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Original Article

Prediction of Non-exercise Equation for Estimating Cardiorespiratory Fitness and Investigation of the Effective Components on Society: An analytic (case-control) study

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Abstract

Background & Aims: In large populations, the level of cardiorespiratory fitness (CRF) can be evaluated by estimating non-exercise models with the least amount of time and money. In this study, we present non-exercise equations for predicting CRF and also investigate the effect of socio-environmental factors on it.

Materials & Methods: 2490 male and female subjects aged 25-65 years old from different cities of Iran participated in this study. Rockport and Bruce (10% in each age category and gender) exercise test measured VO2max, a global standard for evaluation of CRF. Three non-exercise equations including, VO2masStep, VO2maxIPAQ-s, and VO2maxIPAQ-l were estimated using Stepwise Linear Regression. Variables for estimating these models are physical activity (PA) (obtained by pedometer and short and long-form of the International Physical Activity Questionnaire (IPAQ), separately), Body Mass Index (BMI) , Waist-Hip Ratio(WHR), Body Adiposity Index (BAI), age, gender, and VO2maxROC. For comparison between measured and predicted VO2max values based on age, gender, level of education and city of residence Repeated Measures Analysis with Bonferroni Compare Main Effect test was used.

***Results*:** There were significant relationships between measured and estimated VO2max ($p<0.05$) (VO2maxIPAQ-l: $R^2_{adj}=0.671$ and SEE=4.381, VO2maxStep: $R^2_{adj}=0.543$ and SEE=5.331 and VO2maxIPAQ-s: $R^2_{adj}=0.621$ and SEE=4.823). Also, there were significant differences between VO2max values in males and females in different age categories and city of residence ($p<0.05$).

***Conclusion*:** The results of this study demonstrated that predicted VO2max models with SC, IPAQ-s, and IPAQ-l can be used as non-exercise models for estimating VO2max in Iranian society, and socio-environmental factors are influential variables on PA and level of CRF.

***Keywords*:** cardiorespiratory fitness, non-exercise models, pedometer, International Physical Activity Questionnaire, socio-environmental factors

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Introduction

CRF refers to the ability of the circulatory and respiratory systems to supply oxygen (O2) to active peripheral tissues for a long period of time, as well as their capability to utilize O2 for aerobic reactions (1). Low CRF is associated with the risk of various diseases including cardiovascular diseases and it is one of the most important factors affecting public health (2).

In Iran, chronic diseases, especially cardiovascular diseases, are the most important cause of death (3). It is expected that with the spread of urbanization and the prevalence of an inactive lifestyle, in the near future, the incidence of these diseases will increase (4,5).

Personal, social, and environmental factors can influence CRF and its related diseases with change in PA behavior and human life (6). Maximum Oxygen uptake (VO2max) is accepted as a global standard for the measurement of CRF (7). Today, there are several fields and laboratory methods for measuring VO2max (7,8). Despite their accuracy and validity, these methods have certain limitations, such as, the need for daily calibration of devices, technical operational difficulties, high costs and time-consuming, the need for an experienced assessor and adequate and appropriate space for testing. Therefore, non-exercise methods replaced these methods (9,10).

Levels of PA and body composition as important parts of lifestyle are the most substantial components of CRF (10). Methods for assessing PA include Laboratory techniques, questionnaires and interviews and motion assessment tools (accelerometer and pedometer), each presenting own advantages and drawbacks (7). Many studies, estimated models for predicting VO2max based on the level of PA, demographic factors, and anthropometric parameters (7–9). For example, Cao et al. used the step count, age, and BMI to estimate the VO2max prediction model in women aged 20-69. They showed that there is a significant correlation between the measured VO2max by the maximum exercise test and the estimated VO2max (9). Also, Schember et al. estimated non-exercise VO2max by a short form of International Physical Activity Questionnaire (IPAQ-s) in College-aged males and females. In this study, they estimated the model by gender, BMI, and vigorous physical activity from the questionnaire. The relationship between the estimated VO2max and the calculated VO2max by Bruce maximum exercise test was significant (8).

Based on the previous studies, estimated models are valid and can be used for a larger population. Accuracy and validation of these models are related to demographic and socio-environmental factors, including age, gender, race, culture, geographical region, and living environment (7–9). In this study, we estimated different non-exercise models to predict VO2max based on body composition and PA and also investigated the effective components on society in Iranian males and females.

Materials and Methods

Participants

The statistical population of this study is Iranian male and female subjects within the age range of 25 to 65 years old. Participants were categorized according to age (25-34 years, 35-44 years, 45-54 years and 55-65 years) and educational level (Diploma, Associate, Bachelor, Master and Doctoral and higher) and they were selected randomly by stratified sampling method from different cities of Iran. These cities were Babolsar, Mashhad, Tabriz, Zahedan, Qom, Bushehr, Isfahan, Tehran, Shiraz, Qazvin, and Hamedan.

After coordination with the relevant authorities in each city, universities, public centers (parks and sport clubs) and some departments were visited. Then, the general objectives of the research, the conditions of entry and the manner of conducting the test were explained to the individuals. Subjects who were interested in participating in the project, signed the written consent form. The ethical committee of the Department of sports physiology, University of Mazandaran, approved this study. Participant Characteristics are shown in Table 1.

Table 1. Participant Characteristics

Variable	Female					Male				
	n	Max	Min	Mean	SD	n	Max	Min	Mean	SD
Demographic										
Age (Year)	1325	65	25	42.08	11.32	1165	65	25	42.31	12
Height (cm)	1325	183	140	162.5	6.75	1165	199	168	178.67	8.75
Body mass (kg)	1325	104.11	39.8	64.63	10.83	1165	128.44	50	75.54	12.66
Anthropometric										
BMI (kg/m2)	1325	37.51	17.1	25.36	3.66	1165	38.04	17.49	25.76	3.88
WHR	1325	1.05	0.67	0.79	0.09	1165	1.18	0.71	0.89	0.08
BAI	1325	54.06	14.5	31.85	5.45	1165	37.43	4.91	20.21	3.95
PA										
SC	1325	13077	1870	5501	2100	1165	19728	1987	6105	2652
Vig-l	1325	2440	0	1098	445	1165	4120	0	1432	516
Vig-s	1325	2180	0	1021	568	1165	3650	0	1325	472
CRF										
VO2maxROC	1325	56.12	19.6	34.02	7.29	1165	65.83	21.32	41.58	9.62
VO2maxBRC	227	51.42	20	33.96	7.71	240	60.33	20.11	41.43	9.35

Vig-l: IPAQ-l vigorous intensity activities (MET-min/wk)

Vig-s: IPAQ-s vigorous intensity activities (MET-min/wk)

SC: step count (step/day)

VO2maxBRC: Maximal oxygen uptake estimated using Bruce Test (ml.kg-1.min-1) VO2maxROC: Maximal oxygen uptake estimated using Rockport Test (ml.kg-1.min-1)

Inclusion and exclusion criteria

Subjects were excluded if they (I) had any prior history of cardiovascular or chronic pulmonary disease, diabetes, or were using medication known to affect cardiovascular function; (II) exercise-limiting orthopedic impairment ; (III) were professional or semi-professional athletes; (IV) had smoked in the past two weeks.

Measurements

- **Anthropometric assessment**

A SECA wall-mounted stadiometer and digital scales with 0.5 cm and 0.1 kg accuracy, respectively measured height without shoes and body mass. Waist circumference (WC) (the slimmer part of the waist) and hip circumference (HC) (the most prominent part of gluteal muscles) were measured in a horizontal plane. Based on these initial measurements, Body Mass Index (BMI), Waist to Hip Ratio (WHR), and Body Adiposity Index (BAI) were calculated from the following equations (11):

BMI=($\frac{Weight(kg)}{Height^2(m)}$) WHR=($\frac{WC(cm)}{HC(cm)}$) BAI=($(\frac{HC(cm)}{(Height(m))^{1.5}})-18$)

- **Physical activity measurement**

Pedometer step count - Participants were requested to always wear a pedometer (OMRON-HJ 113), as worn in most studies, for seven days. They were also asked to follow their usual routine daily activities and to remove the pedometer only when bathing, showering, or sleeping (9,12).

Short and long International Physical Activity Questionnaire (IPAQ)- All subjects were provided with the Iranian versions of the short and long forms of IPAQ. The long-form (IPAQ-l) consists of twenty seven questions and the short-form (IPAQ-s) includes seven questions. Questions in IPAQ-s provide scores on walking, moderate-intensity activities, and vigorous-intensity activities. On the other hand, IPAQ-l provides separate domain-specific scores for walking, moderate-intensity, and vigorous-intensity activity within each of the work, transportation, domestic chores, gardening (yard), and leisure-time domains (13,14). Based on the previous studies, among IPAQ outcomes, vigorous-intensity activities have a stronger association with CRF (8).

According to the IPAQ scoring protocol, MET-minutes/week of Vig-s and Vig-l vigorous PA was computed by the following equations (15):

Vig-s = 8.0 × vigorous PA minutes × vigorous PA days (Eq. 1)

Vig-l = Vigorous PA (at Work +in Leisure) (Eq. 2)

- **Cardiorespiratory fitness assessment**

Rockport test- The Rockport Walking Test is a sub-maximal test to estimate VO2max. The test consists of 1-mile walking as fast as possible, without jogging or running. At the end of the test, heart rate is measured using a Polar Heart Rate Monitor (NY‹WestburgPolar, Ing). Vo2max (ml.kg^{-1}.min^{-1}) is computed for each participant using the following formula (16):

132.853 - (0.0769 × Weight) - (0.3877 × Age) + (6.315 × Gender) - (3.2649 × Time) - (0.1565 × Heart Rate)

As calculated: Weight is in pounds (lbs), Gender Male = 1 and Female = 0, Time is expressed in minutes and 100ths of minutes, Heart rate is in beats/minute, Age is in years.

Bruce test- To increase the accuracy and validity of the work, for 10% of males and females of every age group in each city, VO2max was calculated using the Bruce test. The Bruce test protocol is a maximum treadmill test that involves several stages lasting three minutes each. At the end of each stage, both slope and speed were increased until the participant reached volenterical fatigue. VO2max (ml.kg-1.min-1) was estimated using total time on the treadmill (17).

Statistical Analyses

Descriptive statistics are presented as mean, SD, Max, and Min. The relationship between the measured VO2max values with demographic, anthropometric, and PA characteristics was calculated by Pearson correlations. Estimation of VO2max equations, from independent variables, were obtained using stepwise multiple linear regression. For comparison between measured and predicted VO2max values based on the effect of components on society, repeated measures analysis with Bonferroni was used. Statistical analyses were done using SPSS 21 and at a significant level of P <0.05.

Results

2490 Iranian male (n=1165) and female (n=1325) (age: 42.2 ±11.34 years, BMI: 25.56 ±3.17 kg/m^2) subjects participated in this study. Their demographic, CRF, PA, and anthropometric parameters are shown in Table 1.

1. Model estimation

The results of Pearson correlations in Table 2 shows significant association between ROC with BRC, SC, Vig-s, Vig-l, BMI, WHR, BAI, gender, and age (P<0.01).

Table 2. Correlations between VO2max and independent variable

Variable	ROC	BRC	SC	Vig-s	Vig-l	BMI	WHR	BAI	Gender	City	Edo
ROC	-										
BRC	0.89 **	-									
SC	0.77 **	0.74 **	-								
Vig-s	0.64 **	0.66 **	0.54 *	-							
Vig-l	0.65**	0.67 **	0.51 *	0.81 **	-						
BMI	-0.69 **	-0.65 **	-0.67 **	-0.31 *	-0.36 *	-					
WHR	-0.26 *	-0.22 *	-0.41 *	-0.08	-0.05	0.54 *	-				
BAI	-0.71 **	-0.68 **	-0.61 **	-0.48 *	-0.49 *	0.52 *	-0.19	-			
Gender	0.44 *	0.44 *	0.23 *	0.30 *	0.32 *	-0.1	0.42 *	-0.67 **	-		
City	0.041	0.095	0.021	0.07	0.04	0.07	0.012	0.061	0.27 *	-	
Edo	0.063	0.054	0.03	0.02	0.032	0.09	0.018	0.081	0.05	0.04	-
Age	-0.63 **	-0.5 **	-0.58 **	-0.19 *	-0.2 *	0.6 **	0.58 **	0.35 *	0.05	0.02	-0.01

Vig-l: IPAQ-l vigorous intensity activities (MET-min/wk)
Vig-s: IPAQ-s vigorous intensity activities (MET-min/wk)
SC: step count (step/day)
Edo: Educational levels
BRC: Maximal oxygen uptake estimated using Bruce Test (ml.kg-1.min-1)
ROC: Maximal oxygen uptake estimated using Rockport Test (ml.kg-1.min-1)
** Correlation is significant at the 0.01 (P<0.01), **Correlation is significant at the 0.001 (P<0.001)*

So, VO2max equation models for IPAQ-s, IPAQ-l, and step count were estimated using stepwise linear regression. For each method, 6 models were predicted. In each of these models, independent variables were entered and the relationship between these factors and ROC were investigated by Coefficient correlations.

Table 3. Estimated models for all methods.

Methods	Models	R2adj	SEE
Step	43.683 + 8.177 (gender) – 0.419 (BMI) – 9.352 (WHR) – 0.086 (BAI) + 0.001 (SC) – 0.170 (age)	0.543	5.331
IPAQ-l	56.344 + 7.308 (gender) – 0.437 (BMI) – 13.201 (WHR) + 0.006 (Vig-l) – 0.251 (age)	0.671	4.381
IPAQ-s	54.622 + 5.099 (gender) – 0.457 (BMI) – 11.835 (WHR) + 0.002 (Vig-s) – 0.286 (age)	0.621	4.823

Female=1, Male=2, BMI (kg.m-2), Vig-s and l (MET-min.week-1), Age (year), SC (step.day-1), SEE (ml.kg-1.min-1)

Step: Maximal oxygen uptake estimated using Step Count

IPAQ-l: Maximal oxygen uptake estimated using long form IPAQ

IPAQ-s: Maximal oxygen uptake estimated using short form IPAQ

Estimated equations are based on final models that contain the most relevant factors to the dependent variable. Estimated VO2max equations and regression analysis are shown in Table 3. The level of adjusted R squared (R^2_{adj}) and standard errors of estimate (SEE) are also reported (IPAQ-l: R^2_{adj}=0.671 and SEE=4.381, Step: R^2_{adj}=0.543 and SEE=5.331 and IPAQ-s: R^2_{adj}=0.621 and SEE=4.823).

Associations between measured and estimated VO2max values are shown in Table 4. Based on the results, there are significant relationships between obtained VO2max by all methods.

Table 4. Relationship between measured and estimated VO2max values

Average VO2max values		ROC	BRC	Step	IPAQ-s	IPAQ-l
		36.66	36.37	36.49	36.81	37.14
ROC	36.66	1				
BRC	36.37	0.955**	1			
Step	36.49	0.967**	0.982**	1		
IPAQ-s	36.81	0.903**	0.767**	0.780**	1	
IPAQ-l	37.14	0.930**	0.646**	0.681**	0.937**	1

BRC: Maximal oxygen uptake estimated using Bruce Test (ml.kg-1.min-1)

ROC: Maximal oxygen uptake estimated using Rockport Test (ml.kg-1.min-1)

Step: Maximal oxygen uptake estimated using Step Count (ml.kg-1.min-1)

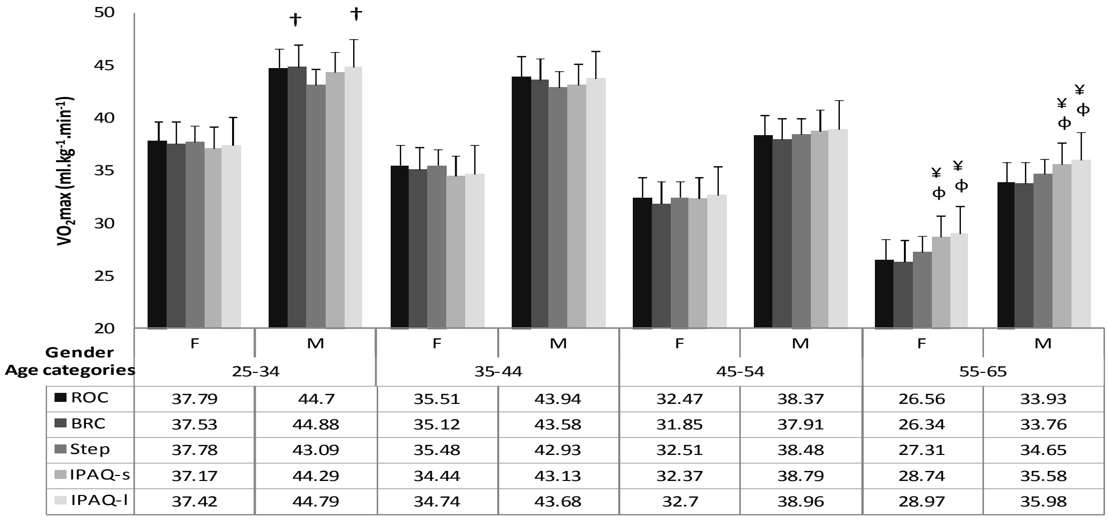
IPAQ-l: Maximal oxygen uptake estimated using long form IPAQ (ml.kg-1.min-1)

IPAQ-s: Maximal oxygen uptake estimated using short form IPAQ (ml.kg-1.min-1)

***Correlation is significant at the 0.001(P<0.001)*

2. Comparison of estimated and measured VO2max

The comparison between measured and estimated VO2max values is investigated by Repeated measures analysis. Based on the results of Bonferroni, it is observed that among males within the age range of 25-34 years differences between Step with IPAQ-l and BRC are significant ($p<0.05$). Within the age range of 55-65 years, differences between IPAQ-s and IPAQ-l with ROC and BRC are significant in both males and females ($p<0.05$) (Figure 1).

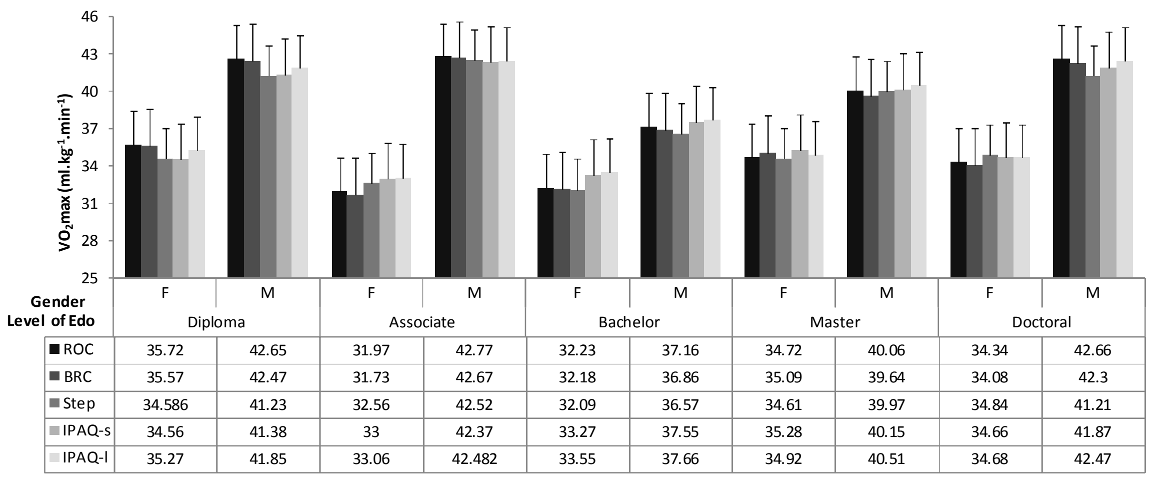


	F 25-34	M 25-34	F 35-44	M 35-44	F 45-54	M 45-54	F 55-65	M 55-65
ROC	37.79	44.7	35.51	43.94	32.47	38.37	26.56	33.93
BRC	37.53	44.88	35.12	43.58	31.85	37.91	26.34	33.76
Step	37.78	43.09	35.48	42.93	32.51	38.48	27.31	34.65
IPAQ-s	37.17	44.29	34.44	43.13	32.37	38.79	28.74	35.58
IPAQ-l	37.42	44.79	34.74	43.68	32.7	38.96	28.97	35.98

† Significantly different with Step, ¥ significantly different with ROC, ϕ significantly different with BRC

Figure 1. Differences between estimated and measured VO2max values based on gender and age categories

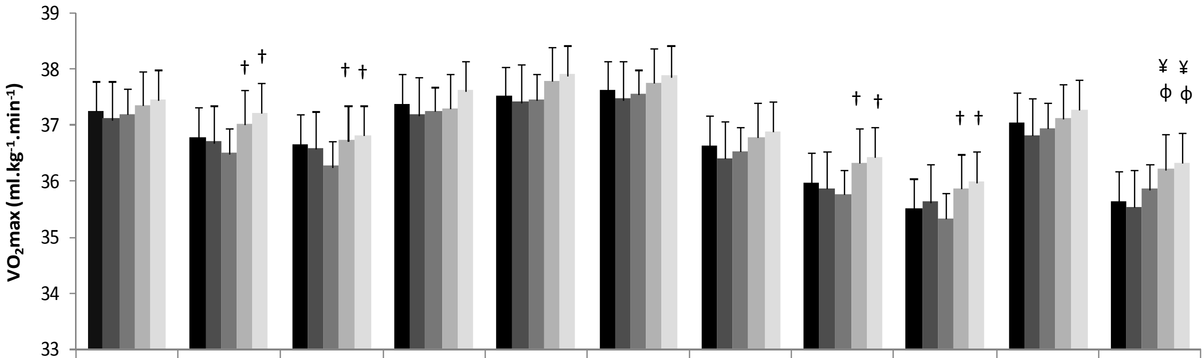
The results of the comparison between obtained VO2max values by various methods, based on levels of education and gender, are shown in Figure 2. There are not any significant differences between measured and estimated VO2max values across categories of education in females and males.



	F Diploma	M Diploma	F Associate	M Associate	F Bachelor	M Bachelor	F Master	M Master	F Doctoral	M Doctoral
ROC	35.72	42.65	31.97	42.77	32.23	37.16	34.72	40.06	34.34	42.66
BRC	35.57	42.47	31.73	42.67	32.18	36.86	35.09	39.64	34.08	42.3
Step	34.586	41.23	32.56	42.52	32.09	36.57	34.61	39.97	34.84	41.21
IPAQ-s	34.56	41.38	33	42.37	33.27	37.55	35.28	40.15	34.66	41.87
IPAQ-l	35.27	41.85	33.06	42.482	33.55	37.66	34.92	40.51	34.68	42.47

Significantly different with IPAQ-s, Ψ Significantly different with IPAQ-l

Figure 2. Differences between estimated and measured VO2max values based on gender and the level of education



City	Babolsar	Mashhad	Tehran	Hamedan	Qazvin	Tabriz	Isfahan	Bushehr	Qom	Shiraz	Zahedan
ROC	37.24	36.78	36.65	37.37	37.51	37.61	36.62	35.97	35.51	37.03	35.64
BRC	37.1	36.69	36.57	37.18	37.41	37.46	36.4	35.86	35.62	36.8	35.54
Step	37.2	36.49	36.26	37.24	37.45	37.54	36.52	35.76	35.33	36.94	35.85
IPAQ-s	37.35	37.01	36.72	37.29	37.77	37.76	36.78	36.33	35.87	37.11	36.21
IPAQ-l	37.45	37.21	36.8	37.61	37.89	37.87	36.89	36.43	35.98	37.26	36.33

†significantly different with Step, ¥ significantly different with ROC, ϕ significantly different with BRC

Figure 3. Differences between estimated and measured VO2max values based on the city of residence

Figure 3 shows the differences between estimated and measured VO2max values based on the city of residence. Based on the results, in Mashhad, Tehran, Qom and Bushehr differences between VO2maxStep with VO2maxIPAQ-s and VO2maxIPAQ-l are significant ($p<0.05$). Also, in Zahedan, differences between VO2maxIPAQ-s and VO2maxIPAQ-l with VO2maxBRC and VO2maxROC are significant ($p<0.05$).

Discussion

The main finding of the present study was the prediction of non-exercise VO2max models in Iranian males and females based on the demographic components, body composition, and the level of PA (by SC, IPAQ-s and IPAQ-l, separately). Also, the comparison between estimated and measured values were investigated under the influence of age categories, gender, the level of education, and the city of residence.

VO2max is strongly related to CRF and is considered a pivotal parameter to predict it (10). Whereas VO2max assessment during maximum exercise testing is often time-consuming, cost-prohibitive, and almost impractical in epidemiological studies, these considerations have fostered the development of simpler methods to predict CRF (7,18). Considering the linear relationship between VO2max and PA, it can be used as a valuable method to predict VO2max (18). The most important methods for measuring PA are body motion detection tools and questionnaires (10).

IPAQ as a standard PA questionnaire was proposed by the World Health Organization (WHO). IPAQ outcomes, particularly those related to vigorous PA, could lead to reliable CRF estimation (19,20). A pedometer is the simplest motion sensor and a non-invasive approach without interfering with daily life. These instruments are used to determine the level of PA in large groups (12). Many studies published non-exercise VO2max prediction models using vigorous PA outcomes and step counts in various populations (8,9,12).

In this study, we estimated three non-exercise VO2max models for prediction of CRF in healthy Iranian male and female subjects from PA (obtained using IPAQ-s, IPAQ-l, and pedometer separately), age, gender, BMI, WHR, and BAI. The highest level of R^2_{adj} and the lowest level of SEE is related to VO2maxIPAQ-l (R^2_{adj}=0.671 and SEE=4.381 ml.kg^{-1}.min^{-1}) and conversely, the lowest level of R^2_{adj} (0.543) and the highest level of SEE (5.331 ml.kg^{-1}.min^{-1}) are related to VO2maxStep. R^2_{adj} and SEE for VO2maxIPAQ-s are respectively 0.621 and 4.823 ml.kg^{-1}.min^{-1}.

In agreement with our study, many studies predict non-exercise VO2max models from different factors including demographic factors, anthropometric characteristics, and PA levels (7–9,12,18,21). The range of SEE and R^2 are different in these studies. The reason for these differences are 1. types and number of predictor variables, 2. subjects' conditions and study population, 3. type of PA measurement tools.

Most models that estimated VO2max, for subjects in all situations are the same (22). In the present study, we investigated the differences between VO2max values obtained by non-exercise models based on age categories, gender, level of education, and the city of residence.

After comparing the average of the estimated and measured VO2max values in Figure 1, we noticed significant differences between VO2maxStep, VO2maxBRC, and VO2maxIPAQ-l in male subjects within the age range of 25-34 years. Daily step count is one of the many ways to obtain PA and CRF. Most young people prefer to count minutes of activity to determine their PA. Also, pedometer-determined step counts are more related to ambulatory activities and cannot record some types of activities like isometric activity, cycling, and swimming (23).

Also the results of Figure 1 show, in 55-65 age group, VO2max values determined by IPAQ-s and IPAQ-l are higher than other methods. Albeit there are significant associations between measured VO2max (ROC and BRC) and estimated VO2max (IPAQ-s and IPAQ-l) (Table 4), but differences between these values are significant. When the age increases, levels of VO2max in both groups of males and females are reduced. Among the IPAQ outcomes, vigorous PA is used to estimate VO2maxIPAQ-s and VO2maxIPAQ-l (8). It seems that the individual's CRF levels and the perception threshold of intensity of activities is reduced by increasing the age (13). In this case, the person may consider a normal activity as a tough and time-consuming one. In line with the results of present study, Cleland et al. proposed that for more reliable results of IPAQ in older adults, it is better to provide additional details of types of activities; and along with IPAQ, using another measurement tool for obtaining the level of PA is helpful (24).

Socioeconomic status as a lifestyle factor is related to the PA and CRF status (25). In this study, we use the level of education, as a socioeconomic status index, for non-exercise prediction of VO2max. There was not any significant relationship between the level of education with independent variables and VO2max (Table 2). In agreement with our findings, Willis et al. reported that there is not any relationship between educational levels with CRF and leisure-time PA (25). While Mielke et al. reported a positive association between inactivity and the level of education (26) and Chastin et al. suggests that level of education as a cultural factor has an inverse association with inactivity (27). Also, we found no significant differences between VO2max values among the various levels of education in males and females (Figure 2). Based on the results of this study and other similar studies, it seems that other influential factors about quality of life such as environmental factors are more effective on PA and CRF (28).

As the results of Figure 3 show, there are significant differences between obtained VO2max values by IPAQ-s and IPAQ-l methods with VO2maxBRC (in Zahedan), VO2maxStep (in Qom, Tehran, Bushehr, and Mashhad), and VO2maxROC (in Zahedan).

In this study, obtained PA by questionnaire and pedometers are used to predict non-exercise VO2max equations. As you can see (Figure 3), in cities of Mashhad, Tehran, Qom, and Bushehr, the highest predicted VO2max values are related to IPAQ and the lowest values are related to step. Based on the results of previous studies, socio-environmental factors including climate condition, air pollution, built environment, and culture affect PA and public health and they can change CRF and all-causes of mortality (6,28). Also, according to Arciniega et al., determined PA based on IPAQ is related to regional language, culture, and the type of the population under study (29).

Such as the previous investigation, using non-exercise models to estimate CRF are easy and inexpensive methods for monitoring public health in large populations.

The limitation of this study is related to the model used in practice. VO2max estimation by proposed models in this study are performed for healthy subjects of the same age as the research group.

Conclusion

Based on the findings of the current research there are significant relationships between measured VO2max by Bruce and Rockport exercise tests and predicted VO2max values with obtained PA by SC, IPAQ-s and IPAQ-l (separately), anthropometric and demographic factors. So, it is demonstrated that predicted VO2max models with SC, IPAQ-s and IPAQ-l can be used as non-exercise models for estimating VO2max in Iranian society. Also, after investigating the differences between VO2max values based on the effective component in society, we found that, age, gender, and socio-environmental factors are influential variables on PA and the level of CRF.

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