difference. 6MWT = 6-minute walk test. ASA = American Society of Anesthesiologists. BMI = Body Mass Index. HGS = Handgrip strength. HM = HeartMate. HVAD = Heartware Ventricular Assist Device. N = number of participants. SD = Standard Deviation. SEM = Standard Error of the Mean.

Course of physical capacity

Mean scores of physical capacity from the total cohort and different improvement groups are presented in Table 2. The mean time between T0 and T1 was 2.1 months (SEM: 0.2). Physical capacity increased by 138.0 meters (SEM: 33.3) from 287.1 meters (SEM: 30.6) at T0 to 425.1 meters (SEM: 10.5) at T1 (p: < 0.001). At T1, 35 patients walked less than 300 on the 6MWT (16.4%). The mean time between T1 and T2 was 7.6 months (SEM: 0.5). Physical capacity kept on increasing by 50.7 meters (SEM: 18.2), to 475.8 meters (SEM: 16.1) at T2 (p: < 0.001). The mean time between T0 and T2 was 10.8 months (SEM: 0.4). During this period, the average improvement is 188.7 meters (SEM: 39.9) (p: < 0.001).

Among the improvers, the mean baseline score was 256.0 meters (SEM: 22.2), this improved with 195.2 meters (SEM: 15.7) to 451.2 meters (SEM: 16.2) at T1 (p: < 0.001). The lack of improvement group had a mean baseline score of 391.7 meters (SEM: 32.9) but their physical capacity decreased with 54.9 meters (SEM: 26.6) to 336.8 meters (SEM: 32.5) at T1 (p: < 0.05). Between T0 and T2 the improvers increased their physical capacity by 233.3 meters (SEM: 22.2) (p: < 0.001), and the lack of improvement increased by 43.7 meters (SEM: 57.3) (p: < 0.05).

Table 2: Mean physical capacity scores LVAD cohort (n = 214)

	T0	**T1**	**Δ T0 – T1**	**p-value**	**T2**	**Δ T0 – T2**	**p-value**
Distance walked in meters (SEM)	287.1 (30.6)	425.1 (10.5)	138.0 (33.3)	< 0.001	475.8 (16.1)	188.7 (39.9)	< 0.001
Distance walked in improvers (n = 165) (SEM)	256.0 (22.2)	451.2 (16.2)	195.2 (15.7)	< 0.001	489.3 (16.0)	233.3 (22.2)	< 0.001
Distance walked in lack of improvement group (n = 49) (SEM)	391.7 (32.9)	336.8 (32.5)	-54.9 (26.6)	< 0.05	435.4 (39.7)	43.7 (57.3)	< 0.05

N = Number of participants. SEM = Standard Error of the Mean

Factors related to lack of physical improvement

Univariate analysis of all included factors and indicators of a lack of physical improvement revealed that walking distance on the 6MWT > 300m (OR 5.572, 95% C.I., 2.044 – 15.899) was a significant predictor for a lack of physical improvement with a p-value of 0.001 (R = 0.217). The results of the univariate analysis are shown in Table 3. Since only one variable meets the set p-value no multivariate analysis was conducted. No significance was found on Hosmer and Lemeshow test (p: 0.316).

Table 3: Binary logistic regression analysis of factors associated with a lack of improvement of physical capacity within the first three months after LVAD placement

	Total cohort (n = 214)	
	Odds ratio (95% CI)	p-value
Age	1.060 (0.914-1.229)	0.377
Man	0.766 (0.249-2.361)	0.631
BMI	1.100 (0.935-1.295)	0.231
Device		
HM3	Reference	
HM-II	0.940 (0.030-29.614)	0.969
HVAD	1.747 (0.502-6.084)	0.372
ASA score		
3	Reference	
4	1.356 (0.158-11.655)	0.760
5	0.033 (0.000-0)	1.000
Charlson Comorbidity Index		
No	0.627 (0.142-2.763)	0.515
Mild	0.961 (0.155-5.948)	0.961
Moderate	0.000 (0.000-0)	0.999
Severe	Reference	
No comorbidities	1.020 (0.216-4.817)	0.979
Non-smoker	0.026 (0.000-0)	0.999
Hospital days	1.020 (0.981-1.060)	0.288
6MWT > 300m	5.572 (2.006-15.471)	0.001
HGS > 80% pred	0.796 (0.211-3.001)	0.727
No physical therapy	1.538 (0.335-7.063)	0.559

6MWT = 6-minute walk test. ASA = American Society of Anesthesiologists. BMI = Body Mass Index. CI = Confidence Interval. HGS = Handgrip strength. HM = HeartMate. HVAD = Heartware Ventricular Assist Device. N = number of participants.

DISCUSSION

This study aimed to determine if patient characteristics and physical fitness could predict a lack of physical improvement after LVAD placement. This study shows that a lack of physical improvement can be predicted by the distance walked on the 6MWT at discharge. Persons walking more than 300m on the 6MWT at baseline have a significantly higher chance of not increasing more than 45 meters in the first three months after discharge. Additionally, this study described the physical course after LVAD implantation. Overall improvement of the total cohort of LVAD patients was significant in the short-term after discharge and continued to improve significantly in the long-term after discharge, overall improvement in the twelve months after discharge was also significant. These improvements exceeded the MCID in the total cohort.

In this study, 22.9% of the total cohort of LVAD patients treated in the UMCU experienced a lack of improvement after LVAD placement. This result is in line with previous trials, demonstrating that 20 – 30% of LVAD patients fail to improve their physical capacity(13,16). These other studies took a cut-off point of 300 meters on the 6MWT for physical improvement. If the 300-meter cut-off point was used in this study 16.4% of the patients would have had a lack of improvement insinuating that the physical improvement is better in the current study than in previous trials. For this reason, the 300-meter cut-off point would not be relevant. The studies which include physical capacity used different follow-up times to determine physical improvement, at three months(13) similar to the current study but also six months follow-up have been used(16). In comparison to these studies, in one study the average age of the cohort was higher and only HMII implantations were included(13). In another study the average BMI was slightly higher and only HM-3 implantations were included(16), whereas the current study included all different types of devices.

Also, the significant improvement in physical capacity is in line with the literature(4,5,9,11,12,15). In comparison with systematic reviews by McNamara and Abshire, and a two-year follow-up study by Starling it shows that the distance walked at baseline in the current study was higher(4,5,9). In the short term, the functional capacity stated by McNamara at six months is lower than the walking distance in the current study, with an even further increasing walking distance over time(5). In the long-term, the walking distance at twelve months is higher in the current study than in the McNamara review and is in line with Abshire(5,9). There is no difference in the average age of patients between the current study and the other studies(4,5,9). All studies included by McNamara who used the 6MWT were observational industry-funded trials and had a higher number of participants(5). Abshire included in their systematic review two intervention studies and based on these studies the physical capacity was in line with the results of the current study(9). These intervention studies had a smaller number of participants, 14 and 15 participants, and they had a lower age, 37.2 and 48.7 years(29,30). These studies also described specific intervention programs, whereas the current study only described that

patients received physical therapy, with no specific description of the content of this therapy. Specific interventions can potentially influence the results. The walking distances of the observational studies included by Abshire were all lower than in this study(9). At twelve months there is still a slight difference between the improvers and lack of improvement group in the current study.

It is expected that the predictor for a lack of physical improvement, walking more than 300 meters on a 6MWT at baseline, is derived from the fact that if a person scores below 300 meters, the amount of improvement one can expect will be higher than scores above 300 meters. The 6MWT is valid, easy to use and interpret, and a particularly useful tool in conditions such as chronic heart failure(13,14,31). This makes the 6MWT a good measurement tool for physical capacity in this population. As mentioned above a noted downside of the 6MWT is that it seems that patients with high baseline scores on 6MWT are probably less likely to improve any further, this is supported by the assumption that LVAD patients apparently reach a plateau on the 6MWT distance(11). This way the chance of not improving more than 45 meters is more likely and patients were categorized into the lack of improvement group because of their high baseline scores.

The role of older age and the number of comorbidities could not be supported based on the current study(13,15). The mean age in both studies that associate age with a lack of physical improvement was higher than in the current study, 60(15) and 65(13) years. Noteworthy is the walking distances in these studies at baseline and three months being lower than the walking distance in the current study. Also, the amount of improvement in the first three months of both studies is lower compared to this study. One study noted zero meters walked if a person was not capable to perform a 6MWT, in the current study this data was imputed(15). The other study only included HMII(13). The HM-3 is designed to reduce the possibility of thrombus formation, thrombus formation could have a big impact on physical capacity(32).

This study has multiple strengths, previous research tended to under-research woman's representation in the cardiac population(33–35). Abshire stated in their systematic review: ‘’Due to the predominantly white, male LVAD population, the diversity of LVAD research has been limited. According to the Interagency Registry for Mechanically Assisted Circulatory Support women receive about 21% of LVADs.(9)’’ This study has a 34.6% representation of women in their cohort and has the highest number of women reported in literature(5,9,22). This makes the results more generalizable for the general population. With data from 214 patients, this study has one of the biggest sample sizes in the field of LVAD research. Systematic reviews show that most of the research contains data sets of less than 100 people(5,9). Also, by using usual care data this study provides great insights into the demographics of the LVAD population treated in the UMCU.

This study had the limitation that the amount of missing data was high. Data on the administration of the 6MWT at discharge and at three months was available in 50 patients (23.4%). However, in this study, multiple imputation was used. Multiple imputation is accepted as the best general method to deal with incomplete data, it is suggested that multiple imputation can be used even in situations with more than 50% missing data(25,27,36). In cases with 50% missing cases or more, it is highly questionable whether the available data of that particular variable are valid(36). Therefore, a Goodness of fit was performed based on Hosmer and Lemeshow. A significant Goodness of fit test would imply that the model is not well calibrated. In this study, no significance was found meaning that there is no evidence that the model is uncalibrated(25). Alternatively, complete case analysis could be performed in case of data missing completely at random. In that case, the results of the lack of improvement group would have been based on just two patients making the results more unreliable than the current approach.

The current study excluded patients that died within the first three months, therefore potentially resulting in selection bias. Since patients that died could hold characteristics more at risk for death after LVAD placement, and not for physical improvement these patients were excluded. Possible bias is expected to be minimal since 25 patients (8.4%) were excluded. In the overall population, the survival rate after LVAD placement in the Netherlands within the first year is 83%, this study included bridge to transplantation, bridge to decision, and destination therapy(20). At the UMCU most LVAD placements are conducted as bridge to transplantation, and the survival rate was slightly higher (85,9%).

Because of this slightly higher survival rate and being a single-center design extrapolation of results directly to other centers should be interpreted with caution. In the UMCU a majority of patients are treated as a bridge to transplantation. It is suggested that patients receiving an LVAD as destination therapy are more vulnerable and possibly weaker. It is unknown if the results of this study are also applicable in case of LVADs placed as destination therapy. Further research should aim at differences in the course of physical capacity and characteristics of LVAD patients in destination therapy.

Looking back at the results of this study, the chosen value to determine a lack of physical improvement could be revised. It was hypothesized that the patients with a lack of physical improvement would reflect the more vulnerable patients. However, the results show that patients with a lack of improvement were actually the patients with high baseline scores and could possibly reach a plateau and increase their walking distance. Due to this, no clinical implications could be made other than a significant increase in walking distance in the first year after implantation.

CONCLUSION

Lack of physical improvement in LVAD patients is associated with higher mobility and mortality rates. This study shows that a walking distance of more than 300 meters at discharge predicts a lack of physical improvement. However, this study has a big number of missing data which could influence the part of the other variables. Physical capacity increases within the first year after implantation in both lack of improvement and improvers. These results give more certainty to patients relying on an LVAD to be alive. To predict physical improvement personalized care is needed to identify those with a lack of physical improvement. It seems to be important to repeatedly monitor the physical capacity of LVAD patients.

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APPENDIX 1

Overview independent variables:

Collected pre-implantation	• Age. • Sex. • BMI. • ASA score. • Comorbidities. • Cases without comorbidities. • Smoking status.
Collected at discharge	• Device. • Hospital days. • Physical fitness: 6MWT (< 300m v >300m). • Physical fitness: HGS (<80% v >80%).
Collected three months after discharge	• Physical therapy followed.