MEDICINE AND SOCIETY: PEER-REVIEWED ARTICLE
How Body Mass Index Compromises Care of Patients With Disabilities

Alexander E. Jacobs

Abstract
The history of body mass index (BMI) is intertwined with the development of anthropometric statistics used to classify and measure human variation, an intellectual foundation of eugenics. While useful in analyzing population trends in relative body weight, BMI possesses multiple shortcomings when used as an individualized health screening tool. These limitations compromise the just care of people with disabilities, especially patients with achondroplasia and Down syndrome, for whose care BMI use contributes to clinical ostracization.

Introduction
Body mass index (BMI), a metric that divides a person's weight (in kg) by their height (in m²) to estimate their body fat indirectly, was originally known as the Quetelet Index for its creator, the Belgian mathematician Adolphe Quetelet (1796-1874). Quetelet was instrumental in promoting ideal body types defined by a statistical average.[1] Through his development of BMI, among other measures of physical variation, Quetelet helped create medical-physical norms that could be used to sort humans based on how well their measurements conformed to, or deviated from, arbitrary ideals of what a body should be. This paper argues that, in its current clinical application, BMI enforces physical norms that pose risk of medical harm for patients whose bodies do not conform to average measures. In particular, BMI's use as a clinical cutoff value for medical interventions risks harming certain people with disability (PWD), such as those with achondroplasia and Down syndrome.

An "Average Man"
Quetelet was inspired by early 19th-century scientists who worked on error theory. Error theorists had observed that no single scientific measurement was likely to be accurate, whether due to instrument imprecision, user error, or natural variance.[1] However, while solitary measurements were prone to error, the average of multiple measurements most accurately estimated a quantity. Error theorists also discovered that measurements typically followed a bell curve—what we would now call a normal distribution.[1,2] Quetelet observed that certain human features, such as height and weight, are also normally distributed.[2,3]

In addition to his observation that human traits were often normally distributed, Quetelet believed that the mean value of any measured trait defined an ideal—the value least corrupted by error. For Quetelet, the average value of measurable traits—such as height, intelligence, or number of progeny—was of normative significance, as it described what a person *should* possess. A person who, in theory, adhered to the average in every measurable domain would constitute a human ideal. Quetelet named this idealized figure *l'homme moyen*—"the average man."[4] Reifying a statistical artifact into a moral value, Quetelet explicitly linked the average man to beauty, health, and moral goodness, while associating vice, illness, and ugliness with persons who deviated from the mean.[4]

Quetelet's creation of BMI stemmed from his effort to record as many measurable human traits as possible, from chest circumference to height to number of offspring.[3] Quetelet found that among the primary population he studied—Western European adult males—BMI was a consistent index of relative body weight.[3] He did not acknowledge the value of exceptions—such as one might see with certain disabled persons—outside the average.[3] His concern remained with average bodies—those found at the center of the normal distribution.

Francis Galton, the late 19th-century statistician and eugenicist, further developed Quetelet's work. Unlike error theorists, who viewed deviations from the mean as errors to be mitigated,[1] Galton recognized that, in humans, certain deviations were desirable, such as above-average intelligence.[2] He developed the quartile as a way to divide the normal distribution so that people's qualities and abilities could be compared, ranked, and ultimately reproduced (eg, high intelligence) or extinguished (eg, low intelligence) in the name of racial progress.[2] As Donald MacKenzie writes, "The needs of eugenics in large part determined the content of Galton's statistical theory."[2] If Quetelet's *l'homme moyen* was an ideal from which all humans deviate, Galton's quartile enabled humans to be ranked, valued, and bred for perfection. Modern medicine has inherited Quetelet's and Galton's standards of normality, which remain embedded in purportedly objective measurements like BMI.

Limitations of BMI for Patients With Disabilities

Due to the ease of its calculation, BMI is a clinical measure that is widely used to identify obesity and screen for risk of certain diseases.[5] It is, however, imperfectly suited for these tasks. The use of BMI cutoffs for healthy weight is prone to false positives—such as when muscular individuals are considered overweight—and to false negatives—such as when elderly patients with low muscle mass and higher levels of body fat are considered in the "healthy" BMI range.[5,6] Medical guidelines typically acknowledge that BMI is best used to analyze population trends,[5] yet BMI is the measure by which individuals are most commonly categorized as underweight, healthy, overweight, or obese (and possibly further subcategorized, such as "morbidly obese").[5] While not true quartiles, such categories nevertheless express Galton's project of sorting humans into "deviant" and "normal" groupings.

Because BMI originates from statistical efforts to define average bodies, it is less applicable to bodies that deviate from the average due to the way it is calculated. BMI is a 2-dimensional formula, whereas bodies exist in 3 dimensions. In 3-dimensional objects, volume and mass increase with the cube of height, not the square. Thus, BMI fails to consistently track the relationship between height and mass the further an individual's height deviates from average. As summarized by one commentator, "Because BMI uses the square of the height rather than the cube, anyone who is tall but

normally proportioned will tend to have a high BMI and anyone who is short … will tend to have a low BMI, even if they are relatively obese."[7]

Under the social model of disability, in which PWD are disabled by the environment—that is, by physical structures and social attitudes—rather than intrinsic physical or cognitive attributes, the disabled body is defined by its deviance from a socially sanctioned norm of what a body should be.[4] Originating in Quetelet's attempts to define idealized bodies, BMI imposes a physical norm that perpetuates a disabling medical environment for certain PWD.

Consider patients with achondroplasia, the most common cause of dwarfism, which is associated with increased abdominal adiposity and metabolic dysregulation.[8] Owing to their shorter stature, individuals with achondroplasia will have lower BMIs than would be expected in a taller patient with proportionally comparable body fat levels. Even after accounting for their predisposition to increased abdominal adiposity, BMI would still underestimate relative obesity in people with achondroplasia.[7,8] In such cases, there is potential for the use of BMI to adversely affect medical care. For instance, medical interventions such as bariatric surgery for the treatment of morbid obesity have strict minimum BMI cutoffs.[9] A patient with achondroplasia and obesity would need, in effect, to achieve a higher (and arguably less healthy) body fat level relative to a taller person to access the benefits of bariatric surgery. Similarly, BMI cutoffs are used to trigger interventions for people at risk of diabetes and are included in validated diabetes risk calculators.[10,11] Physicians who adhere rigidly to BMI-based guidelines may fail to offer surgical interventions or diabetes prevention measures to shorter patients for whom such treatments are otherwise warranted.[10] The application of BMI to determine treatment eligibility privileges the "normal" bodies BMI was first used to define.

Or consider patients with Down syndrome, which is associated with elevated blood leptin levels.[12] Elevated leptin is linked to many of the inflammatory processes associated with the morbidity of obesity.[12,13] Yet studies demonstrate that, in patients with hyperleptinemia, BMI underestimates obesity compared to dual-energy absorptiometry, the gold standard for measuring body composition.[6] In clinical practice, leptin levels are not routinely evaluated, even in patients with Down syndrome.[12] Thus a patient may experience the inflammatory effects of hyperleptinemia while having a BMI that falls below the cutoffs that trigger medical interventions aimed at curbing obesity and related metabolic dysfunction. In patients with Down syndrome, BMI's use as a screening tool provides inadequate insight into the unique medical needs associated with hyperleptinemia.

BMI's unreliability as an indirect measure of body fat is heightened the further a body deviates from a Queteletian norm, limiting its generalizability across different body types. These inconsistencies apply beyond PWD. For instance, a 5-ft-tall person would have a lower BMI than a 6-ft-tall person with proportional mass. And ethnic differences in BMI-associated health risks have been well established in the contemporary medical literature.[10] All people deviate from one norm or another—even Quetelet understood *l'homme moyen* was unattainable—and physicians should consider whether overreliance on a statistic developed to define average bodies limits their ability to attend to individual patient needs.

Conclusion

While BMI correlates with many markers of ill health, one can look to those markers directly to answer questions that BMI only glancingly addresses. For PWD, who may inhabit bodies poorly described by BMI or require tailored medical care, the costs of BMI's imprecision are commensurately more burdensome than for people without disability.

A critic may fairly argue that BMI is a convenient, low-cost way of gauging patient health and that a capable physician understands no single number reflects a patient's entire story. Yet a historical and clinical assessment of BMI cannot ignore its role in reproducing a concept of normality with the potential to perpetuate medical harm for PWD. The limitations of BMI in medical practice are not limited to PWD, but the case of PWD foregrounds the subtle ways that destructive values can be smuggled into seemingly objective measures.

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Alexander E. Jacobs is a fourth-year student at the University of Minnesota Medical School in Minneapolis.

Conflict of Interest Disclosure
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