RESEARCH ARTICLE

Assessment of cardiorespiratory fitness by the Ruffier Dickson test and its correlation with lifestyle related factors: A cross sectional study among Pakistani youth

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Abstract

Objective: To evaluate the correlation of physical activity, screen time and anthropometric parameters with cardiorespiratory fitness using the Ruffier Dickson test.

Method: The cross-sectional study was conducted at the Riphah International University, Islamabad, Pakistan, from October 2021 to May 2022, and comprised healthy undergraduate medical students of either gender aged 18-23 years. Anthropometric parameters were measured and standardised assessment tools were used to assess screen time and physical activity. Cardiorespiratory fitness was assessed using Ruffier Dickson test. Data was analysed using SPSS 26.

Results: Of the 300 subjects, 186(62%) were females and 114(38%) were males. Body mass index, body weight, resting heart rate, height and the level of physical activity were significantly associated with cardiorespiratory fitness ($p<0.05$).

Conclusion: Physical activity, body weight and body mass index could independently predict cardiorespiratory fitness.

Keywords: Ruffier Dickson test, Cardiorespiratory fitness, Body mass index, Physical activity, Screen time.

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Introduction

Nowadays, physical fitness, in particular cardiorespiratory fitness (CRF), is considered a hallmark of overall adult health.[1] There is a 56% risk of cardiovascular disease (CVD) and 70% higher risk of all-cause mortality among people with low CRF.[2] Likewise, poor CRF is the fourth-leading risk factor for CVD and can predict mortality even better than hypertension (HTN), hyperlipidaemia or type 2 diabetes mellitus (T2DM).[3]

The literature provides sufficient evidence regarding the association of modifiable lifestyle-related risk factors, including physical inactivity, sedentary lifestyle and obesity with CVD.[2] Physical activity is an effective and feasible intervention strategy to improve physical fitness and facilitate better neurocognitive performance. Several epidemiological studies pointed out clearly that regular physical exercise is beneficial to improve sleep quality, working ability, mental wellness as well as reducing the risk of sickness among students.[4] In a recent study, mean CRF was reported to have declined by 7.7% due to decrease intensity of physical activity and sedentary lifestyle in developed countries over the last decade.[5] Similarly, anthropometric parameters, such as body mass index (BMI) and body weight, have also shown significant relationship with maximal oxygen consumption (VO_{2max}) level.[6] However, these relationships have been studied commonly with a couple of tools. It is relatively uncommon to measure CRF in clinical care, mostly because to administer these graded exercise tests, trained personnel and high-cost lab equipments are required. The Ruffier Dickson test (RDT), also known as simple 45s squat test, is the time of heartbeat recovery after 30 squats in 45 seconds. This test has gained popularity in physical education systems because of a simple procedure and a reliable test which provides fast self-evaluation of VO_{2max}.[7,8] The validated prediction model[9] is a heart rate (HR)-based CRF test.

The RDT with HR features has demonstrated validity and good test-retest reliability (Cronbach's alpha 0.86).[10] Neither the test not its relationship with anthropometric and other lifestyle factors have been studied so far. No study could be found taking into account this simple tool. The current study was planned to evaluate the correlation of physical activity, screen time and anthropometric parameters with CRF using RDT.

Subjects and Methods

The cross-sectional study was conducted at the Riphah International University, Islamabad, Pakistan, from October 2021 to May 2022. After approval from the institutional ethics review committee, the sample size was calculated using Raosoft calculator with 95% confidence level, 5% margin of error and 50% response distribution.[11]

The sample was raised using non-probability convenience

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sampling technique. Those included were undergraduate students of either gender aged 18-23 years. Those excluded were known cases of physical or mental disabilities and students with a history of major surgery or medications.

According to the American College of Sports Medicine guidelines for exercise testing, the students were asked to fill Physical Activity Readiness Questionnaire (PAR-Q+) proforma before initiating the test.[12] Those who answered NO to all the 7 questions were enrolled After taking informed consent.

Height (m) was measured without shoes using a wall-mounted stadiometer, and body weight was measured to the nearest 0.1kg using a digital scale, with the participants wearing light clothing and no shoes. BMI was calculated by dividing the body weight (kg) with height (m^2). Physical Activity Vital Sign (PAVS) is a tool created to quickly measure quantified self-reported physical activity level.[13]

PAVS equation=(days/week with physical activity) x (minutes of physical activity/day)=min of physical activity/wk.

Regarding screen time assessment, the participants were asked to estimate total time spent in hours using television, computer and smartphone. Screen time may show variations throughout the day and week, so the questionnaire further inquired about screen use on a typical college and weekend day.[14]

VO_{2max} is considered the gold standard for assessing CRF.[15] The RDT was performed at the end of the questionnaire, thus giving them time to rest for more than 5 min. A demo of how to do the squatting was also showed to them. After taking the resting HR (HR1), they were instructed to complete 30 squats in 45 min. At the end of the test, the second HR reading (HR2) was measured after 15 sec of the test, and the third heart rate reading (HR3) was measured after 1 min of the test. HR of the participants was measured using a pulse oximeter. The VO_{2max} was estimated using the following equation:

$$VO_{2max} = 3.0143 + 1.1585 \times \text{sex} - 0.0268 \times (HR1/\text{height}) + 118.7611 \times [(HR2 - HR3)/\text{age}^3].$$

The normative value of VO2max was taken as reference value corresponding to age 20-29 years both in males and females. CRF criterion-reference for males (poor: ≤24.9, fair: 25-33.9, average: 34-43.9, good: 44-52.9 and excellent: ≥53) and females (poor: ≤23.9, fair: 24-30.9, average: 31-38.9, good: 44-52.9 and excellent: ≥49) was determined based on the tertiles of CRF and expressed as millilitres per kilogram body mass per minute.[9]

Data was analysed using SPSS 26. Continuous data was presented as mean and standard deviation. The strength of the association between estimated VO_{2max} and variables was assessed by Pearson correlations coefficient test (*r*). The study data passed the normality test and was found to have no outliers. Multiple linear regression was performed to determine the independent contributions of variables on predicting CRF. Chi-square test was used for categorical variables. Statistical significance was set at $p<0.05$.

Results

Of the 300 subjects, 186(62%) were females and 114(38%) were males. The overall mean age was 19.56±1.5 years and mean BMI was 23.92±3.7 kg/m^2. Mean value of VO_{2max} for male subjects was higher than female subjects (Table-1).

There was a strong negative correlation between VO_{2max} and body weight (*r*=-0.54 females, *r*=-0.68 males). VO_{2max} showed positive relationship with physical activity, and negative relationship with BMI, HR1, HR2 and HR3, while the association of CRF with height in males was stronger than females (Table-2). Age and screen time showed no

Table-1: Participants' characteristics.

Variables	Total Mean±SD n=300	Females Mean±SD n=186	Males Mean±SD n=114
Mean Age (years)	19.56±1.5	19.74±1.69	19.26±1.36
Mean Body Weight (kg)	62.54±8.3	59.90±7.6	66.84±7.7
Height (m)	1.66±0.1	1.62±0.08	1.74±0.08
BMI (kg/m^2)	23.92±3.7	23.8±3.9	24.03±3.6
Screen time (hours/day)	3.10±1.0	3.22±0.99	2.8±1.1
Physical activity (min/week)	424.8±252	353.4±204	540±276
HR1 (beats/min)	74.6±12.3	73.8±10.8	75.42±14.8
HR2 (beats/min)	134.1±17.1	135.5±14.9	131.7±20.5
HR3 (beats/min)	95.1±21.3	96.32±21.4	93.21±21.6
Estimated VO_{2max} (L/min)	2.38±1.1	1.78±0.57	3.36±1.1
Estimated VO_{2max} (ml/kg/min)	39.3±12.4	36.05±10.0	44.60±14.2

BMI: body mass index, SD: Standard deviation, HR1: Resting heart rate, HR2: Maximum heart rate after squatting, HR3 = Recovery heart rate after 1 min, Estimated VO2max: Maximal oxygen consumption.

Table-2: Correlation of cardiorespiratory fitness (CRF) (VO2max ml/kg/min) with participant characteristics.

Variables	Females n=186		Males n=114	
	r-value	*p*-value	*r*-value	*p*-value
Age (years)	- 0.04	0.82	- 0.16	0.51
Height (m)	0.29	0.11	0.75	<0.001
Body Weight (kg)	- 0.54	0.001	- 0.68	0.001
Physical activity (min/week)	0.74	<0.001	0.77	<0.001
Screen time (hours/day)	- 0.25	0.16	- 0.14	0.54
BMI (kg/m^2)	- 0.73	<0.001	- 0.95	<0.001
HR1 (beats/min)	- 0.82	<0.001	- 0.75	<0.001
HR2 (beats/min)	- 0.75	<0.001	- 0.87	<0.001
HR3 (beats/min)	- 0.76	<0.001	- 0.85	<0.001

BMI: Body mass index, HR1: Resting heart rate, HR2: Maximum heart rate after squatting, HR3: Recovery heart rate after 1 min.

Table-3: Multiple linear regression analyses to predict cardiorespiratory fitness (CRF) among the study participants (n=300).

Variables	Total Sample				
	B	SE	ß	95% CI	*p*-value
BMI (kg/m^2)	- 1.44	0.40	-0.44	-2.2 to -0.62	0.001
Height (m)	8.28	8.28	0.06	-8.43 to 25.0	0.344
Body weight (kg)	-0.46	0.13	-0.31	0.18 to 0.75	0.002
Physical activity (min/week)	0.99	0.21	0.33	0.55 to 1.44	<0.001
HR1 (beats/min)	-2.08	0.09	-0.20	-0.39 to -0.01	0.034
HR2 (beats/min)	-0.12	0.07	-0.17	-0.26 to 0.01	0.084
HR3 (beats/min)	-0.05	0.06	-0.09	-0.17 to 0.06	0.352
Total R2				0.87	

BMI: Body mass index, HR1: Resting heart rate, HR2: Maximum heart rate after squatting, HR3: Recovery heart rate after 1 min, SE: Standard error, CI: Confidence interval.

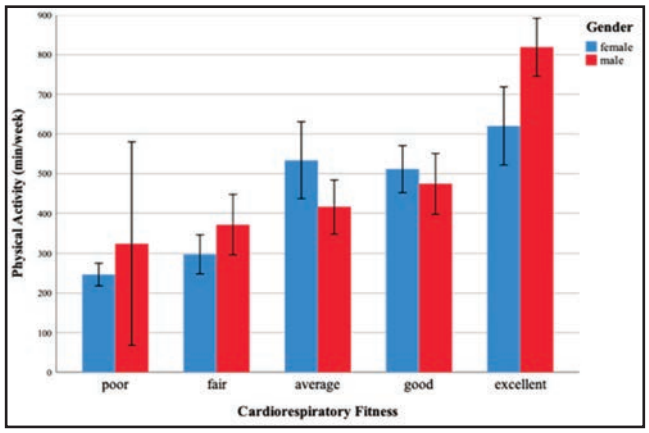

Figure: Cardiorespiratory fitness (CRF) (estimated VO2max) and physical activity levels of males and females. The dotted line represents current recommendations for physical activity.

significant association (p>0.05).

CRF was independent and positively associated with physical activity (p<0.001). There was significant inverse association of CRF with BMI, body weight and HR1 (Table 3). The model accounted for 87% of the variance of CRF.

Males in excellent CRF category were more physically active compared to those in poor, fair, average and good CRF categories, and significantly more males than females were in the average/excellent CRF category (Figure).

Discussion

RDT is an inexpensive valid method to assess CRF as a part of preventive medicine. The current study showed that physical activity was significantly correlated with VO_{2max} using the RDT. The findings are in line with previous studies.[16]

A Pakistani study reported that CRF capability and body composition of youth population can be strengthened by improving their routine physical exercise.[17] According to the current results, females were less physically active and spent more time watching TV or using computers then the male medical students. As a result, female participants had below-average CRF compared to males. Another possible explanation for females could be lack of time and completing priorities towards aerobic activities.[18] Another study mentioned barriers to physical activity, such as safety issues, limited indoor space for exercise and lack of affordable physical activity facilities and programmes for Pakistani females.[19] Therefore, understanding and addressing social and contextual influences on regular physical activity is essential to establish affordable programmes and facilities.

In medical colleges, students are at higher risk of getting obese due to physical inactivity and sedentary lifestyle. Obesity is responsible for decrease in lung compliance and stiffening of the respiratory muscles which may lead to increased risk of cardiovascular disease mortality.[20] The current findings demonstrated that the VO2max estimated by RDT was inversely correlated although significantly related with body weight and BMI. These findings are in line with earlier reports.[8] A recent study[7] suggested that body fat mass and BMI value could be helpful in achieving optimum physical fitness. In addition, poor performance during RDT evaluation predicts that overweight adolescents showed significantly decreased VO_{2max} due to increased oxygen demand to move excess body weight.[21] Excess adiposity may result in a state of cardiopulmonary deconditioning associated with greater cardiac load and functional impairment, which was also reported earlier.[22]

HR parameters were inversely correlated with the estimated VO2max. However, in multivariate model, only HR1 proved to be a significant predictor of the estimated VO2max. The participants with lower HR1 had significantly higher CRF due to low sympathetic activity.[23] Therefore, it is suggested that change in HR1 may be used to accurately detect changes in CRF over time. The strength of correlation between CRF and HR features found in the current study was comparable to previous studies.[10]

The current study has its limitations as it had a cross-sectional design with a relatively small sample size to allow generalisation. Also, only apparently healthy young adults without any medications or current disease history were included. Besides, the study participants were young adults aged 18-23 years. Further studies are required for better understanding of relation between different age groups with a wide range of BMI affecting CRF.

Conclusion

RDT could be used in clinical settings as it a rapid and inexpensive method. Physical activity, body weight and BMI had an influence on CRF. As such, appropriate

improvement in physical fitness programmes regarding physical exercise and healthy lifestyle should be incorporated in daily routine, which can greatly improve the quality of students' life and slow down the aging process.

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