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Review Article

Six-Minute Walk Test in Pediatric Cardiac Patients

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Abstract

Background: The 6MWT (6MWT) is a self-paced walking test generally used to assess the functional capacity in people with chronic conditions the main outcome is the distance that a person can walk in 6 minutes. The 6 MWT is originally developed to measure the submaximal level of functional capacity in adult patients with moderate to severe heart or lung diseases and has been extensively used in other patient populations. Because the test reflects an exercise level close to that of daily life activities, it is easy to administer, is well tolerated by patients, and is increasingly being used as a functional outcome measure for people with chronic conditions, including pediatric populations.

Patients and methods: Our study is a cross sectional study to discuss the effect of cardiac diseases on the functional capacity of pediatric patients suffering from cardiac diseases compared with control group via 6MWT. The study included pediatric patients admitted to pediatric cardiology unit at Assiut University children hospital from age of 5 to 18 years at duration of one year from 1/8/2016 to 31/7/2017.

The Patients: One hundred cases (100) cases (52 males and 48 females) were suffering from cardiac diseases (42 suffering from CHD, 38 suffering from RHD and remaining 20 cases suffering from cardiomyopathy).

The Control: Hundred healthy children (50 males and 50 females). From primary, preparatory and secondary schools from the same age category of the patients.

Results: The 6MWT is a simple, applicable test with a significant value in the demonstration of the effect of cardiac diseases on the functional capacity of pediatric cardiac patients. In our study we concluded that cardiac diseases are common in low socioeconomic nations, congenital heart diseases and rheumatic heart diseases are the most common cardiac diseases in children, cardiac diseases affect growth and development of pediatric cardiac patients, cardiac diseases affects daily activities of affected children by decreasing the distance that they can walk and cardiomyopathy affect the functional capacity more than other cardiac diseases

Keywords: Six-Minute walk test, Pediatric, Exercise, Cardiac diseases

Introduction

The individual response to exercise is an important clinical assessment tool because it provides a composite assessment of the respiratory, cardiac, and metabolic systems. The current gold standard for assessing one's aerobic exercise response is the maximum incremental cardiopulmonary exercise test. However, most daily activities are performed at submaximal levels of exertion; thus, using submaximal functional tests would provide a more realistic simulation of one's physical capability [1-4]. The ability to walk for a distance is a quick, easy, and inexpensive way to assess the physical function of an individual. It is also an important component of quality of life as it reflects the ability to undertake day-to-day activities. Balke developed a simple test to examine the functional capacity by measuring the distance walked during a defined period of time [5]. A 12-minute performance test was then developed to evaluate the physical fitness of healthy individuals [6]. This test was subsequently modified for use in patients with chronic bronchitis [7]. To allow patients with respiratory diseases for whom walking a 12-minute distance was too demanding, a shortened version, of 6 minutes, was found to provide comparable clinical information [8]. A recent review of functional walking tests concluded that the six-minute-walk test (6MWT) is easy to perform with better acceptability by participants, and provides a better reflection of activities of daily living than other walk tests [4]. The American Thoracic Society has also recently endorsed and published guidelines for performing the 6MWT in clinical settings [9]. The 6MWT has been frequently used to measure outcomes before and

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after treatment in patients with moderate to severe heart and lung diseases [10].

The aim of the study

- To estimate the incapacity of cardiac patients through the 6-minute walk test (6MWT) data.
- To compare data of cardiac patient group (PG; n = 100) with those of control group (CG).

Subjects

The Patients

One hundred cases (100) cases (52 males and 48 females) were suffering from cardiac diseases (42 suffering from CHD, 38 suffering from RHD and remaining 20 cases suffering from cardiomyopathy).

The Control

One hundred (100) healthy children (50 males, 50 females). From primary, preparatory and secondary schools from the same age category of the patients.

Inclusion criteria

All children have cardiac diseases from age of 5 to 18 years.

Exclusion criteria

- Children with acute respiratory condition.
- Children with chronic systemic illness like respiratory, hepatic, renal, neurologic, or GIT conditions.
- Children with skeletal disorders.
- Children with hemodynamic disorder like anemia or heart failure**.**

Tools of study

- All cases (patients and control) included in the study were subjected to Anthropometric measures like (weight and height) according to methods described by Reiter and Rosenfield.
- 6MWT was performed according to the guidelines of the American Thoracic Society.

Patient preparation

All patients' worn comfortable clothes, appropriate shoeses for walking were worn, the patient's usual medical regimen was continued, a light meal was taken before the test and patients were not exercised vigorously 2 hours before the test.

Safety issues

The test was performed in pediatric cardiology unit at Assiut University children hospital, where rapid response to an emergency was possible. Oxygen source and telephone were in place to enable a call for help.

Technical aspects of the 6MWT

Location

The 6MWT was performed in pediatric cardiology unit at Assiut University children hospital, where a long, flat, straight, enclosed corridor at a course of 30 Meters was assigned. The length of the corridor was marked every 3 m. The turnaround point was marked with a cone.

Results

The study was conducted on pediatric cardiac patients from 5 years to 18 years of age admitted at cardiology unit at Assiut University Children Hospital over one year in the period from the 1st of August, 2016 to the 31th of July, 2017 and 100 healthy children age and sex matched with the patients.

Discussion

This study is a cross sectional study, that was conducted in the pediatric cardiology unit at Assiut University children hospital to demonstrate the effect of cardiac diseases on the functional capacity of children. It included 100 children with heart disease and 100 age and sex matched control children. The higher prevalence of children coming from rural areas in our studied cases (Table 1) represents the pattern of patients attending Assiut University Hospitals rather than increased incidence of heart diseases in children of rural areas. However, Okello et al. [11]**,** reported that there was a trend towards increased cardiac diseases in children in association with overcrowding, unemployment and consanguinity marriage.

Congenital heart defects represent the most common heart disease in children 12]. Rheumatic heart disease in children still represents a major cause of cardiac morbidity in developing countries [13]**.** Our results in this regard were in agreement with these authors. It was found that congenital heart disease comprised 42 of the patients and 38% have rheumatic heart diseases as showed in Table 2 and Figures 1-7.

Table 3 showed that mean of the weight of the patients was 28.46 ± 12.892 , while that of the control was 37.05 ±17.391 this difference was statistically significant (p. value <0.001), also mean

Variable	The patients		The Control	
	%	No (100)	%	No (100)
Age :				
5 : <12	58%	58	60%	60
12:18	42%	42	40%	40
Mean ± SD	10.8 ± 3.73		11 ± 4.15	
Sex:				
Male	52%	52	50%	50
Female	48%	48	50%	50
Residence:				
Rural	90%	90	100%	100
Urban	10%	10	0%	0

Table 1: Demographic Data.

Heart disease	Number (N=100)	Percentage %
Congenital heart disease:	42	42%
ASD	14	14%
VSD	12	12%
TGA	4	4%
Tetralogy of Fallot	6	6%
PDA	6	6%
Rheumatic heart disease	38	38%
Cardiomyopathy	20	20%
Restrictive cardiomyopathy	4	4%
Dilated cardiomyopathy	16	16%

Table 2: Cardiac diseases among the studied patients.

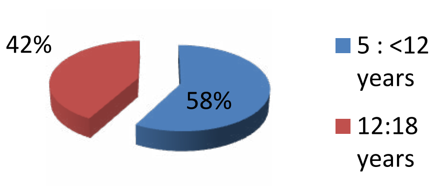

Figure 1: The age distribution of the patients.

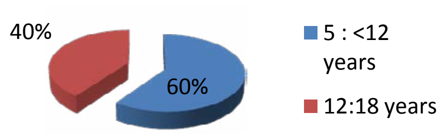

Figure 2: The age distribution of the Control.

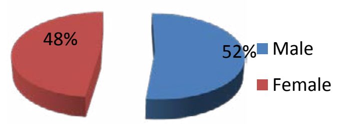

Figure 3: The sex distribution of the patients.

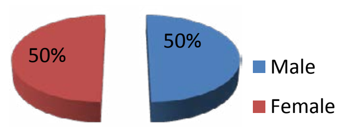

Figure 4: The sex distribution of the control.

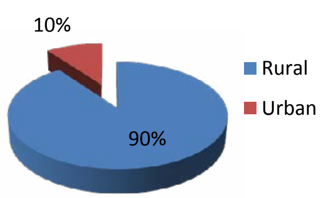

Figure 5: The residence distribution of the patients.

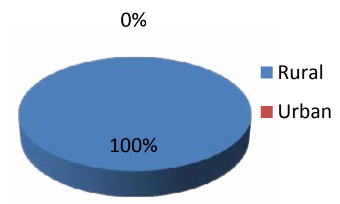

Figure 6: The residence distribution of the control.

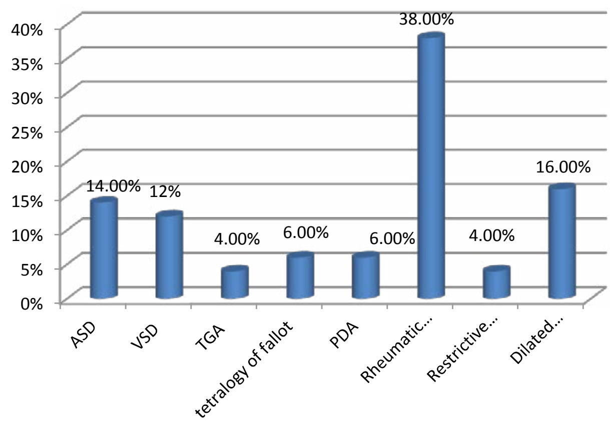

Figure 7: Cardiac diseases among the studied patients.

of the height was 130.12 ± 21.720 in the patients ,while in the control it was 139.45 ± 22.321 which also statistically significant (p.value = 0.003) , this can be explained by that cardiac diseases are chronic diseases that affect growth and development of the patients, and this was in agreement with Nasiruzzamarrt et al. [14] who reported that children having heart diseases were more prone to developed growth and developmental delay. This growth retardation in children with heart diseases is due to recurrent infections and long hospitals stay [15].

During exercise there is increase in oxygen consumption and increase carbon dioxide production which leading to increase work of breathing (RR) to compensate increased level of oxygen consumption and to eliminate carbon dioxide, also during exercise blood flow to the muscles is increased due to increase oxygen consumption , which requires increase in cardiac output. The cardiac output is increased by both a rise in the heart rate and the stroke volume attributable to a more complete emptying of the heart by a forcible systolic contraction. Regarding blood pressure during exercise there is only a moderate increase in blood pressure secondary to the rise in cardiac output. This is caused by stretching of the walls of the arterioles and vasodilatation. Despite increase oxygen consumption during exercise oxygen saturation not significantly affected due to increase work of breathing (RR) and cardiac output (HR and stroke volume). This is matched with our results in Tables 4 & 5 which show that mean HR of the patient before the 6MWT was 100 ± 12.7 and after test was 130 ± 11.06, which was statistically significant (p.value = 0.001), regarding mean HR of the control before 6MWT was 89 ± 12.18 and after the test was 109 ± 9.47 , which also statistically significant (p.value = 0.001). About mean RR of the patient it was 24 ± 5.73 before the 6MWT and 42 ± 6.007 after the test with statistical significance (p.value = 0.001), regarding mean RR of the control it was 20 ± 2.24 before the test and 32 ± 4.59 after the test with statistical significance (p.value = 0.001). Regarding mean systolic / diastolic BP for the patients it was 108 ± 9.22/65 ± 6.7 before the test and 117 ± 8.9/72 ± 6.2 after the test with statistical significance (p.value = 0.001), also mean systolic / diastolic BP of the control was 103 ± 10/ 62 ± 11.3 before the 6MWT and 108 ± 9.22 /65 ± 6.7 after the test with statistical significance (p.value = 0.001). Oxygen saturation showed no statistical significance for both the patients and the control. And this in agreement with Deborah et al., (2004) [16], who reported that exercise increase cardiac output (HR and stroke volume), increase work of breathing (RR) with moderate increase in blood pressure. But oxygen saturation not affected.

Table 6 showed comparison between HR, RR, BP and SPO2 of the patients and the control before the 6MWT, about mean HR of the patients was 100 ± 12 and for that of the control was 89 ± 12.18 which was statistically significant (p.value = 0.001). Regarding mean RR it was 24 ± 5.73 for the patients and 20 ± 2.24 for the control, which was also statistically significant (p.value = 0.001).mean Systolic / diastolic BP of the patients was 108 ± 9.22/65 ± 6.7 and of the control was 103 ± 10/ 62 ± 11.3, which was statistically significant (p.value = 0.005 for systolic and 0.023 for diastolic). Regarding oxygen saturation it was 95 ± 8.48 for the patients and was 98 ± 0.488 for the control, which was statistically significant (p.value = 0.005). This can be explained by recurrent infections and recurrent attacks of heart failure for which patients are exposed, and this in agreement with Jayaprasad [17], reported that the clinical features suggestive of heart failure in children include tachypnea, tachycardia, feeding difficulty and diaphoresis.

Table 7 showed comparison between HR, RR, BP and SPO2 of the patients and the control after the 6MWT, about mean HR of the patients was 130 ± 11 and for that of the control was 109 ± 9.47 which was statistically significant (p.value = 0.001). Regarding mean RR it was 42 ± 6 for the patients and 32 ± 4.59 for the control, which was also statistically significant (p.value = 0.001). mean Systolic / diastolic BP of the patients was 120 ± 10/72 ± 8.1 and of the control was 109 ± 10/ 65 ± 6.2, which was statistically significant (p.value = 0.029 for systolic and 0.023 for diastolic). Regarding oxygen saturation it was 93 ± 9.7 for the patients and was 95 ± 8.48 for the control, which was statistically significant (p.value = 0.034). Table 8 shows that the mean of the 6MWD of the males in the controls was 630 ± 90.12, which was in agreement with a study done by Albert et al., (2007)[18], who reported that the mean of 6MWD of his studied male subjects was 680.9 ± 65.3, also in our study the mean of the 6MWD of the males in the patients was 342.5 ± 102, which was 288 M less than the controls, and it was statistically significant (p.value = 0.001). Also Table 8 shows that the mean of the 6MWD of the females in the controls was 575 ± 63.2, which was in agreement with a study done by Albert et al. [18], who reported that the mean of 6MWD of his studied female subjects was 642.7 (58.9), also in our study the mean of the 6MWD of the females in the patients was 308 ± 118.2, which was 267 M less than the controls, and it was statistically significant (p.value = 0.001), this

Variable	The patients No (100)	The control No (100)	P value
Mean Weight:	28.46 ± 12.892	37.05 ±17.391	<0.001**
Mean Height:	130.12 ± 21.720	139.45 ± 22.321	0.003**

Table 3: Anthropometric parameters of the patients and the controls.

Variable	The patients		p.value
	Pre 6MWT	Post 6MWT	
Mean HR	100 ± 12.7	130 ± 11.06	0.001**
Mean RR	24 ± 5.73	42 ± 6.007	0.001**
Mean BP			
Systolic	103 ± 10.7	120 ± 10.39	0.001**
diastolic	62± 11.3	71 ± 8.1	0.001**
Mean SPO2	95 ± 8.48	93 ± 9.7	0.122

Table 4: Vital signs (HR, RR, BP, SPO2) pre and post 6MWT of the patients.

Variable	The control		p.value
	Pre 6MWT	Post 6MWT	
Mean HR	89 ± 12.18	109 ± 9.47	0.001**
Mean RR	20 ± 2.24	32 ± 4.59	0.001**
Mean BP			
Systolic	108 ± 9.22	117 ± 8.9	0.001**
diastolic	65 ± 6.7	72 ± 6.2	0.001**
SPO2	98 ± 0.488	97 ± 15.97	0.532

Table 5: Vital signs (HR, RR, BP and SPO2) pre and post 6MWT of the control.

Variable	The patient	The control	p.value
Mean HR	100 ± 12	89 ± 12.18	0.001**
Mean RR	24 ± 5.73	20 ± 2.24	0.001**
Mean BP			
Systolic	103 ± 10	108 ± 9.22	0.005**
diastolic	62 ± 11.3	65 ± 6.7	0.023**
SPO2	95 ± 8.48	98 ± 0.488	0.005**

Table 6: Vital signs (HR, RR, BP and SPO2) pre 6MWT of the patient and control.

Variable	Patient	Control	p Value
Mean HR	130 ± 11	109 ± 9.47	0.001**
Mean RR	42 ± 6	32 ± 4.59	0.001**
Mean BP			
Systolic	120 ± 10	117 ± 8.9	0.029*
diastolic	72 ± 8.1	65 ± 6.2	0.023*
SPO2	93 ± 9.7	95 ± 8.48	0.034**

Table 7: vital signs (HR, RR, BP and SPO2) post 6MWT of the patient and the control.

Sex	NO	The Mean Distance of 6MWD of the patients (in meters)	NO	The Mean Distance of 6MWD of the controls (in meters)	P.value
Males	52	342.5 ± 102	50	630 ± 90.12	0.001**
Females	48	308 ± 118.2	50	575 ± 63.2	0.001**

Table 8: Mean of the 6MWD of both the patients group and the control.

Cardiac disease	Number (N=100)	Mean Walked distance (in meters)	P.value
Congenital heart diseases	42	370 ± 120.079	1 vs 3 <0.001**
Rheumatic heart diseases	38	330.54 ± 82.61	1 vs 2 <0.094
Cardiomyopathy	20	215 ± 55.855	2 vs 3 <0.001**

Table 9: Mean of the 6MWD of each category of cardiac diseases.

indicate that heart diseases affect the daily physical activities of the patients, which was in agreement with NeslihaN et al. [19] who reported that cardiac diseases, their assessment and treatment are major challenges for health care providers throughout the world , it was found that patients with cardiac diseases reported problems with diverse activities.

Table 9 shows that the mean of the 6MWD in patients suffering from cardiomyopathy was 215 ± 55.855, while that of the patients having congenital heart diseases and rheumatic heart diseases was (370 ± 120.079 and 330.54 ± 82.61) respectively for patients, which was statistically significant (p.value <0.001), this is in agreement with Susanna et al. [20], who reported that large number of patients with dilated cardiomyopathy undergo heart transplantation due to effect of cardiomyopathy in quality of life. Which mean that the functional capacity of patients having cardiomyopathy affected more than that of patients with CHD or RHD, this because patients with cardiomyopathy may have impaired systolic and diastolic functions which reflect on the function capacity.

Conclusion

The 6MWT is a simple, applicable test with a significant value in the demonstration of the effect of cardiac diseases on the functional capacity of pediatric cardiac patients. In our study we concluded that cardiac diseases affects daily activities of affected children by decreasing the distance that they can walk and cardiomyopathy affect the functional capacity more than other cardiac diseases, cardiac diseases are common in low socioeconomic nations, congenital heart diseases and rheumatic heart diseases are the most common cardiac diseases in children and cardiac diseases affect growth and development of pediatric cardiac patients.

Recommendations

1. The 6MWT is a useful measure of functional capacity targeted at people with at least moderately to severe impairment.
2. The test should be widely used for preoperative and postoperative evaluation and for measuring the response to therapeutic interventions for pulmonary and cardiac disease.
3. It is recommended to make a data base for 6MWT in Egypt as up to our knowledge there is no study done about the test in Egypt in Egyptian children.
4. Early treatment and surgical intervention if indicated in pediatric cardiac patients to avoid complications and to avoid growth and development affection in those patients.

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