

# Health & Fitness Journal of Canada

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Volume 10

Dec 30, 2017

Number 4

## NARRATIVE REVIEW

### How should we assess body fatness? Part 1: Qualitative field methods available to the epidemiologist and the practitioner.

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#### Abstract

**Objective:** The objectives of this narrative review are to consider the simple qualitative field methods that have been used to describe inter-individual differences in body form over the centuries, to explore attempts to use such measures in predicting personality characteristics, susceptibility to disease, and athletic aptitudes, to understand the significance of regional differences in the distribution of body fat, and to decide the current relevance of subjective descriptions of body build. **Methods:** Information obtained from Ovid/Medline and Google Scholar through to December 2017 was supplemented by a search of the author's personal files. **Results:** Although a variety of nomenclature has been proposed, most observers from antiquity to the present day have described three main body types, now generally termed ectomorphic (a lean and elongated body form), mesomorphic (a thick-set, muscular individual) and endomorphic (the person with a rounded figure, and a substantial accumulation of body fat). Although extreme examples of each of these body types are readily recognized, most people have an intermediate body form, incorporating feature of two if not three of the potential body types, and this seriously limits the usefulness of such a classification. Correlations between body type and personality have now been largely discredited, and correlations with disease susceptibility reflect in part the effect of disease on body build rather than the converse. Top athletes in a given sport discipline tend to have a common somatotype, but a substantial range of body builds are still compatible with outstanding performance. An android distribution of body fat continues to be of prognostic value; this body type is more common in men than in women, and is associated with a substantial increase in the risk of cardiovascular disease. **Conclusions:** Earlier interest in the subjective assessment of body build has waned as it has

become recognized that extreme body types are uncommon, and that numerical classifications of somatotype make little contribution to the definition of an individual's personality, susceptibility to disease or athletic aptitude. Nevertheless, simple subjective ratings of body fatness and muscularity can help to distinguish the cause of an excessive body mass in relation to height, and simple determinations of the distribution of body fat provide helpful prognostic information. **Health & Fitness Journal of Canada 2017;10(4):23-44.**

**Keywords:** Body mass; body mass index; body build; impedance; photogrammetry; skinfold measurements

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#### Introduction

Whether one is a health and fitness practitioner assessing the health of an individual client, or an epidemiologist who is looking at the health of an entire community, the amount and distribution of body fat is an important component of a health and fitness evaluation. This narrative review considers advantages and drawbacks to the various qualitative approaches that can be applied under field conditions to estimations of the amount of body fat and its distribution, and comments on the interpretations that have been placed upon inter-individual differences in body type from antiquity to the present day. A companion review

(Shephard, 2017b) looks at quantitative methods for the field measurement of body fat by the epidemiologist and the health and fitness practitioner.

### Overall body form

The idea of looking at a person's body form and then making inferences about issues such as general health and fitness, personality, possible psycho-pathologies, moral attributes, and athletic aptitudes dates back to antiquity. However, interest in the process has periodically revived over the centuries, beginning in the Middle Ages, and continuing through the Reformation and the Enlightenment into the Modern era.

### Classical appraisals of body type

Hippocrates (c. 460-370 BCE) and other physicians of ancient Greece and Rome such as Aristotle (384-322 BCE) and Galen (c. 129-200 CE) suggested that there were associations between a person's body type and his or her personality. They argued that both body form and personality reflected differences in the individual's balance of the four basic humours that were seen as constituting the universe (air, water, fire, and earth). In general, classical physicians distinguished the sanguine person (who was enthusiastic, social and active, with a preponderance of air in the body), the phlegmatic individual (who was relaxed and peaceful, with a preponderance of water), the choleric type (who was short-tempered and irritable, with a preponderance of fire) and the melancholic patient (who was analytical, wise and quiet, with a preponderance of earth).

Although most Greek and Roman scholars subscribed to this four-way categorization of body types, Hippocrates also offered a simpler, binary

classification, linking this to the individual's prognosis. Thus, he distinguished the patient with a *habitus apoplecticus* (red-faced, plump, jovial and forceful, essentially a sanguine person) who was destined to die of apoplexy, and the person with a *habitus phthisicus*, who had a long and thin body form, and was prone to die of tuberculosis. Hippocrates was careful to distinguish the heavy but muscular "athlete" from the "fat man." The weight of the first type of person was attributable to an abundance of flesh, but the second sort of individual suffered from an excessive accumulation of body fat. However, not all classical physicians made the important distinction between muscle and fat, and some writers from early Greek scholars to the 5th century Roman physician Caelius Aurelianus grouped an excess of either fat or muscle under the generic term *polisarkos* or *excessive flesh (superflua carnis incrementa)*.

The book *Physiognomika*, possibly authored by Aristotle and probably written about 300 BCE, sought to justify the postulated relationship between body form and a person's mental and moral attributes (Figure 1), an idea that had become widely discussed among Greek scholars. Galen

**Figure 1:** Illustration from della Porta's *de Humana Physiognomonia* (1586 CE). Source: [https://en.wikipedia.org/wiki/Giambattista\\_della\\_Porta#Technological\\_contributions](https://en.wikipedia.org/wiki/Giambattista_della_Porta#Technological_contributions)



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went further, describing nine temperaments that were to be found in people with differing proportions of the four basic body humours (Rees, 1945). However, his nine-fold classification does not seem to have been generally accepted, even by his classical contemporaries.

### Body type in the Middle Ages

Ideas of an association between body build and personality persisted into the Middle Ages, as seen in the writings of Avicenna (980-1037 CE), Albertus Magnus (1209-1280 CE), Agrippa von Nettesheim (1486-1535 CE), Girolamo Savonarola (1452-1498 CE), Alexander Achillini (1463-1512 CE), Tommaso Campanella (1568-1639 CE), and Rudolf Goclenius (1547-1628). Indeed, even the playwright William Shakespeare (1564-1616 CE) commented [in Julius Caesar (Act 1, Scene 2)] on a possible linkage between body type and temperament:

*"Let me have men about me that are fat,  
Sleek-headed men and such as sleep a-nights.  
Yond Cassius has a lean and hungry look,  
He thinks too much; such men are dangerous."*

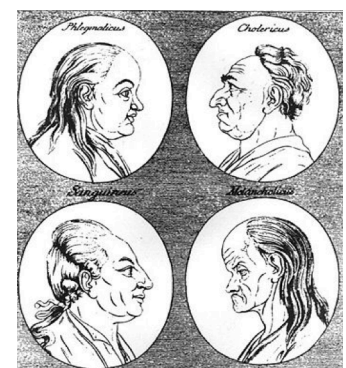
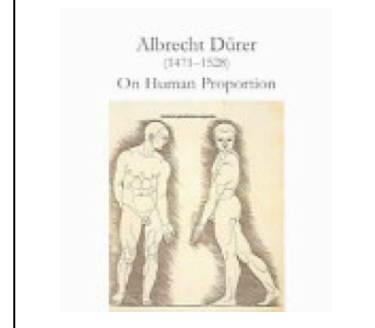
Likewise, the artist Albrecht Durer (1471-1528 CE) developed an elaborate theory of body proportions (Durer, 2005), seeking to represent human form correctly (Figure 2), and to depict differing body temperaments in the various subjects of his artistic brush (Sklerj, 1959).

Enquiry into relationships between appearance and personality flourished during the Reformation, as the printed page allowed a widespread study of inter-individual differences in facial features

and body builds (Wilson, 2003). A leader in this renewed interest was the Italian polymath Giambattista della Porta (1535-1615 CE), who wrote a book entitled *de Humana Physiognomonia* (Porta, 1586). He suggested that the external appearances of the body reflected the inner truths about a person (Figure 3). For instance, a man whose face resembled that of a sheep was likely to have the mind of a sheep. He viewed the whole world as forming a web of such secret analogies, a concept that was expanded into a method for the choice of appropriate herbal remedies (the "doctrine of signatures," (Shephard, 2015).

The English physician and polymath Sir Thomas Browne (1605-1682 CE) also believed that a person's face provided a window into their inner being. In a book entitled "*Christian Morals*" (1675), he wrote: "*the Brow speaks often true, since*

**Figure 2:** Cover to Durer's book "On human proportions." Source: <https://books.google.ca/books?id=ku3PQAACAAJ>



**Figure 3:** Illustration of the 4 temperaments (sanguine, phlegmatic, choleric and melancholic) by the Swiss physiognomist Johann Lavater, 1741-1801 CE. Source: [https://en.wikipedia.org/wiki/Four\\_temperaments](https://en.wikipedia.org/wiki/Four_temperaments)

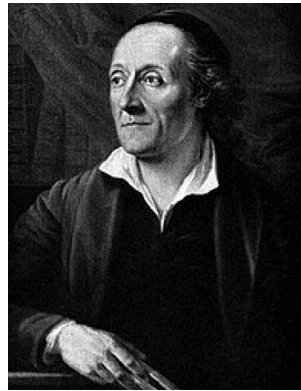
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*Eyes and Noses have Tongues, and the countenance proclaims the heart and inclinations*" (Browne, 1844)

della Porta and Browne strongly influenced the subsequent thinking of the Swiss poet, theologian and physiognomist Johann Kaspar Lavater (1741-1801 CE) (Figure 4). In the text "*Physiognomische Fragmente zur Beförderung der Menschenkenntnis und Menschenliebe*" ("*Physiognomic fragments for the promotion of human knowledge and philanthropy*"), Lavater stressed the relationship between external appearance and specific character traits.

He saw an involuntary natural language in the face, and indeed the whole externality of a person. The world, including differences in human body form, was as readable as a "*natural language*" or a "*divine alphabet*." Lavater was so successful in promoting his views that it became a fashionable form of entertainment to draw silhouettes of guests who were attending a party, and then to interpret them in terms of personality. The Prussian polymath and explorer of South America Alexander von Humboldt (1769-1859 CE) appears to have embraced such ideas as he wrote of: "*the mind, which makes people's faces different from each other.*" However, Johann Wolfgang Goethe (1740-1832 CE), initially a supporter of Lavater, later distanced himself, noting that the soul of a

**Figure 4:** Johann Kaspar Lavater (1741-1801 CE), Swiss Physiognomist. Source: [https://en.wikipedia.org/wiki/Johann\\_Kaspar\\_Lavater](https://en.wikipedia.org/wiki/Johann_Kaspar_Lavater)



human being may perhaps be read from his exterior, but only if traces of disease have become apparent on the body through illness or fate.

The German physicist Georg Christoph Lichtenberg (1742-1799 CE) wrote several polemics and satires railing against what he called the "physiognomic frenzy" of the age. In his view, pathognomy (observing a person's behaviour) was a more reliable guide to character than the deepest study of facial features or body build. By the end of the eighteenth century, Lavater still had many followers, including Franz Joseph Gall (1758-1828 CE), George Coombe (1788-1858 CE) and Johann Spurzheim (1776-1832 CE), but they had turned from looking at the overall body form, and wandered off into the now discredited morass of phrenology, trying to draw conclusions from the lines on a person's face.

Racial overtones to the discipline of biometrics first began to appear with the Dutch physician Petrus Camper (1722-1789 CE). He focused on the dimensions of the face, measuring the angle between a horizontal line running from the bridge of the nose to the ear opening, and a "line of sight" running from the tip of the nose to the apex of the forehead (Figure 5). Reinforcing the growing racist views of

**Figure 5:** Drawings of the angles of the face from a baby to an old man. Petrus Camper (1722-1789). Source: [https://en.wikipedia.org/wiki/Facial\\_Angles\\_\(Camper\)#/media/File:Petrus\\_Camper\\_facial\\_angles\\_by\\_son\\_Adriaan\\_Gilles\\_-\\_baby\\_to\\_old\\_man.jpg](https://en.wikipedia.org/wiki/Facial_Angles_(Camper)#/media/File:Petrus_Camper_facial_angles_by_son_Adriaan_Gilles_-_baby_to_old_man.jpg)



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European society, Camper reported average angles of 58 degrees for orangutans, 70 for "black people", 80 for "Europeans," and 100 degrees for the intelligentsia as portrayed in the statues of antiquity. These negative views were pursued further by the Italian criminologist Cesare Lombroso (1835-1909 CE), who linked body form to criminal behaviour (Shephard, 2017a), and more recently by Joset Mengele (1911-1979 CE), Otmar von Verschuer (1896-1969 CE) and the National Socialist government in Germany, with their arbitrary rankings of skull shapes for "higher"

and "lower" races, and attempts to discriminate anthropometrically between "Aryan" and "Jewish" body features (Figure 6).

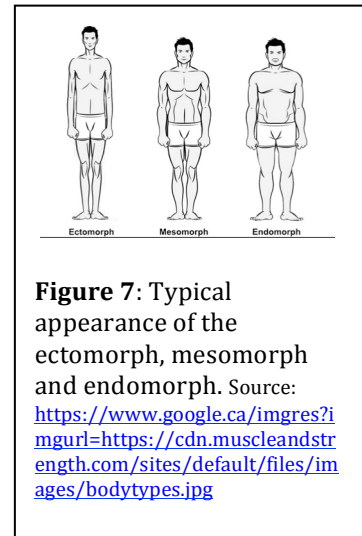
**Figure 6:** Otmar von Verschuer (1896-1969 CE) and his assistants used anthropometry to make racial classifications of German citizens in National Socialist Germany. Source: [https://en.wikipedia.org/wiki/Otmar\\_Freiherr\\_von\\_Verschuer](https://en.wikipedia.org/wiki/Otmar_Freiherr_von_Verschuer)



### More modern approaches to body type

During the Victorian and modern eras, some scholars continued to follow the classical Hippocratic dichotomy of body form, but more commonly three whole body types were distinguished (Bauer, 1923; Burt, 1947; Beneke, 1878; Eysenk, 1970; Hooton, 1951; Kretschmer, 1948; Martiny, 1948; Rostan, 1828, Viola, 1933; Wells, 1869}. Thus, in 1797, Halle categorized people as having "abdominal" (fat), "muscular," "thoracic" (long and

slender) or "cephalic" (large-headed) body builds, and Wells (1869) spoke of "vital," "motive" and "mental" body types. Although a wide variety of other terms were also proposed, in general investigators seemed to be recognizing the same 3 categories of body form (Table 1). Some of the choices of nomenclature reflected an attempt to highlight postulated linkages between the adult body form and expression of the three germ layers of the human embryo (Bauer, 1923; Bessonnet-Favre and Raymond, 1910; Castellino, 1927). Nevertheless, most anthropometrists were in essence distinguishing the lean and long-legged ectomorph, the stockier and muscular mesomorph, and the fat endomorph (Figure 7).



**Figure 7:** Typical appearance of the ectomorph, mesomorph and endomorph. Source: <https://www.google.ca/imgres?imgurl=https://cdn.muscleanandstrength.com/sites/default/files/images/bodytypes.jpg>

**Friedrich Eduard Beneke.** The German psychologist Friedrich Eduard Beneke (1798-1854 CE) was interested in the relationship between body type, age and disease (Beneke, 1878). He described hyperplastic and hypostatic body forms, with the former being characterized by a marked hyperplasia of connective tissue. Beneke was the first to include not only a description of the external features, but also details of the dimensions of internal body organs in his research. He believed that the pyknic body type was associated with rickets in children and cancer in adults.

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**Table 1:** Names ascribed to the three basic body types over the centuries, based in part on a tabulation by Eysenck (Eysenk, 1970)\*.

Author	Endomorph	Mesomorph	Ectomorph
Hippocrates (~430 BCE)	Habitus apoplecticus		Habitus phthisicus
Halle (1797)	Abdominal	Muscular	Cephalic
Rostan (1828)	Digestive	Muscular	Cephalic
Walker (1852)	Nutritive	Locomotive	Mental
Carus (1852)	Phlegmatic	Athletic	Cerebral-asthenic
Wells (1869)	Vital	Motive	Mental
Beneke (1878)	Hyperplastic	Normal	Hypoplastic
Huter (1880)	Food-type	Strength-type	Sensation-type
Virenius (1904)	Connective	Muscular	Nervous-epithelial
Sigaud (1914)	Digestive	Muscular	Cerebral-respiratory
Mills (1917)	Hypersthenic	Sthenic	Asthenic
Stockard (1923)	Lateral	Intermediate	Linear
Bauer (1924)	Hyperstheic	Sthenic	Asthenic
Weidenreich (1927)	**	Eurysomatic	Leptosomatic
Viola (1933)	Megalosplanchnic	Normosplanchnic	Microsplanchnic
Sheldon (1940)	Endomorph	Mesomorph	Ectomorph
Burt (1947)	Pachysome		Leptosome
Martiny (1948)	Entoblastique	Mesoblastique	Ectoblastique
Kretschmer (1948)	Pyknic	Athletic	Leptosome (asthenic)
Hooton (1951)	Attenuation	Muscularity	Fat
Eysenck (1953)	Eurymorph	Mesomorph	Leptomorph

\* Most authors have made these classifications on a subjective basis, but Rees and Eysenck (Rees and Eysenck, 1945) regarded the mesomorph as the normative body form, classifying as eurymorph and leptomorph those individuals who had a body build index at least 1 SD removed from that of the mesomorph. \*\*Weidenreich saw people as fitting on bipolar vectors.

**Achille De Giovanni, Giacinta Viola and Nicola Pende.** Achille De Giovanni (1838-1916 CE), Professor of Clinical Medicine in Padua, pursued the ideas of Beneke. In his book *"Morfologia de Corpora Umano; studi"* (*"Morphology of the human body: studies"*). (De Giovanni, 1919) argued that morbidity was likely to arise in an organ if it had an unusual

morphology. More recently, Giacinta Viola supported the idea of a morphological predisposition to disease, at times regarding such predisposition as outweighing other known causal agents. She suggested further there was an inverse relationship between growth of the trunk and the limbs (Viola, 1933). Nicola Pende (1880-1970 CE) was a student of Viola's.

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As Professor of Clinical Medicine in Genoa, (Pende, 1928) was the main exponent of Italian "Constitutionalism" and Fascist eugenics, and he became a member of the National Fascist party *honoris causa* for his studies in this area. He added the complication of endocrinal sub-types to descriptions of body form.

**Ernst Kretschmer.** The German psychologist Ernst Kretschmer (1888-1964 CE (Figure 8) became director of the psychiatric clinic at Marburg university. (Kretschmer, 1948) followed many earlier investigators by dividing the population into discrete body types, rather than seeing people as lying along a normally distributed continuum of physical appearance s. Thus, he distinguished the long, thin, and weak "asthenic/ leptosomic" body build from that of the muscular, large-boned athlete and the short, squat and rounded "pyknic" somatotype. Further, based on a study of 10,000 patients in German mental hospitals, he associated each of these three body forms with specific personality traits and psychopathologies. Thus, asthenic types were said to be introverted and timid, with a risk of becoming withdrawn schizophrenics. Muscular types accounted for 85% of the patients who subsequently developed paranoia, and such individuals were also

**Figure 8:** Ernst Kretschmer (1888-1964 CE), director of the Psychiatric Clinic at Marburg University. Source: [https://en.wikipedia.org/wiki/Ernst\\_Kretschmer](https://en.wikipedia.org/wiki/Ernst_Kretschmer)



slightly more prone to schizophrenia. Finally, those with a pyknic body build were found to be interpersonally dependent and gregarious, with a predisposition towards developing manic-depressive illnesses. Although his conclusions were based on a large population sample, no rigorous statistics were presented to back up these claims.

Kretschmer subscribed to earlier ideas of a linkage between body build and criminal behaviour, seeing ectomorphs as liable to sexual assaults and crimes of passion, mesomorphs as prone to crimes of violence, and endomorphs as being involved in non-violent property crimes. Like many of his colleagues, during the late 1930s Kretschmer put his knowledge and views on anthropometry at the service of Hitler's Reich, signing the vow of allegiance of German professors to Adolf Hitler and the National Socialist state ("*Bekanntnis der Professoren an den deutschen Universitäten und Hochschulen zu Adolf Hitler und dem nationalsozialistischen Staat*"). Further, there is no evidence that he expressed any opposition to the eugenic policies of the Führer.

**Franz Weidenreich and Bozo Skerlj.** Franz Weidenreich (1873-1948 CE) studied as an anatomist and physical anthropologist in Strasbourg, and later served with the Cenozoic Research Laboratory. He was one of a group of prominent anthropologists who determined that the "Piltdown man" was a scientific hoax. He regarded individuals as lying along a continuous distribution of body forms stretching along a line between opposite extremes of mesomorphy and ectomorphy. He further recognized that this line could be skewed by such factors as nutritional status, employment, race and the like. In order to place a given person appropriately on

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such a continuum, it was necessary to make assessments of body characteristics in at least six body regions.

Bozo Sklerj (1904-1961 CE)(Sklerj, 1959), Professor of Anthropology in Ljubiana, had rather similar ideas to Weidenreich. In contrast with some of his predecessors, Sklerj placed his emphasis upon the characteristics of healthy individuals, rather than those with psychiatric disorders. Rather than looking for discontinuous "types," like Weidenreich, he sought to identify continuous functions, or vectors. Scales running from -1.0 to +1.0 or 0 to 1.0 described four aspects of body form (male/female, frame size, amount and distribution of body fat). He suggested representing the combined impact of the four vectors as radii distributed around a circle, and he applied this system to exploring differences across various European populations. He criticized the subjectivity of many previous classifications, but nevertheless claimed that he could rate people on his fatness vector by visual inspection, finding that his ratings agreed reasonably well with measurements of body density made by underwater weighing ( $r = -0.58$  in young women.  $r = -0.76$  in young men and  $r = -0.69$  in middle-aged men).

**William Herbert Sheldon.** With the widespread availability of the camera, William Herbert Sheldon (1898-1987 CE)(Figure 9) and his associates (Sheldon et al., 1940) used photographs taken from three different angles as the basis for their subjective classification of people into "ectomorphic," "mesomorphic" and "endomorph" body builds. Although these terms are now generally attributed to Sheldon, some critics have alleged that they were "borrowed" without due acknowledgment from Huter and Von Rohden (Tucker and Lessa, 1940).

Photography was regarded as "more efficient" than direct measurement of the body. The raters of the photographs looked for the rounded and inflated contours of the endomorph and the squareness, ruggedness, and muscularity of the mesomorph. However, the

**Figure 9:** William Herbert Sheldon (1898-1987 CE), a prominent exponent of somatotyping. Source: [https://en.wikipedia.org/wiki/William\\_Herbert\\_Sheldon](https://en.wikipedia.org/wiki/William_Herbert_Sheldon)



photogrammetric approach has not become widely popular, as most investigators have lacked the training and experience needed to make precise ratings.

Sheldon considered a person's body build as an inborn, innate, and stable characteristic, and he rated individuals on each of the three somatotypic axes, using a seven-point semi-quantitative scale (later, this was expanded to a 13-point scale). When using the more widely adopted seven-point scale, individuals were characterized by a three-digit score such as 227; Sheldon further required that the total of the three ratings fall within the range nine to 12, thus forcing most people to be classified towards the extremes on each of the three scales. A 227 designation would imply a person with a relatively low score for both ectomorphy and mesomorphy, but a high score for endomorphy (Figure 10). At the time of Sheldon's survey (in the 1930s, before the onset of the current obesity epidemic), Sheldon estimated that almost



three quarters of a well-nourished U.S. sample would show some characteristics of two or even three somatotypes, but that seven percent would be classed unequivocally as ectomorphs, 12% as mesomorphs, and seven percent as endomorphs.

As a part of his research, Sheldon and his assistants examined photographs of over 4000 male bodies, finding among this sample extreme examples of the three variants of body form that had been described by

Kretschmer. However, he also reported that some people showed what he termed *dysplasia*, with differing physical characteristics in different parts of the body. (Sklerj, 1959) had previously underlined a similar problem of dysplasia. Sheldon further estimated a *g* or gynandromorphy index (reflecting the extent to which a person's body form incorporated characteristics of the opposite sex), a *t* score (based on the beauty or coarseness of an individual's appearance), and an *h* score (based upon the extent of hirsutism). Sheldon pursued ideas of a linkage between body physique and personality type in his book "*Atlas of Men*" (1954), claiming close relationships in a study of 200 university students. However, a proposed "*Atlas of Women*" was never published.

Earnest Hooton (1897-1954 CE) was a contemporary of Sheldon who originally

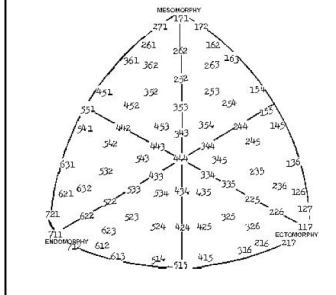
supported these ideas, but later criticized many technical aspects of Sheldon's work, including the limited validation of methodology, claims of permanence in an individual's somatotype, the use of an identical scale for men and women, and belief in an underlying embryological basis for the three body types.

Sheldon's concepts fell into more general disfavour after World War II (Shephard, 2015). There were several reasons for this. In part, Sheldon had difficult personal relationships with many of his colleagues and social contacts, being cited in a Federal court case over alleged thefts from the American Numismatic Society. Moreover, subsequent observers found much weaker associations between body type and personality than Sheldon had claimed. A part of the problem was apparently that Sheldon had used the same person to measure both characteristics, without any blinding of the data. Further, his observations were entirely cross-sectional, and it seemed quite possible that some neuroses had arisen because people had attempted to act out of character with their physique, rather than an initial body type determining their personality.

The racial profiling and eugenic overtones of Sheldon's research seemed to echo the worst eugenic thinking of Dalton and scientists associated with the Nazi regime, and in much of his writing Sheldon regarded physique as a predictor of destiny.

Accusations were also made that Sheldon and Hooton had obtained access without explicit consent to numerous nude photographs of shapely young coeds that had been taken originally in the early 1900s during a study of posture and health. It was alleged that Sheldon and Hooton had kept these pictures long after

**Figure 10:** Illustrating the 3-digit classification of a person's ectomorphy, mesomorphy and endomorphy used by Sheldon to characterize an individual's body form. Source: [http://www.mysomatotype.com/body-type/?page\\_id=58](http://www.mysomatotype.com/body-type/?page_id=58)



they had been taken, and that they had taken further photos between 1940 and 1960, again purportedly to examine posture, but in fact that they had applied them to now discredited analyses of relationships between body build and intelligence. New York Times journalist Ron Rosenbaum trumpeted in 1995 "Great Ivy League Nude Posture Photo

**Fig. 11.** A New York Times reporter in 1995 spoke of the "Great Ivy League Nude Posture Photo Scandal." Source: <https://www.google.ca/search?q=%22Great+Ivy+League+Nude+Posture+Photo+Scandal>



Scandal" (Figure 11), and one female correspondent wrote to the newspaper recalling that she had spent long hours in a backroom at the Harvard School of Public Health examining "18,000" photos of naked men, seeking relationships between body build and intelligence. Enquiry established that many scholars at Ivy League schools had indeed undergone "postural photography," including such well-known names as George Bush, Meryl Streep, and Hillary Rodham Clinton. After the scandal had erupted, the photographs were for a time sealed at the Smithsonian Institute, but they were eventually shredded.

Perhaps the most damning criticism of Sheldon's work came from a former laboratory assistant, Barbara Honeyman Heath. She alleged that he had manipulated his anthropometric data to fit preconceived ideas, apparently "adjusting" findings to remain within the extremes of somatotype implied by his 9-12 range of ratings, as well as ignoring the

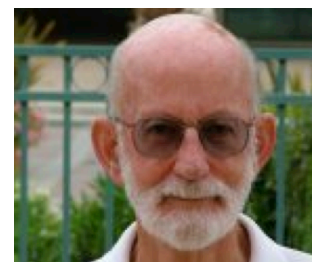
effects of both aging and overall body size upon somatotype (Carter and Heath, 1988; Vertinsky, 2007).

There is now a strong desire among the scientific community for a more objective approach to the description of body build than that adopted by Sheldon. Nevertheless, in the minority of individuals with a clearly identifiable body type, the concepts of mesomorphy and endomorphy still have some value in distinguishing the large body mass of a strength athlete from the weight gain due to a substantial accumulation of body fat.

**Heath-Carter method of classification.** Despite the strong criticism of Sheldon's approach, Lindsay Carter (Figure 12) and Barbara Honeyman Heath (Carter and Heath, 1988) have continued to use the terms ectomorphy, mesomorphy and endomorphy, introducing a range of objective measurements to calculate the corresponding scores, including body mass (kg), height (cm), upper arm circumference (cm), maximal calf circumference (cm), femoral breadth (cm), humeral breadth (cm), triceps skinfold (mm), subscapular skinfold (mm), suprascapular skinfold (mm), and medial calf skinfold (mm) thicknesses. Thus:

- **Ectomorphy** is derived from the ponderal index (PI, mass/height<sup>3</sup>); if PI >40.7, ectomorphy rating = (0.732 PI - 28.6),

**Figure 12:** J.E. Lindsay Carter taught applied anatomy and kinesiology at San Diego State University from 1962-1992.



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if  $PI > 39.7 < 40.71$ , ectomorphy rating  
=  $(0.463 PI - 17.6)$

if  $PI < 39.7$ , ectomorphy rating = 0.5

- **Mesomorphy** =  $0.858$  (humeral breadth) +  $0.601$  (femoral breadth) +  $0.188$  (upper arm girth) +  $0.161$  (max. calf girth) -  $0.131$  (height) +  $4.5$
- **Endomorphy** =  $-0.718 + 0.145 X - 0.00068 X^2 + 0.0000014 X^3$   
where  $X = S$  (triceps + subscapular + supraspinal skinfolds) \*  $170.18/H$

Rod Rempel (Rempel, 1990) has suggested some minor modifications to these formulae, but the ratings obtained have remained relatively similar. Potential scores for an individual on any given axis range from 0 to 7, with scores of less than 2.5 considered as low, 3-5 as moderate, 5.5-7 as high, and  $>7.5$  as very high. Using this new approach, Heath and Carter found a fairly close relationship between the Sheldon subjective endomorphy score and objective estimates of body fat content as derived from the height-adjusted function of triceps, subscapular and supraspinal skinfold thicknesses. Likewise, there was a close relationship between a high Sheldon mesomorphy rating and an individual's lean tissue mass per unit of stature as estimated anatomically from humeral and femoral breadths and arm and calf girths. However, like Sheldon, Heath and Carter did not find the somatotype score to be particularly helpful in describing the average individual. Most of their sample had intermediate scores for two if not three of the defining characteristics. Moreover, although the objective rating of body type improved the precision of assessments, having made measurements of skinfold

thicknesses and limb dimensions, it seems simpler simply to report estimates of body fat content and lean tissue mass rather than to convert such information to arbitrary ratings of ectomorphy, mesomorphy, and endomorphy.

### Body type and psychological characteristics

The ancient Greeks linked body type with personality, distinguishing the sanguine, phlegmatic, choleric, and melancholic body types, with their accompanying physique. In more recent times, perhaps the first person to link constitution with psychiatric disease was the English cleric Thomas Walkington (?-1621 CE), In his "*Optik Glasse of Humors*," (Walkington, 1607) set forth "*The touchstone of a golden temper, or the Philosophers stone to make a golden temper wherein the foure complections sanguine, cholericke, phlegmaticke, melancholicke are succinctly painted forth, and their externall intimates laide open to the purblind eye of ignorance it selfe, by which eevery one may iudge of what complection he is, and answerably learne what is most sutable to his nature.*" Lavater also pursued the connection between facial appearance and temperament.

Beginning with Kretschmer (1948) and his book "*Körperbau und Charakter*," psychiatrists made further attempts to link personality and body build (Eysenk, 1970). However, the arguments of Kretschmer were not well received because of a lack of sophistication in the handling of his data.

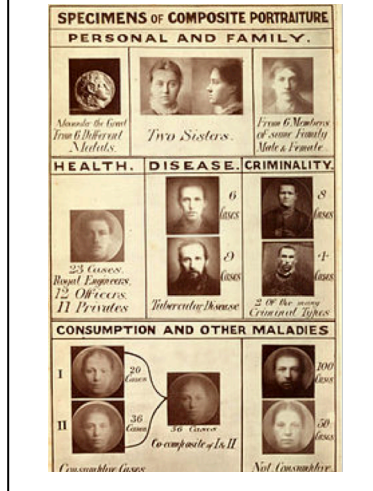
Students of eugenics such as Francis Galton (1822-1911 CE) further pursued the idea that a person's body shape, and particularly their facial appearance was an indicator not only of health and disease, but also of moral wealth,

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potential for achievement and the risk of criminal behaviour (Vertinsky, 2007). Galton studied the problem by superimposing several facial images on the same photographic plate (Galton, 1878), a technique that became known as composite portraiture (Figure 13).

**Figure 13:** The technique of composite portraiture, as used by Francis Galton.

Source: [https://en.wikipedia.org/wiki/Composite\\_portrait](https://en.wikipedia.org/wiki/Composite_portrait)



a correlation of 0.79 was reported between endomorph and a personality characteristic that Sheldon described as viscerotonia (the convivial, complacent and tolerant person with a love of food). Likewise, mesomorphy was said to show a correlation of 0.72 with the characteristic of somatotonia (the aggressive, vigorous and alert lover of physical activity), and ectomorphy was said to show a correlation of 0.83 with the trait of cerebrotonia (the sensitive, shy and introverted personality). However, critics suggested that these high correlations may have arisen because the same person assessed body build and temperament. Certainly, other investigators have found much weaker correlations when the subjects made self-assessments of their temperaments (Child, 1950; Humphreys, 1957). The views of Galton and Sheldon were roundly dismissed by the American psychologist and forensic scientist Donald G. Paterson (1892-1961 CE) (Paterson, 1930), and the whole concept of a linkage between body build and temperament has since been criticized (Hooton, 1951; Humphreys, 1957; Vertinsky, 2007), to the point that it is no longer pursued by current investigators.

### Body build and disease

A relationship between body type and susceptibility to disease was postulated by Hippocrates and his colleagues in classical Greece, as they wrote of the

**Table 2:** Relationships between psychiatric tendencies and body form (based on the observations of Phyllis Wittman and colleagues (1948)).

Psychiatric tendency	Endomorphy	Mesomorphy	Ectomorphy
Manic-depression	0.54	0.41	-0.59
Paranoia	-0.04	0.57	-0.34
Hebephrenia*	-0.25	-0.68	0.64

\* The term hebephrenia denotes a chronic form of schizophrenia.

*habitus apoplecticus* and the *habitus phthisicus*. In more recent times, this area of enquiry found one avenue of expression in the system of endocrinological biotypes, as proposed by Pende (Pende, 1928). (Benedetti, 1931) claimed that the risk of cancer was lower than average in microsplanchnics (ectomorphs), and Lister and Tanner further suggested that the body build of the late incidence diabetic differed from that of the early onset type (Lister and Tanner, 1955). An abdominal accumulation of body fat was later widely accepted as associated with an increased risk of cardiovascular disease.

With many illnesses, there remains an issue of cause and effect. Plainly, an increase of body fat predisposes to various diseases, and a person who has accumulated body fat is then likely to be classed as an endomorph. In contrast, diseases such as tuberculosis and cancer lead to wasting, and a person is then likely to be classed as an ectomorph. However, there is some evidence that body type may precede the onset of disease. Thus, a study by (Berry and Nash, 1955) suggested that the ectomorphic body build preceded the diagnosis of overt tuberculosis by months or even years, a view that was supported by Palmer et al. (Palmer et al., 1957). Others have linked height/weight ratios and an ectomorphic form to malignant hypertension (Perera and Damon, 1957) and a stocky body build to the subsequent development of essential hypertension (Robinson and Brucer, 1940). Possibly, long-standing differences in nutrition and social environment contributed to both body type and the subsequent appearance of disease.

Although many of the suggested linkages between body form and disease seems rather tenuous, somatotyping may

still have some value in guiding clinicians as to conditions that they should watch for in particular patients.

### **Body build and athletic performance**

Charlotte Lorentz of Huboldt University in Berlin sought for constitutional characteristics when examining athletes who were attending the 1936 Olympic Games. Some physical educators, sports physicians and anthropometrists have subsequently persisted in seeking relationships between qualitative descriptions of body build and athletic performance (Carter, 1970; Carter and Heath, 1988; de Garay et al., 1974; Eisenmann and Malina, 2000; Hawes and Sovak, 1994; Orvanová, 1987), with poorly substantiated claims that this approach is helpful in identifying suitability for a particular sport and/or the choice of playing position (Tóth et al., 2014).

Lindsay Carter (Carter, 1970) reviewed the somatotypes found on plotting data for 35 groups of athletes from 14 different sports. Striking differences of average somatotype were seen between participants in the various sports, and the somatotypic profiles of competitors became progressively more consistent as the level of competition increased. Orvanová (1987) compared the somatotype and other anthropometric data from many reported studies of skiers and ice-hockey players, again finding striking average differences between participants in the two classes of activity. She thus suggested that an optimal body form was an important factor in an individual's selection of athletic discipline (Orvanová, 1987). Hawes and Sovak, (1994) looked at the somatotypic and anthropometric profiles of Olympic competitors in speed and figure skating and swimming and synchronized

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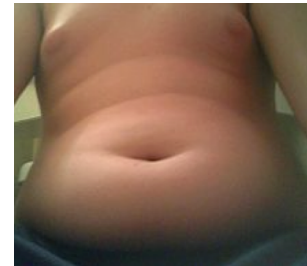
swimming, suggesting that it might be possible to identify an ideal somatotype for any given sport, and then to watch the progress of young competitors towards this ideal (Hawes and Sovak, 1994).

The use of somatotyping was evidently still popular in East Germany when Tittle and Wutsherk (1992) contributed to the International Olympic Committee's text on "Endurance in Sport." Tittel suggested that top athletes in all endurance sports were low in endomorphy, with average scores for the men ranging from an average of 1.4 in distance runners to 2.5 in rowers, and for the women from 2.4 in distance runners and rowers to 3.5 in cross-country skiers. Ectomorphy was relatively similar across all classes of endurance athlete, although distance runners generally showed the highest ratings. Eisenmann and Malina (2000) prepared an analogous chapter for the second edition of the IOC text, and they developed an extensive table of somatotypes for various categories of Olympic competitor. Nevertheless, as in the study of de Garay et al., (1974) the range of body types (Table 3) within a given category of sport was sufficiently large as to limit the usefulness of this measure in determining athletic ability. Indeed, some top performers have set world records with anthropometric profiles that might be regarded as totally inappropriate for their discipline.

### The regional distribution of body fat.

Of modern anthropologists, Bauer (1923) was probably the first to comment on regional differences in fat distribution. He wrote: "*One may, therefore, call this variety the Rubens type. It corresponds to what is known as the girdle type of fat distribution. Other women show a particular accumulation of fat tissue in the trochanteric region, protruding from the outline of the body. One may call this variety the breeches or trochanteric type of fat distribution.*" Sheldon also commented on inter-individual differences in the regional distribution of body fat, rating this characteristic as the *g* component of his somatotype.

Jean Vague (1911-2003 CE), a physician practicing in Marseilles, France, was the first clinician to draw formal attention to the health importance of such differences in the distribution of adipose tissue. He distinguished an android/abdominal from a gynoid/gluteal fat pattern (Vague, 1947 1956). Vague further noted that the risk of various metabolic complications of obesity such as diabetes mellitus, gout and



**Figure 14:** Android type of fat accumulation.

Source:

[https://en.wikipedia.org/wiki/Android\\_fat\\_distribution](https://en.wikipedia.org/wiki/Android_fat_distribution)

**Table 3:** Illustration of the range of somatotypes encountered in male long-distance runners at the Mexico City Olympic Games of 1968 (based on data of Garay et al. (1974)).

Variable	Minimum value	Maximum value
Stature (m)	1.56	1.86
Body mass (kg)	48.7	71.7
Ectomorphy	1.5	5.0
Mesomorphy	2.5	3.5
Endomorphy	1.0	3.0

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arteriosclerosis was greater in individuals who had a centralized, android fat distribution (Figure 14), rather than a centripetal, pear-shaped gynoid distribution. A gynoid distribution had a relatively minor impact on future health. Vague's original paper was published in 1947, and it became available in English-language form in 1956. However, it was not until the 1980s that his ideas were confirmed by Swedish and U.S. investigators (Kissebah et al., 1982; Larsson et al., 1984b) and that his ideas became widely accepted. Some subsequent authors have sought to distinguish two types of android fat accumulation, with differing metabolic profiles, depending on whether the majority of the fat is found in the thoracic region or in the visceral cavity (Bouchard et al., 1990); the second sub-type is said to be particularly strongly linked to glucose intolerance. However, few people make this further sub-division of their clients.

The first objective studies of fat distribution were based on skinfold measurements, but findings were quickly confirmed using the more precise and effective technique of computed tomography (Sparrow et al., 1986). Observations on 51 obese women demonstrated that the ratio of deep to total fat mass as determined by CT-scan was not correlated with hydrostatic estimates of total fat mass, but that the absolute deep fat mass was related to body density. Only two skinfolds (abdominal and subscapular) showed a moderately strong correlation ( $r = 0.65$ ) with measures of deep body fat; these same skinfolds also had a weak correlation ( $r = 0.38$ ) with the proportion of deep body fat (Ferland et al., 1989).

In a survey of 15,532 obese women, Kissebah et al. (1982) observed that

women with upper body obesity had a greater peak plasma glucose concentration during a glucose tolerance test than those with was the case in those with lower body obesity. Moreover, those with upper body obesity had higher plasma triglyceride levels and a greater insulin resistance, with a 10-fold higher risk of developing diabetes mellitus. Upper body obesity thus became recognized as an important objective measure of prognosis, with repeated epidemiological studies underlining linkages between upper body or abdominal fat accumulation and cardiovascular disease (Donahue et al., 1987; Ducimitière et al., 1986; Lapidus et al., 1984; Larsson et al., 1984a; Stokes et al., 1985). Larsson et al., (1984a) found that over a 13-year follow up of 792 men, initially aged 54 years, the incidence of both stroke and of ischaemic heart disease was significantly related to initial measurements of waist-hip ratio (although not independently of blood pressure and serum cholesterol levels). In contrast, no such associations were found with estimates of overall obesity such as the body mass index (where associations were possibly obscured by smoking habits).

Lapidus et al., (1984) also based conclusions about fat distribution on waist-hip ratios. In a sample of 1462 women, initially aged 38-60 years; who were followed for 12 years, they found that associations with myocardial infarction, angina pectoris, stroke and death rates were stronger for waist-hip ratios than for any other anthropometric variables that they examined. In their analysis, the association with myocardial infarction was independent of age, body mass index, smoking habits, serum cholesterol and triglycerides, and systolic blood pressure.

Ducimitière et al., (1986) followed 6718 male Parisian municipal workers who were initially aged 42-53 years for a total of 6.6 years. Initial values were recorded for 13 skinfold thickness, and a principal component analysis of this data isolated two dominant factors. The first (F1) was seen as a general index of adiposity, and the second (F2) showed opposing loadings from measurements taken on the trunk and thigh. A combination of the factors F1 and F2 was seen as indicating trunk adiposity, and this measure gave the clearest prediction of coronary heart disease risk.

Thus, it now seems quite widely agreed that at all ages from childhood (Daniels et al., 1999) to old age (Kang et al., 2011), the waist-hip ratio gives a better indication of cardiovascular risk than other commonly used anthropometric indicators of overall body fatness such as the body mass index.

Biological concomitants of an android fat distribution that increase the risk of insulin resistance, hyperinsulinaemia, glucose intolerance, diabetes mellitus, and hypertension continue to be debated (Table 4). Levels of sex steroids are one underlying variable, but some effects upon insulin sensitivity remain after co-varying the data for the observed levels of sex steroids. One important metabolic factor is probably an alteration of plasma lipid transport (Després et al., 1990). Abdominal obesity also leads to a reduced plasma clearance of insulin by the liver, apparently because of an increased turnover of free fatty acids (Jensen et al., 1989). Further, an increased level of free fatty acids is likely to reduce glucose metabolism. Plasma insulin levels may also modulate blood pressure levels (Christlieb et al., 1985). Finally, abdominal obesity is marked by a reduction of HDL cholesterol and

**Table 4:** Metabolic consequences of abdominal fat accumulation.

- reduced hepatic clearance on insulin from the plasma
- altered lipid transport, increased turnover of free fatty acids
- decreased glucose metabolism
- action of plasma insulin upon blood pressures
- reduction of HDL cholesterol
- increased cortisol levels

increased cortisol levels (Després et al., 1990).

An android fat distribution can occur in both men and women (Krotkiewski et al., 1983), although it is somewhat more prevalent in men. One U.S. survey (Ley et al., 1992) found that 49% of men had android fat distributions, compared with 39% of premenstrual women).

It appears that the hormonal regulation of adipocytes in gynoid fat tissue differs from that of adipocytes found elsewhere in the body. Gynoid fat is deposited under the influence of oestrogen, and it is normally relatively stable, although it can be mobilized quite readily during lactation. In contrast, android fat deposition is influenced by testosterone, and it is quickly mobilized during periods of aerobic exercise training and at other times when there is a negative energy balance (Després et al., 1988). Moreover, the android fat cells are resistant to the regulating influence of insulin, so that in a person with an android accumulation of fat, liver metabolism is impaired by high levels of free fatty acids arriving via the portal circulation. The deposition of fat in unwanted sites such as the liver and the



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arteries becomes increasingly likely as the fat cells become insulin resistant and no longer take up surplus fat (Després and Lemieux, 2006).

### Limitations of qualitative information.

Kretschmer, (1948) pointed out one immediate dilemma faced by people who are attempting to classify an individual's body type. Although a few individuals can easily be assigned to one of the three categories listed in Table 1, a large segment of the population presents an amalgam of two or more of the classical body types. Sheldon and Heath and Carter faced similar difficulties, in that many of the people that they studied showed characteristics of two if not three somatotypes (Sheldon et al., 1940).

Moreover, because somatotype scores reflect three partly independent ratings, they are not readily subject to most types of statistical analysis (Cressie et al., 1986). Another important weakness is that although ratings have a measure of temporal stability from childhood through to adult life (Carter and Heath, 1988; Hammond, 1953; Zuk, 1958), the continued consistency of ratings is less clearly proven during adulthood; indeed, a person's classification may change with both age and dietary restriction (Hooton, 1951; Hunt and Barton, 1952; Lasker, 1947; Newman, 1952; Tanner, 1956). Ratings of endomorphy are particularly unstable. Moreover, scores for the three characteristics proposed by Sheldon show considerable inter-correlation (Table 5),

together with a curvilinearity of inter-relationships, to the point that several investigators have queried whether findings could not be handled more parsimoniously using two rather than three factors (Ekman, 1951; Humphreys, 1957; Sills, 1950). Finally, there is the issue of *dysplasia*, with some people showing differing characteristics in different parts of their bodies.

The short-term within-observer reproducibility of three-way classifications of body build is surprisingly good for experienced observers. Tanner claimed that in his experience three well-trained investigators reached agreement on a seven-point rating to within a 1/2 of a rating in 90% of individuals following examination of photographs and given knowledge of a person's height and weight (Tanner, 1956). Further, intra-class reliability coefficients were in the range 0.82-0.92 when somatotype ratings for an entire sample covered the full potential 1-7 scale range. Tanner concluded that ectomorphy was the easiest characteristic to rate, and mesomorphy the most difficult. (Sills, 1950) and two colleagues each rated a sample of 158 subjects, finding correlations with reference ratings for these individuals of 0.95 for ectomorphy, 0.90 for mesomorphy and 0.92 for endomorphy. However, there is also a potential component of inter-observer variation related to the body type of the observer; a fat evaluator is less likely to

**Table 5:** Inter-correlations between ratings for Sheldon's 3 somatotype components in men and women respectively.

	Men			Women		
	Endomorphy	Mesomorphy	Ectomorphy	Endomorphy	Mesomorphy	Ectomorphy
Endomorphy	1.00	-.32	-.27*	1.00	-.11	-.70
Mesomorphy		1.00	-.64		1.00	-.41

\*Humphreys (1957) has suggested that this low correlation coefficient is a computing error.

class a client as fat than someone who is thin.

### Practical applications and conclusions

Sterner and Burke, (1986) have claimed that somatotypic estimates of body fat made by expert raters can be as accurate as those obtained by measurements of skinfolds. Certainly, body form can be rated in qualitative terms, but this is a rather crude endeavour, unless carried out by highly trained observers. Moreover, most people are not clear examples of any one-body type, and suggested linkages with personality and susceptibility to disease are now largely discredited. Participants in a given athletic discipline show some general similarities of body type, but a substantial range of anthropometric characteristics remains compatible with top performance, to the extent that somatotyping has little practical value in athletic selection. Quantitative data on body composition, as discussed in the accompanying paper, are generally required in epidemiological surveys and when assessing the response to a potential weight-reduction regimen.

Nevertheless, qualitative estimates of somatotype can be helpful to field workers when they must decide whether an excess body mass in relation to height is due to muscular development or an accumulation of fat. Further, if it appears that there is an excess of body fat, an impression can be formed as to whether this has a male (android) or a female (gynoid) distribution pattern, with significant implications for future health.

### Acknowledgments

The author acknowledges no funding relationships or other conflicts of interest. The author acknowledges that all images/pictures were obtained via open

sources within the public domain.

### Author's qualifications

The author's qualifications are as follows: Roy J. Shephard, C.M., Ph.D., M.B.B.S., M.D. [Lond.], D.P.E., LL.D., D.Sc., FACSM, FFIMS.

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