DOI- https://doi.org/10.3329/cardio.v17i1.80018

Original Article

Cardiorespiratory Fitness Measured with Exercise Tolerance Testing of Healthy Bangladeshi Adults – An Observational Study

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Key words: *Cardiorespiratory Fitness, Cardiopulmonary Exercise Test, Treadmill Test, Metabolic Equivalent, Bangladesh.*

Abstract:

Background: *Cardiorespiratory fitness (CRF) is a powerful predictor of outcome in health and diseases, including cardiovascular disease (CVD). CRF shows significant racial variation, and for this, region- and county-specific normative values are needed. The study was done to determine the CRF of healthy Bangladeshi adults.*

Methods: *In this prospective observational study involving 240 men and 70 women, CRF was assessed by symptom-limited exercise tolerance testing (ETT), maximal exercise capacity was determined and expressed in metabolic equivalents (METs), maximal oxygen consumption (VO_2 max) was calculated and compared with the previously published data. Apparently healthy men and women aged >18 years without significant disease and with negative ETT test results were included. Those with significant illness, including cardiac, respiratory or rheumatological, those on drugs having potential effect on chronotropic or haemodynamic response were excluded.*

Results: *The mean exercise capacity of men and women was 11.56±6.21 and 9.01±1.61 METs, respectively. The METs and estimated VO_2 max decreased with age in both sexes. Overall, the Bangladeshi men and women had lower maximal exercise capacity than the Western people, almost similar exercise capacity compared to the Koreans, and higher exercise capacity than the Indians.*

Conclusion: *CRF of Bangladeshi healthy subjects should be validated by larger studies and national registry. Future assessment of CRF should be based on cardiopulmonary exercise testing.*

(Cardiovasc j 2024; 17(1): 12-17)

Introduction:

Cardiorespiratory fitness (CRF) is a powerful predictor of outcome in health and diseases.[1-5] For cardiovascular disease (CVD), CRF predicts risk more efficiently than the conventional cardiovascular risk factors.[6] A recent metanalysis showed that a better CRF was associated with lower risk of all-cause mortality in patients with CVD.[7] In clinical practice, CRF of an individual is assessed for different purposes, including medical conditions like acute coronary syndrome (ACS) and heart failure. Realizing the importance of CRF, the American Heart Association (AHA) in her 2016 Scientific Statement considers CRF as a clinical vital sign.[8] Since then, there is a growing interest in CFR, and the test is being done increasingly.

CRF can be assessed by subjective, as well as, by objective evidence. The ability to climb upstairs, including the number of flights that can be climbed, and the New York Heart Association (NYHA) Functional Classification, are used. For

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objective assessment, available are the six-minute walk test, exercise tolerance test (ETT) and cardiopulmonary exercise testing (CPET), the latter being the gold-standard test. In ETT and CPET, exercise capacity is assessed in terms of metabolic equivalent (MET) and maximal oxygen consumption per minute (VO2 max), respectively.[9,10] An individual's CRF depends on age, sex, physical training, body mass index (BMI), and geographical distribution.[11] It may show significant racial variation as well. The CRF measured in terms of exercise capacity of Western people may not be extrapolated to that of the South Asians, including the Bangladeshis. So, region- and county-specific normative values of CRF in health and disease on a global scale should be formulated.[12] To the best of our knowledge, no study concerning the CRF of Bangladeshi people was carried out so far. So, the present study was done to determine the exercise capacity of Bangladeshi people.

Methods:

This prospective observational study was carried out in a private consultation centre of Dhaka City during 2010 to 2022. The protocol was approved by the Institutional Review Committee (ERC) of the institution. The CRF was assessed by ETT. All patients of either sex aged > 18 years without any known significant disease and undergoing maximal exercise test performed on a treadmill by ETT with negative test results were included. The patients with significant illness, including cardiac, respiratory or rheumatological, those on drugs having potential effect on chronotropic or haemodynamic response were excluded.

ETT was done by CASE Exercise Testing System T2100 Treadmill (GE Healthcare, 9900 Innovation Drive, Wauwatosa, WI 53226, USA) using Bruce protocol as per the recommendations of the AHA.[13] Symptom-limited maximal exercise was carried out irrespective of the heart rate achieved. Exercise capacity was expressed in metabolic equivalents (METs). Also, for comparison with the published data, VO2 max was converted to METs using the formula: 1 MET = 3.5 ml O_2/kg/min.

Statistical Analyses

Continuous data are reported as mean (SD), whereas categorical data are reported as frequencies (percentages). Analysis of variance was used to compare differences in VO_2 max values between sex and across age groups. SPSS statistical software, version 22.0 (SPSS Inc), was used for all analyses. All tests with a $p<.05$ were considered statistically significant.

Results:

The study included 310 tests performed by apparently healthy 240 men and 70 women, with ages ranging from 18 to 79 years. Descriptive characteristics of the cohort are listed in Table I.

Peak responses during ETT are presented in Table II and III. There were significant differences between sex for exercise time and exercise capacity in terms of METs, but not for peak heart rate achieved. The overall mean difference in exercise time and exercise capacity between men and women were 2.20 minutes and 2.45 METs, respectively. The overall METs and estimated VO_2 max tended to decrease with increasing age in both men and women. (Table III and Figure 1).

Table-I

Descriptive characteristics of the study subjects (N=310)

Trait	Overall(n=310)	Men (n=240)	Women(n=70)
Age (year)	39.58 ± 10.44	40.2±10.1	37.34 ± 11.4
Height (cm)	160.80 ± 8.13	163.3±6.8	152.3 ± 6.3
Weight (kg)	66.37 ± 10.90	67.9± 10.6	60.9± 10.2
BMI (kg/m^2)	25.66 ± 3.7	25.5±3.6	26.3 ± 4.3

Table-II

Peak responses in exercise test of the study subjects. (N=310)

Parameter	Sex	N	Mean	SD	Mean difference	95% CI	t	p value
Exercise time (min)	Men	240	9.59	1.91	2.20	[1.71,2.96]	8.83	0.000
	Women	70	7.39	1.52				
Estimated maximum workload (METs)	Men	240	11.56	6.21	2.45	[1.37,4.32]	3.79	0.000
	Women	70	9.01	1.61				
Peak heart rate achieved (bpm)	Men	240	172.32	17.62	1.55	[-3.4,6.50]	0.62	0.581
	Women	70	170.77	21.43				

Table-III

METs and calculated VO2max at maximal effort according to sex and age group. (N=310)

Age(Year)	Men (n=240)				Women (n=70)			
	N	Maximum Workload (METs) Mean ± SD	p value	Estimated VO2max (mLO_2/kg/min)	N	Maximum Workload (METs) Mean ± SD	p value	Estimated VO2max (mLO_2/kg/min)
<20	03	15.8±3.8	0.442	55.3±13.3	03	10.9±0.8	0.153	38.3±2.7
21-30	37	12.3±2.2		43.1±7.7	20	9.2±1.4		32.3±5.0
31-40	93	11.7±2.2		41.0±7.7	23	9.1±1.7		32.0±5.9
41-50	75	11.1±2.1		38.9±7.4	14	8.3±1.9		28.9±6.5
51-60	25	10.5±2.2		36.8±7.7	09	8.8±1.2		31.0±4.3
61-70	05	9.7±1.9		34.0±6.7	01	9.0±00		31.5±0.0
>70	02	10.2±0.1		35.7±0.4	00	00		00

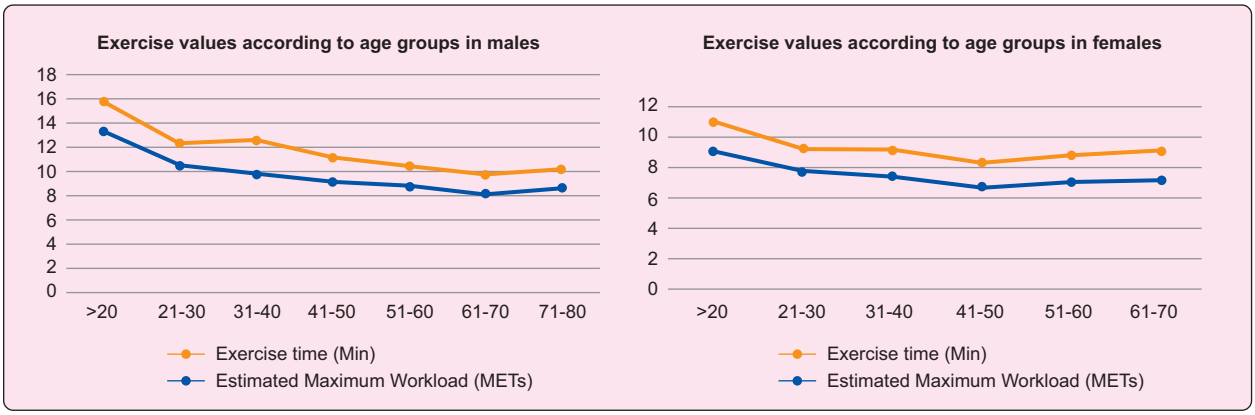

Figure 1: *Trend of changes in exercise time and METs with age.*

The exercise capacity of different age groups in the present study (in METs) and those of the United States (US),[11,12] Norwegian,[14,15] Korean,[16] and Indian[17] cohorts (converted to METs from VO_2 max) are given in Table III. No formal statistical comparisons could be made due to unavailability of the individual participant data; therefore, the data presented in Table III are for observation only. Overall, the Bangladeshi men and women had lower maximal exercise capacity compared to the Western counterparts. However, when compared to the more recently studied US cohort, the younger (20-29 years) Bangladeshi men and women had lower maximal exercise capacity, while the older Bangladeshis had higher exercise capacity than the US people. On the other hand, the studied Bangladeshi men and women had almost similar exercise capacity when compared

Table-IV

Comparison of exercise capacity in terms of METs in recent studies.

Study	Sex	21-30 years	31-40 years	41-50 years	51-60 years
Current study	Male	12.3±2.2	11.7±2.2	11.1±2.1	10.5±2.2
	Female	9.2±1.4	9.1±1.7	8.3±1.9	8.8±1.2
Friend Registry, 2015[11]	Male	13.6±3.2	12.3±2.8	11.1±2.7	9.7±2.6
	Female	10.7±2.9	8.8±2.4	8.0±2.2	6.9±1.7
Friend Registry, 2022[12]	Male	12.9±3.4	11.4±3.3	10.2±3.1	8.6±2.8
	Female	10.4±2.9	8.4±2.6	7.6±2.3	6.8±1.9
Evardsen et al.[14]	Male	14.0±1.9	13.2±2.4	12.2±2.7	10.5±1.9
	Female	11.5±2.0	10.7±2.1	9.5±1.8	8.7±1.5
Loe et al.[15]	Male	15.6±2.4	14.0±2.1	13.5±2.2	12.2±2.1
	Female	12.3±2.2	11.4±1.9	11.0±2.0	9.8±1.6
Jang et al.[16]	Male	12.1±1.8	12.0±1.4	11.8±1.6	10.9±1.6
	Female	9.8±1.2	9.2±1.3	8.8±1.3	8.1±1.3
Raj et al.[17]	Male and female, combined	9.9±1.8	8.3±2.2	7.9±1.9	6.7±1.8

to the Koreans, and higher exercise capacity than the Indians.

Discussion:

The current study represents the first reference data for CRF using measures obtained from ETT in Bangladesh. CRF depends on sex and age of the individuals. In general, men have higher exercise capacity than the women which is evident in the current study as well as, in the studies involving other population. Also, CRF decreases with increasing age in both sexes, however, the rate of decline may not be similar in all population. Race, ethnicity and geographical distribution appear to have significant influence on CRF.[18,19]

In the present study, Bangladeshi men and women had lower exercise capacity compared to the Western counterparts. Among the Western population studied so far, Norwegians have higher CRF than the Americans, e.g., for the 21–30-year age group, the mean difference were 2.0 and 1.6 METs for men and women, respectively.[11,15] Even for a particular population, CRF may vary over decades; the CRF found in the FRIEND Registry 2022[12] is significantly lower than that of the FRIEND Registry 2015.[11] Whether these changes are due simply to inclusion of more data, or due to lifestyle-related factors need further study. The comparable CRF of the studied Bangladeshis and Koreans may be due to closer body habitus, other yet-to-be identified factors. On the other hand, Bangladeshis and Indians belong to the same geographical territory of South Asia, and might have closer ancestry. Despite these similarities, significant difference exists between these two nations across all age groups in both sexes. The underlying cause needs exploration. In fact, normative values of CRF in health may differ significantly among populations, and hence, region- and county-specific reference values on a global scale should be formulated.[12]

To date, the largest data on CRF have been made available from the FRIEND Registry, which is an ongoing registry from the United States. In 2015 and 2017, the Registry published the CRF data in healthy people based on cardiopulmonary exercise testing (CPT) using treadmill and bicycle ergometer, respectively.[11,20] Before that, the widely used Cooper Clinic data on CRF was based on ETT; the values used for VO_2max were predicted from maximal exercise test workload or test time on the Balke protocol.[21] In 2022, the FRIEND Registry published an update on the previous data, and included 22,379 tests (16,278 treadmill and 6101 cycle ergometer) from 34 participating laboratories in the United States

that were performed from January 1, 1968, through March 31, 2021.[12]

The study has got some important limitations. In this study, CRF was assessed by EET, not CPET, and hence, the functional capacity was expressed in terms of METs, and the VO_2max was predicted from METs. The CRF assessed by ETT and CPET may differ.[12] In Bangladesh, at present, CPET is available only in few centres, though ETT is common. The "apparently healthy" subjects included in this study may not be truly healthy for some as some participants might have "occult" diseases compromising the optimum physical performance. Also, the sample size is relatively small, and particularly the women were fewer in number, and extremes of age group have got poor representation.

The strengths of the study include are that, it was a prospective study, and all the tests were done by a single operator using a uniform protocol and a single machine.

Conclusion:

CRF of Bangladeshi healthy men appears to be higher than that of women, and declines with age. In general, the people of Bangladesh may have maximal exercise capacity lower than that of Western people, but higher than the Indians. However, these findings should be validated by larger studies, or preferably by a nationally registry. Future assessment of CRF should be based on CPET, not only on ETT. Children and young adults, as well as, the elderly should be included to formulate to cover the people of all ages.

Conflict of Interest - None.

Acknowledgement:

Ms. Nusrat Zahan, Echo Lab Assistant, Popular Diagnostic Centre Ltd. (Shyamoli Branch), Dhaka, Bangladesh.

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