Scientific Research Publishing

Open Journal of Therapy and Rehabilitation, 2023, 11, 1-16
https://www.scirp.org/journal/ojtr
ISSN Online: 2332-1830
ISSN Print: 2332-1822

Health Related Physical Fitness Measures: Reference Values and Predictive Equations for Saudi Female College Students

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How to cite this paper: Shaheen, A.A.M. (2023) Health Related Physical Fitness Measures: Reference Values and Predictive Equations for Saudi Female College Students. *Open Journal of Therapy and Rehabilitation*, **11**, 1-16.
https://doi.org/10.4236/ojtr.2023.111001

Received: January 2, 2023
Accepted: February 5, 2023
Published: February 8, 2023

Abstract

Health related-physical fitness (HRPF) is critical for maintaining and enhancing health and quality of life. **Purposes:** To estimate the reference values and predictive equations for frequently used clinical field HRPF measures in a sample of Saudi female college students aged 18 - 24 years. **Methods:** In this cross-sectional study, body fat percentage (BF %) was estimated. Curl-up test (CUT) and sit and reach test (SRT) were applied in 216 students. The Queen's College Step Test (QCST) was used to predict maximal oxygen consumption (VO_2 max). Physical activity (PA) level was also measured using International Physical Activity Questionnaire (IPAQ). **Results:** The mean of BF %, SRT, CUT, and predicted VO_2 max were 23.98% ± 6.13%, 17.10 ± 7.50 cm, 28.17 ± 7.72 number/min, and 39.58 ± 4.01 ml/kg/min respectively. There was no significant effect of age on all HRPF measures except for BF % ($F_{(6,215)} = 3.25$, $p < 0.005$) and CUT ($F_{(6,215)} = 4.01$, $p < 0.001$). Regression analysis demonstrated that BMI was the predictor for BF % and SRT and explained 65% and 4% of total variance respectively. IPAQ score, age, and height were the predictors of CUT counting 17% of total variance. While, BMI and IPAQ score were the predictors for VO_2 max and explained 13% of the total variance. **Conclusion:** Reference values can be used clinically in the evaluation of HRPF, in the rehabilitation process as well as in designing a program to improve the HRPF for female college students with consideration of age, height, BMI, and PA level for a particular population.

Keywords

Physical Activity, Health Related Physical Fitness, Female College Students, Saudi Arabia

1. Introduction

Health-related physical fitness (HRPF) has been defined as a set of attributes or characteristics that people have or achieve, that relates to the ability to perform physical activity (PA). These characteristics are divided mainly into health-or skill-related components [1]. It is considered as an indirect marker of a person's health and wellbeing reflecting the interplay and integration of many persons' systems and body functions (musculoskeletal, cardiorespiratory, hemato-circulatory, psycho-neurological, and body composition) [2]. The HRPF involves: body composition, muscle strength and endurance, cardiorespiratory fitness (CRF), and flexibility. Improvement of these components reduces the risk of diseases and disability, along with risk of the mortality and morbidity. Several factors may influence HRPF including: age, gender, genetic [3], nutritional habits [4], race, and ethnics [5] and many are outside a person's control.

Until now a lot of people use the PA and physical fitness terms interchangeably. Although PA and physical fitness are different in concept from each other, they are directly related. Simply PA is a behavior while physical fitness is a set of attributes that are either health- or skill-related, biological or physical characteristic [6].

PA clearly affects the HRPF and vice versa. There is an association between low physical fitness, low PA level, and sedentary lifestyle which is a common issue in Saudi society [7]. Saudi Arabia (SA) has one of the highest prevalence of obesity and overweight in recent decades [8]. Furthermore, the high prevalence of physical inactivity is a significant public health issue particularly among Saudi females [9]. More than 91% of Saudi females, according to the results of a recent study, did not participate in any type of PA [10].

HRPF testing is a highly evident and significant part of physical fitness programs. It is important to monitor fitness to evaluate risk factors for health dangers [11]. Additionally, clinicians need measurement tools that can be used in clinical settings to assess HRPF [12]. For clinical viability, field tests of physical performance that are easily accessible, quick to complete, time-efficient, and requiring no or only portable equipment can be used [13]. Subsequently, reference values and predictive equations for HRPF measures are necessary to detect individual with high risk, to improve the interpretability and clinical usefulness of clinical field tests, to monitor physical fitness in clinical practice especially in physical therapy field, for research purposes [14], and to design a program to improve HRPF for female college students.

Normative values and predictive equations are previously established for body fat percentage (BF %) [15] [16], Sit and reach test (SRT) [17], curl-up test (CUT), and maximus oxygen consumption (VO_2 max) [18], but these values were derived from studies presented for some specific age groups in different nationalities and races. Based on literature, every population needs specific reference values because of the differences on race, gene, native, environment, and PA level. Up to the author's knowledge, assessment of HRPF components among Saudi females is scarce. Few studies have addressed HRPF components in a sample of Saudi females with different age groups in Riyadh city [19], Qassim [20], and Madinah (western region) [21] without establishment of predictive equations. Therefore, this study aimed to estimate the reference values for the frequently used clinical field HRPF measures and establish the predictive equations in a sample of Saudi female college students aged 18 - 24 years in Riyadh-SA.

2. Methods

2.1. Ethical Approval and Consent

This cross-sectional observational study was conducted in accordance with the Helsinki Declaration of 1964 and its later revisions and after the approval from ethical committee, College of Applied Medical Science (CAMS)—King Saud University (KSU) (CAMS 089-3839). All participants signed informed consent form. The data were collected between March and September, 2018.

2.2. Subjects

A convenience sample of 236 female college students was recruited via advertisement, and e-mails. They were stratified according to their age into 7 groups (1-year increments). All participants were healthy, aged from 18 to 24 years, and free from disease or injury [22]. The exclusion criteria were physical or mental limitations [14], pregnancy, history of orthopedic problems such as episodes of hamstrings injuries, fractures, surgery or pain in the spine or hamstring muscles over the past six months, taking beta blocker or beta agonist asthma medication. In addition to the participants who did not abstain from caffeine for 24 hours, food for 2 hours, and strenuous exercise for the 10 hours prior to the test.

The sample size was calculated using the formula "$N > 104 + m$", where "N" is the sample size and "m" is the number of independent variables (n = 5; age, height, weight, BMI, and PA level) [23]. To ensure a representative sample, the participants were included from different colleges.

2.3. Procedure

Before test administration, 60-minute familiarization session was conducted, during which the researcher explained the experimental protocol and demonstrated the correct test performance. Body weight and height were measured to the nearest 0.1 kg and 0.5 cm respectively using Digital weight and mechanical height scale (Cardinal Detecto ProDoc Serries Physician Digital Scale), SN (E16611-0576). Body mass index (BMI) (kg/m^2) was also calculated [24].

The PA level was measured using the valid and reliable Arabic short version of the International Physical Activity Questionnaire (IPAQ). The questionnaire consists of 7 questions on the time spent in vigorous intensity activities, moderate-intensity activities, walking, and sedentary activities [25]. The metabolic equivalent minutes (MET-min)/week for walking, moderate, and vigorous-intensity activities were calculated. PA levels were classified into three categories:

inactive, minimally active, and health-enhancing physically active according to the scoring system provided by the IPAQ website (https://sites.google.com/site/theipaq/) [26].

The anthropometry component data were precisely measured and recorded by well-trained researcher and recorded based on standardized examination protocols. Using Holtain skinfold caliper with an accurate measurement up to a maximum of 45.0 mm, skin fold thickness (SFT) was measured at right triceps (TSF)) and iliac crest according to Ramos-Sepúlveda *et al.*, 2016 [27]. The body density was calculated using Sloan *et al.*, equation [28] that has been validated for both men and women. The equation for women is BD = 1.0764 − (0.0008 × iliac crest skinfold in mm) − (0.00088 × triceps skinfold in mm). Body fat percentage (BF %) was also calculated from body density using Siri method: BF % = (495/body density) − 450 [29]. Based on gender and age, BF % was measured and the participants were classified as having a low (BF % < 21.0%), normal (BF % 21.0% - 32.9%), high (BF % 33.0% - 38.9%), or very high (BF % ≥ 39%) BF % [30].

Abdominal muscle strength and endurance was tested using a valid and reliable curl-up test (CUT). The objective is to complete as many curl-ups as possible at a specified time (number/min). The CUT was selected because it does not include the assistance of the hip flexor muscles spine compared with a full sit-up [1].

To standardize the measurement scale of flexibility, sit and reach test (SRT), a standard meter rule was placed on the site-and-reach box for each test, with the reading of 23 cm in line with the heel position of each test. The participants sat on the floor with shoes removed, and fully extend two legs so that the sole of the foot was flat against the end of the box. They extended their arms forward, placing one hand on top of the other. With palms down, they reached forward sling hands along the measuring scale as far as possible without bending the knee of the extend leg. Higher scores indicated better performance. The score was negative if the participant could not touch the front of the box with her fingertips, where the "0" point is located. The test was performed twice and the greatest distance was recorded as the result. The forward reach scores were recorded in centimeters to the nearest 0.5 cm using the scale on the box [31].

The Queen's College Step Test (QCST) was performed to predict the maximal oxygen consumption (VO_2 max). It was performed using a step of 41.3 cm height. Stepping was done for a total 3 minutes at a rate of 22 cycles/minute which was set by metronome. Upon completion of the test, participants were asked to remain standing comfortably and the carotid pulse rate was measured from the fifth to the twentieth second of the recovery periods in sitting position. Prior to this, each participant was seated for 5 minutes during which their pulse rate (PR) was recorded for a period of 1 minute. The pulse rate obtained after the test was then substituted in the formula: VO_2 max (ml/kg/min) (women) = 65.81 − (0.1847 × pulse rate in beats per min) to yield the VO_2 max values and be categorized according to the norms [32].

2.4. Data Analysis

The data were treated using Statistical package for social sciences program, version 22 (SPSS Inc., Chicago, IL, USA) for Windows ®. Shapiro Wilk test was used to test data normality. Descriptive statistics was used to summarize the population's demographic and clinical parameters. The data were presented as mean ± SD or median as appropriate. The analysis of covariance (ANCOVAs) was measured to determine the effect of age on each component of HRPF. Post hoc analysis (Scheffe-test) was used to detect the difference in each pair-wise condition. Pearson's (r) and/or Spearman's (rho) correlation coefficients were applied to investigate the correlation between the each HRPF components and independent variables. Where values of r and/or rho from 0.0 to 0.25, 0.26 to 0.49, 0.50 to 0.69, 0.70 to 0.89, and 0.90 to 1.00 were considered as little, low, moderate, high, and very high correlation respectively [33]. Stepwise multiple linear regression was used to determine if any of the independent variables predict each HRPF component. The presence of multicollinearity between the independent variables was tested using the variance inflation factors (VIF) at a cut-off point of 5 - 10 [34]. Values was considered statistically significant if $p < 0.05$.

3. Result

Totally, 236 participants volunteer to participate in this study. Of them, 216 met the inclusion criteria and the remining 20 participants were excluded due to smoking (4 participants), inability to complete the step test (6 participants) or refused to complete the study (10 participants).

All the data were normally distributed ($p > 0.05$). The mean age and BMI were 20.78 ± 1.38 years and 24.10 ± 5.19 Kg/cm^2. For the entire sample, 107 (49.54%) have a normal BMI while 81 (37.5%) were overweight and obese while 28 (12.96%) were underweight. The majority of the participants 86 (39.8%) have a moderate PA level (**Table 1**). About 57 (26.4%) of the participants have low BF %, while 117 (54.2%), 40 (18.5%), and 2 (0.9%) has normal, high, and very high BF % respectively.

The Mean ± SD of the BF %, SRT, CUT and estimated VO_2 max after QCST were summarized in **Table 2**. The results of ANCOVA showed non-significant effect of age on all HRPF measures except for BF % ($F_{(6,215)} = 3.25$, $p < 0.005$) and CUT ($F_{(6,215)} = 4.01$, $p < 0.001$). On average, the 18 years old females have a significant higher BF % compared to 21 years old (mean difference = 6.74, p = 0.024). Additionally, the 24 years females performed a higher number of counting in CUT with significant difference between the age groups; 18- and 24-year (mean difference = −12.70, p = 0.026), 19- and 24-year (mean difference = −12.61, p = 0.008), and 20- and 24-year (mean difference = −9.17, p = 0.042).

The correlations between the independent variables and HRPF measures using r coefficient were summarized in **Table 3**. Weight and BMI showed high significant positive correlation with BF % (r = 0.75, p = 0.000 and r = 0.80, p = 0.000, respectively) and little positive correlation with SRT (r = 0.17, p = 0.01

Table 1. Characteristic of the participants (n = 216).

Age (yr)	N	Height (cm)	Weight (Kg)	BMI Kg/cm^2	PA level		
					Low	Moderate	High
18	10	156.00 ± 6.79	68.84 ± 9.27	28.65 ± 4.10	2 (20%)	5 (50%)	3 (30%)
19	16	158.03 ± 5.88	62.23 ± 13.61	25.01 ± 5.60	5 (31.2%)	8 (50%)	3 (18%)
20	70	156.52 ± 5.07	56.56 ± 14.30	22.96 ± 5.47	33 (47.1%)	21 (30.0%)	16 (22.9%)
21	55	157.69 ± 6.37	58.39 ± 13.87	23.49 ± 5.03	14 (25.5%)	27 (49.1%)	14 (25.5%)
22	43	158.01 ± 4.47	61.87 ± 13.93	25.62 ± 5.15	15 (34.9%)	20 (46.5%)	8 (18.6%)
23	12	157.50 ± 4.73	58.56 ± 9.19	23.87 ± 3.13	4 (33.3%)	3 (25.0%)	5 (41.7%)
24	10	159.45 ± 3.82	65.22 ± 11.94	23.09 ± 3.03	5 (50.0%)	2 (20.0%)	3 (30%)
Total	216	157.39 ± 5.39	59.58 ± 13.75	24.10 ± 5.19	78 (36.1%)	86 (39.8%)	52 (24.1%)

Data are represented as mean ± SD or N (%) unless otherwise stated. M: Mean, SD: Standard deviation, Yr: Year, kg: Kilogram, cm: Centimeter, %: percentile, BMI: body mass index, IPAQ: international physical activity questionnaire.

Table 2. Normative values of HRPF measures.

Age (yr)	N	SFT (BF %)	SRT (cm)	CUT (Number/min)	QCST (Predicted VO_2 max) (ml/kg/min)
18	10	28.70 ± 6.15*	17.85 ± 8.71	24.10 ± 7.43	38.83 ± 3.04
19	16	25.62 ± 5.92	17.67 ± 7.72	24.19 ± 7.27	40.59 ± 4.51
20	70	23.16 ± 5.78	16.13 ± 7.39	27.63 ± 7.14	39.53 ± 3.68
21	55	21.28 ± 5.93	16.65 ± 7.43	28.47 ± 5.17	39.51 ± 3.93
22	43	25.28 ± 5.93	17.83 ± 6.88	28.14 ± 8.96	38.71 ± 4.11
23	12	25.08 ± 5.76	19.57 ± 7.35	31.50 ± 5.07	39.84 ± 5.09
24	10	26.50 ± 5.84	18.69 ± 10.33	36.80 ± 13.34*	42.94 ± 3.96
Total	216	23.98 ± 6.13	17.10 ± 7.50	28.17 ± 7.72	39.58 ± 4.01

M: Mean, SD: Standard Deviation, %: percentage, Count/min: number/ minute, cm: Centimeter, ml/kg/min: milliliter/kilogram/minute. *Significant difference between age groups ($p < 0.5$).

Table 3. Correlations age, height, weight, BMI, and IPAQ score and HRPF using Pearson correlation coefficient.

HRPF measures	Independent variables				
	Age	**Height**	**Weight**	**BMI**	**IPAQ score**
	r	**r**	**r**	**r**	**r**
BF %	−0.12	0.02	0.75**	0.803**	−0.02
SRT	0.08	0.08	0.17*	0.20**	0.13*

Continued

CUT	0.28**	0.22**	0.10	(0.02)	0.30**
VO_2 max	0.05	−0.001	−0.22**	−0.31**	0.14*

*Correlation is significant at p < 0.05; **Correlation is significant at the 0.01 level. BMI: body mass index. IPAQ: International Physical Activity Questionnaire.

and 0.20, p = 0.001, respectively). Little to moderate significant positive correlations between age, height, IPAQ score, and CUT were reported. Additionally, there were little to low significant negative correlations between weight, BMI, and VO_2 max. Finally, little positive correlation was also observed between IPAQ score and predicted VO_2 max.

BF % is negatively correlated with CUT score (−0.2, p = 0.001), and VO_2 max (−0.15, p = 0.03) indicating poor physical fitness outcomes. On the other hand, CUT score is positively correlated with flexibility (SRT) (0.217, p = 0.001) and VO_2 max (r = 0.3, p = 0.001).

For each HRPF measure, the significantly associated factors were included in stepwise regression analysis. BMI, age, IPAQ score, and height were the significant predictors (Table 4). BMI was the predictor for BF % and SRT and explained 65% and 4% of total variance of tests' values respectively. IPAQ score, age, and height were the predictors of CUT representing 17% of total variance of the test score. For VO_2 max, the predictors were BMI and IPAQ score. They explained 13% of total variance of VO_2 max value.

The Predictive equations were:

BF % = 1.14 + 0.95 × [BMI (Kg/cm^2)]; r = 0.80

SRT (cm) = 10.24 + 0.29 × [BMI (Kg/cm^2)]; r = 0.20

CUT (number/min) = −35.00 + 0.001 × [IPAQ score] + 1.37 [age (yr)] + 0.21 × [Height (cm)]; r = 0.42

VO_2 max (ml/kg/min) = 45.05 − 0.25 × [BMI (Kg/cm^2)] + 0.001 × [IPAQ score]; r = 0.35

4. Discussion

This study aimed to estimate the reference values for the frequently used HRPF measures and establish the predictive equations in a sample of Saudi female college students aged 18 - 24 years in Riyadh-SA. In this manner, this study sought to fill a gap in literature regarding the reference values for this population. There was no significant effect of age on all HRPF measures except for BF % and CUT score. Also, the increase of BMI was associated with increase of BF %, SRT score and decrease of predicted VO_2 max. On the other hand, the increase in IPAQ score was positively correlated with CUT score and predicted VO_2 max. Based on the stepwise regression analysis, BMI was the predictor for BF % and SRT score. IPAQ score, age, and height were the predictors of CUT. Additionally, BMI and IPAQ score were the predictors of VO_2 max.

Table 4. A stepwise multiple linear regression analysis and reference equations for HRPF tests.

Model	Independent Variables	R	R^2	unstandardized coefficients		Standardized coefficients	t	p-value
				B	St. Error	β		
BF %								
1	**(Constant)**	0.80	0.65	1.14	1.18		0.91	0.34
	BMI			0.95	0.05	0.80	19.74	0.000
SRT (cm)								
1	**(Constant)**	0.20	0.04	10.24	2.39		4.29	0.000
	BMI			0.29	0.09	0.20	2.94	0.004
CUT (count/min)								
1	**Constant**	0.30	0.09	26.26	0.66		39.99	0.000
	IPAQ			0.001	0.00	0.30	4.53	0.000
2	**Constant**	0.39	0.15	−3.98	7.48		−0.53	0.595
	IPAQ			0.001	0.00	0.28	4.41	0.000
	Age			1.46	0.36	0.26	4.06	0.000
3	**(Constant)**	0.42	0.17	−35.00	15.38		−2.28	0.024
	IPAQ			0.001	0.00	0.26	4.03	0.000
	Age			1.37	0.36	0.24	3.82	0.000
	Height			0.21	0.09	0.15	2.30	0.022
CRF (Predicted VO_2 max) (ml/kg/min)								
1	**(Constant)**	0.31	0.10	45.33	1.24		36.61	0.000
	BMI			−0.24	0.05	−0.31	−4.75	0.000
2	**(Constant)**	0.35	0.13	45.05	1.225		36.76	0.000
	BMI			−0.25	0.05	−0.33	−5.04	0.000
	IPAQ			0.001	0.00	0.17	2.68	0.000

%: Percentage, BMI: Body Mass Index, IPAQ: International Physical Activity Questionnaire; St. Error: Standard Error, BF %: Body Fat percentage, SRT: Sit and Reach Test, CRF: Cardiorespiratory Fitness.

At the population level, body composition can be used to assess the nutrition status and to study both the determinants and consequences of malnutrition and/or other risk factors [35]. Body composition is expressed as BF % when used as one of HRPF components and it is considered to be a good indicator [36]. The worrisome prevalence of obesity and overweight status in SA has rapidly increased over the past few decades, making it one of the highest rates of these conditions worldwide [8]. Saudi female university students are known to have bad lifestyle and BF %. A cross-sectional study among students aged 22.5 ± 10.3 years discovered a connection between low levels of PA, poor sleep quality, skipping breakfast, and excessive body fat as measured by bioelectrical impendence analysis [37].

The mean of BF % reported in this study (23.98% ± 6.13%) did not exceed the normal value. Comparable to previous studies, the BF % is considerably low indicating a substantially low risk of disease, particularly when accompanied by a healthy lifestyle. This value is lower than that of Saudi female physical education and sport sciences (PESS) students with mean age 18.7 ± 0.6 years (BF % = 32.3%), female college students at Taibah University (35.1% ± 12.4%) [30], and Saudi female adults between 20 - 60 years (40.4%) [21].

The discrepancy may be attributed to many factors. First, despite the mean BMI of the participants is consistent with similar target populations in SA and in different countries (24.10 ± 5.19 kg/m^2) [38] [39] [40] smaller proportion of the participants (37.5%) were overweight and obese compared to 57.5% of PESS female students. In addition, only 19.44% of the participants had high or very high levels of total BF % compared to the percentage reported by Al-Rethaiaa *et al.*, 2010 where more than 55% had high or very high levels of total BF % [41]. The second attribute may be the difference in measurement techniques. In consistent with previous studies [42] [43] [44], the increase of BMI was associated with increase of BF %. Additionally, the negative correlation between the BF % and PA was supported by literature [44] [45].

Fitness and health both benefit from flexibility [46]. Reduced risk of lower back pain and other musculoskeletal injuries has been associated with flexibility in the lower back and hamstring areas [47]. High levels of flexibility in adolescence have also been found to reduce the risk of neck tension in older men [48]. Research further suggests that children who have high adiposity or low flexibility levels are more likely to continue to do so into adolescence, putting them at greater risk of developing diseases later in life [49].

The present study's findings showed that the average flexibility value was 17.10 ± 7.50 cm which considered "Good" according to Australian collage of sport and fitness. Up to author's knowledge, only one available study used a SRT to assess muscle flexibility in Saudi female PESS [21]. The average of SRT was 16.6 ± 3.0 cm which is slightly lower than ours. On the other hand, the score of SRT elaborated in this study was lower that reported in previous studies [50] [51].

In agreement with Huang *et al.*, 2002, [52] a positive significant correlation was found between PA and flexibility. However, Kordi *et al.*, 2010 reported non-significant correlation between flexibility and PA. One may criticize because the sample size, age, and physical habits [53]. Interestingly, the increase of BMI was associated with increase of flexibility. Unlike, Kordi *et al.*, 2010 [54] demonstrated a negative relationship between BMI and flexibility [19] [55].

Since several negative health effects, as disability, morbidity, and mortality, have been linked to muscle weakness, muscle strength is an important indication to measure [56]. Supporting our result, strong evidence suggests that muscle strength has positive relation with PA [57] [58] [59] [60]. Contrary, no correlation between abdominal muscle strength and PA was established in Taiwanese adolescents [52]. In this study, the value of CUT was 28.17 ± 7.72 number/min which considered "average" according to ACSM's [1].

One independent risk factor for cardiovascular disease is the CRF [61]. Using different exercise protocols, few studies were conducted in SA to assess CRF using a standard exercise fitness test. Therefore, it was challenging to compare our results. Up to author's knowledge, only one study measured VO_2 max directly using a gas exchange analyzer (COSMED system) and concluded that collegiate students with low VO_2 max (<28.9 ml/kg/min) have an increased risk of developing cardiovascular diseases, compared to those with high VO_2 max (>33 ml·kg·min) [62].

Two studies used indirect measures and applied the Bruce Treadmill Protocol to predict VO_2 max from the total time until exhaustion in young Saudi female university students and showed that the average VO_2 max was between 30.7 and 32.0 ml/kg/min [63]. Using the QCST, another study conducted in Saudi female PESS students who achieved a slightly lower value of VO_2 max (36.3 ml/kg/min) [21] than that reported in the present study (39.58 ± 4.01 ml/kg/min). However, in both studies, the participants achieved higher CRF scores than those previously recorded in the abovementioned studies conducted in a similar population. Meanwhile, in both studies the CRF level was similar to those reported elsewhere using QCST test to predicate VO_2 max [64].

Hingorjo *et al.*, (2017) assessed CRF by estimating the predicted VO_2 max after QCST for medical college students, the female VO_2 max mean (39.91 ± 3.14 ml/kg/min) was very similar to our result [65]. However, Kordi *et al.*, (2010) established a normative value of HRPF tests on healthy women aged 20 - 60 years old. The VO_2 max level for 20 - 29-year-old age group was very low (32.61 ± 3.29 ml/kg/min) compared to ours [53]. In addition, Nabi *et al.*, (2015) measured CRF in young adult medical students and observed their VO_2 max level that was lower than ours, especially in females as their mean VO_2 max was 37.85 ± 4.3 ml/kg/min [66].

A recent study also found a nearly similar VO_2 max score of 38.5 ± 8.2 ml/kg/min in young females (aged 16 - 18 years) [64]. The variations in the VO_2 max protocols utilized (e.g. the Bruce Treadmill Protocol, the Gas Exchange Analyzer, the QCST, etc.), decreased PA, unhealthy lifestyle behaviors, and different test protocol may be accounted for the discrepancies in cardiovascular fitness components among the aforementioned research.

In this study, the VO_2 max was affected negatively by BMI. The higher is the BMI the higher is the exertion level and the lower is their CRF. This result is supported by several studies showing a significant indirect correlation between CRF and BMI [65] [67]. Similar to Kurtze et al the predicted VO_2 max was positively correlated with PA [68]. However, da Cunha *et al.*, 2013 found non-significant correlation between VO_2 max and PA ($r = 0.41$, $p \le 0.01$) [69].

To improve the clinical applicability, the predictive equations for the BF %, SRT, and predicted VO_2 max were calculated. The established prediction equations using the predictive variables could be applied easily in both rehabilitation and research settings. However, the main problem when comparing normative values among similar studies starts from scares of the studies, variations in the methodology, data presentation [34], and differences in sample size and age.

5. Strength and Limitation

In short, this study is unique, up to the author's knowledge, this is the first to assess a set of HRPF components in a distinct sample of Saudi female college students and established the reference equations for the four main components of HRPF. Based on the results; programs based on nutrition, strengthening, and flexibility training are recommended. This study has several limitations: the use of a convenience sample, relatively small sample size, and including females only with limited age range (18 - 24 years). In addition, the PA was measured using a subjective self-reported questionnaire. Further studies to investigate normative values of HRPF measures on larger sample size for both genders in wide age range at different geographic regions of SA were recommended.

6. Conclusion

This study provides reference values and predictive equations for commonly used HRPF measures which may be helpful for physiotherapists and healthcare providers when conducting HRPF assessment, in clinical decision making, designing and compilation of intervention programs with consideration of age, height, BMI, and PA level for a particular population.

Conflicts of Interest

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

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