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Adolphe Quetelet (1796–1874)—the average man and indices of obesity

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Abstract

The quest for a practical index of relative body weight that began shortly after actuaries reported the increased mortality of their overweight policyholders culminated after World War II, when the relationship between weight and cardiovascular disease became the subject of epidemiological studies. It became evident then that the best index was the ratio of the weight in kilograms divided by the square of the height in meters, or the Quetelet Index described in 1832. Adolphe Quetelet (1796–1874) was a Belgian mathematician, astronomer and statistician, who developed a passionate interest in probability calculus that he applied to study human physical characteristics and social aptitudes. His pioneering cross-sectional studies of human growth led him to conclude that other than the spurts of growth after birth and during puberty, 'the weight increases as the square of the height', known as the Quetelet Index until it was termed the Body Mass Index in 1972 by Ancel Keys (1904–2004). For his application of comparative statistics to social conditions and moral issues, Quetelet is considered a founder of the social sciences. His principal work, 'A Treatise of Man and the development of his faculties' published in 1835 is considered 'one of the greatest books of the 19th century'. A tireless promoter of statistical data collection based on standard methods and definitions, Quetelet organized in 1853 the first International Statistical Congress, which launched the development of 'a uniform nomenclature of the causes of death applicable to all countries', progenitor of the current International Classification of Diseases.

Keywords: Adolphe Quetelet; Body Mass Index; International Classification of Diseases; obesity; probability calculus; Quetelet Index; statistics

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Obesity as a disease, with well-defined complications, is approximately one century old. For much of human history, corpulence was considered a sign of good health and fat an advantage. The impact of gross obesity on quality of life began to be appreciated late in the 18th century and on ill health in the middle of 19th century, but it was only in the first decades of the 20th century that the morbid complications and increased mortality of obesity began to be documented by the insurance industry. What has made the problem alarming is the exponential increase in the prevalence and incidence of obesity over the past few decades; this increase has led the World Health Organization (WHO) to declare it a global epidemic and worldwide public health crisis [1].

The need for an index of normal relative body weight was recognized soon after the actuaries noted the increased death claims of their obese policyholders [2]. Louis I. Dublin (1882–1969), a statistician and vice president of the Metropolitan Life Insurance Company, was the first to lead the development of tables of normal weights, based on the average weights recorded for a given height. However, as data accrued, he noted a rather wide range of weights for persons of the same sex and height, which he attributed to differences in body 'shape' or 'frame'. To resolve the problem, he divided the distribution of weight at a given height into thirds, and labelled them 'small', 'medium' and 'large' frames. The average weights of those thirds were then termed 'ideal' weights, later less presumptuously labelled 'desirable' weight, for each of the three frame types [1,3]. For purposes of insurance, undesired weight was considered at 20–25%, and morbid obesity at 70–100% above the desirable weight for a given frame.

As the relation between body weight and mortality, particularly cardiac disease and diabetes, gradually became a medical concern following the Second World War, the quest for a reliable and practical index of relative weight began to assume increasing importance in the epidemiological and clinical studies that were being initiated. In exploring various indices combining weight and height, it became evident in

Fig. 1. Stamp issued by Belgium to commemorate the centenary of the death of Adolphe Quetelet (1796–1874), who in 1832 developed the 'Quetelet Index' now known as the Body Mass Index (BMI). – © Belgium post.

the 1960s that, in adults, normal body weight in kilograms was proportional to the square of the height in meters, as originally proposed in 1832 by Adolphe Quetelet (1796–1874) (Figure 1), generally known in the then small circle of experts as the Quetelet Index [4,5].

One of the first studies to confirm the validity of the Quetelet Index in epidemiological studies comprised data gathered during the fourth examination of the Framingham study [6]. In a subsequent comparative study of available indices of relative weight and obesity published in 1972, Ancel Keys (1904–2004) confirmed the validity of the Quetelet Index and named it the Body Mass Index (BMI) [7]. Since then, as evidence of the association of obesity with various diseases continues to accrue, the BMI has been used as an expression to report the link of excess relative weight to morbidity and mortality. Primarily derived from data obtained on Anglo-Saxon populations, the generalizibility and applicability of the BMI and its cut-off points to other populations has been questioned and its sensitivity as a measure of excess fat queried. Nevertheless, it remains a dependable value and the basis of much of the associations reported heretofore with obesity, including its detrimental effect on normal kidney function and the course of chronic kidney disease [1].

Adolphe Quetelet

Born in the historic Belgian town of Gent on 22 February 1796, the fifth child of a family of nine children, Quetelet grew in politically challenging and intellectually stimulating times. An exceptionally talented student, his mathematical abilities were evident early, when he received prizes in algebra, geometry, grammar and drawing in secondary school at the Lycée de Gent. But it was his love of the humanities that dominated his early years. He published poetry, exhibited his paintings, studied sculpture, co-authored the libretto of an opera and translated Byron and Schiller into French. Following graduation from the lycée in 1813, and after a year of teaching at a private college in Audernarde, he returned to teach in Gent until 1817, when he entered the new University of Gent founded by order of William I of Orange-Nassau, the then king of the Netherlands, to which the Belgian provinces had been granted by the Congress of Vienna in 1815. The university was inaugurated on 9 October 1817, with an entering class of 190 students and a professional staff of 16 members. Quetelet elected to pursue his university studies with one of the newly recruited ordinary professors, Jean Guillaume Garnier (1766–1840), a mathematician who had been a professor and examiner at the Ecole Polytechnique in Paris. Having served as one of Garnier's teaching assistants, Quetelet successfully argued with the authorities that as a teacher, he should be exempt from regular examinations and proceed directly with defending his thesis, which he did on 24 July 1819, thereby becoming the first recipient of a doctorate in science from the University of Gent, when he was only 23 years old [8–11].

Recruited to teach mathematics at the Athenée in Brussels, he soon conceived the need for an observatory and convinced the government to fund his trip to Paris in 1823 to study astronomical activities. That was a defining moment in his life, for while in Paris he met Joseph Fourier (1768–1830), Siméon Poisson (1781–1840) and Pierre Laplace (1749–1827), became impassioned by the subject of probability, and went on to put it to practical use in the study of the human body, a subject in which he had developed an early interest as a painter and sculptor. In doing so, he became the first to develop height and weight tables to study their relationships, and a pioneer in the application of mathematical analysis to the study of man [8–11].

Quetelet's interest in the subject was kindled when on his return from Paris, he got involved in a national population census of the Netherlands and argued that a random sample from a representative diversified group could be used to estimate the total population. His subsequent conceptual evolution in the study of man evolved from the study of averages (physical characteristics), to rates (birth, marriage, growth) and ultimately distributions (around an average, over time, between regions and countries) [12]. The latter was the basis of one of his contributions to statistics; the demonstration that the normal Gaussian distribution, typical throughout nature, applied equally to physical attributes of humans, including body parts, derived from large-scale population studies (Figure 2).

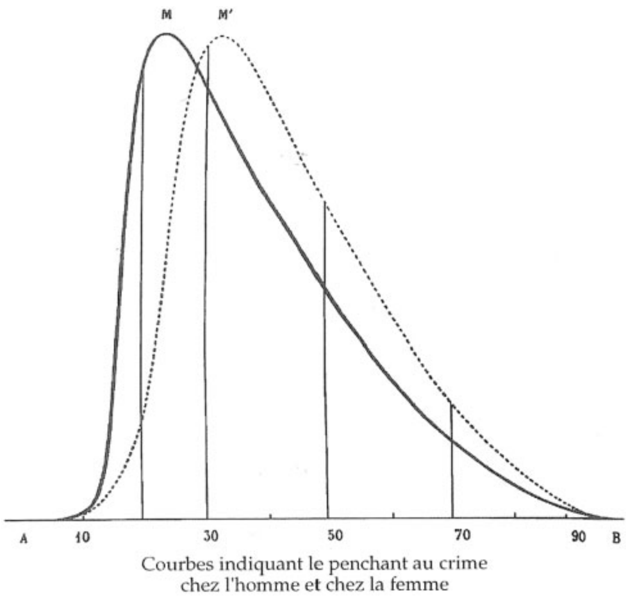

Fig. 2. Quetelet's diagram showing the distribution of crime by age in Belgium. The figure sums the principal contributions of Quetelet: the concept of an average, the fitting of the distribution around the average and the applicability of the calculus of probabilities to social data. In addition, as the data presented for both men (bold line) and women (dotted line) illustrates Quetelet analysed data from both genders and highlighted differences where they existed; despite his exclusive use of the singular masculine in the title of his book and writings (reproduced with permission from ref. [10]).

After that, he saw bell-shaped curves everywhere he looked, including in social phenomena and the variables that determine character and aptitudes [13,14]. To his credit, he realized the limitation of deriving conclusions from cross-sectional homogeneous data and in his attempts to analyse causes, referred to variables that may affect them, by classifying them as due to systematic or constant (terrain), random or variable (weather), and occasional or accidental (war) causes [10,15]. Importantly, he persistently emphasized the accuracy and reliability of the data used in his tables and figures.

The construction of the observatory that launched his statistical career did not begin until 1826 and was completed in 1832, after Belgium had achieved its independence from the Netherlands in 1830, with Quetelet as its director. One year after obtaining his doctorate, Quetelet was elected to the Royal Academy of Sciences, served as its president from 1832–1834 and from 1834, as its permanent secretary for 40 years. It is from these two positions, director of the observatory and permanent secretary of the academy, that Quetelet conducted his subsequent groundbreaking studies. He died on 17 February 1874, 5 days before his 78th birthday [8–12].

Normal man and the Quetelet Index

In developing his index, Quetelet had no interest in obesity. His concern was defining the characteristics of 'normal man' and fitting the distribution around the norm. Much like Dublin a century later, he encountered difficulty in fitting the weight to height relationship into a Gaussian curve and began his quest for a solution. In 1831–1832, he conducted what has been considered the first cross-sectional study of newborns and children based on height and weight, and extended it to the study of adults. In 1832, he published his studies in the Proceedings of the Academy of Sciences as an article entitled '*Recherches sur le poids de l'homme aux différent âges*' (Research on the weight of man at different ages), and subsequently published it as a book [9,16]. In 1835, he collated all his studies in a book entitled *A Treatise on Man and the development of his aptitudes*. Divided into three books, Chapter 2 of the second book of the 'Treatise on Man' is entitled *Of the development of weight, and of its relation to the development of the height of the body* [17]. The first half of the chapter is devoted to the changes of height and weight at different ages, wherein he discusses the variable rates of growth (height and weight) following birth, at puberty and the age when they stabilize in males and females. The second half of the chapter is on the relation between the weight and height, principally after growth is stabilized. The introductory paragraph to this section succinctly summarizes Quetelet's observations in his own words, 'If man increased equally in all dimensions, his weight at different ages would be as the cube of his height. Now, this is not what we really observe. The increase of weight is slower, except during the first year after birth; then the proportion we have just pointed out is pretty regularly observed. But after this period, and until near the age of puberty, weight increases nearly as the square of the height. The development of weight again becomes very rapid at puberty, and almost stops after the twenty-fifth year. In general, we do not err much when we assume that during development the squares of the weight at different ages are as the fifth powers of the height; which naturally leads to this conclusion, in supporting the specific gravity constant, that the transverse growth of man is less than the vertical' [17].

The 'Treatise on Man' was translated into several languages. The English translation, from which the above quote is cited, was published in Edinburgh in 1842 under the direction of Dr Robert Knox, Fellow of the Royal Society of Edinburgh and Lecturer of Anatomy in Edinburgh. Knox is better known for his involvement in the case of Burke and Hare, the body snatchers who supplied him with cadavers and were apprehended when the body of a Mrs Docherty was discovered in Knox's cellars. Knox served as the character of the doctor in the movie script of Dylan Thomas (1914–1953), 'The doctor and the devils' and in the play of Jamie Bridie (1888–1951), 'The Anatomist' [18,19].

Quetelet was invited to write a preface to the English edition of 1842, in which he states his goal as 'the analysis of normal man through his actions and of intellectual man through his productions' [17], which explains the subtitle of the original French version of his book, *Essai de Physique Sociale* (Essays on Social Physics). Essentially, in the course of time, Quetelet had extended his mathematical analysis of the demographic and anthropometric characteristics of man to that of the other aptitudes of man, such as behaviour, mind and soul. In doing so, he demonstrated for the first time the value of comparative statistics in understanding social conditions and the application of the calculus of probability to moral and social issues. For this he is considered a founder of social sciences [12]. George Sarton (1884–1956), himself a 1911 graduate with a PhD in mathematics from the University of Gent, a founding father of the history of science, and biographer of Quetelet called the *Treatise of Man* 'one of the greatest books of the 19th century' [9]. An opinion shared by Florence Nightingale (1820–1910), who was greatly influenced by the work of Quetelet, read and annotated his book, maintained a correspondence with him, used his statistical methods to argue for the radical innovations she introduced in nursing care, and in her eulogy of him characterized him as 'the founder of the most important science in the world' [20].

Pleased and encouraged by the reception of his book and strengthened by the evolution of his thinking, Quetelet, in 1869, published an expanded version of the book for which he reversed the title and subtitle of the 1835 version, now termed 'Social Physics or an Assay on the Development of the Faculties of Man' [21].

Other contributions

Prior to the appearance of the 'Treatise on Man', Quetelet had already attained a high reputation for his cautious, accurate, comprehensive and innovative studies. As a result, he was instrumental in founding the Statistical Section of the British Association for the Advancement of Science at Cambridge in 1833, and within a year, the Statistical Society of London, predecessor of the present Royal Statistical Society. With the increased fame achieved by his book and as a tireless promoter of accurate statistical data collection based on standard methods and definitions, Quetelet conceived, organized, hosted and presided over the First International Statistical Congress (ISC) in Brussels, in 1853. At this meeting, William Farr (1807–1883) of London and Marc D'Espine (1806–1860) of Geneva were appointed to prepare a 'uniform nomenclature of the causes of death applicable to all countries' [8–12,22,23]. Their report at the second ISC in Paris, in 1855, is the progenitor of the current International Classification of Diseases (ICD), the name it assumed after the successor of the ISC in 1885, the International Statistical Institute, began to cooperate with the WHO in developing a uniform nomenclature of diseases [23].

Quetelet's studies are said to have influenced the thinking of Charles Darwin, who was familiar with his works. But it is Darwin's cousin, Francis Galton (1822–1911), who fully recognized and cited extensively the contributions of Quetelet and pursued the application of the bell-shaped curve with even greater enthusiasm. The difference between them being that where Quetelet saw homogeneity and applied it to define the norm, Galton saw heterogeneity and applied it to the study of the abnormal in his search for 'nature's preeminently nobles', a field he termed eugenics. Interestingly, the person to question the validity of the bell-shaped curve, Karl Pearson (1857–1936), was in fact the Galton Professor of Eugenics at the University College of London [13,15,24].

Conclusion

The life and work of Quetelet are closely related to the events of society in the first half of the 19th century [11]. The French Revolution and Napoleonic wars had

Fig. 3. Statue of Adolphe Quetelet in the gardens of the Palais des Académies in Brussels. It shows him holding a globe in his left hand to reflect his international interests and the worldwide impact of his studies. Photograph courtesy of www.BrusselsRemebers.irisnet.be.

shaken the roots of Europe, and after the Congress of Vienna in 1815, a new Europe began to take shape. The social and economic structure of Europe was undergoing dramatic changes due to industrialization, mechanization and urban migrations. It was a time of burgeoning research in several fields of knowledge, the establishment and growth of national academies, and the foundation of higher institutions of research [25]. This was the fertile environment that nurtured the creative mind and scientific entrepreneurial spirit of Quetelet. From the perspective of nephrology, it was also the time that Richard Bright (1789–1858), a contemporary of Quetelet, began to publish his reports on proteinuria and kidney disease [26].

A polymath (equally versed in the arts and sciences) and a polyglot (in addition to his native French, fluent in English, Spanish, Italian, German and Latin, in which he defended his doctoral thesis), Quetelet was a dogged investigator, a prodigious author, a dauntless undertaker with infectious enthusiasm and abundant ambition and a talented organizer who saw opportunity in everything he encountered and capitalized on it. In brief, he exemplified the 'philosophes' of the 18th century in which in he was born, and the 'savants' of the 19th century in which he grew and helped shape.

This article highlights his contributions to the statistical study of the physical and social phenomena of man. His actual contributions were much more varied. He was equally productive in astronomy and meteorology, though less famous for them [9,10,15]. As he grew older, he realized that the best way to originate new endeavors was to tell the history of earlier times, and this probably induced him to devote part of his last years to recounting the history of the development of mathematics, statistics, and the sciences in Belgium [9].

In recognition of his contributions to the sciences in Belgium and to the Royal Academy, a statue of Quetelet was commissioned and paid for by public subscriptions. Unveiled in 1880, it now stands at the southeast corner of the Places des Palais in Brussels, at the entrance to the Palais des Académies (Figure 3). He is shown sitting with his left hand holding a globe reflecting his own international interests and the global influence of his studies, recounted in this article as they pertain to obesity.

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