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Usefulness of Upper and Lower Limb Muscles Strength in the Evaluation of Clinical Severity of Heart Failure in Elderly Patients

Mohamed Abdou

Cardiology Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt
Email: mhmdabdou11@gmail.com

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Abstract

Aim: Assess upper and lower limb functions in elderly with heart failure (HF) and evaluate its relation to HF severity. **Methods:** Handgrip strength (HGS) in kilograms (kgs.) of both hands using handle mechanical dynamometer and counting the repetitions (rep.) of stand and sit on a chair during 30 seconds [the 30 seconds chair-stand test (CST)] were used in 71 elderly (≥65 years old) patients with clinically stable HF and other matched 32 healthy elderly as a control. HF was diagnosed clinically, by plasma B-Type natriuretic peptide (BNP) and by echocardiography. The New York Heart Association (NYHA) functional classification of HF was used to obtain two groups: NYHA class I-II (33 patients), and NYHA class III (38 patients). **Results:** Showed significant decrease in both HGS and CST score in all HF patients (9.7 ± 4.4 kgs., 8.8 ± 3.1 rep., respectively) compared to controls (77.8 ± 11 kgs., 13.5 ± 1.1 rep., respectively, $p < 0.001$). NYHA class III patients had the more significant decline (6.2 ± 3.3 kgs., 6.8 ± 2.0 rep., respectively) compared to both controls ($p < 0.001$) and class 1-II patients (14.9 ± 6.2 kgs., 11.8 ± 2.4 rep., respectively), with significant difference noticed also between the latter two groups. Both HGS and CST scores correlated significantly negatively with NYHA class and BNP levels ($p < 0.001$), and significantly positively with ejection fraction ($p < 0.002$). **Conclusion**: Upper and lower limb muscles strength, assessed by two easy and inexpensive tests (HGS and CST), may reflect clinical severity of HF in elderly patients who cannot usually perform exercise tests. Its prognostic value requires further follow-up studies to verify.

Keywords

Congestive Heart Failure, Hand Grip Strength, Chair Standing Test, B-Type Natriuretic Peptide

1. Introduction

Worldwide, congestive heart failure (CHF) is a growing public health problem, mainly because of an aging population. It is a leading cause of hospitalization and death and has a major adverse effect on patient health status, including functional incapacity, symptoms and impaired health-related quality of life [1].

Individuals with heart failure report considerable impairment in daily activities and walking than patients with angina or acute myocardial infarction. In addition, many elderly patients with CHF may try to avoid or may not complete cardiopulmonary exercise testing. Thus, it is necessary to discover other measures that could be used for the physical assessment of CHF in elderly patients, like upper and lower extremity muscle strength which may also be a predictor of survival in patients with heart failure (HF) [2].

Generally, strong hands is a sign of health elsewhere, so handgrip strength is a good marker of overall muscle strength and a predictor of clinical severity in diseased and other elderly people [3]. It is readily available bedside test, easily performed, not affected by inflammation or the hydration state [4].

Also, knee flexor muscle Strength (chair standing test) is better tolerated than the exercise test, found to be a cornerstone for detecting early declines in functional independence in the elderly, and better tolerated than the exercise test [5].

2. Aim of the Study

Assess upper and lower limbs functions in elderly with heart failure and evaluate its relation to the severity of heart failure.

3. Subjects and Methods

This cross sectional study was conducted from March 2013 to December 2014 and included 71 patients with clinically stable CHF (45 males and 26 females) who had regular follow-up in the Heart failure clinic in our centre and met the inclusion criteria. Their mean ages were 71.1 ± 4.1 years, and were subdivided according to NYHA classification into 2 groups:

Group (1): included 33 patients in NYHA class I-II (21 males and 12 females) with mean ages of 73.1 ± 3.1 years.

Group (2): included 38 patients in NYHA class III (24 males and 14 females) with mean ages of 70.1 ± 4.3 years.

Inclusion criteria: Adults male and females aged 65 years or older with left ventricular ejection fraction (LVEF) less than 45%, able to track verbal instructions and able to sign informed consent.

Control group: included 32, community-dwelling, healthy (18 males and 14 females), non-cardiac persons, from rural and urban areas, matched in age, gender, occupation and body mass index to patients group. Their mean ages were 70.5 ± 2.2 years and were selected from relatives of patients and/or hospital staff.

The participants' interview was conducted before the study to discuss equipments used according to the study protocol. History, demographic characteristics, medications, daily living activities dependence, weight and height measurements were collected.

All subjects were informed about the aims and the procedures of the study and signed an informed consent form prior to beginning and the investigations conformed to the principles outlined in the Declaration of Helsinki [6].

Exclusion criteria: patients with CHF "NYHA class IV", DM, CKD, neurologic, peripheral vascular, orthopedic, pulmonary and joint diseases, either acute or chronic, participants with poor subjective health status.

All participants were subjected to:

1) **Full history taking and thorough clinical examination:** We used the clinical criteria for the diagnosis of heart failure according to the Framingham researchers [7].
2) **12-Leads surface ECG.**
3) **Routine laboratory investigations:** Blood urea nitrogen, serum creatinine, serum albumin, complete blood picture, fasting blood sugar, serum calcium and phosphorous.
4) **BNP measurement:** Samples of blood collected by venipuncture were placed in tubes containing EDTA. BNP fluorescence immunoassay was used (Biosite Diagnostics) [8].
5) **Complete resting echocardiographic study: The following data were stressed upon:**

a) Measurement of LV dimensions and LV volumes: M-mode was used to measure septal (IVS) and posterior wall thickness (PWT) in diastole as well as LV end systolic diameter (LVSd) and LV end diastolic diameter (LVDd). We used the most commonly used algorithm to calculate LV volumes (Modified Simpson method) [9]. Patients with LVEF less than 45% were included in the study.

b) Assessment of left ventricular regional systolic function: The left ventricular wall was divided into 17 segments according to the recommendation of the American Society of Echocardiography to evaluate regional LV function [9].

6) **Handgrip strength test:** To evaluate the strength of the upper limb muscles by measuring the maximum isometric strength of the forearm and hand muscles using ***a standard adjustable handle dynamometer***.

Procedure: The dynamometer handle was adjusted if required and held in the hand to be tested, its handle rest on the middle of four fingers while the base should rest on the heel of the palm (first metacarpal). The subject elbow should stay by the side of the body and the forearm at right angles. The subject was strongly encouraged to give the best effort, stop other body movement, and when ready squeezed the dynamometer with maximum isometric effort, which was maintained around 5 seconds.

Variations:

- The position of the hand can vary in different protocols but *American Society of Hand Therapists* (ASHT) protocol was used for all our subjects for avoiding the false results and putting patients in the same conditions.
- The accuracy of the measurements depends on correct adjustment of the dynamometer for hand size.
- As the non-dominant hand usually scores about 10% lower, the subjects' dominant hand must be recorded and evaluated during results interpretation.
- The forearm muscles are easily fatigued, so the best scores are achieved usually in the first or second trial.

Scoring: Each hand was tested with a recovery time allowed around 15 - 30 seconds between each effort. The best result was recorded. The values (in kg) are listed in **Table 1(a)**. Combine the best score of each hand to give a total grip strength reading [10].

7) **30 sec *Chair standing test***: To evaluate the strength of the lower limb muscles (particularly legs) by measuring the strength of knee extensor and flexor muscles.

This is related to the ability to perform daily activities like getting in and out of a bed or bath or climbing stairs.

Equipment required: A stop watch, a seat around 43 cm, and a chair with a straight back.

Procedure: After sitting in the middle of the chair, the participant placed both hands on the opposite shoulder crossed at the wrists. The feet were kept flat on the floor and the back was kept straight. For safety, the rear legs of chair were put against a wall preventing its sliding backward. By start of the signal, participant began rise to a complete standing position and then sat down back again. These up and down movements were repeated for 30 seconds and a person was ready to help the participant if they got imbalance. When tired, the participant was allowed to stop and rest and the time keeps going.

Measurements: The stop watch was started with the beginning of the signal. *During 30 seconds*, the number of times the participant reaches to full standing position was recorded. If the 30 seconds had passed and the subject was over halfway to a standing position, counted it as a stand.

The results were interpreted according to the reference of the normal range of scores of the general population (*i.e.* between the 25% and 75% percentiles) (**Table 1(b)**) [11].

Data analysis:

All data were coded, checked, entered and analyzed using SPSS Soft-ware version 19. Data were expressed as Mean ± standard deviation for quantitative variables; number and percentage for qualitative variables. ANOVA, Chi-square, and correlation were also used. P-value was corrected from special tables for x^2 and t according to the degree of freedom.

A P-value of less than 0.05 was considered significant [12].

4. Results

The study included 103 participants: 32 healthy persons as a control and 71 patients with stable CHF; of them 13 (18.3%) patients were in NYHA class I, 20 (28.2%) patients were in NYHA class II, and 38 (53.5%) patients were in NYHA class III. There was significant decrement in hand grip strength (HGS) and chair standing test (CST) scores in all patients with CHF compared to controls and in patients with NYHA class III compared to NYHA class I-II patients. Also, there was significant difference between patients with NYHA class I-II and controls regarding both parameters. BNP levels were significantly higher in CHF patients compared to control and in NYHA III patients compared to NYHA I-II patients (Table 2 & Table 3, Figure 1 & Figure 2).

No significant difference was found between patients with NYHA class I-II and patients with NYHA class III regarding hemoglobin concentration but there was significant decrement in LVEF% and systolic BP in patients with NYHA class III (Table 3).

No significant difference was found regarding gender distribution, body mass index, hand dominance, living area, or educational level among the 3 groups (Table 2 & Table 3). Also, no gender difference was found in CHF patients regarding the results of HGS and chair standing test (Table 4).

Table 1. Grip strength norms and percentiles by age groups and gender for combined right and left hand grip strength (a), and normal ranges of scores of 30 seconds chair stand test (b).

(a)

Age	15 - 19		20 - 29		30 - 39		40 - 49		50 - 59		60 - 69	
Gender	M	F	M	F	M	F	M	F	M	F	M	F
Above Average	103 - 112	64 - 70	113 - 123	65 - 70	113 - 122	66 - 72	110 - 118	65 - 72	102 - 109	59 - 64	98 - 101	54 - 59
Average	95 - 102	59 - 63	106 - 112	61 - 64	105 - 112	61 - 65	102 - 109	59 - 64	96 - 101	55 - 58	86 - 92	51 - 53
Below Average	84 - 94	54 - 58	97 - 105	55 - 60	97 - 104	55 - 60	94 - 101	55 - 58	87 - 95	51 - 54	79 - 85	48 - 50
Poor	≤83	≤53	≤96	≤54	≤96	≤55	≤93	≤54	≤86	≤50	≤78	≤47

(b)

Age	Number of stands-Women	Number of stands-Men
60 - 64	12 - 17	14 - 19
65 - 79	11 - 16	12 - 18
70 - 74	10 -15	12 - 17
75 - 79	10 - 15	11 - 17
80 - 84	9 - 14	10 - 15
85 - 90	8 - 13	8 - 14
90 - 95	4 - 11	7 - 12

Table 2. Comparison of characteristics, clinical, BNP level, handgrip strength and chair stand test score in both controls and CHF patients.

variables	Controls n = 32	CHF n = 71	P-value
Age (years)	70.5 ± 2.2	71.1 ± 4.1	NS
Sex			
Male	18 (56.3%)	45 (63.4%)	NS
Female	14 (43.7%)	26 (36.6%)	
BMI (kg/m²)	23.8 ± 0.8	25.4 ± 0.6	NS
Dominant hand			
Right hand	28 (87.5%)	60 (84.5%)	NS
Left hand	4 (12.5%)	9 (12.7%)	
Both hands	0 (0%)	2 (2.8%)	
Residential status			
Rural	14 (43.8%)	28 (39.4%)	NS
Urban	18 (56.2%)	43 (60.6%)	
Education level			
None	3 (9.4%)	12 (16.9%)	
Elementary	10 (31.2%)	23 (32.4%)	NS
High school	11 (34.4%)	22 (31%)	
Higher education	8 (25%)	14 (19.7%)	
Systolic blood pressure (mmHg)	110.8 ± 7	109 ± 17.1	NS
Diastolic blood pressure (mmHg)	70.4 ± 9.6	69.6 ± 12	NS
Pulse (bpm)	76.6 ± 5.3	83.2 ± 8.5	<0.05
BNP (pg/ml)	32.8 ± 9.3	513.5 ± 17.5	<0.001
HGS of both hands (kg)	77.8 ± 11	9.71 ± 4.4	<0.001
30 s. Chair standing test (rep.)	13.5 ± 1.12	8.8 ± 3.1	<0.001

HGS = hand grip strength, bpm = beat per minute, rep. = repetitions, BNP = B-Type natriuretic peptide.

Table 3. Comparison of means ± SD of some variables including BNP levels in CHF patients group 1 "NYHA I-II" and group 2 "NYHA III".

Variables	group 1 "NYHA I-II" n = 33	group 2 "NYHA III" n = 38	P-value
Age (years)	73.1 ± 3.1	70.1 ± 4.3	NS
Sex			
Male	21 (63.6%)	24 (63.2%)	NS
Female	12 (36.4%)	14 (36.8%)	
BMI (kg/m²)	24.6 ± 0.7	26.3 ± 0.4	NS
Dominant hand			
Right hand	29 (87.9%)	30 (78.9%)	NS
Left hand	4 (12.1%)	6 (15.8%)	
Both hands	0 (0%)	2 (5.3%)	
Residential status			
Rural	14 (42.4%)	14 (36.8%)	NS
Urban	19 (57.6%)	24 (63.2%)	

Continued

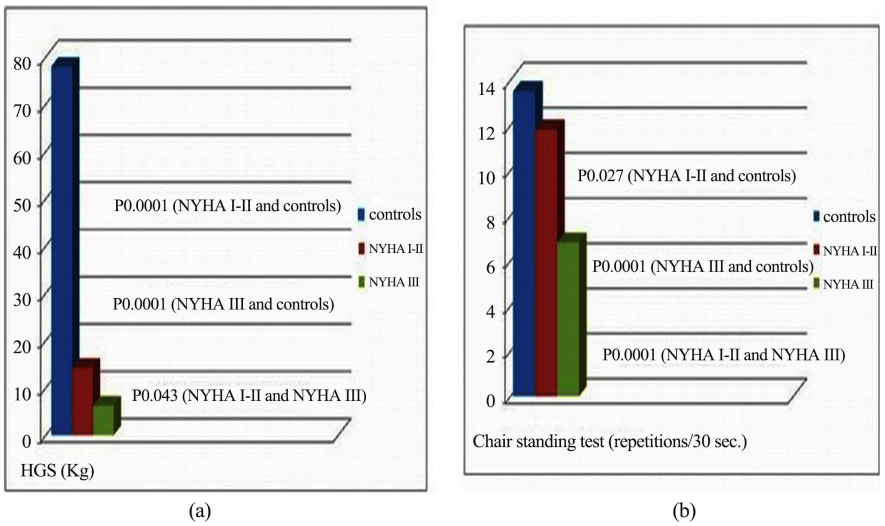
Education level			
None	4 (12.1%)	8 (21.1%)	
Elementary	10 (30.3%)	13 (34.2%)	NS
High school	11 (33.3%)	11 (28.9%)	
Higher education	8 (24.3%)	6 (15.8%)	
Systolic blood pressure (mmHg)	116.7 ± 18.9	104 ± 13.7	<0.05
Diastolic blood pressure (mmHg)	73.5 ± 14.4	66.6 ± 9	NS
Pulse (bpm)	84 ± 10	82.7 ± 7.3	NS
Hb (gm/dl)	10.6 ± 1.9	9.5 ± 1.7	NS
BNP (pg/ml)	411.8 ± 13.7	581.6 ± 19.7	<0.001
LVEF (%)	42 ± 2.5	34.8 ± 6.8	<0.001
HGS of both hands (kg)	14.9 ± 6.2	6.20 ± 3.3	<0.05
30 s. Chair standing test (rep.)	11.8 ± 2.4	6.8 ± 2.0	<0.001

HGS = hand grip strength, bpm = beat per minute, rep. = repetitions, LVEF = left ventricular ejection fraction, Hb = hemoglobin, BNP = B-Type natriuretic peptide.

Table 4. Gender difference between CHF patients regarding handgrip strength (HGS) and chair stand test score.

Variables	Males n = 45	Females n = 26	P
HGS of both hands (kg)	11.15 ± 7.31	7.33 ± 3.6	0.102 (NS)
30 s. chair stand test (rep)	9.35 ± 3.54	8.08 ± 2.35	0.279 (NS)

HGS = hand grip strength, rep. = repetitions.



(a) (b)

Figure 1. Comparison of means ± SD of handgrip strength (HGS) (a) and chair stand test score (b) in patients with severe CHF "NYHA III", mild-moderate CHF "NYHA I-II" and controls.

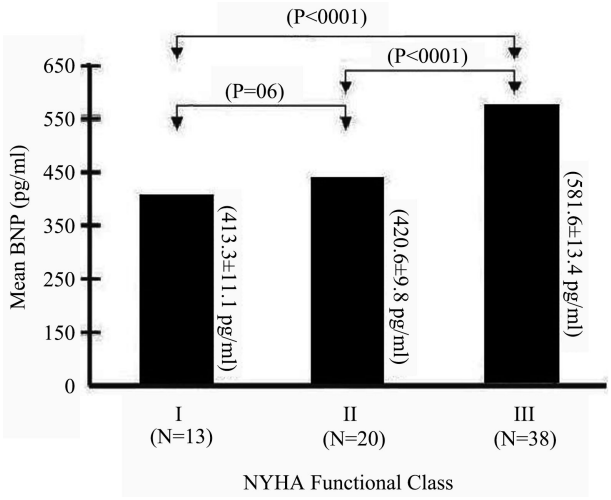


Figure 2. Relation between BNP and NYHA functional class in CHF patients after adjustment for gender and age.

Both HGS and CST scores correlated significantly negatively with NYHA and BNP levels and significantly positively with left ventricular ejection fraction and systolic blood pressure. There was a significant positive correlation between HGS and CST scores (**Figure 3**).

5. Discussion

Patients with chronic heart failure have a decreased capacity for physical activity. Beside cardiac dysfunction, many other pathophysiological mechanisms lead to exercise intolerance in CHF including skeletal muscle weakness, reduced endurance, and atrophy. These adaptations occurred in the peripheral skeletal muscle restrict physical activity independent of cardiac dysfunction and persist even after correction of cardiac impairment [13].

In spite of the fact that the performance of both lower and upper limbs is lower in patients with heart failure than in healthy persons, the level of this impairment appears to differ between the upper and lower limbs because different muscle areas, individual muscles, or muscle groups could have different reactions to a variety of stimuli [14].

This study showed significantly decreased handgrip strength (HGS) and 30 sec repetitive chair standing test (CST) in elderly patients with CHF compared to healthy elderly people and a significant negative association between both HGS and CST score and NYHA class and BNP levels were found. Levels of blood BNP can quantify severity of heart failure symptoms [15] [16] [17] [18] as we noticed in this study and are linked to the degree of left ventricular dysfunction [19] [20] [21] [22] [23].

A significant decreased in both upper and lower limbs muscle strength with disease progression was also found (more deterioration in patients with NYHA III). Few studies searched these issues as Izawa *et al.*, 2007 [24] who reported that muscle strength indices including HGS decreased significantly with increase

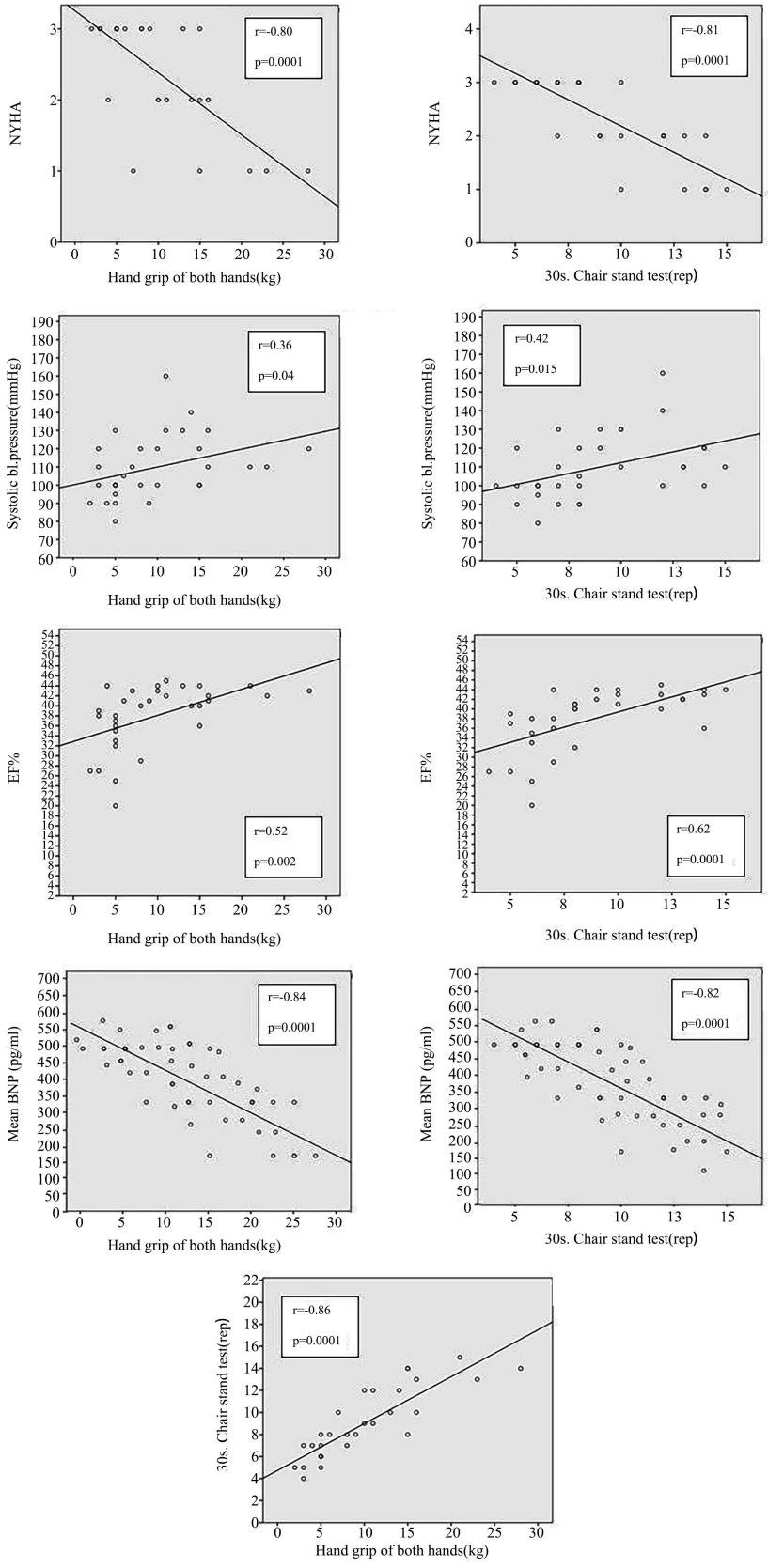


Figure 3. Correlation between NYHA class, systolic blood pressure, left ventricular ejection fraction (EF %), mean BNP and both hand grip strength and chair stand test scores in patients with CHF.

in NYHA class in elderly patients with stable CHF. They concluded that exercise capacity and disease severity in CHF patients may be influenced not only by upper limb, but also by lower limb muscle strength. Meral *et al.*, 2011 [25] reported significantly low HGS in CHF patients with NYHA class III compared to CHF patients with NYHA class II and found significant negative correlation between NYHA class and HGS. They concluded that functional capacity and peripheral muscle strength decrease as the illness progress. Also, Loncar *et al.*, 2013 [26] found reduced HGS in elderly patients with chronic HF (NYHA class II-III) and poor LVEF%, and concluded that peripheral muscle mass and strength are reduced in those patients.

To the best of our knowledge, no investigator used the CST in evaluation of lower limb muscles function in elderly with CHF. Other methods were used like the knee extensor and flexor muscle strength, used by Izawa *et al.*, 2007 [24]. Also, 6-min walk test was used to assess the lower limb function in stable CHF patients with muscle wasting compared to CHF patients without muscle wasting and the same NYHA grade [27].

The CST was used before to assess lower limb muscles strength in elderly individuals with stable coronary artery disease to evaluate individual's functional capacity when cardiopulmonary exercise testing was neither practical nor necessary for clinical reasons [28]. Also, it was used to assess the effect of one month cardiac rehabilitation on lower limb strength in patients with coronary artery bypass graft [29].

The CST was found to be useful in other studies on non-cardiac elderly individuals. Batista *et al.* (2012) [30] used this test to assess the relationship between lower limb muscle strength and frailty. It was also used to assess lower limb function in women with SLE [31].

In this study, significant positive correlations were noticed between HGS and each of systolic blood pressure, LVEF%, and CST score. Also, significant positive correlations were noticed between CST score and each of systolic blood pressure and LVEF%.

To our knowledge no previous study assessed these associations in patients with CHF.

The power of statistical significance of the correlations between CST score and these variables especially LVEF% and SBP was higher than that between same variables and HGS. This may signify that the lower limb muscle strength may be associated with disease severity of CHF more than the upper limb which can be explained by the morphological and functional differences between upper and lower limbs and by the compartment theory mentioned before [32].

The selection of participants in this study was based on trying to avoid big differences in BMI, dominant hands, residential status, educational level as well as occupation between the study groups. We found no significant difference in both HGS and CST score between males and females in elderly patients with CHF.

HGS was generally higher for the dominant hand and in males in a study done

by Puh, 2010 [33]. On the other hand, Jansen *et al.* (2008) [34] found that men's HGS decline was steeper than that of women over successive age groups, and the gap between men's and women's HGS narrowed and virtually disappeared in successively older age groups. Also, Barbosa *et al.*, 2011 [35] reported significant increase in HGS and CST scores in young men compared to young women, while this significant difference disappeared in older age group**.** The factors that may cause variations in results of these tests in different studies include different demographic and epidemiological factors, ethnicity, nutritional status, physical activity, working conditions and/or occurrence of diseases [35]. In the present study, the lack of gender difference may be due to small sample size and/or older age of participants.

6. Conclusion

Both upper and lower limb functions are reduced in elderly patients with heart failure and that lower limbs appeared to be affected more. A two simple, easy to perform test, named HGS and CST may be useful indicators of severity of CHF in elderly patients. Gender may have little or no effect on both tests in elderly CHF patients. Further studies are needed to correlate these tests with prognosis in CHF patients and to test the effect of various treatment modalities of CHF.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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