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Cardiorespiratory responses to incremental exercise in dominant somatotypes

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ABSTRACT

Objectives: Somatotype rating is used to categorise human physiques using parameters related to body shape and composition. These parameters are adiposity, musculoskeletal robustness, and linearity. Somatotype rating is based on anthropometric dimensions that influence a person's ability to perform physical activity. This study aimed to measure cardiorespiratory responses to incremental exercise in different somatotypes.

Materials and Methods: Fifty (50) healthy male participants with a mean age of 24.10 ± 4.55 years were recruited in this study. The dominant somatotype was determined using the Heath and Carter method. Cardiopulmonary exercise testing was done to measure peak VO_2, peak VO_2/kg, metabolic equivalents (METS), breathing reserve (BR), minute ventilation (V.E), oxygen pulse (VO_2/HR), and heart rate.

Results: The cardiorespiratory parameters showed significant differences between the endomorphs and mesomorphs. Mesomorphs showed significantly higher peak oxygen consumption (mL/min) (2487 ± 364.3 vs. 2151 ± 287.8; P = 0.013) and exhibited significantly higher peak VO_2 % predicted values (78.13 ± 10.11 vs. 66.92 ± 10.09; P = 0.003) than the endomorphs. METS % predicted was significantly higher in mesomorphs than endomorphs (78.13 ± 11.95 vs. 66.92 ± 10.09; P = 0.003). Similarly, the V.E (L) of mesomorphs was also higher than that of endomorphs (95.32 ± 18.63 vs 71.13 ± 25.39), but the BR (L) of mesomorphs was lower than endomorphs (38.38 ± 11.87 vs 53.80 ± 17.16) and ectomorphs (38.38 ± 11.87 vs 52.79 ± 9.47). Mesomorphs showed higher O_2 pulse than endomorphs (14.8 [10.3–24.0] vs 12.8 [9.2–21.9]; P = 0.02); they also showed significantly higher respiratory frequency than endomorphs (1/s) (48.25 ± 11.34 vs. 38.19 ± 6.89; P = 0.001) and ectomorphs (48.25 ± 11.34 vs. 40.92 ± 7.03; P = 0.03).

Conclusion: Cardiorespiratory responses to exercise vary among different somatotypes. Exercise capacity, as measured by VO_2 peak, is higher in mesomorphs.

Keywords: Cardiopulmonary exercise test, Peak oxygen uptake, Somatotypes

INTRODUCTION

Somatotype rating is used to categorise human physiques using parameters related to body shape and composition. These parameters are adiposity, musculoskeletal robustness and linearity or slenderness. W.H. Sheldon first used the word "somatotype" in 1940.[1] The word 'somatotyping' today refers to a variety of method-specific procedures, all of which are based on the original Sheldonian notions and use a three-component rating system. Heath and Carter pioneered the most frequently utilised somatotyping technique. This technique has three components – endomorphy, mesomorphy and ectomorphy – that empirically characterise relative fatness, relative musculoskeletal development and relative body linearity, respectively.[2] For example, a 2-5-1 rating expressed in this form would read as two for endomorphy, five for mesomorphy and one for ectomorphy. Thus, these figures indicate the magnitudes of the three components. A rating of ½–2½ for a component is considered low, 3–5 is considered moderate, 5½–7 is high, and 7½ and above is very high.[3]

It is known that anthropometric parameters influence the ability to perform physical activity. Heath and Carter's anthropometric method of somatotype determination takes into consideration ten anthropometric parameters. These are height, weight, skinfold thickness (triceps, subscapular, supraspinal and medial calf), bone breadth (bi-epicondylar humerus and femur) and limb girth (arm flexed and tensed calf). It is a better predictor of body composition than other methods.[4] Compared to only using body mass index (BMI) and waist-hip ratio, this technique provides more accurate data on body composition. Thus, somatotype is a crucial component of someone's physical fitness and health profile. During physical activity and training, people of various somatotypes exhibit unique performance capabilities.[5] It has been demonstrated that the dominant somatotype affects functional responses during maximal exercise.[5,6]

Cardiopulmonary exercise testing (CPET) offers a comprehensive evaluation of integrative exercise responses encompassing the pulmonary, cardiovascular, hematopoietic, neuropsychological and skeletal muscle systems that are not adequately reflected by the measurement of individual organ system function.[7] Hence, the objective of the present study was to measure cardiorespiratory responses to incremental exercise in different somatotypes.

MATERIALS AND METHODS

This study was approved by the Institute Ethics Committee for Human Subjects (Ref. No.: IECPG-520/23.09.2021, RT-02/28.10.2021 dated 29.10.21).

Written informed consent was taken from all participants as per the institute's ethical norms.

Participants

This is an observational and cross-sectional study. After screening 75 healthy volunteers, 50 participants were enrolled in the study. A detailed history was recorded, and a physical examination was conducted to rule out the presence of any disease. Healthy volunteers who were willing to participate in the study were enrolled based on the following inclusion and exclusion criteria – the young (age group 18–35 years) healthy male (as exercise capacity is affected by gender) participants having only dominant somatotypes were recruited. Somatotype dominance is defined as a component rating for one somatotype that is at least 0.5 points greater than the rating of the other two components (for example, 5,2,1 represent dominant endomorphs). The subjects who do regular physical exercise or have cardiovascular, respiratory and musculoskeletal disorders, as well as active smokers, were excluded from the study.

Somatotype determination

The most popular approach for determining a person's somatotype is the Heath-Carter somatotyping method. All participants were subjected to the following anthropometric measurements to determine their somatotype: Height, body weight, four skinfold thicknesses (triceps, subscapular, supraspinal and medial calf), two bone breadths (bi-epicondylar humerus and femur) and two limb girths (arm flexed and tensed calf).[2]

A small sliding calliper (Dasqua Monoblock 1380 Series [0–150 mm], UK) was used to measure bone breadths. A Harpenden calliper (British Indicators, c/o Assist Creative Resources, Wrexham, UK) was used to measure skinfold thicknesses, which can read to 0.1 mm by interpolation. The girths of the limbs were measured using fibreglass tape (Zyouu's Tailor Inch [150 cm], In).

The somatotype components were derived using the equations given in the Heath-Carter somatotyping method.[2]

Measurement of cardiopulmonary parameters

Cardiopulmonary exercise test parameters were measured according to ATS guidelines using the Cosmed Quark breath-by-breath CPET system (Cosmed, Italy).[8] The goal of CPET was to implement an exercise program with progressively higher intensities until fatigue and the onset of limiting symptoms and indications. On a treadmill (Trackmaster, Full Vision Inc., USA), participants underwent a symptom-limited exercise test using the Bruce protocol. During the test, 12 lead electrocardiograms were recorded. The oxygen saturation of the blood was measured using a pulse oximeter placed on the finger. The participant wore a reusable oro-nasal mask during testing and breathed through a flow meter to measure breath-by-breath ventilation (VE) (L/min). A gas analyser and an open-circuit sampling system were used to calculate gas exchange. The test began with a 3-minute warm-up phase at 2.7 km/h and 0 % inclination, which was followed by the Bruce Protocol. It was terminated when the individual was unable to continue the exercise due to limiting symptoms such as fatigue, dyspnoea and pain in the legs. Following the exercise session, there was a 2-minute recovery period at the speed of 2 km/h with 0 % inclination. At the end of the exercise, a modified Borg dyspnoea scale was used to assess breathlessness.

The following parameters were measured using Omnia software: peak oxygen uptake ($\dot{V}O_2$), peak VO_2/kg, metabolic equivalent (METS) in exercise testing, respiratory quotient (VCO_2/VO_2), VO_2 at anaerobic threshold (VAT), minute ventilation (V.E), breathing reserve (BR), tidal volume (VT), O_2 pulse, ventilatory equivalent for oxygen (VE/VO_2), ventilatory equivalent for carbon dioxide (VE/VCO_2), heart rate (HR), HR reserve, HR recovery in 1min, end-tidal partial pressure of carbon dioxide, end-tidal partial pressure of oxygen, respiratory compensation and oxygen uptake efficiency slope (OUES).

Statistical analysis

The Shapiro–Wilk test was used to assess the distribution of the data. A comparison was done among somatotypes using the one-way analysis of variance test and the Kruskal–Wallis test for parametric and non-parametric data, respectively. Based on distribution, the data are provided as mean ± standard deviation or median (min. to max. range). The results were considered significant when $P < 0.05$. GraphPad Prism 9.0 (GraphPad Software, San Diego, California) software was used for the statistical analysis.

RESULTS

Demographic profile of subjects

Young males with a mean age of 24.10 ± 4.55 years (n = 50) took part in the study. Table 1 presents the demographic information as well as the parameters required to calculate an individual's somatotype, duration of exercise and modified Borg dyspnoea scale. Age was comparable among the somatotypes. Ectomorphs were significantly taller than endomorphs and mesomorphs. In terms of weight, endomorphs were significantly heavier than ectomorphs. As compared to mesomorphs and ectomorphs, endomorphs had significantly higher triceps, subscapular, supraspinal and calf skinfold thickness. Mesomorphs had significantly thicker subscapular skinfolds than ectomorphs do and significantly greater humerus breadth than endomorphs and ectomorphs. Arm and calf girths were significantly lower in ectomorphs than in endomorphs and mesomorphs.

CPET finding in different somatotypes

We examined the absolute values and percentage predicted values of CPET parameters in various somatotypes, as shown in Table 2 and Figures 1-3. We found that mesomorphs significantly outperformed endomorphs in terms of peak VO_2, peak VO_2 %predicted, peak VO_2/kg, peak VO_2/kg %predicted, METS, METS %predicted, V.E, oxygen pulse (O_2 pulse) and VE/VO_2 values. In contrast, ectomorphs significantly outperformed endomorphs in terms of peak VO_2/kg and METS values. Mesomorphs achieved significantly lower maximum HR during exercise than ectomorphs and had significantly smaller BR than endomorphs and ectomorphs but significantly higher %predicted O_2 pulse compared to endomorphs and ectomorphs. Other parameters were comparable.

Correlation between determinants of somatotype and the parameters of CPET

We investigated the correlation between somatotype determinants and the cardiopulmonary exercise test parameters listed in Table 3 and Figure 4. Weight had a positive correlation with O_2 pulse and OUES. BR, VO_2 at anaerobic threshold, VO_2 at anaerobic threshold %predicted, and OUES all showed positive correlations with height. Humerus breadth was positively correlated with OUES.

Table 1: Demographic details and parameters used for somatotype calculation among different somatotypes as well as, exercise duration and modified Borg dyspnoea scale.

Parameters of somatotype	Endomorphs (n=20)	Mesomorphs (n=15)	Ectomorphs (n=15)	P-value
Age (yrs.)	26.00 (18.00–34.00)	25.00 (18.00–33.00)	21.00 (18.00–34.00)	P=0.07
Height (cm)	168.3 (161.3–184.9)	167.5 (154–177)	178.8 (165.8–190.5)	P^b=0.0104 P^c=0.0018
Weight (kg)	74.03±11.51	69.74±8.90	61.31±8.92	P^b=0.0004
Triceps skinfold (mm)	19.84±4.338	13.92±4.536	10.59±3.231	P^a=0.0001 P^b<0.0001
Subscapular skinfold (mm)	19.24±4.135	15.04±4.170	9.906±3.144	P^a=0.0044 P^b<0.0001 P^c=0.0010
Supraspinale skinfold (mm)	16.15±4.077	9.814±2.183	7.156±2.277	P^a<0.0001 P^b<0.0001
Calf skinfold (mm)	16.20 (9.800–27.00)	10.50 (6.200–18.60)	11.50 (6.800–17.20)	P^a=0.0002 P^b=0.0006
Humerus breadth (cm)	6.629±0.3986	6.935±0.4295	6.596±0.2605	P^a=0.0372 P^c=0.0339
Femur breadth (cm)	7.885±0.5176	8.113±0.9032	7.824±0.5727	P=0.4156
Arm girth (cm)	32.55 (28.20–39.70)	33.10 (29.00–36.50)	27.65 (21.80–29.50)	P^b<0.0001 P^c<0.0001
Calf girth (cm)	36.84±2.852	36.91±2.430	33.53±2.055	P^b=0.0002 P^c=0.0010
Modified Borg dyspnoea scale	3.00 (0.50–6.00)	2.00 (0.50–5.00)	2.00 (0.50–4.00)	P=0.41
Mean duration of exercise (min: sec)	07:46	08:54	09:35	

[a]Endomorphs vs. Mesomorphs, [b]Endomorphs vs. Ectomorphs, [c]Mesomorph vs. Ectomorphs. Values presented are mean±standard deviation or *median (minimum–maximum)*, analysed by one-way analysis of variance (*post hoc*-Tukey) or Kruskal–Wallis test (*post hoc*-Dunn's), respectively

Table 2: This graph displays the parameters of the cardiopulmonary exercise test in different somatotypes.

CPET parameters	Endomorphs (*n*=20)	Mesomorphs (*n*=15)	Ectomorphs (*n*=15)	*P*-value
Peak oxygen consumption (mL/min)	2151±287.8	2487±364.3	2342±403.8	P^a=0.01
Peak oxygen consumption (%predicted)	66.96±10.11	78.13±11.95	70.06±8.18	P^a=0.003
Peak oxygen consumption/kg	30.11±5.52	36.04±6.16	38.32±5.38	P^a=0.0057 P^b<0.0001
Peak oxygen consumption/kg (%predicted)	66.96±10.11	78.13±11.95	70.06±8.18	P^a=0.003
METS	8.77±1.86	10.29±1.74	10.95±1.54	P^a=0.026 P^b=0.0004
METS %predicted	66.92±10.09	78.13±11.95	70.06±8.18	P^a=0.003
RQ	1.27 (1.05–1.58)	1.31 (1.15–1.58)	1.26 (1.09–1.44)	*P*=0.80
BR	53.80±17.16	38.38±11.87	52.79±9.47	P^a=0.004 P^c=0.001
Tidal volume (L (btps))	1.78±0.50	2.03±0.41	1.99±0.40	*P*=0.17
V.E	71.13±25.39	95.32±18.63	80.29±14.43	P^a=0.002
Respiratory frequency (1/min)	38.19±6.89	48.25±11.34	40.92±7.03	P^a=0.001 P^c=0.03
O_2 pulse (mL/beat)	12.80 (9.20–21.90)	14.80 (10.30–24.00)	12.85 (10.10–18.50)	P^a=0.02
O_2 pulse %predicted	77.50 (51.00–115.00)	90.00 (67.00–147.00)	76.50 (17.60–98.00)	P^a=0.006 P^c=0.033
HR (bpm)	171.5 (142.00–194.00)	166.00 (125.00–186.00)	178.00 (159.00–189.00)	P^c=0.04
HR % predicted	87.23±8.673	82.67±10.55	88.94±5.418	*P*=0.097
HRR (bpm)	23.00 (5.00–54.00)	20.50 (9.00–55.00)	17.00 (4.00–36.00)	*P*>0.99
VE/VO_2	34.24±5.99	39.40±7.02	35.80±5.82	P^a=0.03
VE/VCO_2	27.45 (19.50–42.40)	29.10 (25.60–40.50)	26.55 (23.00–34.50)	*P*=0.17
OUES	2550±422.9	2647±414.2	2645±447.8	*P*=0.70
OUES (%predicted)	81.00±14.04	83.80±10.01	83.72±12.23	*P*=0.70
VO_2 at anaerobic threshold (mL/min)	1686±406.1	1651±326.2	1795±382.5	*P*=0.51
VO_2 at anaerobic threshold (%pred)	75.40±16.02	66.73±11.02	76.89±13.93	*P*=0.09
End-tidal PO_2 ($PetO_2$)	105.7±6.41	109.7±4.60	106.2±4.60	*P*=0.07
End-tidal PCO_2 ($PetCO_2$)	44.04±6.26	39.87±4.82	42.78±4.50	*P*=0.06

[a]Endomorphs vs. Mesomorphs, [b]Endomorphs vs. Ectomorphs, [c]Mesomorph vs. Ectomorphs. Values presented are mean±standard deviation or *median (minimum–maximum)*, analysed by one-way Analysis of Variance (*post hoc*-Tukey) or Kruskal–Wallis test (*post hoc*-Dunn's), respectively. OUES: Oxygen uptake efficiency slope, METS: Metabolic equivalent, RQ: Respiratory quotient, BR: Breathing reserve, HR: Heart rate, HRR: Heart rate reserve, VE/VO_2: Ventilatory equivalents for oxygen, VE/VCO_2: Ventilatory equivalent for carbon dioxide, O_2: Oxygen pulse, V.E: Minute ventilation, PO_2: partial pressure of O_2, PCO_2: partial pressure of CO_2

Arm girth was inversely associated with HR but positively correlated with O_2 pulse and VE/VCO_2 slope. Calf girth was positively correlated with oxygen pulse but negatively correlated with peak VO_2/kg, METS, breathing reserve, heart rate and heart rate % predicted.

DISCUSSION

In the present study, cardiorespiratory responses to incremental exercise have been investigated in young adults having dominant somatotypes.

Compared to other approaches, the Heath and Carter method is a better predictor of body composition since it accounts for variables including height, weight, skinfold thickness, bone width and limb girths. This approach offers more precise information on body composition than BMI and waist-hip ratio alone.

Mesomorphs having higher muscle mass compared to endomorphs may explain their significantly higher peak VO_2, peak VO_2% predicted, peak VO_2/kg and peak VO_2/kg% predicted compared to endomorphs. Imms *et al*. have reported greater oxygen consumption during contraction of the large mass muscle (quadriceps) than that during small mass muscle (hand gripping) at 20% maximum voluntary contraction.[9] The significantly lower values in endomorphs may be explained by their comparatively slower metabolism, which causes more fat accumulation in the body. Pourhassan *et al*. studied the relationship between submaximal oxygen uptake and body composition and reported a strong association between VO_2submax and fat-free mass (FFM) and concluded that FFM is the determinant of VO_2 submax.[10] Saha has determined the impact of somatic and body composition variables on aerobic capacity in different somatotypes. She observed a negative correlation between VO_2 max and body fat percentage, body surface area and endomorphy component of somatotype, while it correlated positively with the lean body mass, percentage of skeletal muscle mass and mesomorphy

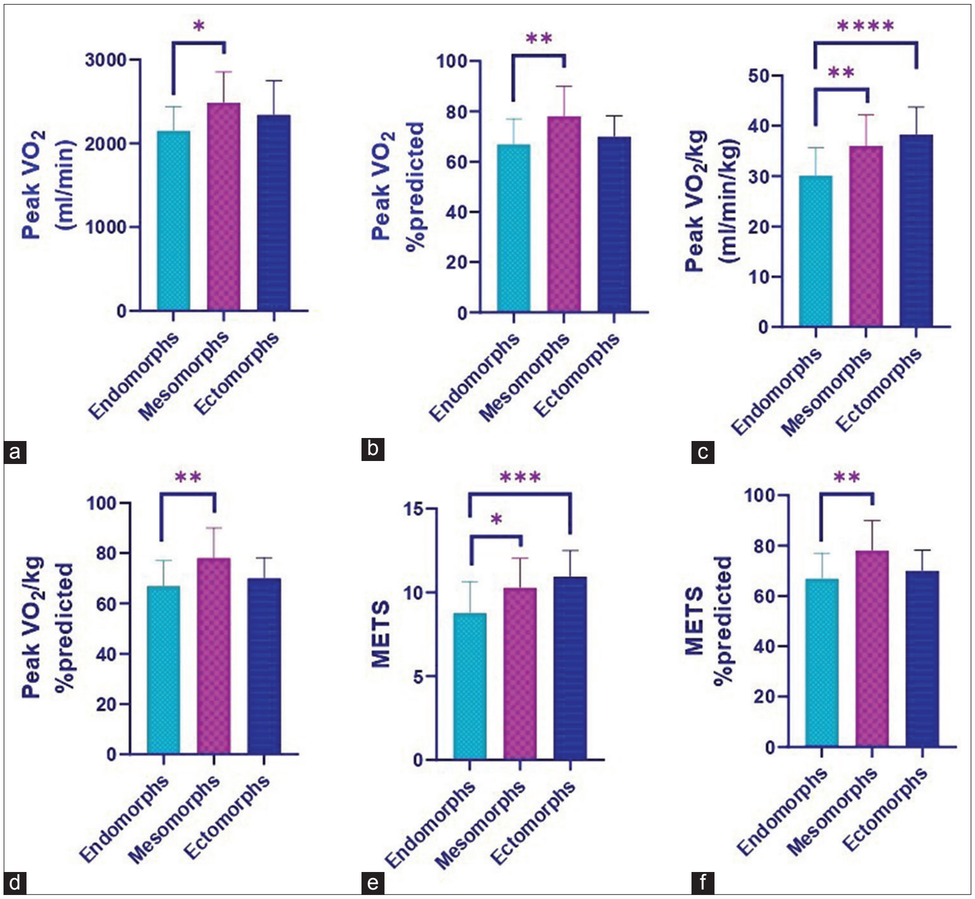

Figure 1: The graphs depicting cardiopulmonary exercise parameters in different somatotypes: (a) Peak VO_2 (b) Peak VO_2 %predicted (c) Peak VO_2/kg (d) Peak VO_2/kg % predicted (e) METS (f) METS % predicted Values are plotted as mean ± standard deviation or median (minimum to maximum). $^*P < 0.05$, $^{**}P < 0.01$ and $^{***}P < 0.001$, $^{****}P \leq 0.0001$ for inter group comparison. VO_2: Peak oxygen consumption; METS: Metabolic equivalent in exercise testing.

component of somatotype.[11] Oda *et al*. also reported a significant negative correlation between peak oxygen uptake with total body fat percentage.[12] These findings suggest that VO_2max is influenced by the total active muscle mass being recruited during exercise, where the more muscle mass is involved during exercise, the higher the VO_2max.[13]

A MET is the quantity of oxygen consumed while at rest, the value of which is around 3.5 mL O_2/kg/min (1.2 kcal/min for a person weighing 70 kg). The MET concept offers a straightforward, understandable method for describing the energy expenditure of physical activity as a multiple of resting metabolic rate. The energy cost of an activity may be calculated by dividing the relative oxygen cost of the activity (ml O_2/kg/min) by 3.5.[14] In the present study, METS values were significantly lower in endomorphs than other somatotypes for maximum physical activity. The amount of skeletal muscle is a key factor in the rise in metabolism during exercise and the absolute maximum oxygen consumption. Lean tissue has a significant relationship with basal metabolism, and skeletal muscles are the source of energy used during physical activity.[15] This might be the reason why mesomorphs achieved higher METS than endomorphs. Thus, higher VO_{2peak}/kg and METS values observed in mesomorphs may be explained by the higher muscle mass in these individuals.

In an exercising person, maximal oxygen uptake is limited by the ability of the cardiorespiratory system to deliver oxygen to the exercising muscles.[16] The increase in the O_2 pulse after the training session may reflect the degree of peripheral and cardiac adaptation to training. In our study, we observed that O_2 pulse (the amount of oxygen consumed per heartbeat during exercise), which can be used as an indirect indicator of cardiac stroke volume,[17] was significantly higher in mesomorphs as compared to endomorphs. Chaouachi *et al*. have also reported higher values of O_2 pulse in mesomorphs in comparison to the endomorphs and ectomorphs' groups.[18] We also observed that O_2 pulse significantly correlated with arm and calf girths. The calf muscle pump plays a very important role in increasing venous return, which can also affect the cardiac output.

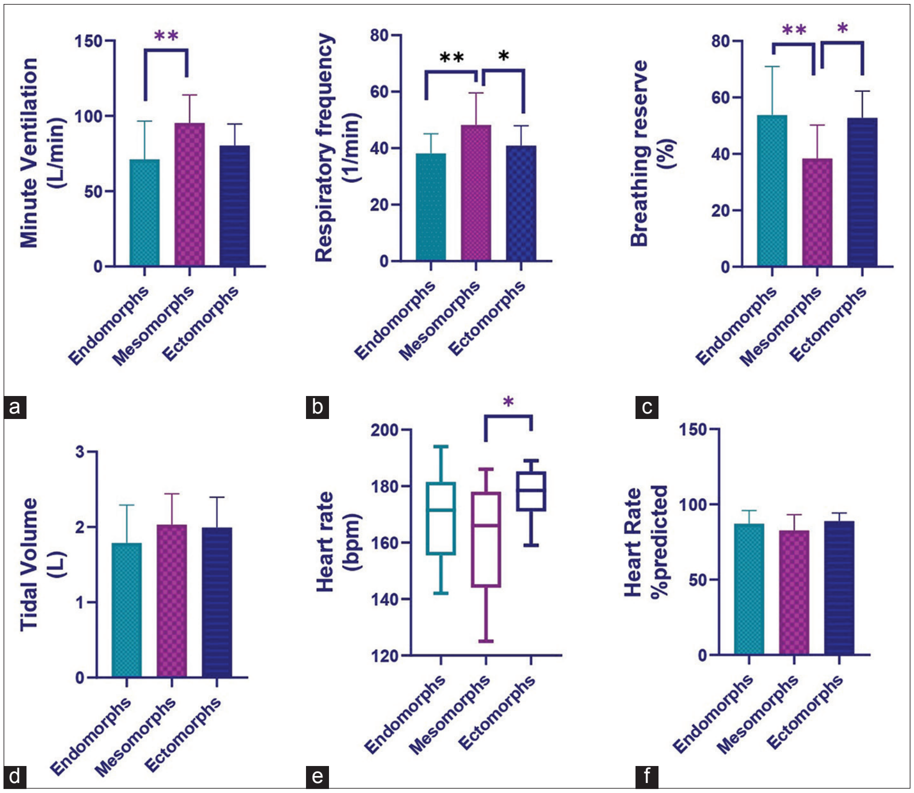

Figure 2: The graphs depicting the cardiopulmonary exercise parameters in different somatotypes: (a) Minute ventilation, (b) Respiratory frequency (c) Breathing reserve (d) Tidal volume, (e) Heart rate, (f) Heart rate % predicted. Values are plotted as mean ± standard deviation or median (minimum to maximum). **P* < 0.05, ***P* < 0.01 for inter group comparison.

Table 3: Correlation between determinants of somatotype and cardiopulmonary exercise test parameters.

Spearman correlation	Weight	Height	Humerus breadth	Arm girth	Calf girth
Peak VO_2/kg	r=−0.55 *P*=5.48	r=0.02 *P*=0.86	r=−0.11 *P*=0.40	r=−0.49 *P*=7.73	**r=−0.37** ***P*=0.003**
METS	r=−0.50 *P*=3.82	r=0.06 *P*=0.62	r=−0.05 *P*=0.70	r=−0.48 *P*=1.08	**r=−0.33** ***P*=0.009**
BR	r=0.03 *P*=0.77	**r=0.39** ***P*=0.002**	r=0.01 *P*=0.91	**r=−0.22** ***P*=0.08**	**r=−0.10** ***P*=0.45**
HR	r=−0.18 *P*=0.16	r=0.12 *P*=0.28	r=−0.17 *P*=0.18	**r=−0.35** ***P*=0.005**	**r=−0.34** ***P*=0.007**
HR %pred	r=−0.03 *P*=0.79	r=−0.11 *P*=0.33	r=−0.16 *P*=0.22	r=−0.19 *P*=0.14	**r=−0.26** ***P*=0.04**
VO_2/HR	**r=0.29** ***P*=0.02**	r=0.14 *P*=0.26	r=0.21 *P*=0.09	**r=0.26** ***P*=0.04**	**r=0.29** ***P*=0.02**
VO_2 at AT	r=0.24 *P*=0.06	**r=0.36** ***P*=0.004**	r=0.13 *P*=0.29	**r=0.05** ***P*=0.69**	r=0.15 *P*=0.23
VO_2 at AT %pred	r=0.15 *P*=0.24	**r=0.27** ***P*=0.03**	r=0.07 *P*=0.55	r=3.80 *P*=0.99	r=0.09 *P*=0.47
Respiratory compensation	**r=0.29** ***P*=0.02**	r=0.17 *P*=0.18	r=0.01 *P*=0.89	r=0.22 *P*=0.08	r=0.15 *P*=0.23
VE/VCO_2 slope	r=0.11 *P*=0.40	r=−0.14 *P*=0.27	r=0.08 *P*=0.54	**r=0.29** ***P*=0.02**	r=0.17 *P*=0.18
OUES	**r=0.32** ***P*=0.01**	**r=0.35** ***P*=0.006**	**r=0.27** ***P*=0.03**	r=0.12 *P*=0.33	**r=0.27** ***P*=0.03**

In this correlation, *P* values and r-values are presented, and the bold text represents a significant correlation analysed by the Spearman correlation test. METS: Metabolic equivalent, HR: Heart rate, BR: Breathing reserve, AT: Anaerobic threshold, VE/VCO_2: Ventilatory equivalent for carbon dioxide, OUES: Oxygen uptake efficiency slope, VO_2: Oxygen consumption

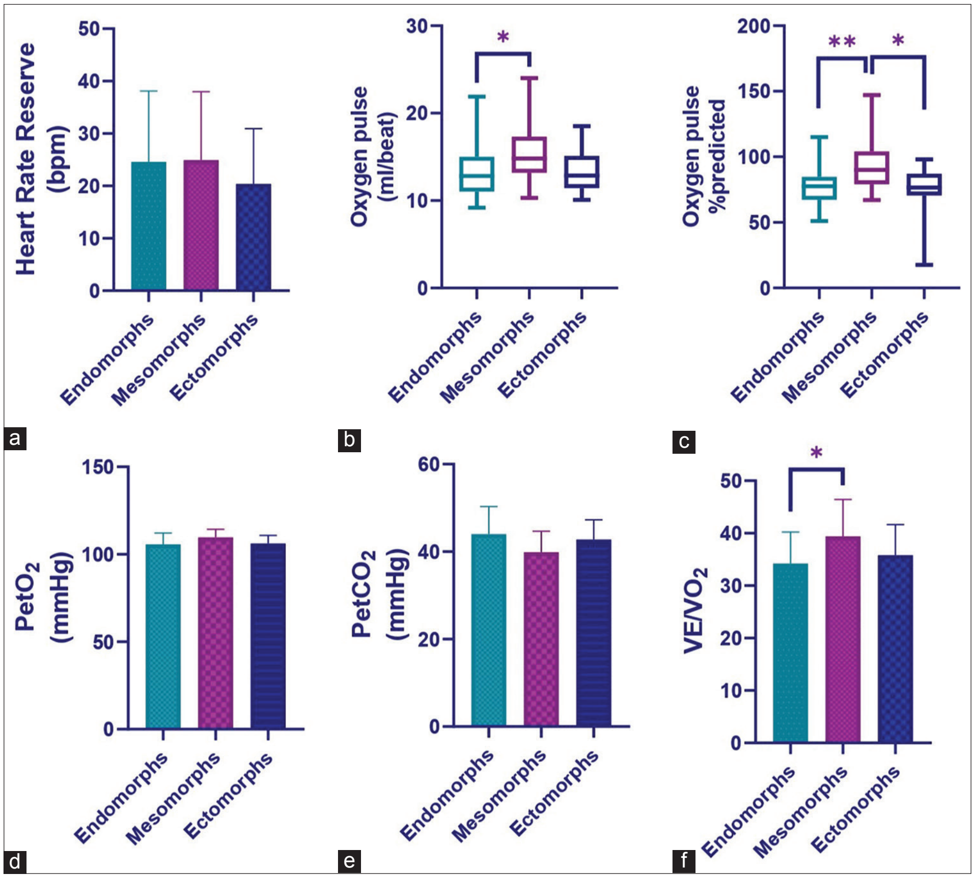

Figure 3: The graphs depicting the cardiopulmonary exercise parameters in different somatotypes: (a) Heart rate reserve (b) Oxygen pulse (c) Oxygen pulse % predicted (d) $PetO_2$ (e) $PetCO_2$ (f) VE/VO_2. Values are plotted as mean ± standard deviation or median (minimum to maximum). $*P < 0.05$, $**P < 0.01$ and for inter group comparison. $petO_2$: End-tidal PO_2; $PetCO_2$: End-tidal PCO_2; VE/VO_2: Ventilatory equivalent for oxygen.

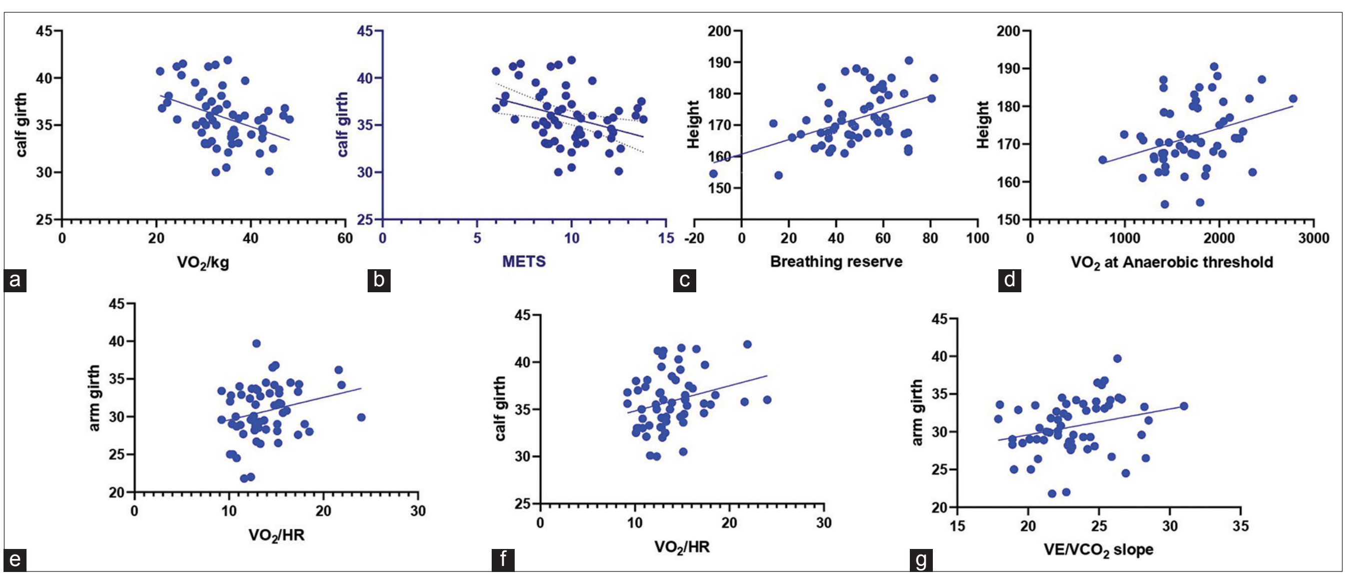

Figure 4: The graphs show correlation between somatotype dimensions and cardiopulmonary exercise test parameters. Calf girth correlates negatively with (a) peak VO_2/kg and (b) METS. Height correlates positively with (c) breathing reserve and (d) VO_2 at anaerobic threshold. Arm girth correlates positively with (e) VO_2/HR. Calf girth correlates positively with (f) VO_2/HR. Arm girth correlates positively with (g) VE/VCO_2 slope.

We found that mesomorphs had significantly higher V.E than endomorphs, and respiratory frequency was significantly higher compared to endomorphs and ectomorphs, but the BR was significantly lower as compared to endomorphs and ectomorphs. While exercising, VTs and respiratory rates are increased, increasing oxygen consumption. This is generally achieved by raising the respiratory rate because VTs are frequently not raised. Uneven body fat distribution may restrict diaphragmatic excursion and impede further VT augmentation during exercise.[19] Mesomorphs have a significantly smaller BR, which may be related to their increased V.E.

Subhan *et al.* reported that there is no significant difference in maximal HR achieved during exercise among persons who are overweight, normal weight and obese as determined by BMI.[20] Nevertheless, we noticed that ectomorphs achieved significantly higher maximal HR during exercise than mesomorphs. The reason behind this is not yet clear.

High airway resistance might be the cause of the VE/VO_2 and VE/VCO_2 not rising with maximum activity.[21] We found that VE/VO_2 was significantly higher in mesomorphs than in endomorphs. This may be a result of their significantly higher respiratory frequency and V.E. One of the possibilities might be that endomorphs have a significantly higher peripheral airway resistance, leading to a decreased VE/VO_2 ratio.

Mesomorphs have a higher percentage of muscular components, and endomorphs have relatively more body fat than mesomorphs.[22] Excess body fat may exert an unfavourable burden and a hindering action on cardiac function, particularly during exhausting exercise when excessively hyperactive body muscles fail to uptake enough oxygen due to the deposition of a proportionately higher amount of fat mass. Extra body fat affects mechanical efficiency for a given workload and impairs cardiorespiratory functions.[23]

CONCLUSION

Mesomorphs have higher peak oxygen consumption than endomorphs, along with higher METS, V.E and O_2 pulse. Clinicians should consider somatotype when interpreting the results since, even though all the participants were in good health, there is still variation in their cardiorespiratory responses.

Ethical approval

This study was approved by the Institute Ethics Committee for Human Subjects (Ref. No.: IECPG-520/23.09.2021, RT-02/28.10.2021 dated 29.10.21).

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Conflicts of interest

There are no conflicts of interest.

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Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Parnell RW. Somatotyping by physical anthropometry. Am J Phys Anthropol 1954;12:209-39.
2. Carter J. The heath-carter anthropometric somatotype - instruction manual-2002; Available from: https://www.semanticscholar.org/paper/the-heath-carter-anthropometric-somatotype manual-carter/13bf62be916b98b2b05b3297f7bf4ca11f6c09b3 [Last accessed on 2023 Nov 02].
3. Carter JE, Carter JE, Heath BH. Somatotyping: Development and applications. Cambridge, UK: Cambridge University Press; 1990. p. 524.
4. Silventoinen K. Chapter 23: Anthropometric twin studies. In: Tarnoki A, Tarnoki D, Harris J, Segal N, editors. Twin research for everyone. United States: Academic Press; 2022. p. 387-402. Available from: https://www.sciencedirect.com/science/article/pii/B9780128215142000246 [Last accessed on 2024 Aug 31].
5. Bolonchuk WW, Siders WA, Lykken GI, Lukaski HC. Association of dominant somatotype of men with body structure, function during exercise, and nutritional assessment. Am J Hum Biol 2000;12:167-80.
6. Schreiber ML. Anaerobic capacity as a function of somatotype and participation in varsity athletics. Res Q 1973;44:197-205.
7. Albouaini K, Egred M, Alahmar A. Cardiopulmonary exercise testing and its application. Postgrad Med J 2007;83:675-82.
8. American Thoracic Society, American College of Chest Physicians. ATS/ACCP Statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med 2003;167:211-77.
9. Imms FJ, Mehta D. Respiratory responses to sustained isometric muscle contractions in man: The effect of muscle mass. J Physiol 1989;419:1-14.
10. Pourhassan M, Eggeling B, Schautz B, Johannsen M, Kiosz D, Glüer CC, *et al*. Relationship between submaximal oxygen uptake, detailed body composition, and resting energy expenditure in overweight subjects. Am J Hum Biol 2015;27:397-406.
11. Saha S. Somatic and body composition factors underlying aerobic capacity. Am J Sports Sci 2015;3:36.
12. Oda K, Miyatake N, Sakano N, Saito T, Miyachi M, Tabata I, *et al*. Relationship between peak oxygen uptake and regional body composition in Japanese subjects. J Sport Health Sci

2014;3:233-8.
13. Kim CH, Wheatley CM, Behnia M, Johnson BD. The effect of aging on relationships between lean body mass and VO_2max in rowers. PLoS One 2016;11:e0160275.
14. Jetté M, Sidney K, Blümchen G. Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. Clin Cardiol 1990;13:555-65.
15. Tompuri TT. Metabolic equivalents of task are confounded by adiposity, which disturbs objective measurement of physical activity. Front Physiol 2015;6:226.
16. Bassett DR, Howley ET. Limiting factors for maximum oxygen uptake and determinants of endurance performance. Med Sci Sports Exerc 2000;32:70-84.
17. Kinnear W, Blakey J. Oxygen pulse; 2014. Available from: https://academic.oup.com/book/24372/chapter/187250763 [Last accessed on 2022 Jul 27].
18. Chaouachi M, Chaouachi A, Chamari K, Chtara M, Feki Y, Amri M, *et al*. Effects of dominant somatotype on aerobic capacity trainability. Br J Sports Med 2005;39:954-9.
19. Littleton SW. Impact of obesity on respiratory function. Respirology 2012;17:43-9.
20. Subhan MM, Ali SA, Bokhari SS, Khan MN, Ahmad HR. Underweight and overweight men have greater exercise-induced dyspnoea than normal weight men. Ups J Med Sci 2012;117:383-9.
21. Datta D, Normandin E, ZuWallack R. Cardiopulmonary exercise testing in the assessment of exertional dyspnea. Ann Thorac Med 2015;10:77-86.
22. Miroshnichenko VM, Furman YM, Brezdeniuk OY, Onyshchuk VE, Gavrylova NV, Salnykova SV. Correlation of maximum oxygen consumption with component composition of the body, body mass of men with different somatotypes aged 25-35. Pedagogy Phys Cult Sports 2020;24:290-6.
23. Buskirk E, Taylor HL. Maximal oxygen intake and its relation to body composition, with special reference to chronic physical activity and obesity. J Appl Physiol 1957;11:72-8.

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