Influence of Lipid Profileand Somatotype on Aerobic Capacity in Athletes

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ABSTRACT

PURPOSE:In recent times, the incidence of sudden cardiac death in athletes has increased. Therefore, this study aimed to establish the influence of somatotype components and lipid profile on VO2 max, a cardiovascular risk indicator in physically active young South Indian males.

METHODS:Eighty-six male athletes were included (Age 21.99 ± 2.78 years, Body mass 65.24 ± 8.77 Kg, Height 171.42 ± 6.19 cm) and somatotyped by the Heath-Carter method. Bruce protocol treadmill test was done and VO2 max norms were calculated using the total exercise time in the treadmill test. Based on the VO2 max, subjects were grouped into Fair VO2 max (36.5 – 42.4, Good VO2 max (42.5 – 46.4), Excellent VO2 max (46.5 – 52.4), and Superior VO2 max group (> 52.4).Blood tests were done for fasting cholesterol and triglyceride levels. Spearman correlation was done to understand the relationship between the VO2 max groups, somatotype components, and lipid profile.

RESULTS:An increase in endomorphy and mesomorphy components negatively correlated with VO2 max in young male athletes. A significant influence of somatotype components on lipid profile was observed only in the Excellent and Superior VO2 max groups. In these groups, a negative relationship was observed between ectomorphy and cholesterol level, low-density lipoprotein-cholesterol (LDL-C), and Cholesterol High-density lipoprotein-cholesterol (Chol-HDL-C) ratio. Similarly, an increase in the endomorphy component showed a positive relationship with LDL-C and the Chol-HDL-C ratio. An increase in endomorph had a negative relationship with high-density lipoprotein-cholesterol (HDL-C) in these groups. Athletes in the Fair, Good, and Excellent VO2 max categories demonstrated LDL-C levels in the "Near Optimum" range, while those in the Superior VO2 max group exhibited LDL-C levels within the "Optimum" range as per the Adult Treatment Panel, (ATP) III classification of serum lipid parameters and this is a new clinical observation recorded.

CONCLUSION:These findings suggest that the somatotype components and lipid profile have an impact on VO2 max, a determinant of cardiovascular endurance, and a risk indicator.in various Scopus indexed journals was examined bibliometrically, for the years 2014-2024.

Introduction

By establishing a relationship between the composition of the human body and the VO2 max, we can gain a deeper comprehension of the ideal performance and overall well-being of athletes. VO2 max is an indicator of cardiopulmonary endurance and risk of developing cardiovascular problems [32]. Studies have shown that body composition and anthropometric measurements do influence physical performance[2, 4, 10]. Somatotyping is a measuring technique to evaluate the shape and composition of the human build [22, 31]. This technique quantifies the morphology and body composition by a three-number rating[5, 37]. Matiegka in 1921 was the first person to describe human somatotype and he divided human body structure into four components: body weight, subcutaneous fat mass, muscle weight, and residual weight [22, 31]. In addition, William Herbert Sheldon used the photoscopic method to reconstruct the human somatotype and related it to the three embryonic germ layers namely endoderm, mesoderm, and ectoderm [5, 31]. He theoretically related endomorph to endoderm, mesomorph to mesoderm, and ectomorph to ectoderm. According to Sheldon, endomorphs accumulate fat mass; mesomorph develops large muscle masses and ectomorphs are thin, losing fat and muscle mass[5, 31].

Somatotyping by the Heath-Carter method is the most used method [5]. According to this, three-number rating, somatotype includes three components in-relation to height: endomorphy, mesomorphy, and ectomorphy. Endomorphy defines and quantifies relative adiposity, mesomorphy quantifies musculoskeletal development and ectomorphy defines relative linearity of the body[5, 22, 31, 37]. To calculate the anthropometric somatotype by Heath–Carter's method, ten anthropometric measurements are needed. They are body mass, stretch stature (standing height), four skinfold thickness, bi-epicondylar breath (the distance between medial and lateral epicondyles) of humerus and femur, and girth (circumference) of arm and calf[5,14, 31]. Anthropometric somatotype can be a better indicator of risk of developing diseases [35] and sports performance than BMI because it gives information about body composition [11, 17].

Exercise endurance is decided by a person's aerobic capacity. Cardiorespiratory functions decide the aerobic capacity[33, 37]. Athletes' aerobic capacity is described in VO2 max which is the maximum consumption of oxygen during sustained physical activity. VO2 max is an indicator of the maximum oxygen-utilizing capacity of the cardiovascular and respiratory systems [32]. The aerobic capacity of a human can be described as a unit of metabolic equivalents (METs) and VO2 max [10]. Aerobic capacity can be measured either through standard graded exercise ergometry or treadmill protocols [8]. Aerobic capacity decides physical performance and is the functional index of cardiovascular, pulmonary, and musculoskeletal systems [8, 21]. Other factors that influence aerobic endurance and cardiovascular fitness are the frequency, intensity, duration of regular physical training, and favorable genetics [25].

Major underlying causes for sudden cardiac death related to exercise in sportspersons are coronary artery disease (CAD), hypertrophic cardiomyopathy(HCM), and myocardial infarction(MI)[1]. Screening by exercise stress testing, cardiac imaging, and checking the lipid profile will help identify and prevent these incidents in asymptomatic athletes [20, 23, 39]. A minimum exercise threshold (65 – 80 % VO2 max) can cause changes in serum lipid levels and studies have proved that regular physical activity influences the levels of circulating lipoproteins by lowering blood triglyceride, low-density lipoprotein cholesterol (LDL-C) and increasing high-density lipoprotein cholesterol (HDL-C) levels [9, 24, 29, 30]. Circulating levels of lipoproteins are well associated with cardiovascular function and the development of higher coronary heart disease (CHD) [9, 24]. Regular physical training improves the VO2 max [30] and physical inactivity is related to Coronary diseases [36].

Most of the earlier anthropometric somatotype studies have focused on how a particular body type is more prone to diseases like diabetes mellitus, hypertension, metabolic syndrome, liver diseases and mental depression [3, 35]. In the field of sports, anthropometric somatotyping is used to understand how somatotype profiles of sportspersonsinfluence the physical-athletic performance, exercise capacity and endurance level [2,4, 6, 10, 31, 37]. Research about the influence of the three somatotype components namely endomorphy, mesomorphy, ectomorphy, and lipid profile based on VO2 max classification, the indicator of cardiovascular endurance in young male sportspersons is inadequate. Considering this, the present study was focused on observing the possible correlation between somatotype components, lipid profile, and VO2 max.

Materials and Methods

This somatotyping cross-sectional study was pursued in Chennai city in Tamil Nadu located in South India. The Institutional Research Committee and Institutional Human Ethical Committee approved this research protocol. Approval by an institutional review board was obtained which is essential in the field of human exercise science as indicated by Navalta *et al*[26]. This study was conducted according to all ethical considerations in the field of exercise science as indicated by Navalta *et al* [26].

1. Participants

With G*power 3.1.9.4 (Franz Faul, University at Kiel, Germany) a power analysis was conducted, and decided that 84 subjects were required for this research protocol for 0.90 power for an effect size of 0.4 and an $\alpha = 0.05$. A total number of eighty-six male sportspersons aged between 18 to 29 years were included in this study. A written informed consent explaining the study procedure was collected from the participating subjects. Participant demographics are presented in Table. 1

Table 1. Participant demographics and physical training details

Age	21.99 ± 2.78
Trained duration in years	6.47 ± 2.87
Training in hours per day	2.81 ± 1.27
Body mass (Kg)	65.24 ± 8.77
Standing stature/ Height (cms)	171.42 ± 6.19
BMI (kg/m2)	22.18 ± 2.61

The inclusion criteria were as follows: Young male athletes undergoing regular physical training were considered for this study because an increase in age declines the VO2 max capacity [12]. Participants who voluntarily consented and were undergoing regular physical training for a minimum duration of 1 hour per day related to any sport for ≥ 6 months were included.

The exclusion criteria were: Young male sportsperson with a thyroid condition, musculoskeletal injuries, metabolic disease, cardiac and pulmonary conditions [7]. Subjects who were taking weight loss supplements and oral steroids were not considered for this study [16].

A structured questionnaire permitted by the Institutional Research Board was administered to obtain details about the physical training duration and health history to rule out any musculoskeletal, pulmonary, metabolic disease and family history of cardiac incidents.

2. Sample collection: After overnight fasting, under aseptic conditions blood sample was collected from the participants by a health professional by vein puncture for estimating the lipid profile.

3.Biochemical assays: Serum total cholesterol (TC) and triglycerides were determined by CHOD-POD (Cholesterol oxidase phenol 4-aminoantipyrine peroxidase) enzymatic method. Direct method was used for estimating high-density lipoprotein (HDL) cholesterol that is dependent on particles enriched with apolipoprotein E(apoE). LDL cholesterol and VLDL were calculated.

4. Anthropometric measurements: Subject's anthropometric parameters were measured by a trained anthropometrist following the protocol developed by the International Society for the Advancement of Kinanthropometry(ISAK)[14,28, 33, 34]. An electronic weighing scale (Kalenji scale 100) was used for weighing the body mass of the subject in kilograms. Stadiometer (Prestige SM-P-W-210) was used to measure the standing height and sitting height of the subject. Cescorf anthropometric tape was used for measuring arm span and 5 girths (arm, waist, hip, mid-thigh, and calf). Skin folds in ten places (Biceps, Triceps, subscapular, Iliac crest, supraspinal, abdominal, thigh, and calf) were measured using a Cescorf skinfold caliper.Cescorf's anthropometric sliding caliper was used for measuring bi-epicondylar breadths of the femur and humerus. BMI was calculated for all the subjects.

Heath and Carter's method was followed for somatotype rating [5, 6, 14, 28].

Endomorphy = $– 0. 7182 + 0.1451 \times (X) – 0.00068 \times (X)^2 + 0.0000014 \times (X)^3$

X = Triceps + subscapular +supraspinal skinfolds multiplied by (170.18/height in cm)

Mesomorphy = 0.858 x humerus breadth + femur breadth + 0.188 x corrected arm girth + 0.161 x corrected calf girth – height x 0.131 + 4.5

Ectomorphy is determined based on the body height (BH) and the third power of the body mass.

$$HWR = \frac{BH}{\sqrt[3]{W}}$$

Three equations are used based on the height–weight ratio (HWR) to calculate ectomorphy.

If HWR

– is greater than or equal to 40.75: Ectomorphy = 0.732 HWR – 28.58

– is between 40.75 – 38.25: Ectomorphy = 0.463 HWR – 17.63

– is lesser than or equal to 38.25: Ectomorphy = 0.1

5. Exercise capacity: Exercise testing (graded exercise ergometry or treadmill protocols) was used to assess peak aerobic capacity. Aerobic capacity in VO2 max value reflects the cardiorespiratory endurance of an individual. To measure the maximum aerobic capacity a graded symptom-limited exercise testing was followed [19, 38]. Exercise testing was done using the GE Cardiac Assessment for Exercise Testing (CASE) V6.73 T-2100 treadmill. The test is performed until the subject reaches his sub-maximal heart rate to prevent cardiac injury and reduction in the ventricular filling time that will reduce cardiac output. Screening echocardiography was done for all the subjects to rule out the structural defects in the heart that are related to potential risks associated with exercise testing. Total exercise time on the treadmill is used to calculate the VO2 max using the Bruce protocol formula for young men [3, 19, 25]. VO_{2max} (ml/kg/min) = 3.62 x T + 3.91(T =Total exercise time in minutes).

Based on the Bruce protocol VO2 max norms for young male subjects were categorized into four groups[3, 19, 25] as Fair VO2 max with values between 36.5 – 42.4, Good VO2 max with values between 42.5 – 46.4, Excellent VO2 max with values between 46.5 – 52.4 and Superior VO2 max with values above 52.4. Very poor VO2 max with values below 33 and poor VO2 max with values between 33 – 36.4 were not present in the recruited subjects since they were undergoing physical training [3]. During this test 12 lead ECG recording, heart rate and blood pressure monitoring and recording were continuously done. This exercise stress test is an indicator of cardiovascular endurance.

6. Statistical Analysis

Analysis of collected data using IBM Statistical Package for Social Sciences (SPSS. Version 24) was done for the interpretation of results. Lipid parameters and anthropometric somatotype components among the VO2 max groups were analyzed to measure the possible difference by one-way analysis of variance (ANOVA). Descriptive statistics are given as the mean values ± Standard Deviation (SD). A level of $\alpha \leq 0.05$ was set for statistical significance. Spearman correlation was used for nonparametric coefficient of correlations between the somatotype components of different VO2 max groups and lipid profile.

Results

This study was conducted on 86 male athletes who were undergoing regular physical training.

a) Somatotype component among the groups:

Table 2 describes the somatotype components among the VO2 max group.

Table 2. Somatotype component among the groups

	VO2 Max norms					
	Fair (n= 9)	Good (n= 6)	Excellent (n=24)	Superior (n= 47)	One way ANOVA	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean± SD	*F*-Value	*p*-Value
Endomorphy	3.41±1.33	3.12±.68	2.92±1.17	2.33±.99	3.783	.014*

Mesomorphy	4.69±1.75	4.45±1.35	4.39±1.06	4.03±1.06	1.148	.335
Ectomorphy	2.23±1.23	2.47±1.60	2.33±1.24	3.11±1.26	2.681	.052*

* P value significance < 0.05

One-way ANOVA was carried out after ascertaining that the parameters, Endomorphy, Mesomorphy, and Ectomorphy follow normal distribution. Post-hoc tests indicate that the mean values of endomorphy differ significantly between Fair and Superior Groups based on VO2max norms.A significant difference was seen in the endomorphycomponent among the four VO2 max groups. The Fair VO2 max group in which the aerobic capacity is lesser showed higher values of endomorphic component than the Superior group which showed higher VO2 max.

b)Lipid profile among the four VO2 max group:

Table 3 represents the Lipid profile among the VO2max groups.

Table 3. Lipid profile among the four VO2 max group

	VO2 max norms				One way ANOVA	
	Fair	Good	Excellent	Superior		
	Mean ± SD	Mean± SD	Mean± SD	Mean± SD	*F*-Value	*p*-Value
Cholesterol	165.33 ± 33.37	170.33 ± 37.85	164.08 ± 28.91	153.66 ± 25.69	1.287	.284
Triglycerides	63.44 ± 25.42	77.00 ± 44.96	96.54 ± 101.78	61.85 ± 43.51	1.609	.194
HDL Cholesterol	46.22 ±11.58	47.50 ± 14.67	43.29 ± 13.06	47.64 ± 10.71	.747	.527
LDL Cholesterol	106.11 ± 22.50	107.33 ± 28.85	104.63 ± 23.67	93.66 ± 24.81	1.644	.186
VLDL cholesterol	12.89 ± 5.06	15.50 ± 8.73	16.00 ± 7.73	12.36 ± 8.72	1.183	.321
CHOL/HDL Ratio	3.64 ±.55	3.70 ± 1.22	4.04 ± 1.11	3.39 ± .95	2.266	.087

* *p* value significance < 0.05

No significant difference in the lipid profile among the groups was found but a clinical significant finding was recorded among the VO2 max groups for LDL-C. Fair, Good, and Excellent VO2 max groups showed a “Near optimum” range for LDL-C whereas the Superior VO2 max group showed an “Optimum” range.

c)Correlation between VO2 max groups, somatotype, and lipid profile:

Table 4 Correlation between somatotype components of the Fair, Good, Excellent, and Superior VO2max group subjects and lipid profile

VO2 max norms group	Somatotype component		Cholesterol	Triglycerides	HDL – C	LDL – C	VLDL – C	CHOL/HDL Ratio
Fair (36.5 – 42.4)	Endomorphy	Spearman row	.300	.251	-.084	.293	.203	.502
		Sig. (2-tailed)	.433	.515	.831	.444	.600	.168
	Mesomorphy	Spearman row	.117	-.168	.202	.130	-.128	-.160
		Sig. (2-tailed)	.764	.666	.603	.738	.743	.682
	Ectomorphy	Spearman row	.109	.193	.172	.067	.221	-.080
		Sig. (2-tailed)	.781	.618	.658	.864	.567	.838

Good (42.5 – 46.4)	Endomorphy	Spearman row	-.152	-.030	-.395	-.152	-.030	.030
		Sig. (2-tailed)	.774	.954	.439	.774	.954	.954
	Mesomorphy	Spearman row	-.543	-.314	-.600	-.543	-.314	-.143
		Sig. (2-tailed)	.266	.544	.208	.266	.544	.787
	Ectomorphy	Spearman row	.464	.174	.667	.435	.174	.029
		Sig. (2-tailed)	.354	.742	.148	.389	.742	.957
Excellent (46.5 – 52.4)	Endomorphy	Spearman row	.176	.456	.064	.041	.486	.139
		Sig. (2-tailed)	.410	.025*	.767	.850	.016*	.517
	Mesomorphy	Spearman row	.114	.111	.027	.212	.136	.273
		Sig. (2-tailed)	.597	.605	.899	.320	.527	.198
	Ectomorphy	Spearman row	-.125	-.233	.018	-.186	-.256	-.298
		Sig. (2-tailed)	.561	.273	.933	.383	.227	.157
Superior (>52.4)	Endomorphy	Spearman row	.198	.189	-.361	.382	.207	.435
		Sig. (2-tailed)	.181	.204	.013*	.008*	.163	.002*
	Mesomorphy	Spearman row	.137	-.075	-.098	.245	-.061	.138
		Sig. (2-tailed)	.359	.614	.513	.098	.682	.353
	Ectomorphy	Spearman row	-.289	-.018	.183	-.429	-.033	-.313
		Sig. (2-tailed)	.049*	.904	.217	.003*	.825	.032*

* *p* value significance < 0.05

In the Fair and Good VO2 max group increase in endomorphy, mesomorphy, and ectomorphy did not have any relationship with cholesterol, triglycerides, LDL cholesterol, HDL cholesterol, VLDL cholesterol, and cholesterol / HDL cholesterol ratio ($p > 0.05$).

In the Excellent VO2 max group, endomorphy had a significant positive correlation with triglycerides and VLDL cholesterol but increases in mesomorph and ectomorphy are not correlated with the lipid profile.

In the Superior VO2max group, endomorphy had a significant negative relationship with HDL cholesterol but had a significant positive relationship with LDL-cholesterol and Chol-HDL-C ratio, which is a risk indicator of probability for developing cardiovascular diseases. An increase in ectomorphy in this highest VO2 max group caused a significant negative relation with the total cholesterol, LDL cholesterol, and Chol-HDL-C ratio.

Discussion

The primary purpose of this study was to identify how VO2 max was influenced by somatotype components and lipid profiles in male athletes to prevent cardiac-related incidents. The findings of this study show that somatotype components and lipid profile do influence VO2 max. Participants in this study were grouped based on VO2 max and not based on the different somatotypes by Heath–Carter. There was a significant difference in endomorphy which represents relative fatness among the VO2 max groups. The more the endomorphy component, the lesser the VO2 max value. Somatotype studies show that the endomorphy component that represents fat decreases with an increase in physical activity and endurance[10, 33]. In the Superior VO2 max group which had maximum cardiorespiratory endurance, the endomorphy component was less compared to the Fair VO2 max group. Thus, in athletes, less endomorphy and more ectomorphy components can have a positive influence on VO2 max which defines aerobic capacity.Among VO2 max groups, while total cholesterol, triglycerides, HDL-C, LDL-C, VLDL-C, and the CHOL/HDL ratio all fall within the normal range, a notable observation pertains to LDL-C levels. Specifically, LDL-C was categorized as "Optimal" in the Superior VO2 max group, whereas the Fair, Good, and Excellent VO2 max groups exhibited levels classified as "Above optimal" (13). This discovery marks a novel clinical finding.

The relationship between somatotype components, lipid profile, and VO2 max was well pronounced in the Excellent and Superior groups. A significant positive correlation between the endomorph component with triglycerides, LDL cholesterol, VLDL cholesterol, and cholesterol HDL ratio was observed in Excellent and Superior VO2 max groups. Though the lipid profile was influenced by somatotype components in fair and good VO2 max categories it was not statistically significant. HDL cholesterol significantly correlated negatively with an increase in the endomorphy component in the excellent VO2 max group. The influence of the ectomorphy component on lipid profile was significant in the Excellent VO2 max group and this matched with the finding of Kamarudin et al., [18]. Total cholesterol, LDL-C and VLDL cholesterol, and Chol-HDL ratio had a negative correlation with the ectomorphy component of the Superior VO2 max group. A significant positive correlation between HDL cholesterol and ectomorphy component was found in the excellent VO2 max group. These findings between VO2 max and lipid profile match with the studies by Oranwa C *et al*[30] and other studies [9, 15, 24].

This study's findings suggest that along with the physical training that enhances cardiac and muscle endurance, if a sportsperson is having less endomorphy and more ectomorphy they can have a healthy lipid profile and better VO2 max. VO2 max in athletes indicates their cardiorespiratory endurance. VO2 max increase related to regular physical activity is associated with sympathetic stimulation that can directly enhance cardiac output, coronary blood flow, and coronary vasomotor tone and helps in providing the increasing myocardial oxygen demand and utilization that can increase the cardiorespiratory endurance [38]. Exercise-mediated effects on lipid parameters are via increases in Lecithin-cholesterol acyltransferase (LCAT), lipoprotein lipase (LPL) and hepatic triglyceride lipase (HTGL). Increased exercise endurance denoted by VO2 max may be because of improved triglyceride clearance and lipid oxidation [9, 24, 30]. Exercise-related enhanced lipolysis may be the reason for the decrease in endomorphy and increase in ectomorphy component that represents leanness in Good, Excellent and superior VO2 max groups. This finding matches with the studies that have proved that somatotype influences cardiovascular endurance that is quantified in VO2 max [27]. Lesser endomorphy and mesomorphyreduce the cardiovascular risk of coronary artery disease [27, 39, 40].

In conclusion, the findings of this study clearly indicate that there is a strong interrelationship between VO2 max, lipid profile and somatotype components in athletes. This study finding shall be implemented by physical instructors or health professionals for planning the training sessions of a sportsperson and implementing the pre and regular periodic screening to prevent any sudden cardiac incidents and to improve the lipid profile and VO2 max. Regular screening by exercise stress testing, imaging techniques and measurement of blood lipid profile will help the athletes to understand and improve their body composition by modifying and planning their diet and physical training to enhance their exercise endurance.

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Conflict of interest
The author declares no competing interest

Author contribution

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