Somatotype and Disease – A Review

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INTRODUCTION

Somatotyping is a unique method for the classification of human physique which was first invented by Sheldon et al. (1940) and later on modified by Heath and Carter (1967). It reflects an overall outlook of the body and conveys a meaning of the totality of morphological features of the human body. Numerous studies indicate that somatotype components have a strong genetic basis. Familial transmission of these components has also supported this viewpoint. Harrison et al. (1976) are of the opinion that certain relationship must exist between body build and endocrine functions and metabolism. To further support this logic they emphasize that it is highly unlikely that persons of different builds have similar basal or habitual functions. Whether physique, constitution and disease are interlinked to each other or not has always been a point of great interest. The present paper tries to explore the relationship between somatotype and disease from a review of the available literature alongwith its possible explanation.

SHELDON'S SOMATOTYPE

The history of classification and analysis of human physique can be traced back to the very ancient times when the people with strong bodies with great ability to fight, hunt and organize must have achieved distinction and got noticed by the society, kings. This seemed to have impressed the rulers and administrators to look for those with cherished human bodies and to recruit them as their subordinates. The foundations of visual classification of human physique might have started then. Hippocrates a great Greek philosopher and physician of the fifth century BC described two different types of bodies; thin and lean persons with long extremities and short persons with thick and massive bodies. While the former were assumed to have a greater susceptibility to tuberculosis the letter were very much prone to the diseases of the cardiovascular system.

Kretschmer (1921), a German psychiatrist, in the beginning of the twentieth century, gave a detailed account of the characteristics of three categories of humans which were named as pyknic or fatty, athletic or muscular and leptosome or lean. His method was based on making anthroposcopic observations on the human subjects. Kretschmer also correlated the physique with the characteristics including the temperament of the person. An Italian physician Viola (1921) during the early part of the twentieth century devised a method of human physique analysis by utilised body measurements. He grouped physique as *a) longitype* having relatively long limbs compared to the trunk, massive thorax compared to the abdomen, and greater transverse diameters relative to the antero-posterior ones; *b) brachitype* or broad type, having the characteristics opposite to those of the longitype; *c) normotype* which fall in between the above two categories and *d) mixed type* who show characteristics of different types in different parts of the body, i.e. they may be brachitype in one part, longitype in the other and normotype in still another, etc.

The morphological and structural differences among human beings are unique and that is why no two humans are alike in body form. Even the identical twins (monozygotic) can be identified from each other although they develop from the single ovum and share exactly similar genetic information. These large differences in body form, morphology and physique in humans must form the basis for any attempt at classification and analysis of human physique. It must be a precondition that all these variations from one extreme to another cannot simply be divided into a few discrete types or groups. The classification which is based on only the discrete types involves the human physique at the extreme poles whereas the majority of the other physiques falling in between the extremes remain unattended. So, a good classification must take care of the subtle human morphological variations and must be able to classify human physique into a large number of categories.

The human physique is a continuously distributed characteristic which was appreciated by Sheldon et al. (1940), who successfully devised a method to analyse and quantify human body form called Somatotyping. According to Sheldon et al.

(1940, 1954) "*Somatotypes are morphophenotypic ranges along continua of variation which possess constantly recognizable characteristics and are the functional end products of the whole genetic and develop-mental complex*". The somatotype is aimed at providing some sort of identification tag to the subject and may be regarded as an attempt towards general human taxonomy or classification. It may also be referred to as something similar to the Mendeleyev's periodic table of the elements in chemistry. Sheldon recognised three basic components of physique, viz., endomorphy, mesomorphy, ectomorphy. Each individual has varying degrees of development of these three components. The somatotype is always written in three numerals: the first indicating the development of endomorphy, the second the mesomorphy and the third the ectomorphy. Sheldon was perhaps the first one not only to appreciate the continuity of human physique (not a few discrete types) but also invented a workable method to achieve this.

The term endomorphy reflects the component of physique which quite obviously is derived from the innermost embryonic layer – *the endoderm*. The characteristic endomorphs who exhibit fatty deposition and soft rounded features seem to be the result of the predominance of digestive viscera. There are tendencies of overeating therefore the body assimilates more than what is actually needed. This results in the excessive fat storage resulting in fatty deposits. The middle embryonic layer or *mesoderm* produces bones, muscles and connective tissues. These constituents are present in the second component of physique or mesomorphy. Relatively large surface area of the body predominates in the ectomorph. The outer embryonic layer or *ectoderm* forms the skin, nails and sensory organs. These features derived from ectodermic layer are most prominent in ectomorphs. Somatotyping is done by visual observations on nude photographs of the subjects taken in three poses; front, side and back.

Sheldon studied 4000 male college students in order to know the possible range of variations in human physiques. He was able to recognise as many as 79 types of physiques from the above sample. Among them there were three extremes, 711, 171 and 117 which were in a negligible proportion in the whole series indicating that these extreme types are very rare. The recommended scale for each component is from 1 to 7 where 1 represents the minimum possible development and 7 the maximum. From 1 to 7 the ratings at each step represent equal-appearing intervals, e.g. the magnitude of difference in characteristics for any component between the ratings of 1and 2 is the same as between the ratings of 2 and 3 and so on. The reason why 1 was retained as the minimum rating instead of a possible 0, was that no human exhibits a total lack of any component of physique.

Any subject who is extreme in one component cannot be extreme in the other two components. Sheldon found that a person cannot have a rating of more than 5 in two components. Similarly, there cannot be anybody having somatotypes as 111 or 777. Since there is some dependence of one component on another, hence the sum of three components is also limited from 9 to 12 instead of a theoretical value of 3 to 21. The person who is fat may have muscles to support it but he will not be linear then.

Later on in 1954 Sheldon Published a book *"Atlas of Men"* based on a mammoth sample of 46,000 human subjects in the age range of 18 to 64 years which included people of all walks of life including academicians, delinquents, patients (1954). Not only White but Negro and Jews also got a place in this atlas. On the basis of this extensive data, tables of the distribution of height over cube root of weight ratios at different ages were devised. Somatotyping procedure was made less cumbersome and less subjective by utilising this distribution. Only a few somatotypes are possible at any given height weight ratio First of all, the height weight ratio is obtained and the possible somatotypes at that ratio are noted. Then the somatotype photograph of the subject is compared with standard photographs available in an atlas, to make out with which it tallies most and a final decision is made regarding his somatotype.

In order to make the designations of somatotypes quite lively and absorbing, Sheldon attached animal totems to different somatotypes to which they resemble most. For example, 711 was designated as an *'American manatee-siren or mermaid'*, 171 as an *'eagle'*, 117 as *'walking sticks'*, 741 as an *'Ancient hippopotamus'* and so on.

The somatotype, as conceived of a biological tag to the individual should remain unaltered throughout life but in the absence of grossly disturbing pathology and malnutrition. The subjectivity of this system is in a sense its strength in achieving the above aim. It is expected of the experienced raters to possess the capacity to explore and judge deep inside the body for the amount of different components. That mass of tissues which would remain static throughout life and even under slight environmental insults. The person should also be experienced in the knowledge of the normal age changes taking place in various tissues and the effect of various factors impinging upon them. Sheldon perceived the usefulness of his method in constitutional studies where the particular type of body build may have some associations with certain diseases, behavioural characteristics, physical fitness and prowess.

In his later works, Sheldon et al. (1954) constructed somatotype-HWR tables to help the rater in quickly doing the job of somatotyping. These tables would depict the possible somatotypes at a given HWR value. It is easier to find out the best suitable somatotype from a limited range. In this study (Atlas of Men) 1175 somatotype photographs were given which were based on men of all ages beyond 18 years. The major objections of immutability of the somatotype along with a lot of subjectivity in rating the subject persisted even in this study. Sheldon then devised a trunk index and took its help in somatotyping procedure.

Trunk index is the ratio of the areas of thoracic trunk to the area of abdominal trunk of the somatotype photograph of a given subject. The areas were calculated with the help of planimeter (a simple geometrical instrument used to calculate the areas of non-uniform figures). The new method of somatotyping was provided on the basis of trunk index (Sheldon et al., 1969).

Needless to say that even with a continuous classification of physique which may include around 80 different body types, every type still may reflect lots of variations among the individuals themselves. Sheldon thought of grading every somatotype on the basis of some other features so that within a given somatotype further classification can be made and the individuals can be distinguished from one another. The features he thought of included; Gynandromorphy (mixing of male-female features), Dysplasia (disproportionate body), Textural aspect (quality of the texture of the skin) and Hirsutism (growth of body hair).

Parnell (1954) a British physician described a method to objectively somatotype human subjects by physical anthropometry instead of by the visual inspection of photographs of the subjects. Parnell's effort was to describe a short physical anthropometric method for obtaining somatotype with the following purposes: to provide objective guidance on the dominance of somatotype components in a healthy person, to estimate the Sheldonian somatotype objectively and as accurately at least as the agreement achieved between experts in photoscopic somatotyping, to make an estimate of women's somatotype possible although in the absence of a published reference somatotype data the estimate cannot be compared, to reduce on cost, labour and time while doing somatotypes. The method of estimating dominance of somatotype components chiefly depends on Standard Deviation Chart. This chart has been designed on the basis of different body measurements. For judging the somatotype, a Standard Deviation Chart was designed which is based upon the anthropometric data obtained from 405 undergraduates at Oxford and Birmingham.

HEATH-CARTER ANTHROPOMETRIC SOMATOTYPE (1967)

After Sheldon's method of somatotyping, there have been many attempts to make it simpler, easily executable and more objective. Several attempts were later made in this direction to somatotype on the basis of anthropometric measurements (Bullen and Hardy, 1946; Cureton, 1947; Hooton, 1951; Damon et al., 1962; Petersen, 1967; Clarke, 1971); however, these methods remained relatively unused because of certain discrepancies. The Heat-Carter method of somatotyping is one such attempt which fulfils to a major extent these requirements and is widely in use throughout the world during the last two decades. Its application is immense in the fields of sports sciences, anthropology, human biology, child growth, etc. It is based on anthropometric measurements which are easy to take on the subjects. Heath (1963) critically examined the shortcomings in Sheldon's method and suggested alterations and modifications in it. Later on, Heath and Carter in 1967 gave their own method of somatotyping. Though this method differs from that of Sheldon's in the sense that it evaluates the body form or physique at the given time compared to the unchanging somatotype of Sheldon. The ratings of three primary components of physique are assigned from the tables or can be calculated directly using equa-tions given by Carter (1980), Heath and Carter (1990) and Carter (1996) on the basis of the anthropometric measurements. Before going into the details of the method, it is necessary to acquaint with their concepts of somatotype and the three components, viz., endomorphy, mesomorphy, ectomorphy.

Heath and Carter (1967) have defined these concepts as follows:

"A somatotype is a description of the present morphological conformation. It is expressed in a three numeral rating, consisting of three sequential numbers, always recorded in the same manner. Each numeral represents the evaluation of three primary components of physique which describe individual variations in human morphology and composition"

"First component (or endomorphy) refers to relative fatness in individual physiques; it also refers to relative leanness. That is, first component ratings are evaluations or degrees of fatness which lie on a continuum from the lowest recorded values to the highest recorded values".

"Second component (or mesomorphy) refers to relative musculo-skeletal development per unit of height. Second component ratings are evaluations of musculo-skeletal development which lie on a continuum from lowest to highest degrees recorded. The second component can be thought of as Lean Body Mass relative to Height".

"Third component (or ectomorphy) refers to relative linearity or individual physiques. Third component ratings are based largely, but not entirely on height/cube root of weight ratios. Height/cube root of weight ratios and third component ratings are closely related, so that at the low ends of their distributions both connote relative shortness of the several body segments, and the high ends connote elongation or linearity of several body segments. Ectomorphy ratings evaluate the form and degree of longitudinal distribution of the first and the second component".

The Heath-Carter method of somatotyping described below is "The Heath Carter Anthropometric Somatotype Method" requires the following anthropometric measurements obtaining the somatotype: Height, Weight, Triceps skinfold, Subscapular skinfold, Supraspinale skinfold, Calf skinfold, Humerus biepicondylar diameter, Femur biepicondylar diameter, Biceps girth, Calf girth.

Exact decimal rating of endomorphy can be assigned from the measurements directly using the following equation of Carter (1980):

$$\text{Endomorphy} = -0.7182 + 0.1451(X) - 0.00068(X)^2 + 0.0000014(X)^3$$

Where X is the sum of triceps, subscapular and supraspinale skinfolds, which should be corrected for the height of the subject.

Mesomorphy= (0.858 humerus width + 0.188 corrected arm girth + 0.161 corrected calf girth) – (height x 0.131) + 4.50

Ectomorphy rating can be directly calculated from Height Weight Ratios (HWR = Height/ Weight $^{0.33}$)employing the following equation of Carter (1980):

Ectomorphy = HWR x 0.732 – 28.58

If HWR <40.75 but >38.25, then

Ectomorphy = HWR x 0.463- 17.63

If HWR <38.25, a rating of 0.1 is to be assigned.

There emerges a basic question of concordance or discordance of Sheldon versus Heath-Carter estimates of somatotypes. Singh and Malhotra (1986) investigated the differences in the estimates of Sheldonian and Heath-Carter somatotypes from a sample of Olympic athletes. The average values of three components were lower when estimated by Heath-Carter method, the maximum deviations are noticed in the case of endomorphy. The differences reaching up to a mean of 0.81 units in endomorphy. When the same subjects were investigated for Heath-Carter photoscopic method and Sheldon's method, a mean difference of 0.66 units noticed in case of endomorphy which was the largest difference (Singh and Malhotra, 1989). Large data on different aspects of growth, disease, physical activity and somatotypes using Heath Carter anthropometric techniques have been published by Carter and Heath (1990).

DISEASE AND SOMATOTYPE

The relationship between somatotype and disease has been first investigated by Sheldon et al. (1940, 1954, 1969). Being a psychologist himself, he wanted to relate somatotype with abnormality of behaviour and function. Sheldon et al. (1969) studied psychotic patterns with somatotype and found that paranoid schizophrenic patients were localized towards mesomorphic ectomorphic type of physique where these two components were almost equal and lacking in endomorphy. On the other hand, hebephrenic paranoids were showing a physique where endomorphy and ectomorphy were equally poised but with a lack of mesomorphy. The manic depressives were equally endowed with endomorphy and mesomorphy and lacked ectomorphy. Catell and Metzner (1993) also found associations of behaviour and somatotype on the much expected lines given by Sheldon. There is a linking of centripetal or abdominal fat with somatotype components as investigated by Rosique et al. (1994).

In case of patients of coronary artery disease (CAD), endomorphy was significantly correlated with abdominal circumference, the abdomen-to-hip ratio and the abdominal sagittal diameter whereas mesomorphy was not related to these indicators of android or abdominal adiposity following partial adjustment (Williams et al. 2000). On the other hand, ectomorphy was inversely related to the indices of general and regional adiposity. This study suggests that adiposity and muscularity are important features in terms of increased CAD risk, whereas linearity is beneficial.

According to a study by Herrera et al. (2004), the correlation between ectomorphy and both SBP and DBP showed that as ectomorphy increased the blood pressure decreased, except for the oldest age group. Endomorphy and mesomorphy showed a stable correlation pattern with blood pressure in males indicating a neutral stance of these components in determining the blood pressure, while in females this pattern was more irregular and less consistent. The persons with high levels of SBP and DBP had mean somatotypes, which were closer to those of other male groups characterized by myocardial infarct, coronary heart disease and the risk of hypertension, indicating that these somatotypes may be associated with cardiovascular risk factors. The individuals who had a cardiovascular risk profile are more endomorphic and mesomorphic and less ectomorphic than those with a lower cardiovascular risk profile.

Katzmarzyk et al. (1999) found that the somatotype has been related to the sum of six skinfolds taken at different sites. In terms of biological risks with a predisposition of disease, the somatotype is a much better predictor than the individual measurements and it was more predictable in males rather than the females.

Kalichman et al. (2004) observed that individuals of robust physique (with high endomorphy and mesomorphy) showed high mean values of systolic and diastolic BP, whereas the smallest persons had the lowest BP values. They also suggested the existence of common physiological mechanisms in the development of body physique and blood pressure regulation with the possibility of the involvement of pleiotropic genetic and/or epigenetic mechanisms in this regulation.

A longitudinal follow up study of blood pressure was conducted by Harlan et al. (1962) in which a group of young men followed for 18-years. Seven hundred and eighty-five (96 per cent) of the surviving members have been re-evaluated, and the mean age at the time of re-examination was 42 years. Significant correlations were observed between the indicators of weight and somatotype. A significantly greater increase in blood pressure was noted in association with increasing weight. Subjects with a predominance of ectomorphic characteristics had a smaller increment of blood pressure over the period of study whereas endomorphic subjects had a greater increment of blood pressure. A significantly greater increase in blood pressure had a predisposition because of the family history in these subjects. The greater increment in blood pressure associated with a positive family history was independent of weight gain that means if there is a family history the chances of hypertension increase.

According to Badenhorst et al. (2003) somatotype and elevated blood pressure showed associations which indicated that the blood pressure of the endomorphic boys was the highest which increased with an increase in physical activity levels. An increase in physical activity did not lower the resting blood pressure values of endomorphic boys.

Relationships between cardiovascular risk factors and Heath-Carter anthropometric somatotype components were investigated by Malina et al. (1997) in 642 healthy adults. Risk factors included systolic and diastolic blood pressures (SBP, DBP), fasting glycaemia (GLYC), and blood lipids. Correlations between risk factors and each somatotype component were calculated after controlling for the effects of the other two somatotype components. Low and moderate correlations were observed which ranged from -0.23 to +0.23 in males and -0.20 to +0.30 in females. The older group presented stronger relationships, however, there was a sexual difference in these correlations. Endomorphy which represented relative fatness tended to be positively related to risk factors in older females, whereas ectomorphy or relative linearity tended to be negatively related to risk factors in older males. Comparison of somatotypes of those individuals who were represented at the extremes of the distributions for each risk factor, lower as well as higher, fell in line with the other results. Persons with higher risk profile tended to be more endomorphic and mesomorphic and less ectomorphic than those with a lower risk profile.

Katzmarzyk (1998) explored the relationship between physique and metabolic fitness from a sample of 413 boys and 343 girls in the age ranger of 9-18 years from Québec. Physique was assessed using the Heath-Carter anthropometric somatotype. The metabolic fitness was assessed from plasma triglyceride levels (TG), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), and blood glucose levels (GLY). In both boys and girls the first canonical correlation is significant ($P \leq 0.001$) and indicates a relationship between the physique and metabolic fitness variables. The Heath-Carter anthropometric somatotype explains 8% to 19% of the variance in metabolic fitness . The physique domain highlights a positive loading for ectomorphy and negative loadings for endomorphy and mesomorphy. The metabolic fitness domain has a positive loading for HDL-C and negative loadings for TG, LDL-C, and GLY. The results indicate that a physique characterized by high endomorphy and mesomorphy has a propensity to have higher blood lipids as these are associated with higher levels of TG, LDL-C, and GLY during 9-18 years.

The somatotypes of female patients has been investigated for different categories of genital tract cancer by Eiben et al. (2004). The ovarian cancer patients had a somatotype as 6.8-5.3-1.0, whereas those with endometrial cancer had it as 7.9-5.8-0.9. The variance analysis showed that there was no significant difference among majority of the patients who had mesomorphic-endomorph forms where endomorphic elements dominated in their physique and mesomorphy (robusticity) was greater than ectomorphy (linearity).

Butova et al. (2005) investigated the somatotypic characteristics of healthy women and patients with mammary. Age peculiarities of morphological typing revealed the dominance of athletic type which means a high development of mesomorphy in mature age and mesoplastic type in the elderly one. The anthropometric parameters of women with oncological pathology in the studied periods of ontogenesis has demonstrated a predominance of a mesomorphic vector in shaping their somatotype

Caldin et al. (1959) investigated 400 patients admitted consecutively to a Veterans Hospital for pulmonary tuberculosis with the help of photographs for obtaining somatotype evaluation according to Sheldon's method. Analysis of the data revealed that almost of the patients had mesomorphy and endomorphic-mesomorphy predominant in their body characteristics. Only 14 per cent of the subjects of the study showed the thin, narrow ectomorphic physique which traditionally has been associated with tuberculosis. Clinical impression of the patients , however, suggests that tuberculosis patients may be having weak-looking body physiques. The folk wisdom which seems to relate thin body build and tuberculosis in the past has been attributed by the present authors to confusion between weight loss or emaciation which may be a consequence of the disease and the fundamental physique which existed prior to the onset of the illness.

According to Solomon et al. (1982) the patients suffering from osteoarthritis (OA) of the hip may be considered a subset of the population because of their greater predisposition to joint failure. A comparative study of somatotype, bone density, disc degeneration, polyarticular joint degeneration, and soft-tissue calcification was carried out by Solomon et al. (1982) in 3 groups of individuals: (1) patients presenting with OA of the hip; (2) patients with acute femoral neck fracture; (3) healthy controls. There were significant differences in somatotype in the 2 patient groups; 94% of those with OA were endomorphic mesomorphs.

Patients with Down's syndrome seem to have a somatotype which goes much beyond the boundary of the endo-mesomorphic sector and meso-endomorphic sector of the soamtochart. Most of these patients possess endomorphy and mesomorphy ratings above 6 each (Buday and Eiben, 1982; Buday, 1990). A study on thallasemia child patients has been conducted by Gaur and Sarkar (1998) which reflect a different set of somatotypes of the patients from those of the control children.

Koleva e al. (2002) examined the association between the somatotype and its main components (endomorphy, mesomorphy and ectomorphy), and the prevalence of several chronic diseases. The data were obtained from a cross-sectional survey designed to assess somatotype and morbidity with special reference to most often diagnosed diseases. In five different disease groups, the frequency of patients was significantly related to a somatotype. Those with mesomorphic endomorph of physique most frequently suffered from digestive system diseases (40.6%, $p<0.05$), neuroses (30.1%, $p<0.05$), and radicalises lumbosacralis (15.4%). The prevalence of arterial hypertension in mesomorph-endomorphs has been found in 37.1% of he cases, endomorphic mesomorphs in 35.5% and mesomorphic endomorphs in 34.3%. Cluster analysis showed that those who suffered most frequently from arterial hypertension and liver disease were having highest endomorphy and mesomorphy and the lowest ectomorphy. In conclusion the somatotype with a dominant mesomorphy and endomorphy constitutes a risk factor having predisposition toward certain diseases and requires body weight control.

The basic question of how much is the variability in Sheldonian somatotype of an individual through time (growing years) must be answered. Though the concept of immutability of somatotype has been preserved by Sheldon yet many authors do not believe it to be true. Walker and Tanner (1980) studied the photographs of 82 boys from the Harpenden Growth Study and assigned somatotype ratings at different ages of 5, 8, 11, 14, and 18 years. These being subjective assessments, inter-judge correlations were obtained for the anthroposcopic ratings of the 18-year-olds which ranged from 0.79 to 0.93 for the three components and these ratings can be considered to be quite reliable. According to them there were very little changes in mean somatotype ratings with age. These findings point towards the direction of the somatotype (especially the Sheldonian) being largely immutable. Damon et al. (1962) studied the somatotype with age and was of the opinion that the prediction of somatotype from earlier ages can be made.

Singh and Singh (2000) reported the somatotypes of father-son duo in Punjabi Sikhs. The mean somatotypes of fathers were 3.87 – 5.07 – 2.12 compared to 3.20 – 43.1 – 2.66 of sons. Mesomorphy is significantly greater in case of fathers whereas sons have significantly larger values of ectomorphy. Endomorphy does not show significant differences between the fathers and sons. Studies on growing children have indicated a change in somatotype from central location towards ectomorphy and showed a wide range between 4 and 20 years of age especially in case of the Gaddi tribe of the Himalayas (Singh and Sidhu, 1980).

Rebato et al. (2000) analysed the Heath-Carter somatotype to find out familial resemblance in a sample of 1350 siblings (685 males and 665 females) from 634 nuclear families in the province of Biscay (Basque Country, Spain). Maximum likelihood procedure was adopted to estimate sibling correlations for endomorphy, mesomorphy, ectomorphy and somatotypical attitudinal distance (SADi), after adjusting for age and sex. All sibling correlations of the somatotype components were significant, however, these were higher in the case of mesomorphy than in the case of endomorphy. Same-sex siblings exhibited significant resemblances for mesomorphic and ectomorphic components. So, the genetic similarity seems to have been reflected in the somatotype components as well.

Heritability estimates of somatotype components based upon familial data from French Canadian families were made by Bouchard (2000) and Bouchard et al. (1980). Somatotype components were obtained with the help of Heath-Carter method in 239 French-Canadian families from Montreal in the later study. Sibling correlations for somatotype components were 0.40 for endomorphy, 0.30 for mesomorphy, and 0.38 for ectomorphy. Partial ling out the effects of 7 socioeconomic indicators permitted an estimate of common familial environment upon co variation between relatives. Residual sibling correlations provided broad heritability estimates (HB) of 0.50 for endomorphy, 0.42 for mesomorphy and 0.54 for ectomorphy.

Familial transmission of Heath-Carter anthropometric somatotype was investigated in a sample of 328 participants from 103 nuclear families in Northern Ontario (Canada) by Katzmarzyk et al. (2000). The three somatotype components (endomorphy, mesomorphy, ectomorphy) were subjected to principal components analysis to generate an additional index of physique. Maximal heritabilities observed were 56%, 68%, 56% and 64% for endomorphy, mesomorphy, ectomorphy and PCI, respectively, which provided enough proof of familial resemblance for the Heath-Carter anthro-pometric somatotype. This also highlighted the role of genetic factors in explaining variation in human physique.

Peeters et al. (2003) concluded from a review of the available literature that several studies with different designs have attempted to estimate the heritability of somatotype components but ignored the covariation between the three components as well as possible sex and age effects. This study explores the pattern of genetic and environmental determination from a longitudinal sample of Belgian same-aged twins followed from 10 to 18 years (n = 105 pairs, equally divided over five zygosity groups), with the help of multivariate path analysis. Heritability estimates from 10 to 18 years range from 0.21 to 0.88 for endomorphy, 0.46 to 0.76 for mesomorphy and 0.16 to 0.73 for ectomorphy in boys. In girls, heritability estimates range from 0.76 to 0.89, 0.36 to 0.57 and 0.57 to 0.76 for the respective somatotype components. Sex differences in heritability become significant from 14 years onwards. More than half of the variance in all somatotype components for both sexes at all time points is explained by factors the three components have in common. The finding supports the hypothesis that the variability of somatotype components is influenced by genetic factors. Somatotypes though reflect changes with age during growing years yet these fluctuations do not seem to be reaching extraordinary levels (Hebbelinck et al., 1995). There is a differential role of genetic and environmental influences on the development of somatotype components as reflected in a family study by Sanchez-Andres (1995).

Kaul et al. (1994) found a correlation between the somatotypes among family members in North Indian population and found that significant correlations existed among all the combinations. Kaul et al. (1996) reviewed the somatotype literature especially from India and found gaps in information on somatotype and disease. A comparison of Heath-Carter anthropometric somatotype components was attempted in 28 male and 34 female monozygotic (MZ) twin pairs and 19 male and 21 female dizygotic (DZ) twin pairs from 9.3-23.5 years of age by Song et al. (1994). The results indicated that there are no differences in mean somatotypes of male twins and female twins although the male twins were significantly more mesomorphic than female twins. Intra-class correlations were consistently higher in MZ than in DZ twins of both sexes. Within-pair variances were consistently lower in MZ than in DZ twins of both sexes. The authors reinforce the viewpoint that the genetic variation affects the physique in adolescents and young adults.

In a nutshell, it emerges from the above review of literature that the somatotype has a strong familial transmission tendencies and the similarities in the somatotype components exist between the sibs and parent child combinations. Though the proponents of Sheldonian somatotype advocate that the somatotype is immutable and does not change with age yet the evidence put forth by Heath-Carter anthropometric studies indicate that the children do undergo shifts in their somatotypes with age. However, drastic changes in somatotype do not seem to take place with age. An overwhelming number of studies have established the links of somatotype with disease and have explained the amounts of associations of different diseases with somatotype components

EPILOGUE

Epidemiological studies on many organic diseases indicate that there is a clustering of the risks in the families . It seems likely that there exists some common link between somatotype and disease. However, the physiological path indicating the clear cut relationship between the two remains obscure. Sing et al. (2003) are of the opinion that the distribution of disease among individuals, families, and populations result from interactions between the effects of many susceptibility genes and many environmental exposures. All quantum regulatory mechanisms ultimately become integrated to produce the disease phenotype (Sing et al., 1992; Strohman, 2002; Dennis, 2003). Many organic diseases seem to have a complex multifactorial etiology where neither the genetic nor environmental inputs of an organism act independently to cause disease. Even complete information about an individual's hereditary constitution or exposures to adverse environments cannot predict with certainty the onset, progression, or severity of disease. According to Zerba et al. (2000) disease develops as a consequence of interactions between the "initial" conditions, which the genes exhibit alongwith exposures to environmental agents and which develops through special temporal plane.

One of the beliefs is that each case of a disease is caused by a variation in a single agent while the other viewpoint is that disease is a consequence of the 'Complex' organization of interacting agents. There is a need to understand the complexity of the etiologies of disease with the help of extensive studies which include variations in gender, age, and other measures of environmental effects. So the researchers must look into the vast laboratory the mother nature provides to find out about the type of model that should be used to describe nature of disease (Anderson 1972, Kardia et al. 1999, Stengård et al. 1999). Sing et al. (2003) reinforce the viewpoint to adopt holistic models to unravel the mystery of disease by focusing on every single factor including the morphological structure and physique and state that "An unwillingness to adopt a realistic biological model for health when designing and analyzing studies of disease might be the greatest deterrent to answering these questions that are most relevant to the practice of medicine without prejudice".

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KEYWORDS Somatotype. Disease. Heath-Carter. Sheldon

ABSTRACT The clustering of the risk factors in the families for many organic diseases indicates that there exists some common link between physiology, constitution, genetics, somatotype and pathology, however, the physiological path indicating the clear cut relationship between the two remains obscure. Many organic diseases seem to have a complex multifactorial etiology where neither the genetic nor environmental inputs of an organism act independently to cause disease. There is a need to understand the complexity of the etiologies of disease and to adopt holistic models to unravel the mystery of disease by focusing on every single factor including the morphological structure and physique. This viewpoint has perhaps been adopted by numerous researchers who have tried to explore the missing link between disease and physique or somatotype. The present paper attempts to review the available literature on somatotype and disease alongwith the issue of its plasticity with age. An overwhelming number of studies have established the links of somatotype with disease and have explained the amounts of associations of different diseases with somatotype components.

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