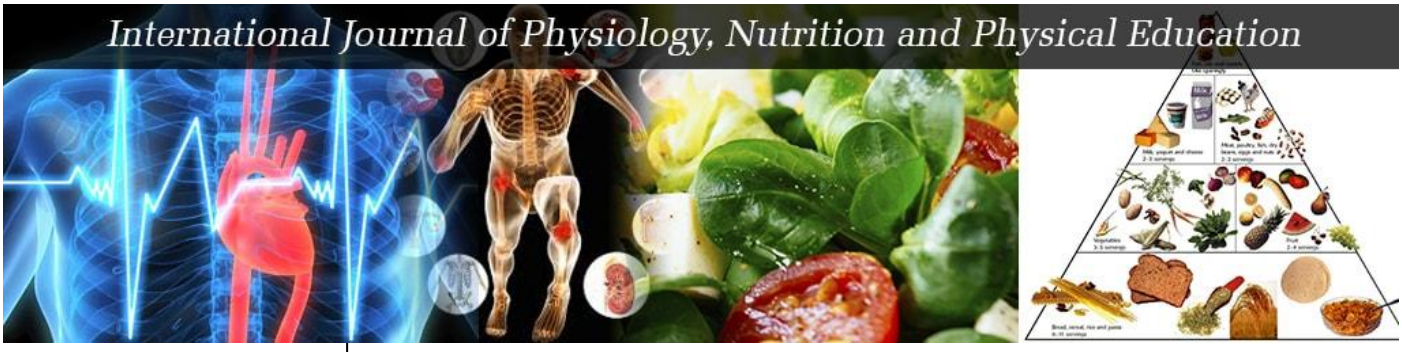

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Development of norms of maximal oxygen uptake (VO_2 max.) as an indicator of aerobic fitness of high altitude male youth of Kashmir

Sajjadh Ahmad Bhat and Dhananjoy Shaw

Abstract
The aim of the study was to develop norms in regard to the Maximal Oxygen Uptake (VO_2 Max.) of male youth, habitat of Kashmir valley. The study was conducted on two hundred forty two healthy male youth of Kashmir (attitude: 6070 feet/1850 meters). The age of the subjects ranged from 18 to 23 years. The youth were administered with submaximal bench step test (American College of Sports Medicine Protocol) to estimate the VO_2 max.by plotting HR-workload combinations calculated by Karvonen heart rate reserve method. Data was collected using Cardio-Sport heart rate monitor and step test protocol. The selected variables were Age in years, Body weight in kilograms (B.Wt.), Height in centimeters (Ht.), Resting Heart Rate (HRrest), Target Heart Rate (THR), Maximal Heart Rate (HRmax.), Heart Rate at Two minutes of step testing with cadence 15 steps/min (ExHR2), Heart Rate at Four minutes of step testing with cadence 20 steps/min (ExHR4) and Heart Rate at Six minutes of step testing with cadence 30 steps/min (ExHR6),(As per the formula advocated by American College of Sports Medicine). The collected data was computed with mean, standard deviation, six sigma scale and chi square using SPSS. The study concluded that the developed scale is good normative in reference to Kashmir youth in regard to their VO_2 max. (Aerobic fitness).

Keywords: Maximal oxygen consumption (VO_2 max.), heart rate, step testing, high altitude, aerobic fitness, six sigma scale

Introduction
VO_2 max. also known as maximal oxygen consumption/maximal oxygen uptake/peak oxygen uptake or maximal aerobic capacity is the maximum rate of oxygen consumption as measured during incremental exercise, most typically on a motorized treadmill or on a bench step test (Dlugosz 2013) [6]. Maximal oxygen consumption reflects the aerobic physical fitness of the individual and is an important determinant of their endurance capacity. The name is derived from V = volume, O_2 = oxygen, max. = maximum.

VO_2 max is expressed either as an absolute rate in (for example) liters of oxygen per minute (L/min) or as a relative rate in (for example) milliliters of oxygen per kilogram of body mass per minute (e.g., ml//kg/min). The latter expression is often used to compare the performance of endurance sports athletes. However, VO_2 max generally does not vary linearly with body mass. (Wikipedia, July 2017) [13].

VO_2max. is the very important determinant of cardio-respiratory fitness and aerobic performance.VO_2 max (ml/min/kg) is a measure of the maximum amount of oxygen that one use during intense physical activity. This measurement determines fitness level by calculating how efficiently cells use oxygen for energy (Tipton, 1977) [5]. There are several methods one can use to measure VO_2 max, but many require sophisticated equipment such as a treadmill or a specially calibrated exercise cycle with calorimetry /spirometery /gas analyzer. The step test with heart rate recordings is quickest, easiest and safest as well as feasible way to measure one's VO_2 max taking in consideration the Karvonen formula for a step testing protocol and sub maximal exercise heart rate (Practical Math for Health Fitness Professionals, 1996).

Heart rate is arguably a very easy cardiovascular measurement, especially in comparison to the invasive or noninvasive procedures used to estimate stroke volume and cardiac output. Consequently, measurement of heart rate is routinely used to assess the response of the heart to

exercise, or the recovery from exercise, as well as to prescribe exercise intensities (Froeliche, 2000) [7]. Given that the increase in heart rate during incremental exercise mirrors the increase in cardiac output, maximal heart rate is often interpreted as the upper ceiling for an increase in central cardiovascular function. Indeed, research for the last 100 years has demonstrated that heart rate does in fact have a maximal value; one that cannot be surpassed despite continued increases in exercise intensity or training adaptations (Robert 2008) [11].

The regular exercise leads to adoptive changes in cardiac and physical performance and oxygen uptake capacity. Physically trained individuals are found to have maximum oxygen uptake capacity than physically untrained ones (Heyward, 1997) [7]. The requirement or adaptation of VO_2 Max. for different games and sports or physical activity are different. The following tables (table 1 and table 2) show the value and the norms for VO_2 max. for different games, sports or physical activity respectively.

Table 1: VO_2 Max. Values for Males and Females for Different Games and Sports.

S. No	Game/Sports/Physical Activity	Age Category	Male (VO_2 max.)	Female (VO_2 max.)
1	Baseball/Softball	18-30	40-56	52-57
2	Basket ball	18-30	40-60	43-60
3	Bicycling	18-30	62-74	47-57
4	Football	20-35	42-60	-
5	Hockey	20-35	50-60	46-60
6	Swimming	10-25	50-70	40-60
7	Track and Field	18-30	60-85	50-75
8	Volley Ball	18-25	40-52	40-56
9	Cricket	18-30	40-54	46-52
10	Weight lifting	18-30	38-52	-

Source: VO_2 max. norms were adopted from Astrand: ACTA Physiol Scand.49(Suppl):169,1960

Table 2: VO_2 Max. Norms Chart.

AGE	Women	Low	Fair	Avg.	Good	High	Athletic	Olympic
AGE	20-29	<20	29-34	35-43	44-48	49-53	54-59	60+
	30-39	<27	28-33	34-41	42-47	48-52	53-58	59+
	40-49	<25	26-31	32-40	41-45	46-50	51-56	57+
	50-65	<21	22-28	29-36	37-41	42-45	46-49	50+
	Men							
	20-29	<38	39-43	44-51	52-56	57-62	63-69	70+
	30-39	<34	35-39	40-47	48-51	52-57	58-64	65+
	40-49	<30	31-35	36-43	44-47	48-53	54-60	61+
	50-59	<25	26-31	32-39	40-43	44-48	49-55	56+
	60-65	<21	22-26	27-35	36-39	40-44	45-49	50+

Note: VO_2 is expressed as milliliters of oxygen per kilogram of body weight per minute
Source: VO_2 max. Norms were adopted from Astrand: ACTA Physiol Scand. 49(Suppl): 169, 1960

Recent research revealed that the Queens College step test provides a valid estimate of VO_2 max. Step test performance at 3800 meters was reduced by 11% compared to sea level, whereas no change was observed at 2040 meters. These data corroborate previous findings that indicate a threshold at which altitude adversely affects aerobic capacity (Tiaira Bates, 2015) [2].

Healthy high altitude dwellers show excellent adaptation to their environment. These adaptations are likely to be associated with altered gene expression as the expression of genes associated with vascular control and reactions to hypoxia have been found to be high in altitude dwellers (Appenzeller 2006) [1]. Blood volumes are larger in high altitude dwellers. This is due to a large packed cell volume whereas at sea levels plasma volume was found to be large. Probably as the result of the large blood volumes, tolerance to orthostatic stress was greater than that in sea-level residents (Claydon, 2005) [4].

It is summarized that at altitudes over 5000 feet (1524 meters), the ability to perform physical work is decreased due to hypoxia (lowered PO_2). However, physical performance at moderate altitude may sometimes be improved with continued stay at altitude due to the acclimatization process. This involves: (1) increased pulmonary ventilation (hyper ventilation), (2) increased red blood cells and hemoglobin concentrations, (3) elimination of bicarbonate (HCO_3) in the urine and (4) in those chronically exposed to altitude, tissue level changes. Increased physical fitness does not alone acclimatize the individual to altitude (Houmard, 1991) [10].

The Kashmir Valley being at high altitude with mountainous environment around demands a great deal of physical efficiency to survive and to live a graceful and healthy life. Kashmiri youth has to perform best in different changing altitudes, time and again, with or without any acclimatization for the life and social requirements, because of the very nature of its geographical, political, social, administrative, vocational requirement/s. Kashmiri youth is a habitat of high altitude, but they interact with rest of India (low altitude), whether it is games/sports (nationals, inter-university, senior nationals, junior nationals, rural nationals etc.) or cultural exchange programs, education and others. Hence, a VO_2 max. norm as an indicator of aerobic fitness suitable to them becomes imperative and significant. The Purpose of the study was to develop norms in regard to maximal oxygen uptake (VO_2 max.) of high altitude Kashmiri male youth which will be useful for evaluation, grading, grouping and monitoring the aerobic fitness.

Methodology

The study was conducted on two hundred and forty two healthy male subjects of Kashmir valley (altitude: 6070 feet/1850 meters). The age of the subjects ranged from 17 to

23 years. The youth were administered submaximal bench step test to determine the VO_2 max. by plotting HR-workload combinations calculated by Karvonen heart rate reserve method. The following physical variables and supporting cardio-circulatory variables were selected for measurement of VO_2 Max: Age in years, Body weight in kilograms (B.Wt.), Height in centimeters (Ht.), Resting Heart Rate (HRrest), Target Heart Rate (THR), Maximal Heart Rate (HRmax.), Heart Rate at Two minutes of step testing with cadence 15 steps/min (ExHR2), Heart Rate at Four minutes of step testing with cadence 20 steps/min (ExHR4) and Heart Rate at Six minutes of step testing with cadence 30 steps/min (ExHR6), (As per the formula advocated by American College of Sports Medicine).

Submaximal exercise testing can be used for predicting VO_2 max by taking advantage of linear relationship between heart rate responses and workload VO_2 values. This linear relationship was taken in consideration by plotting HR-workload combinations calculated by Karvonen heart rate reserve method. (Practical Math for Health Fitness Professionals, 1996).

The statistical analysis was descriptive statistics (Mean and standard deviation), 6 sigma scale and chi-square using SPSS.

Findings

Table 3: Descriptive Statistics of Physical Data of the Subjects (High Altitude Kashmiri Male Youth)

Age (Yrs)*	Weight(Kg)*	Height(cm)*
18.75±1.01	54.53±6.88	171.97±6.02

N=242 * the numbers are expressed as mean±SD

Table 4: Descriptive Statistics of Maximal Oxygen Uptake (VO_2 max.) of High Altitude Kashmiri Male Youth

Variables	Gender	Mean	SD
VO_2 max.*	Male	53.20	5.11

N=242, * VO_2 is expressed as milliliters of oxygen per kilogram of body weight per minute (ml/kg/min).

Table 5: Six Sigma Scale of Maximal Oxygen Uptake (VO_2 max.) of Habitat of High Altitude Kashmiri Male Youth

Six Sigma Scale	VO_2 max	Six Sigma Scale	VO_2 max	Six Sigma Scale	VO_2 max	Six Sigma Scale	VO_2 max
100	68.2	75	60.7	50	53.2	25	45.7
99	67.9	74	60.4	49	52.9	24	45.4
98	67.6	73	60.1	48	52.6	23	45.1
97	67.3	72	59.8	47	52.3	22	44.8
96	67	71	59.5	46	52	21	44.5
95	66.7	70	59.2	45	51.7	20	44.2
94	66.4	69	58.9	44	51.4	19	43.9
93	66.1	68	58.6	43	51.1	18	43.6
92	65.8	67	58.3	42	50.8	17	43.3
91	65.5	66	58	41	50.5	16	43
90	65.2	65	57.7	40	50.2	15	42.7
89	64.9	64	57.4	39	49.9	14	42.4
88	64.6	63	57.1	38	49.6	13	42.1
87	64.3	62	56.8	37	49.3	12	41.8
86	64	61	56.5	36	49	11	41.5
85	63.7	60	56.2	35	48.7	10	41.2
84	63.4	59	55.9	34	48.4	9	40.9
83	63.1	58	55.6	33	48.1	8	40.6
82	62.8	57	55.3	32	47.8	7	40.3
81	62.5	56	55	31	47.5	6	40
80	62.2	55	54.7	30	47.2	5	39.7
79	61.9	54	54.4	29	46.9	4	39.4
78	61.6	53	54.1	28	46.6	3	39.1
77	61.3	52	53.8	27	46.3	2	38.8
76	61	51	53.5	26	46	1	38.5

N= 243

According to table-5, the 100 point of six sigma scale documented 68.2 ml of oxygen/kg/min, the 90 point documented 65.2 ml/kg/min, the 80 point documented 62.2 ml/kg/min, the 70 point documented 59.2 ml/kg/min, the 60 point documented 56.2 ml/kg/min, the 50 point documented 53.2 ml/kg/min, the 40 point documented 50.2 ml/kg/min, the 30 point documented 47.2 ml/kg/min, the 20 point documented 44.2 ml/kg/min, the 10 point documented 41.2 ml/kg/min and the 01 point documented 38.5 ml/kg/min.

Table 6: Grading of Maximal Oxygen Uptake (VO_2 max.) in Six Sigma of Habitat of High Altitude Kashmiri Male Youth.

Grade	Minimum Value	Maximum Value	Frequency Distribution	Chi-square
Excellent	62.40	68.53	2	44.48*
Above Average	56.26	62.39	75	14.61*
Average	50.13	56.25	88	32.4*
Below Average	44.00	50.12	72	15.89*
Poor	37.87	39.99	5	38.91*

N=242

According to table-6, a subject score VO_2 max. between 62.40 and 68.53 will be considered as Excellent, a subject score VO_2 max. between 56.26 and 62.39 will be considered as above average, a subject score VO_2 max. between 50.13 and 56.25 will be considered as Average, a subject score VO_2 max. between 44.00 and 50.12 will be considered as Below average and a subject score VO_2 max. between 37.87 and 39.99 will be considered as poor. The chi-square demonstrated asymmetric distribution among the grades, descending towards both sides thus supporting normal distribution. Highest frequency was observed at average grade followed by above average, below average, poor and excellent. The findings have been graphically illustrated in figure-1 below:

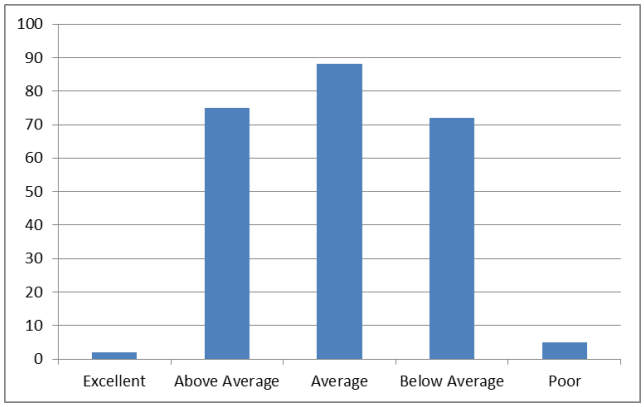

Fig 1: Plotting of Frequency in Selected Grades

Conclusions

- A 100 point 6 sigma scale has been developed in reference to VO_2 max. For habitat of high altitude Kashmiri youth for aerobic fitness evaluation.
- A grade scale with grades as Excellent, Above Average, Average, Below Average and Poor has been developed for Kashmiri youth in reference to their VO_2 max. For aerobic fitness grading.
- The developed scale/ norms/grades are good normative reference for Kashmiri youth in regard to their VO_2 max (Aerobic fitness).

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