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Cardiorespiratory Fitness and Its Relationship with Health Risk Factors Among University Students: A Comparison Between Iran and Italy

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Abstract

Background: Cardiorespiratory Fitness (CRF) and its associated modifiable and non-modifiable health risk factors are very important in clinical studies.

Objectives: This study aimed to compare health risk factors affecting CRF between Iranian and Italian male and female exercise science students. The correlation between VO_2max and these factors was also evaluated.

Methods: The sample consisted of 87 sport science students from the University of Milan (25 males and 17 females) and the University of Mazandaran (20 males and 25 females) aged 23.69 ± 1.95 years. The level of Physical Activity (PA) and body composition indices were obtained as health risk factors. Then, CRF was assessed by the Bruce test. Rate Pressure Product (RPP), blood pressure, and Heart Rate (HR) were measured before, in the end, and six minutes after the end of the test.

Results: Statistical analyses revealed significant differences in RPP, Systolic Blood Pressure (SBP) during exercise, resting SBP, and Waist-to-Height Ratio (WHtR) between Iranian and Italian males and significant differences in Waist-to-Hip Ratio (WHR) and body fat percentage between Iranian and Italian females ($P < 0.05$). The relationships between VO_2max and resting RPP, resting HR, heart rate recovery, step counts, and vigorous PA were significant in all groups ($P < 0.05$).

Conclusions: As an assessment of VO_2max, CRF is associated with hemodynamics and health risk factors. Age, sex, ethnicity, lifestyle, and culture of people in different geographical regions can affect health risk factors.

Keywords: Cardiorespiratory Fitness, Physical Activity, Body Composition, Geographical Variation, Lifestyle Status

1. Background

As a predictor of Cardiovascular Diseases (CVD), Cardiorespiratory Fitness (CRF) refers to the capacity of respiratory and cardiovascular systems to provide muscles with oxygen (1). It can reduce the risk of chronic diseases, promote overall cardiovascular and general health, improve the quality of life, and delay CVD and mortality (2).

A criterion measure of CRF is Maximum Oxygen Uptake (VO_2max), the maximum amount of oxygen that a person can consume during maximal activity, typically expressed in ml/kg/min (1). Another parameter that measures CRF is Rate Pressure Product (RPP) (3). This parameter is used in cardiology to determine the workload of the heart and reflects hemodynamic responses (4).

There are several modifiable (low physical activity, overweight, etc.) and non-modifiable (age, ethnicity, family history, etc.) health risk factors that can affect CRF and lead to cardiovascular mortality (5). Modifiable risk factors can be reduced by changing the lifestyle (5). weight and physical activity are two of the most important modifiable risk factors that can affect CRF in a healthy lifestyle (6).

Regular Physical Activity (PA) by effecting hemodynamic responses, such as blood pressure, Heart Rate (HR), and myocardial work (3), and weight control can improve CRF (1). The frequency, intensity, duration, mode, and energy expenditure of PA are important variables for enhancing fitness and health (1). There are several methods for assessing PA, each of which has some disadvantages and advantages, and the method of choice can be selected based on purpose (1). The International Physical Activity Questionnaire (IPAQ) was proposed by the World Health Organization (WHO) as a standard PA questionnaire. The outcomes of IPAQ, particularly those related to vigorous PA, can lead to reliable CRF estimation (7). The pedometer is the simplest motion sensor and a non-invasive approach without interfering with daily life. This instrument is used to determine the level of PA in large groups (8).

Both low levels of PA and body shape and composition have shown consistently to be powerful predictors of CRF and they are often measured together (9). Complex factors that can cause obesity, including living environment, genetic factors, and lifestyle are related to behaviors such as PA, nutrition, and socioeconomic factors (10). The living environment has been reported to influence health risk factors related to CRF and be associated with obesity (11). As expected, obesity-related features such as Body Mass Index (BMI) and body shape differ significantly between geographical regions (10). A sedentary lifestyle by the design of the living environment may be one of many factors contributing to increasing obesity in communities (12). Living environmental factors, like cues to exercise, can dedicate barriers to PA participation or augment regular activity (11). In the context of the public health goal, walking, as one of the most common types of PA, is most to be amenable to change based on the built of the living environment (12).

Many studies have focused on CRF and health risk factors in different student communities, both inside and abroad (8, 13, 14). There are a lot of differences between Iran and Italy. Their cultures, geography, public health status, and educational systems are different. The understanding of regional variations in obesity, PA, and CRF among students of different regions can provide planning knowledge to improve and change the lifestyle.

2. Objectives

The objective of the present study was to compare health risk factors affecting CRF of Iranian and Italian male and female exercise science students. The correlation between VO_2max and these factors were also evaluated.

3. Methods

3.1. Participants

The study sample included 87 exercise science students that were selected from the University of Mazandaran (20 males and 25 females) and the University of Milan (25 males and 17 females). A stratified sampling method was used to select the subjects. Based on initial medical examinations, subjects did not have heart disease and chronic illness. Also, they were not professional athletes and passed the same practical units. Before participation, all participants signed informed consent forms. Besides, the study followed the guidelines of both Universities' Ethics Committees.

3.2. CRF Assessment

The Bruce test protocol is usually used to assess VO_2max (15). It is a treadmill test that involves several stages lasting three minutes each. The test started with warm-up at a speed of 2.7 km/h and a 10% incline. At the end of each stage, the incline and speed increased until the participant reached volitional fatigue (13). Then, VO_2max was estimated using the Bruce protocol formula by Foster et al. for males and females (Equations 1 and 2) (15).

$$For\ males:\ 14.8\quad (1.397 \times T) + (0.451 \times T2) - (0.012 \times T3) \tag{1}$$

$$For\ females:\ (4.38 \times T) - 3.9 \tag{2}$$

T: Total time on the treadmill as a fraction of minute

Besides, HR was continuously monitored using a Polar HR monitor (mod. S810, Polar, Finland). Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were determined by a blood pressure monitoring device (mod HS-201N, Nation). The RPP was calculated as the product of HR and SBP (3), and HR Recovery (HRR) as the difference between HR at peak exercise and after six minutes of recovery. These parameters were measured at rest, immediately, and six minutes after the test.

3.3. PA Measurement

Step counts: The pedometer stored the number of steps in its memory. Participants were requested to wear a pedometer for three to seven days, as worn in most studies (16), conform their habitual life, and pick up the pedometer only during bathing or sleeping.

IPAQ-S: All students were provided with the Italian and Iranian versions of the short form of IPAQ. According to the IPAQ-S scoring protocol, MET-minutes/week of vigorous PA was computed by multiplying the MET value of vigorous activity by the hours spent in that activity (Equation 3) (16).

$$Vigorous\ PA = 8 \times vigorous\ activity\ minutes \times vigorous\ activity\ days \tag{3}$$

3.4. Body Composition Measurement

Anthropometric measures were completed as part of the health screening event. Body height and body mass were measured by digital scales and portable stadiometers with 0.5 cm and 0.1 kg accuracy, respectively. Waist Circumference (WC) (around the abdomen at the level of the umbilicus) and Hip Circumference (HC) (at the level of the greatest protrusion of the gluteal muscles) were measured in a horizontal plane. Based on these initial measurements, the study variables were calculated as follows (17, 18):

$$BMI = \frac{Weight\,(kg)}{Height^2\,(m)} \quad (4)$$

$$WHR = \frac{WC\,(cm)}{HC\,(cm)} \quad (5)$$

$$WHtR = \frac{WC\,(cm)}{Height\,(cm)} \quad (6)$$

$$BAI = \left(\frac{HC\,(cm)}{(Height\,(m)\,)}^{1.5}\right) - 18 \quad (7)$$

$$ABSI = \frac{WC\,(cm)}{BMI^{\frac{2}{3}}\,Height^{\frac{1}{2}}} \quad (8)$$

3.5. Statistical Analysis

The Kolmogorov-Smirnov analysis was performed for all the main variables to assess the normal distribution of the data. Differences between the groups were assessed by the independent sample *t*-test and the associations of various anthropometric measurements and PA with CRF in each group were assessed by Pearson correlation. The calculations were performed by SPSS version 21 software, and the results were considered statistically significant at $P < 0.05$.

4. Results

Table 1 shows the mean and standard deviation of the demographic characteristics of the participants. The mean age of the participants was 23.78 ± 2.1 years, the height was 170 ± 5.6 cm, and the body mass was 66.01 ± 7.5 kg.

Among the CRF factors, only the differences between RPPmax, SBPmax, and SBPrest ($P < 0.05$) in males were significant (Table 2).

Also, among the body composition and PA factors, only differences between WHtR in males ($P < 0.05$) and WHR and body fat percentage in females ($P < 0.05$) were significant (Table 3).

The relationships between VO_2max and RPPrest, RHR, and HRR were significant in all the groups ($P < 0.05$) (Table 4).

Also, the relationships between VO_2max and vigorous PA and step counts were significant in all the groups ($P < 0.05$) (Table 5).

The relationships of VO_2max with WHtR in Mazandaran male students, VO_2max with BMI in Milan male students, and VO_2max with ABSI and WHR in Milan female students were significant ($P < 0.05$) (Table 5).

5. Discussion

In the present study, we compared CRF, anthropometric parameters, and PA between Iranian and Italian male and female exercise science students. Also, the correlation between VO_2max and these factors was evaluated.

As shown in Table 2, Iranian males had significantly higher SBPrest than Italian males. The relationship between the geographic area and SBPrest in developing countries may be a result of emerging new risk factors for hypertension such as nutrition and psychosocial stress (14). Kramer et al. investigated the association of race and social factors with BP among Spanish and Chinese people. They showed the effect of social factors, such as diet and socioeconomic factors, including education level and economic status on BP (19).

Based on the results of the present study, Italian males had significantly higher SBPmax and RPPmax than Iranian males (Table 2). Physical activity and stress response of the body, through elevating sympathetic activity, reducing parasympathetic activity, and increasing HR and SBP, can lead to increased RPP (3).

Also, there were significant differences in WHtR between Iranian and Italian males and significant differences in BF% and WHR between Iranian and Italian females (Table 3). In general, differences in anthropometric measures among ethnic groups or geographic regions may reflect differences in various aspects of lifestyle and culture, as well as genetic background (20). Lahmann et al. showed significant differences in BMI and WHR between Germans and Swedes in both genders. They showed that differences in lifestyle characteristics, such as smoking, diet, and alcohol consumption, play an important role in the etiology of obesity (20).

The results of this study also showed significant positive relationships between VO_2max and step counts and vigorous PA in all groups (Table 5). That is in agreement with the studies by Schember and Riebe (16) and Lubans et al. (8). Lubans et al. examined the relationship between step counts and VO_2max in male and female school students. Based on their results, participants with high fitness levels accumulated more steps per day (8). Schember et al. used an IPAQ outcome, vigorous-intensity PA, for predicting CRF as a non-exercise predictor in healthy college-aged males and females. The findings from their study revealed a significant relationship between VO_2max and vigorous PA, among other IPAQ outcomes (16).

According to results in Table 5, there were significant inverse relationships between VO_2max and BMI (in Italian males), WHR and ABSI (in Italian females), and WHtR (in Iranian males). People with less CRF are more likely to be overweight or obese than those with high CRF (20). There

Table 1. Demographic Characteristics of the Participants (Mean ± SD)

Variable	Males			Females		
	Mazandaran (N = 20)	Milan (N = 25)	P Value	Mazandaran (N = 25)	Milan (N = 17)	P Value
Age (years)	24.18 ± 1.3	24.6 ± 2.1	0.564	23.03 ± 3.1	22.67 ± 1.3	0.142
Height (cm)	173 ± 7.1	176 ± 5.2	0.398	165 ± 5.1	166 ± 6.2	0.325
Body mass (kg)	71.25 ± 6.23	70.8 ± 5.5	0.217	61.6 ± 9.4	60.41 ± 9.1	0.254

Table 2. CRF Characteristics of Mazandaran and Milan University Male and Female Students (Mean ± SD)

Variable	Male			Female		
	Mazandaran (N = 20)	Milan (N = 25)	P Value[a]	Mazandaran (N = 25)	Milan (N = 17)	P Value[a]
VO_2max (ml/kg/min)	53.43 ± 4.2	55.32 ± 7.8	0.365	42.91 ± 5.5	44.26 ± 5.4	0.529
RPPmax (mmHg•bpm)	15828 ± 3301	18041 ± 2263	0.005[a]	16295 ± 3015	16845 ± 1898	0.081
RPPrest (mmHg•bpm)	9375 ± 1778	8958.6 ± 1090	0.123	9699.93 ± 1811	9732.1 ± 1447	0.998
RPPrec (mmHg•bpm)	10539 ± 1945	10487 ± 1769	0.098	11162.5 ± 1035	10739 ± 2156	0.082
HRmax (bpm)	103.1 ± 8.6	102.9 ± 6.2	0.739	111 ± 9.01	110.5 ± 6.1	0.082
RHR (bpm)	74.6 ± 9.7	75.7 ± 7.4	0.678	82.63 ± 10	81.5 ± 11.6	0.629
HRR (s)	18.68 ± 7.6	18.33 ± 8.3	0.739	16.9 ± 8.3	16.2 ± 7.6	0.981
SBPmax (mmHg)	151 ± 6.1	166 ± 7.2	0.04[a]	141 ± 8.4	150 ± 7.2	0.062
SBPrest (mmHg)	129 ± 8.5	119 ± 7.2	0.049[a]	111 ± 6.9	115 ± 5.2	0.242
SBPrec (mmHg)	122 ± 9.3	123 ± 10	0.732	112 ± 4.1	115 ± 4.7	0.271
DBPrest (mmHg)	84.87 ± 3.3	77.23 ± 4.2	0.089	75.01 ± 4.5	77.22 ± 4.1	0.156
DBPrec (mmHg)	83.6 ± 5.1	72.8 ± 4.2	0.065	74.81 ± 6.1	74.69 ± 4.1	0.894
DBPmax (mmHg)	82.85 ± 5.2	71.8 ± 5.9	0.077	73.21 ± 7.5	74.11 ± 3.5	0.282

Abbreviations: HRR, HR recovery; RHR, Resting HR; RPPrest, Resting RPP, RPPmax, RPP after exercise; RPPrec, RPP after six minutes of recovery
[a] Significantly different from the Mazandaran group

Table 3. Body composition and Physical Activity Characteristics of Mazandaran and Milan University Male and Female Students (Mean ± SD)

Variable	Male			Female		
	Mazandaran (N = 20)	Milan (N = 25)	P Value[a]	Mazandaran (N = 25)	Milan (N = 17)	P Value[a]
Anthropometrics						
BMI (kg/m^2)	23.6 ± 3.3	22.9 ± 2.2	0.41	22.5 ± 2.6	21.6 ± 2.1	0.35
WHR	0.77 ± 0.03	0.79 ± 0.03	0.342	0.74 ± 0.02	0.7 ± 0.04	0.048[a]
WHtR	0.46 ± 0.03	0.42 ± 0.02	0.002[a]	0.42 ± 0.02	0.39 ± 0.02	0.32
ABSI	0.074 ± 0.003	0.073 ± 0.004	0.243	0.067 ± 0.002	0.066 ± 0.003	0.283
BAI	23.27 ± 2.5	22.54 ± 2.3	0.401	27.75 ± 2.6	25.89 ± 2.2	0.348
Body fat %	13.97 ± 4.8	12.03 ± 4.7	0.062	23.39 ± 3.03	18.72 ± 4.2	0.006[a]
PA						
Step counts (n/day)	8160 ± 1995	8391 ± 1845	0.681	8103 ± 1990	7989 ± 1623	0.623
Vigorous PA (MET-min/week)	2365 ± 1009	1750 ± 1697	0.2	2546 ± 1700	1653 ± 1284	0.123

Abbreviations: ABSI, body shape index; BAI, body adiposity index; WHR, waist to hip ratio; WHtR, waist to height ratio
[a] Significantly different from the Mazandaran group

are many anthropometric measures for assessing adiposity, each presenting limitations (21). Various anthropometric measures and their relationship with CRF for surrogate overall adiposity have been studied (17). The results in

Table 4. Correlational Analyses Between VO_2max and CRF Factors of Mazandaran and Milan University Male and Female Students

Variable	VO_2max (ml/kg/min)			
	Mazandaran		Milan	
	Male	Female	Male	Female
RPPmax (mmHg bpm)	-0.118	-0.138	-0.366	-0.188
RPPrest (mmHg bpm)	-0.575[a]	-0.645[a]	-0.451 a	-0.61[a]
RPPrec (mmHg bpm)	-0.181	-0.129	-0.354	-0.325
HRmax (bpm)	-0.121	-0.001	-0.009	-0.095
RHR (bpm)	-0.643[a]	-0.74[a]	-0.458[a]	-0.803[a]
HRR (s)	0.68[a]	0.617[a]	0.468[a]	0.549[a]
SBPmax (mmHg)	-0.037	-0.139	-0.198	-0.374
SBPrest (mmHg)	-0.097	-0.064	-0.287	-0.045
SBPrec (mmHg)	-0.176	-0.239	-0.249	-0.323

[a]Correlation is significant at 0.05

Table 5. Correlational Analyses Between VO_2max and Body Composition and PA Factors of Mazandaran and Milan University Male and Female Students

Variable	VO_2max (ml/kg/min)			
	Mazandaran		Milan	
	Male	Female	Male	Female
Body composition				
BMI (kg/m^2)	-0.343	-0.153	-0.485[a]	-0.346
WHR	-0.249	-0.382	-0.234	-0.631[a]
WHtR	-0.51[a]	-0.238	-0.304	-0.154
ABSI	-0.174	-0.278	-0.342	-0.421[a]
BAI	-0.282	-0.151	-0.356	-0.353
Body fat %	-0.322	-0.395	-0.137	-0.224
PA				
Steps count (n/day)	0.663[a]	0.714[a]	0.543[a]	0.518[a]
Vigorous PA (MET-min/week)	0.658[a]	0.574[a]	0.504[a]	0.69[a]

[a] Correlation is significant at 0.05

Krakauer et al. study showed that ABSI is a more reliable indicator than BMI and WC for the prediction of cardiovascular status in Mexican and black males (18) while He and Chen showed that WC is more suitable than ABSI for diabetes mellitus prediction in Chinese males (22).

Moreover, RPP is useful in determining CRF not only at rest but also under different conditions (4). In the present study, the relationships between VO_2max and RPPrest, RHR, and HRR were significant (Table 4). This result is in line with Sembulingam et al. study. They found a significant relationship between RPPrest and VO_2max in both genders. Low RPPrest is an indicator of increased parasympathetic tone, which effects RHR and improves CRF (3). Lower RHR is indicative of the favorable influence on the autonomic nervous system, tilting the balance toward augmented vagal tone as opposed to sympathetic tone, so it reduces shear stress, decreases adverse ventricular remodeling, and prevents imbalance of myocardial oxygen supply and demand, leading to a favorable impact on CRF (23).

Daanen et al. showed a relationship between HRR and VO_2max in both genders. They observed that students with faster HRR had higher VO_2max (4). The findings suggest that the anatomical and physiological factors affecting RHR may also be important contributors to the HRR pattern (4). Furthermore, some factors, such as age, PA, lifestyle, and cardiac vagal activity, which affect VO_2max, are also associated with HRR (20). Freeman et al. reported changes in the autonomic nervous system modulation and central hemodynamics such as RHR, and similarly, increased HRR (24).

5.1. Conclusions

According to the results of this study, VO_2max as an assessment measure of CRF was associated with hemodynamics and health risk factors. The results showed that hemodynamic responses and health risk factors were different between sport science students from Iran and Italy. These differences may depend on age, sex, ethnicity, lifestyle, and culture of people in each region.

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Footnotes

Authors' Contribution: Study concept and design: Niloofar Karimi, Valiollah Dabidiroshan, and Fabio Esposito; Analysis and interpretation of data: Niloofar Karimi and Valiollah Dabidiroshan; Drafting of the manuscript: Niloofar Karimi; Critical revision of the manuscript for important intellectual content: Niloofar Karimi, Valiollah Dabidiroshan, and Fabio Esposito; Statistical analysis: Niloofar Karimi and Fabio Esposito.

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