Original Article

Dynamic Balance and Mobility Explain Quality of Life in HFpEF, Outperforming All the Other Physical Fitness Components

Cristine Schmidt,[1,5] Mário Santos,[2,3] Lucimere Bohn,[1] Bruno Miguel Delgado,[4] Daniel Moreira-Gonçalves,[1] Adelino Leite-Moreira,[5] José Oliveira[1]

Faculdade de Desporto da Universidade do Porto (FADEUP), Centro de Investigação em Actividade Física, Saúde e Lazer (CIAFEL),[1] Porto – Portugal
Instituto de Ciências Biomédicas Abel Salazar (ICBAS), Universidade do Porto, Unidade de Pesquisa Multidisciplinar em Biomedicina,[2] Porto – Portugal
Centro Hospitalar do Porto, Departamento de Cardiologia,[3] Porto – Portugal
Centro Hospitalar do Porto,[4] Porto – Portugal
Faculdade de Medicina da Universidade do Porto (FMUP), Unidade de Investigação Cardiovascular (UniC),[5] Porto – Portugal

Abstract

Background: **Physical fitness is an important determinant of quality of life (QoL) in heart failure with preserved ejection fraction (HFpEF) patients. However, how the different physical fitness components correlate with the specific dimensions of QoL in HFpEF patients remains unknown.**

Objective: **To evaluate the association between different physical fitness components and QoL dimensions in HFpEF patients, and, assess which physical fitness components were independently associated to QoL.**

Methods: **Patients with HFpEF were assessed for physical fitness [dynamic balance and mobility (8-foot-up-and go test), upper body strength (handgrip), cardiorespiratory fitness (CRF) (6-minute-walking test) and body composition (body mass index)] and for QoL (Minnesota Living With Heart Failure Questionnaire). Partial correlation was used to verify the association between physical fitness components and QoL dimensions. The determination of independent predictors in QoL dimensions was assessed through stepwise multivariate linear regression analysis. Statistical significance was set at $p<0.05$.**

Results: **Both CRF and dynamic balance and mobility are significantly associated with the total score and physical dimensions of QoL ($p<0.05$), but only dynamic balance and mobility were concomitantly associated with the emotional dimension ($r=0.597$; $p=0.004$). Dynamic balance and mobility were independently associated with total score ($\beta=0.651$; $r^2=0.424$; $p=0.001$), physical ($\beta=0.570$; $r^2=0.324$; $p=0.04$) and emotional ($\beta=0.611$; r2=0.373 $p=0.002$) dimensions of QoL.**

Conclusion: **Our data suggests that dynamic balance and mobility better assess QoL than CRF, which is commonly measured in clinical practice. Whether interventions specifically targeting dynamic balance and mobility have different impacts on QoL remains unknown. (Arq Bras Cardiol. 2020; 114(4):701-707)**

Keywords: **Heart Failure/physiopathology; Work-Life Balance/methods; Physical Fitness; Quality of Life; Breathing Exercises; Body Composition.**

Introduction

Heart failure with preserved ejection fraction (HFpEF) accounts for half of all HF cases in the developed world's population.[1] The most common manifestation of the disease is exercise intolerance, which impacts on patients' ability to cope with activities of daily life and reduces their quality of life (QoL).[2] Furthermore, QoL is related with poor outcomes, such as higher frequency of hospital readmission and higher mortality rates.[3] Despite its high prevalence and poor prognosis, HFpEF remains a disease with no approved therapy that improves survival.[4] Therefore, current recommendations for the treatment of these patients highlight the importance to focus on effective therapies capable of alleviating symptoms and meaningfully improve QoL.[5]

Reduced levels of physical fitness are associated with poor QoL in patients with HFpEF.[6,7] Importantly, exercise training has shown to improve physical fitness, together with symptom and QoL improvement.[6,7] Because physical fitness and QoL are mutually related, targeting physical fitness with exercise training programs may be an effective strategy to accomplish the management recommendations of patients with HFpEF.[5] However, physical fitness is a multicomponent (e.g. dynamic

Mailing Address: Cristine Schmidt •
CIAFEL – Faculdade de Desporto da Universidade do Porto. Rua Dr. Plácido da Costa, 91. Postal Code 4200-450, Porto – Portugal
E-mail: schmidtcristine@gmail.com
Manuscript received February 06, 2019, revised manuscript June 10, 2019, accepted June 23, 2019

DOI: https://doi.org/10.36660/abc.20190080

balance and mobility, muscular fitness, cardiorespiratory fitness (CRF) and body composition)[8] and, in parallel, QoL is a multidimensional construct (e.g. general, emotional and physical).[9] Until now, it remains unknown how the different components of physical fitness correlate with the specific dimensions of QoL in HFpEF patients. To date, it has only been demonstrated that a higher CRF is associated with a better QoL, mainly regarding the physical dimension.[7,10] However, the influence of other physical fitness components on QoL dimensions is relatively unknown. Therefore, the clarification of this issue might have important clinical implications in the design of specific interventional programs for HFpEF patients targeting the physical fitness component, which most impacts on QoL, whether overall or one of its depressed dimensions.

Therefore, the aims of the present study are twofold: i) to evaluate the association between different physical fitness components (CRP, upper body strength, dynamic balance and mobility, and body composition) and the QoL dimensions (total, physical and emotional) in HFpEF patients, and ii) to assess which of the physical fitness components are independently associated to different dimensions of QoL in this specific population.

Methods

Study design

This is a cross-sectional study conducted in a Portuguese public hospital (*Centro Hospitalar do Porto - Hospital de Santo Antonio*, Porto) with a convenience sample of HFpEF. Inclusion criteria was diagnosis of HFpEF according to the European Society of Cardiology guidelines.[11] Patients were excluded if they presented with unstable angina, acute coronary syndrome as primary diagnosis, symptomatic severe aortic stenosis, acute pulmonary embolism, acute myocarditis, decompensated heart failure, uncontrolled hypertension, complex ventricular arrhythmias, severe renal dysfunction, severe chronic obstructive pulmonary disease, medical or orthopedic conditions that precluded independent ambulation and exercise testing.

Patients who were potentially eligible to participate in the study were identified from the clinical files of the hospital cardiology department. A total of 30 patients were invited through phone calls by a cardiologist. Of those, 24 patients (17 women and 7 men) accepted to take part in the study. The study was approved by the Ethics Committee of *Centro Hospitalar do Porto - Hospital de Santo Antonio* (*N/S:* 2015.125) and met the ethical standards of the Declaration of Helsinki.

Data were collected from November 2016 to September 2017 during a single day in the hospital.

Data collection

Blood pressure

A trained researcher performed blood pressure measurements after a 10 minute-rest in the sitting position. Blood pressure was assessed (Colin, BP 8 800; Critikron, Inc., USA) in both arms, and the arm showing the highest BP was used. SBP and DBP were computed as the average of 3 readings, with a 2-minute interval between them. Additional readings were performed when differences between readings exceeded 5 mmHg.[12]

Blood collection and biochemical determinations

Peripheral venous blood (15 mL) was collected into an EDTA tube. The EDTA tubes were immediately placed on ice and allowed to clot for 30 minutes before centrifugation for 15 minutes at 1000xg. The plasma was aliquoted and stored at -80ºC for biochemical analysis. Brain Natriuretic Peptide (BNP) was quantified in a certified laboratory using chemiluminescent microparticle immunoassay (ARCHITECT BNP).

Anthropometric and body composition measures

Body height (cm) was measured in the upright position using a stadiometer (Holtain Ltd., Crymmych, UK).[13] Weight (kg), body mass index (BMI; kg·m^2), fat mass (%) and free fat mass (kg) were measured with patients wearing light clothes, using an electronic segmental body composition analyzer (Tanita, BC-418, Tokyo, Japan). Fat mass and free fat mass were measured using bioelectrical impedance. Patients were asked to fast for 10-12 hours, avoid vigorous physical exercise and alcohol intake before being measured. Waist circumference (cm) was measured at the midpoint between the lowest rib and the iliac crest at the end of normal expiration.[14] Obesity was determined as BMI equal or higher than 30 kg/m^2.[15]

Functional classification

Patients were classified by the physician into subgroups based on their symptoms using the New York Heart Association (NYHA) functional class. Patients' symptoms are based on how much they were limited during physical activity (class I to IV).[16]

Echocardiography Evaluation

Supine transthoracic echocardiography was performed using a cardiovascular ultrasound model Vivid E95® (GE Healthcare). All quantitative echocardiographic measurements were performed by a single reader blinded to the results of the other evaluations, using a computerized off-line analysis station. Peak early diastolic tissue velocity was measured at the septal and lateral mitral annulus. Mitral inflow velocity was assessed by pulsed wave Doppler at the apical 4-chamber view, positioning the sample volume at the tip of the mitral leaflets. E/e' ratio was calculated as E wave divided by e' velocities. LV mass was estimated based on LV linear dimensions and indexed to body surface area, as recommended by ESC guidelines.17 LV hypertrophy was defined as LV mass indexed to body surface area (LV mass index) >115 g·m^2 in men or >95 g·m^2 in women. LV volumes were estimated by the modified Simpson method using the apical 4- and 2-chamber views, and LVEF was derived from volumes in the standard manner. LA volume was estimated by the method of disks using apical 4- and 2-chamber views at an end-systolic frame preceding mitral valve opening and was indexed to body surface area to derive LA volume index.

Physical Fitness

Dynamic balance and mobility. It was assessed with the 8-foot up and go (8FUG) test.[18] The patient starts the evaluation in the sitting position. After a signal, the patient must stand up, walk 8 feet (2.44m), make a turn around a cone, and return back to the initial position as fast as possible.[18] The patients tried to perform the test twice. Time (in seconds) to complete each trial was measured with a stopwatch and the result considered was the shorter time.[19]

Upper body strength. Grip strength (kg) was isometrically measured using a Lafayette Instrument Hand dynamometer (*Model 78010, 78011, Indiana, USA*). Both arms were measured 3 times while patients were seated, with shoulder adducted and neutrally rotated, the elbow flexed at 90°, and the forearm and wrist in a neutral position. The average between attempts was used as final score for each arm.[19]

Cardiorespiratory fitness with pulmonary gas exchange assessment. It was assessed by the 6-minute walk test (6MWT) in a 25-m-long unobstructed corridor. Participants were instructed to walk the maximal distance in 6 minutes time. Resting stops were allowed when patients felt it to be necessary. The 6MWT was performed wearing a portable gas analyzer (K4b2, Cosmed, Rome, Italy) and a heart rate monitor (Polar Electro Oy, Kempele, Finland). Oxygen uptake (VO2; mL·min-1·kg-1) and heart rate (HR; bpm) were measured directly and continuously. Respiratory and HR measurements were collected in a breath-by-breath and beat-to-beat basis, respectively, and then, data were averaged over 5-s intervals. Data was calculated as the average of measures taken during the test total duration (6 minutes).

Health-related quality of life

Health-related QoL was measured through an interview using the Minnesota Living With Heart Failure Questionnaire (MLWHFQ). The MLHFQ encompasses 21 questions, whose purpose is to determine how disease affects the physical, psychological and socioeconomic conditions of the patients during the previous month.[20] The questions include symptoms and signs relevant to disease, levels of physical activity, work, social interaction, sexual activity, and emotions. The MLHFQ total score range from 0 to 105 (no impairment to maximum impairment). Two other scores can be determined: the physical dimension (8 items, 0–40), and the emotional dimension (5 items, 0–25). A higher MLHFQ score means a worse QoL. Answers options ranges from 0 (none) to 5 (very much), where 0 represents no limitation and 105 represents maximal limitation.

Statistical analyses

Data normality was verified by Shapiro-Wilk test. Non-normally distributed variables were transformed into a natural logarithm (weight, fat mass, free fat mass, 8FUG, MLHFQ total score, MLHFQ physical and MLHFQ emotional) for subsequent analysis and then transformed back to the original scale for the purpose of clarity. Data are expressed as mean ± standard deviation. Categorical data are reported as absolute values and percentages. Pearson's correlation was used to analyze the association between physical fitness components (dynamic balance and mobility, upper body strength, CRF and BMI) aiming to verify collinearity between variables ($r>0.75$). Partial correlation (adjusted for age, gender and NYHA class) was used to assess the association between physical fitness components and QoL dimensions. A multivariate linear regression analysis, with stepwise selection of variables, was performed to determine the association between QoL dimensions and age, gender, NYHA functional class and physical fitness components, which were identified as potential independent predictors of QoL. The statistical analysis was performed using the IBM SPSS 24 software (SPSS, USA), and the statistical significance was set at $p<0.05$.

Results

Patients' characteristics

The demographic and clinical characteristics of patients are shown in Table 1. The patients' mean age was 76±6 years old, ranging from 59 to 85 years, and 71% (n=17) were females. Hypertension was the most prevalent comorbidity (n=22, 92%), followed by dyslipidemia (n=17, 71%) and obesity (n=14, 58%). Regarding the NYHA functional class, 79% (n=19) of all patients were classified as class II. The average BNP level was 288.9±191.5 pg·mL-1. Regarding cardiac function, the mean ejection fraction was 60±6%, 23% (n=6) of patients had E/e\` >15, while 90% (n=22) had LAVI >34 mL·m^2. All patients had left ventricular hypertrophy.

Quality of life

The score of total MLHFQ scale was 26±24, whereas the physical and emotional MLHFQ subscales' scores were 12±13, and 5±7, respectively.

Physical fitness

Overall, the 6MWT distance, 8FUG and handgrip results were 312±90 meters, 10.9±3.6 seconds, and 18.6±7.1kg, respectively. The mean VO_2 during the test was 11.2± 2.3 mL·min-1·kg-1. A bivariate correlation between physical fitness components showed that the 8FUG test was inversely correlated with handgrip ($r=-0.47$; $p=0.01$) and 6MWT distance ($r=-0.81$; $p>0.001$) (Table 2).

Association between physical fitness and quality of life

A partial correlation between QoL dimensions and physical fitness components are shown in Table 3. A better MLHFQ total score was directly correlated with 8FUG ($r=0.563$; $p=0.008$) and inversely correlated with 6MWT ($r=-0.539$; $p=0.012$) test results. Regarding MLHFQ physical, it was directly correlated with 8FUG ($r=0.529$; $p=0.014$) and inversely correlated with 6MWT ($r=-0.478$ $p=0.028$). Finally, MLHFQ emotional was directly correlated with 8FUG ($r=0.597$; $p=0.004$).

Table 4 shows the multivariate regression analysis for QoL dimensions. All models were adjusted for age, gender and NHYA functional class as potential confounders. For MLHFQ total score, the 8FUG was the only physical fitness parameter that remained an independent predictor ($\beta=0.651$; $p=0.001$). Similarly, for MLHFQ physical dimension, the

Table 1 – General patients' characteristics

	All (n=24)
Sociodemographic characteristics	
Age (years)	76 ± 6.1
Female (n) (%)	17 (71%)
Anthropometrics	
Weight (Kg)	71.8 ± 15.9
Waist circumference (cm)	100.9 ± 12.6
Body fat (%)	36.1±6.5
Free fat mass (kg)	45.4±9.7
Risk factors, n (%)	
Obesity (BMI ≥ 30 kg/m2)	14 (58%)
Ex-smoker	4 (17%)
Hypertension	22 (92%)
Dyslipidemia	17 (71%)
Type 2 diabetes	2 (8%)
Pre-diabetic	9 (38%)
Atrial fibrillation	12 (50%)
Atrial fibrillation (paroxysmal)	4 (17%)
COPD	2 (8%)
Obstructive sleep apnea	6 (25%)
Clinical signs	
Resting HR (bpm)	72 ± 16
SBP (mmHg)	136 ± 19
DBP (mmHg)	70 ± 14
BNP (pg/mL)	289 ± 192
NYHA class II	19 (79%)
NYHA class III	4 (17%)
Medication (%)	
ACE-i/ARB	17 (71%)
ß-Blocker	20 (83%)
Loop diuretics	18 (75%)
Statin	16 (67%)
Digoxin	4 (17%)
MRAs	2 (8%)
Cardiac Function	
LVEF (%)	60 ± 6.3
E/e´	12.2 ± 3.1
E/A	1.0 ± 0.5
LVMI (gm/m^2)	231.3 ± 94.5
LAVI (mL/m^2)	44.2 ± 11.7

COPD: chronic obstructive pulmonary disease; HR: heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; BNP: brain natriuretic peptide; NYHA: New York Heart Association; ACEi/ARB: angiotensin-converting enzyme inhibitor and angiotensin receptor blocker; MRAs: mineralocorticoid receptor antagonists; LVEF: left ventricle ejection fraction; E/e´: ratio of early mitral inflow velocity and mitral annular early diastolic velocity; E/A: mitral ratio of peak early to late diastolic filing velocity; LVMI: left ventricle mass index; LAVI: left atrium volume index.

8FUG was the single physical fitness component that remained an independent predictor (β=0.570; p=0.04). Finally, for MLHFQ emotional, the 8FUG was the single physical fitness component that remained an independent predictor (β=0.611; p=0.002).

Discussion

The data provided by our study indicates that physical fitness is positively correlated with QoL in HFpEF patients. In addition, dynamic balance and mobility was the only physical fitness component that was independently associated with QoL total score, and physical and emotional dimensions. These findings suggest that this specific component of physical fitness outperforms CRF in assessing HFpEF patients' QoL. In addition, it highlights the need to study interventions specifically targeting these fitness components to enhance QoL gains.

Despite the high prevalence and poor prognosis of HFpEF, evidence-based therapies aimed at effectively reducing morbidity or mortality remains to be developed.[4] These patients are often characterized by poor QoL[21] and current treatment guidelines highlight the importance of aiming to improve patients' well-being.[5] Physical fitness is a multicomponent construct[8] and several studies show it is a major determinant of QoL in HFpEF.[6,7] Our results corroborate this finding, as we observed that QoL total score strongly correlated with physical fitness (e.g. dynamic balance and mobility, and CRF) in HFpEF patients.

Because physical fitness might influence QoL, strategies targeting physical fitness might potentially improve QoL, independent of further health benefits.[22] A recent meta-analysis showed that the combination of endurance exercise training together with cardiovascular drugs provide a clinically relevant improvement in both exercise capacity and QoL in HFpEF patients.[23] However, physical fitness and QoL are multicomponent and multidimensional constructs, respectively, and it is crucial to ascertain which dimension/component is better related to each other to maximize possible QoL improvements.

Previous studies have shown that CRF is mainly associated with the physical dimension, but not necessarily with the total score or emotional dimension of QoL.[7,10] We observed that CRF (assessed by the 6MWT) and dynamic balance and mobility (assessed by 8FUG) were both associated with the physical dimensions of QoL. Moreover, dynamic balance and mobility were the only physical fitness components associated with the QoL emotional dimension, while upper body strength (assessed by handgrip) and body composition were not associated with any dimension. In addition, multivariate analysis revealed that the dynamic balance and mobility was the only physical fitness component independently associated with all QoL dimensions, explaining 42% of variance in the total score QoL, 32% of the physical dimension and 37% of the emotional dimension of QoL. Thus, of all physical fitness components, dynamic balance and mobility seems to be the one that better assess QoL in HFpEF patients.

Collectively, our data suggest that improving the specific physical fitness component of dynamic balance and mobility

Table 2 – Bivariate correlation between physical fitness parameters

	Dynamic balance and mobility	Upper body strength	Cardiorespiratory fitness	Body composition		
	8FUG	Handgrip	6MWT	BMI	% FM	FFM
8FUG		-0.478 (0.018)	-0.816 (<0.00)	-0.030 (0.888)	0.184 (0.389)	-0.221 (0.299)
Handgrip	-0.478 (0.018)		0.390 (0.060)	0.017 (0.939)	-0.362 (0.082)	0.284 (0.179)
6MWT	-0.816 (<0.00)	0.390 (0.060)		-0.074 (0.733)	-0.161 (0.453)	0.010 (0.964)
BMI	-0.030 (0.888)	0.017 (0.939)	-0.074 (0.733)		0.566 (0.004)	0.533 (0.007)
Fat Mass	0.184 (0.389)	-0.362 (0.082)	-0.161 (0.453)	0.566 (0.004)		-0.258 (0.224)
FFM	-0.221 (0.299)	0.284 (0.179)	0.010 (0.964)	0.533 (0.007)	-0.258 (0.224)	

8FUG: 8-foot up and go test; 6MWT: six-minute walk test; BMI: body mass index; FM: fat mass; FFM: free fat mass. Data are r (p).

will eventually result in the greatest QoL improvement. The 8FUG reflects the specific demands of activities, such as standing up from a sitting position, walking short distances, turning, stopping and sitting down.[24] This might be explained by the wide range of physical abilities, including lower body strength, dynamic balance, walking ability, agility and gait speed[8] involved in the 8FUG. These abilities are also required during the normal daily tasks of an independent and autonomous life, especially among the elderly.[25] Future studies (e.g. longitudinal training programs) should assess if an exercise training program focused on enhancing motor abilities (e.g. dynamic balance and mobility) can improve the physical and emotional components of QoL in HFpEF in comparison to current standard ones.

Study limitations

The small sample size, cross-sectional and convenience sampling design of our study limits the generalization of our results. Despite that, our sample assembles the usual clinical features of HFpEF population reported in large studies[5] with a higher prevalence of elderly women and a higher prevalence of comorbidities. Further prospective cohort studies with a larger sample size are needed to strengthen or refute our conclusions that dynamic balance and mobility are more efficient in assessing HFpEF patients' QoL.

Conclusion

Overall, our findings indicate that both CRF and dynamic balance and mobility are directly associated with the QoL total score and physical dimensions in patients with HFpEF, but only dynamic balance and mobility were concomitantly associated with the emotional dimension. Multivariate analyses revealed that dynamic balance and mobility outperforms CRF in assessing HFpEF patients' QoL. In addition, our data suggests that specifically targeting motor agility and balance may be an important strategy to enhance QoL gains in all dimensions.

Author contributions

Conception and design of the research and obtaining financing: Schmidt C, Santos M, Moreira-Gonçalves D, Leite-Moreira A, Oliveira J; Acquisition of data: Schmidt C, Santos M, Bohn L, Delgado BM, Moreira-Gonçalves D; Analysis and interpretation of the data, writing of the manuscript and critical revision of the manuscript for intellectual content: Schmidt C, Santos M, Bohn L, Delgado BM, Moreira-Gonçalves D, Leite-Moreira A, Oliveira J; Statistical analysis: Schmidt C, Santos M, Bohn L, Delgado BM, Moreira-Gonçalves D, Oliveira J.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

CIAFEL is supported by FCT under Grant [UID/DTP/00617/2019]. UnIC is supported by FCT under Grant [UID/IC/00051/2019] and [UID/DTP/00617/2019]. This work was supported by the project [PTDC/MEC-CAR/30011/2017] [POCI-01-0145-FEDER-030011]. Cristine Schmidt was supported by individual grant from CAPES [BEX 0554/14-6].

Study Association

This article is part of the thesis of Doctoral submitted by Cristine Schmidt, from Faculdade de Desporto da Universidade do Porto.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Centro Hospitalar do Porto/HSA under the protocol number 2015-125. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Table 3 – Partial correlation between quality of life dimensions and physical fitness components

	Dynamic balance and mobility	Upper body strength	Cardiorespiratory fitness	Body composition		
	8FUG	Handgrip	6MWT	BMI	% FM	FFM
MLHFQ total	0.563 (0.008)	-0.118 (0.611)	-0.539 (0.012)	0.208 (0.366)	-0.012 (0.957)	0.372 (0.097)
MLHFQ physical	0.529 (0.014)	-0.261 (0.254)	-0.478 (0.028)	0.260 (0.255)	-0.027 (0.909)	0.353 (0.116)
MLHFQ emotional	0.597 (0.004)	-0.023 (0.919)	-0.394 (0.077)	0.199 (0.388)	0.002 (0.993)	0.297 (0.191)

Adjusted for age, gender and NYHA functional class. 8FUG, 8-foot up and go test. 6MWT, six-minute walk test. BMI, body mass index. FM, fat mass. FFM, free fat mass. MLHFQ, Minnesota Living with Heart Failure Questionnaire. Data are r (p).

Table 4 – Stepwise regression analysis assessing which physical fitness components were independently associated with specific quality of life dimensions

	β	B	R2	p
MLHFQ total				
Ln 8FUG	0.651	5.015	0.424	0.001
MLHFQ physical				
Ln 8FUG	0.570	3.788	0.324	0.040
MLHFQ emotional				
Ln 8FUG	0.611	3.003	0.373	0.002

Ln 8FUG: natural logarithm of 8-foot up and go test; MLHFQ: Minnesota Living with Heart Failure Questionnaire; β: standardized regression coefficient; B: non-standardized regression coefficient; R^2: adjusted coefficient of determination.

References

1. Dunlay SM, Roger VL, Redfield MM. Epidemiology of heart failure with preserved ejection fraction. Nat Rev Cardiol. 2017;14(10):591-602.
2. Edelmann F, Stahrenberg R, Polzin F, Kockskamper A, Dungen HD, Duvinage A, et al. Impaired physical quality of life in patients with diastolic dysfunction associates more strongly with neurohumoral activation than with echocardiographic parameters: quality of life in diastolic dysfunction. Am Heart J. 2011;161(4):797-804.
3. Rodriguez-Artalejo F, Guallar-Castillon P, Pascual CR, Otero CM, Montes AO, Garcia AN, et al. Health-related quality of life as a predictor of hospital readmission and death among patients with heart failure. Arch Intern Med. 2005;165(11):1274-9.
4. Holland DJ, Kumbhani DJ, Ahmed SH, Marwick TH. Effects of treatment on exercise tolerance, cardiac function, and mortality in heart failure with preserved ejection fraction. A meta-analysis. J Am Coll Cardiol. 2011;57(16):1676-86.
5. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JGF, Coats AJS, et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC)Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. Eur Heart J. 2016;37(27):2129-200.
6. Nolte K, Herrmann-Lingen C, Wachter R, Gelbrich G, Dungen HD, Duvinage A, et al. Effects of exercise training on different quality of life dimensions in heart failure with preserved ejection fraction: the Ex-DHF-P trial. Eur J Prev Cardiol. 2015;22(5):582-93.
7. Kitzman DW, Brubaker PH, Morgan TM, Stewart KP, Little WC. Exercise training in older patients with heart failure and preserved ejection fraction: a randomized, controlled, single-blind trial. Circ Heart Fail. 2010;3(6):659-67.
8. Rikli RE, Jones CJ. Development and validation of criterion-referenced clinically relevant fitness standards for maintaining physical independence in later years. Gerontologist. 2013;53(2):255-67.
9. The World Health Organization Quality of Life Assessment Group. The World Health Organization Quality of Life Assessment (WHOQOL): development and general psychometric properties. Soc Sci Med. 1998;46(12):1569-85.
10. Edelmann F, Gelbrich G, Dungen HD, Frohling S, Wachter R, Stahrenberg R, et al. Exercise training improves exercise capacity and diastolic function in patients with heart failure with preserved ejection fraction: results of the Ex-DHF (Exercise training in Diastolic Heart Failure) pilot study. J Am Coll Cardiol. 2011;58(17):1780-91.
11. McMurray JJ, Adamopoulos S, Anker SD, Auricchio A, Böhm M, Dickstein K, et al. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012. European journal of heart failure. 2012;14(8):803-69.
12. Mancia G, Grassi G, Redon J. Manual of Hypertension of the European Society of Hypertension. 2nd ed. Boca Raton:CRC Press; 2014.
13. Lohman TG, A.F. Roche, and R. Martorell. Anthropometric Standardization Reference Manual. Champaign, IL: Human Kinetics Books; 1988.
14. Riley L, Guthold R, Cowan M, Savin S, Bhatti L, Armstrong T, et al. The World Health Organization STEPwise Approach to Noncommunicable Disease Risk-Factor Surveillance: Methods, Challenges, and Opportunities. Am J Public Health. 2016;106(1):74-8.
15. WHO. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser. 2000;894:1-253.
16. Dolgin M. Nomenclature and criteria for diagnosis of diseases of the heart and great vessels. The Criteria Committee of the New York Heart Association. 9 ed. Boston: Little, Brown & Co; 1994. 253-6 p.

17. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging. 2015;16(3):233-70.

18. Jones CJ, & Rikli, R. E. Measuring functional. The Journal on active aging. 2002;1:24-30.

19. MacDermid J, Solomon G, Valdes KU. Clinical Assessment Recommendations: American Society of Hand Therapists; 2015.

20. Rector TS, Cohn JN. Assessment of patient outcome with the Minnesota Living with Heart Failure questionnaire: reliability and validity during a randomized, double-blind, placebo-controlled trial of pimobendan. Pimobendan Multicenter Research Group. Am Heart J. 1992;124(4):1017-25.

21. Hoekstra T, Lesman-Leegte I, van Veldhuisen DJ, Sanderman R, Jaarsma T. Quality of life is impaired similarly in heart failure patients with preserved and reduced ejection fraction. Eur J Heart Fail. 2011;13(9):1013-8.

22. Pandey A, Parashar A, Kumbhani D, Agarwal S, Garg J, Kitzman D, et al. Exercise training in patients with heart failure and preserved ejection fraction: meta-analysis of randomized control trials. Circ Heart Fail. 2015;8(1):33-40.

23. Fukuta H, Goto T, Wakami K, Ohte N. Effects of drug and exercise intervention on functional capacity and quality of life in heart failure with preserved ejection fraction: A meta-analysis of randomized controlled trials. Eur J Prev Cardiol. 2016;23(1):78-85.

24. Wall JC, Bell C, Campbell S, Davis J. The Timed Get-up-and-Go test revisited: measurement of the component tasks. J Rehabil Res Dev. 2000;37(1):109-13.

25. Mlinac ME, Feng MC. Assessment of Activities of Daily Living, Self-Care, and Independence. Arch Clin Neuropsychol. 2016;31(6):506-16.