SIX-MINUTE WALK TEST AS A TOOL FOR ASSESSING PHYSICAL ACTIVITY IN PATIENTS WITH HEART FAILURE

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Abstract

Background. Heart failure is one of the most significant medical problems of our time, which is associated with the increase in the prevalence of the disease over the past decade. The six-minute walk test is a simple, accessible, and informative tool for assessing the physical activity of patients with heart failure. The test results correlate with peak oxygen consumption and can be used to monitor the effectiveness of rehabilitation programs. The aim of the study is to evaluate the effectiveness of the six-minute walk test as a tool for measuring the level of physical activity and functional status in patients with heart failure, and to determine its correlation with clinical indicators and quality of life in this category of patients.

Materials and methods. In this study, conducted on the basis of the UMC "Heart Center" Astana, Kazakhstan, private institution "National Laboratory Astana ", data of patients with heart failure of class I-IV according to a special classification were analyzed. The main objective of the study was to evaluate the effectiveness of the test as a tool for monitoring physical activity and functional status of patients.

Results. The results showed that the test is a reliable method for assessing the dynamics of physical capabilities and can be used to individualize rehabilitation programs.

Conclusion. The 6MWT remains an important component of clinical practice, helping to optimize functional outcomes and improve the quality of life of patients with heart failure.

Introduction

Heart failure (HF) is recognized as one of the most pressing medical problems worldwide, which is explained by a significant increase in the number of cases of the disease over the past decade.[1] HF symptoms such as shortness of breath (dyspnea), chronic fatigue and edema negatively affect health-related quality of life (HRQOL), impair physical activity and limit the ability of patients to cope with physical activity.[2] In this regard, cardiac rehabilitation programs play a vital role in the recovery of patients and their adaptation to everyday life.

The growing number of elderly people in the population is directly related to the increasing incidence of chronic diseases that can significantly reduce the functional capacity of the body. In this regard, medical professionals increasingly use functional tests to objectively assess the physical performance of patients. The results of such tests allow us to assess the general health and level of mobility. Particular importance is given to the study of spatiotemporal gait parameters, including walking speed, distance, length and frequency of steps. These indicators are critical for predicting the risk of falls, assessing motor activity in the elderly, and monitoring the dynamics of patients who have suffered a stroke or suffer from Parkinson's disease. Thus, the analysis of motor activity is becoming an integral part of the clinical assessment of the patient's functional capacity.[3]

The 6MWT was officially recognized by the American Thoracic Society (ATS) in 2002 as a reliable method for assessing motor function and fatigue levels, which directly affect a patient's functional mobility. The main test parameter is the distance the patient covers in six minutes, which allows for an objective assessment of the dynamics of his or her physical capabilities. During the test, the patient moves at a comfortable pace, taking breaks for rest if necessary.[4]

The length of the corridor used for testing plays an important role in ensuring the accuracy of the results. In a confined space (less than 33 meters), frequent turns may reduce walking speed, resulting in a decrease in the total distance covered and, as a result, underestimation of the results. This may hinder the correct clinical interpretation of the data in accordance with the ATS recommendations. The results of the 6MWT serve as an important indicator of functional activity, since most daily tasks are performed at submaximal levels of exertion. Therefore, compliance with standardized test conditions is necessary to obtain reliable and clinically meaningful results.[5].

One of the key parameters of 6MWT is the distance traveled by the patient in six minutes (6MWD). This indicator has high clinical and research significance, since it is closely related to peak oxygen consumption, which makes it an important tool for assessing the functional state. Interpretation of the test results can be done in two ways: either by comparing the actual distance with the predicted value calculated on the basis of reference equations, or by analyzing the absolute value of the distance traveled.[6,7]

Comparison of actual and predicted 6MWD provides valuable information for assessing the patient's physical performance helps to determine the optimal level of physical activity and is used to monitor the effectiveness of rehabilitation programs. In addition, the test allows assessing the patient's readiness to return to daily life and social activity.[8]

In healthy individuals, the normal distance covered in six minutes is usually between 400 and 700 meters. If the patient covers less than 350 meters, this may indicate significant functional impairment and is associated with an increased risk of mortality. Therefore, 6MWT serves as an important tool for assessing the patient's condition and planning further medical interventions.[8]

In clinical practice, the 6MWT is widely used due to its simplicity and availability. However, despite clear recommendations from the American Thoracic Society (ATS), the standard test protocol is often subject to modifications, especially in resource-limited settings.[8,9]

6MWT has found wide application in cardiac rehabilitation, especially in patients who have undergone heart surgery, myocardial infarction or suffer from chronic heart failure. In addition, the test is an important indicator of the functional state in these pathologies.[9]

The 6MWT is widely used in clinical practice as an effective method for assessing patients' physical capabilities. Its popularity is due to its ease of implementation, availability, and high reliability of results. In the perioperative period, this test is used to predict possible complications after surgical interventions and also serves as an important tool for preliminary assessment of functional risks. In addition, the 6MWT helps to assess the effectiveness of preventive measures, such as prehabilitation. It also plays a key role in the early detection of patients with limited physical activity who may experience difficulties in the recovery process and helps to determine the optimal place for further observation after discharge from a medical institution.[10]

Cardiopulmonary exercise testing (CPET) is recognized as the gold standard for objectively assessing a patient's maximal functional capacity. However, despite its high accuracy, CPET requires significant resources, including specialized equipment and qualified personnel, which limits its availability in a number of clinical situations. In contrast to CPET, 6MWT is widely used in clinical practice due to its simplicity, availability, and minimal resource requirements. This test is universal for various patient groups, does not require complex equipment or special skills, and better reflects everyday physical activity.[11]

Despite the relative standardization of the 6MWT, in real practice, modifications to the ATS-approved protocol are often made. Such adaptations may include changing the length and configuration of the track, introducing a training run, modifying the instructions or the level of reinforcement for participants. These changes may significantly affect the 6MWD, for example by reducing the walking speed, changing the step strategy, or increasing the number of turns.[12]

Materials and methods

Study design

This study is a cross-sectional analysis of data collected from a randomized feasibility study conducted at the KF UMC "Heart Center" Astana, RK, Data were collected from October 2023 to the present by the same investigator.

Study population and sample

Total number of participants: 471 participants in the CHF group and 100 participants in the control group.

The study included adult patients (≥ 18 years) receiving treatment at the UMC Heart Center with a diagnosis of heart failure (HF) of NYHA class I–IV. Inclusion criteria

- Ability to move independently (using assistive devices such as a cane or walker if needed).
- Stable condition without contraindications to physical activity.

Exclusion criteria:

- The presence of acute conditions that prevent the test from being performed (eg, acute myocardial infarction, unstable angina).
- Pregnancy.
- Wheel chair bound.

- Six-minute Walk test (6MWT) protocol
- The test was performed according to the American Thoracic Society (ATS) guidelines and taking into account available resources.

Stages of implementation:

Preparation:

- Participants rested for at least 10 minutes before starting the test.
- Baseline parameters measured included blood pressure, heart rate (HR), oxygen saturation (SpO2), and fatigue and dyspnea levels using the modified Borg scale.

Conducting the test:

- Participants completed a six-minute walk along a "50-meter straight corridor."
- During the test, participants moved at a pace that was comfortable for them, taking breaks to rest when necessary.
- Medical staff recorded the distance traveled (6MWD), as well as changes in heart rate, SpO2, and subjective sensations of the patient.

Completion of the test:

- After completion of the test, blood pressure, heart rate, SpO2 and fatigue level were measured again.
- Any adverse events (chest pain, dizziness, shortness of breath, fatigue) were recorded.
- Data collection

For each participant, demographic characteristics (age, gender), clinical parameters (NYHA heart failure class, comorbidities), six-minute walk test (6MWT) results, including distance traveled, heart rate (HR) changes, oxygen saturation level (SpO_2) and subjective sensations, as well as additional parameters such as medications taken and hospitalization history were recorded. Data analysis was performed using the test results. Descriptive statistics (means, standard deviations), comparison of 6MWD values between patient groups (by NYHA classes), correlation analysis between distance traveled and clinical parameters (HR, SpO_2) and assessment of the minimal clinically important difference (MCID) for 6MWD were used. All participants provided written informed consent. The main limitations of the study are the limited sample of patients from one medical institution, the possible influence of comorbidities on the test results and the lack of long-term follow-up to assess the dynamics of physical activity.

Ethical approval. Private Institution "National Laboratory Astana". This study was approved by the Local Ethics Committee #2023/01-009. All data were recorded digitally using an online platform. Each participant was assigned a unique identifier and the data were anonymized before analysis. Informed consent was obtained from all participants in Kazakh and Russian.

Statistical analysis. The statistical analysis included descriptive and analytical statistics where for variables with a normal distribution, parametric statistical methods were used and presented as means ± standard deviation. Numerical variables of non-normally distributed data were presented as mean values ± standard deviation. For all types of analysis, statistical significance was determined using the Student's t-test, with a significance level set at $p < 0.05$. Statistical analysis was performed using Python v3.9.16 and R v4.2.2. The Mann-Whitney U test and logistic regression were employed, accounting for age, sex, and various oral health parameters.

Results

The Table 1 presents the baseline characteristics of patients in control and case groups, including their age, BMI. The additional values are given for different group regarding the ejection fractions.

Table 1.
Baseline characteristics of control and experimental groups, with different ejection fractions.

Characteristics	Value	Control group	Experimental group	HFpEF	HFmrEF	HFrEF	p value
Age	Mean and SD	57.77 ± 11.23	51.23 ± 9.21	61.41 ± 10.56	58.45 ± 10.93	58.08 ± 10.93	<0.01
	Median and Q1-Q3	59.00 [51.00-65.00]	52.00 [44.00 - 58.00]	63.00 [56.00 - 69.00]	61.00 [53.25 - 65.75]	59.00 [52.50 - 65.00]	<0.01
	Min-Max	21.00 - 81.00	26.00 - 77.00	21.00 - 81.00	25.00 - 78.00	24.00 - 78.00	<0.01
BMI	Mean and SD	29.35 ± 5.08	27.36 ± 4.42	29.67 ± 5.02	29.71 ± 5.78	30.48 ± 4.85	<0.01
	Median and Q1-Q3	29.00 [25.57 - 32.24]	27.00 [24.00 - 30.27]	29.00 [25.78 - 32.80]	30.46 [25.62 - 33.10]	29.98 [27.43 - 32.83]	<0.01
	Min-Max	11.00 - 46.93	17.99 - 46.00	19.07 - 46.93	11.00 - 45.20	20.69 - 45.34	<0.01

HFpEF - Heart Failure With Preserved Ejection Fraction; HFmrEF - Heart Failure with mid-Range Ejection Fraction; HFrEF - Heart failure with Reduced Ejection Fraction; BMI - Body Mass Index.

The differences between the groups of patients with different ejection fraction (EF) of the left ventricle - the control group, HFpEF, HFmrEF and HFrEF - were analyzed according to a number of quantitative variables. The age and BMI variables are given as examples of interpretation of the general approach and structure of analysis.

To identify differences between groups, a non-parametric Kruskal-Walli's test was used, adequate for abnormal distributions and differences in dispersions. This test made it possible to determinewhether there are generally statistically significant differences between four independent groups. For example, for the age variable, the value $p < 0.000001$ indicates the existence of significant age differences between groups. Similarly, the BMI variable showed significant differences with $p = 0.0000002$.

In addition to the Kruskal-Walli's test, the size of the n^2 effect (eta-square) was calculated, which allows to quantify the variance fraction explained by the grouping factor. In the context of medical statistics, the following benchmarks are used to interpret n^2: values less than 0.01 are considered negligibly small, from 0.01 to 0.06 - small, from 0.06 to 0.14 - moderate, and above 0.14 - large. Thus, for the variable, n^2 was 0.132, which is interpreted as a moderate effect. This indicates that the differences between groups explain about 13.2% of the total age variance. For the BMI variable, $n^2 = 0.049$ corresponds to a small effect, which indicates the presence of differences, but less clinical significance.

Since Kruskal-Wallis only indicates the existence of differences in general, post-hock comparisons were made using the Dunn criterion with an amendment to multiple comparisons. For each pair of groups, the values of p and the size of the effect r based on z-statistics were calculated. The interpretation of r values is based on the same principles as for Spearman's correlation coefficient: r about 0.1 indicates a small effect, about 0.3 - a moderate one, and from 0.5 and above - a large effect. For example, the age comparison between the control group and HFpEF gave $p = 0.0000$ and $r = 0.465$, which corresponds to a medium-large effect. This indicates not only a statistically significant difference, but also its severity with potential clinical significance. Similarly, for BMI, when comparing the control group and HFpEF, the value $r = 0.225$ indicates a small but significant effect.

Figure 1.
Comparison of 6-minute walk test results between patients with CHF and the control group

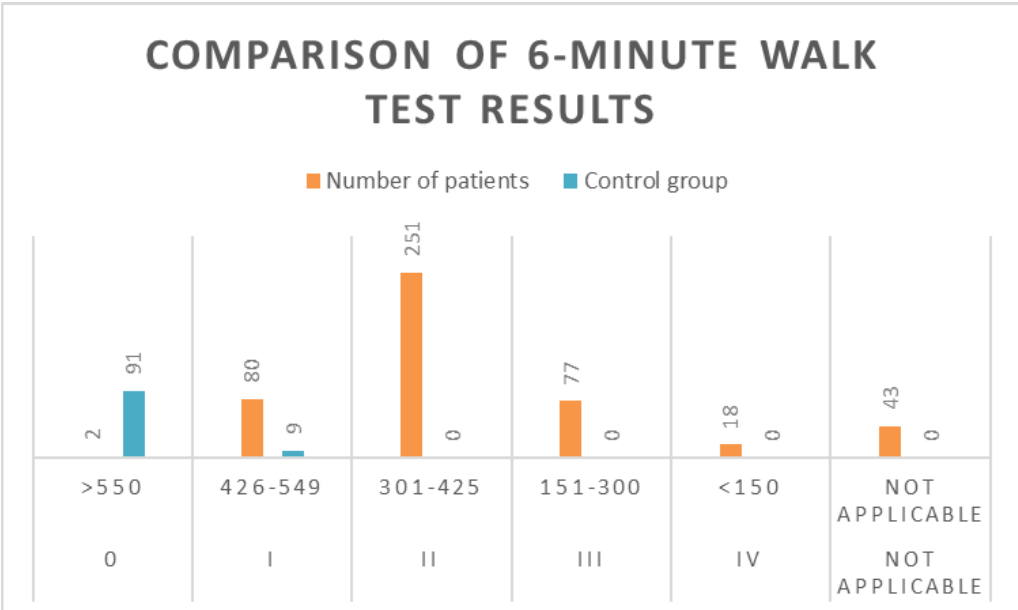

Figure 1 shows the distribution of patients with CHF and control group participants by categories of distance traveled in a 6-minute test corresponding to functional classes (FC).

Control group (healthy):

• 91% of participants covered more than 550 meters (FC 0), indicating excellent physical endurance, as shown in Figure 2.

• Only 9% fell into the 426–549 m (FC I) range, which may be due to individual characteristics or random factors.

• 0% of the control group participants did not show a decrease in physical activity to levels corresponding to FC II–IV. Also, no one refused the test.

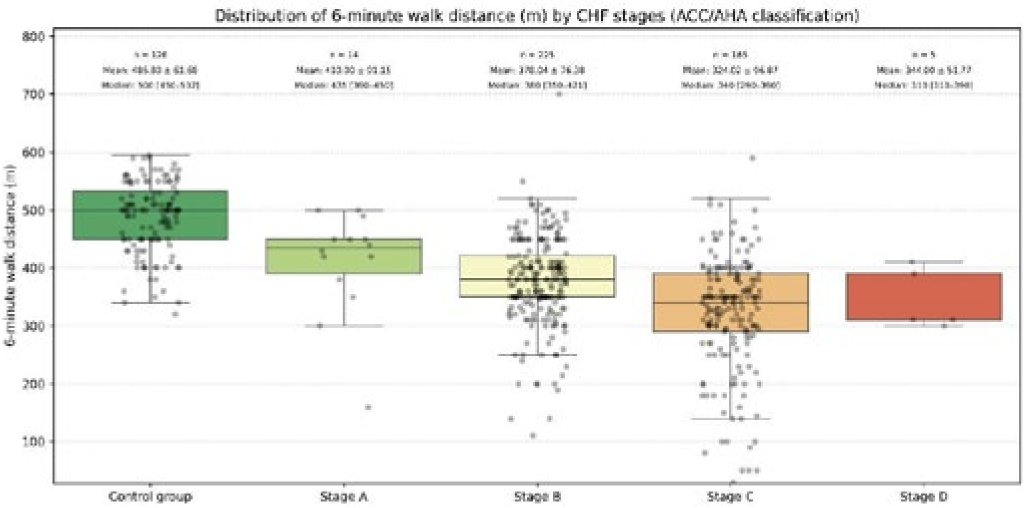

Figure 2.
Distribution of 6-minute walk distance by CHF stages

Patients with CHF:

•Only 0.4% covered more than 550 m, that is, they were comparable to absolutely healthy people.

•17% fell into the FC I category (426–549 m) – moderate decrease in physical activity.

•More than 53% demonstrated significant limitation (FC II, 301–425 m) – the largest group.

•16% showed severe intolerance to the load (FC III, 151–300 m).

•3.8% walked less than 150 m (FC IV), which indicates an extremely serious condition.

•In 9.1% the test was not performed due to severe physical condition; there were no such cases in the control group.

Table 2.
The correlation of 6MWT is compared with the named factors.

Values	6 MWT	Age	BMI	LV ejection fraction	Log (NT-proBNP)	Global longitudinal deformation	SpO2	Chronic kidney disease
6 MWT	p= 1.00	p= -0.41	p= -0.17	p= 0.41	p= -0.47	p= -0.38	p= 0.39	p= -0.16
Age	p= -0.41	p= 1.00	p= -0.02	p= -0.11	p= 0.36	p= 0.13	p= -0.27	p= 0.15
BMI	p= -0.17	p= -0.02	p= 1.00	p= -0.14	p= 0.07	p= 0.23	p= -0.16	p= 0.15
LV ejection fraction	p= 0.41	p= -0.11	p= -0.14	p= 1.00	p= -0.57	p= -0.67	p= 0.20	p= -0.21
log(NT-proBNP)	p= -0.47	p= 0.36	p= 0.07	p= -0.57	p= 1.00	p= 0.54		
Global longitudinal deformation	p= -0.38	p= 0.13	p= 0.23	p= -0.67	p= 0.54	p= 1.00	p= -0.26	p= 0.21
SpO2								
p= 0.39	p= -0.27	p= -0.16	p= 0.20		p= -0.26	p= 1.00		
Chronic kidney disease	p= -0.16	p= 0.15	p= 0.15	p= -0.21		p= 0.21		p= 1.00

Considering the variable 6-minute walk distance as an integral indicator of the patient's functional state, the following statistically significant associations were identified in Table 2 ($p < 0.05$ after FDR correction):

- A moderately positive correlation with the left ventricular ejection fraction ($\rho = 0.41$, $p < 0.05$) was found, reflecting an improvement in functional endurance with preserved systolic function. An inverse relationship with age was observed (ρ = –0.41, p <0.05), which corresponds to the expected decrease in physical performance in elderly patients. A negative correlation with the body mass index (ρ = –0.17, p <0.05) was also found, confirming the effect of excess weight on limiting physical activity.

- A strong negative association was observed between 6MWT and log NT-proBNP (ρ = –0.47, p < 0.05), highlighting the association of low functional capacity with higher cardiac overload. Similarly, 6MWT was negatively associated with myocardial global longitudinal strain (GLS) (ρ = –0.38, p < 0.05), consistent with worse longitudinal contractility in patients with limited exercise capacity.

- The 6MWT distance also positively correlated with the oxygen saturation level after the test (SpO_2 after 6MWT; ρ = 0.29, p = 0.019), which reflects preserved oxygenation in patients with good physical adaptation. Additionally, an inverse relationship was established with the presence of chronic kidney disease (φ = –0.26, p = 0.043), which may be a marker of systemic organ dysfunction limiting exercise tolerance.

6MWT has significant correlations with all CHF metrics used.

Discussion

Our results demonstrate that the six-minute walk test (6MWT) serves as a clinically meaningful measure of functional capacity in heart failure patients, with strong correlations to established disease markers. The significant inverse relationship between 6MWT distance and NT-proBNP levels (ρ = -0.47, p < 0.05) confirms previous findings that this simple test effectively reflects cardiac overload.[1,2,3] Importantly, the moderate positive association with left ventricular ejection fraction (ρ = 0.41) supports its utility in assessing systolic functio,[4] while the negative correlations with age and BMI align with known determinants of exercise tolerance.[7,12]

The clinical value of 6MWT is particularly evident in its ability to stratify patients by disease severity. Our finding that only 0.4% of HF patients achieved distances comparable to healthy controls (>550 m) reinforces its discriminative power. The test's practicality for routine clinical use represents a major advantage over more complex cardiopulmonary exercise testing,[5] especially in resource-limited settings. However, the inability of 9.1% of patients to complete the test suggests limitations in assessing the most severe cases, a finding consistent with other studies.[9]

These results build upon established guidelines[5] while providing new insights from a large patient cohort. The strong correlation with multiple clinical parameters supports the test's role in comprehensive patient assessment and rehabilitation planning.[6] However, our cross-sectional design limits conclusions about long-term prognostic value - an area requiring further investigation.[10]

Clinical Implications:

- Validates 6MWT as practical tool for functional assessment
- Supports use in monitoring disease progression
- Highlights need for standardized administration protocols
- Suggests value in rehabilitation program planning

While confirming the test's established utility, our findings emphasize its particular relevance for clinical practice in diverse healthcare settings. Future research should address longitudinal outcomes and protocol optimization to maximize clinical benefit.

Limitations. Limitations include its single-center, cross-sectional design, lack of long-term follow-up, possible confounding by comorbidities, and exclusion of the sickest patients who could not perform the test. Additionally, protocol adherence challenges in real-world settings may affect result reproducibility.

What's known? The six-minute walk test is a well-established, simple, and cost-effective method recommended by the American Thoracic Society for assessing functional capacity in patients with heart failure, correlating strongly with peak oxygen uptake and widely used in cardiac rehabilitation.

What's new? This study adds new evidence by analyzing a large cohort of 471 HF patients and 100 controls, demonstrating a clear association between 6MWT distance and NYHA class, as well as significant correlations with key clinical indicators such as left ventricular ejection fraction, NT-proBNP, global longitudinal strain, oxygen saturation, and comorbidities. The findings reinforce the 6MWT as a practical tool for functional stratification and individualized rehabilitation planning in resource-limited settings.

Conclusion

The 6-minute walk test is an effective, affordable, and clinically relevant tool for assessing the functional status and physical activity level of patients with heart failure. The results of the study confirm its high diagnostic value for monitoring the dynamics of physical capabilities, as well as for developing personalized cardiac rehabilitation programs. However, to ensure the reliability and reproducibility of the results, strict adherence to standardized protocols recommended by the American Thoracic Society is necessary, especially in resource-limited settings. Thus, the 6MWT remains an important component of clinical practice, helping to optimize functional outcomes and improve the quality of life of patients with heart failure.

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