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The Growing Problem in Ergonomics: Obesity

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Introduction

The prevalence of obesity in the United States continues to climb, exceeding 30% in most gender and age groups. Over the past decade, medical costs associated with obesity have also sky-rocketed and are now $147 billion annually, representing almost 10% of all medical spending (CDC, 2009).

Much of this increased cost is due to the fact that obesity (defined as a Body Mass Index of greater than 30, CDC) is also a risk factor for a variety of chronic conditions including diabetes, hypertension, heart disease, and arthritis. So what does this mean from an ergonomists perspective? It means we cannot continue to ignore this issue and act like it is the "elephant in the room." Ergonomics can actually have a very positive impact on addressing issues that obese and bariatric individuals may face in the workplace. In addition, obesity contributes to the growing number of injuries that health care providers face in terms of safe patient handling with a larger population.

Body Mass Index (BMI)

The Body Mass Index (BMI) stems from the Quetelet Index which was originally developed between 1830 and 1850 by Adolphe Quetelet, a Belgian mathematician/statistician. BMI is calculated using the individual's body weight divided by the square of his or her height (unit of measure kg/m^2). BMI can also be determined using a BMI chart (Figure 1) which displays BMI as a function of weight (horizontal axis) and height (vertical axis) using contour lines for different values of BMI or colors for different BMI categories.

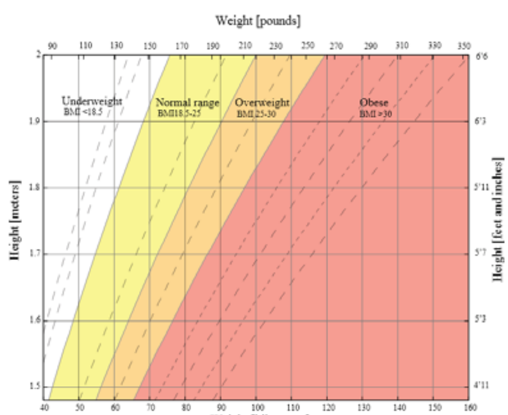

Figure 1: Body Mass Index (BMI) Chart with Classification Systems (*Source: WHO, 2011*)

Several government and health organizations use body mass index (BMI) to classify individuals as "overweight" and "obese" in adult populations (CDC, National Institutes of Health, WHO). BMI categories can vary from country to country; however, in 1998, the United States National Institutes of Health aligned BMI categories with those defined by the World Health Organization (WHO).

Table 1: Body Mass Index (BMI) Categories and Sample Weights (*Source: WHO, 2011*)

Category	BMI range – kg/m^2	Weight of a 5 ft 11 in person with this BMI
Severely underweight	less than 16.0	Less than 118 lb
Underweight	from 16.0 to 18.5	Between 118 and 132 lb
Normal	from 18.5 to 25	Between 130 and 178 lb
Overweight	from 25 to 30	Between 180 and 214 lb
Obese Class I	from 30 to 35	Between 210 and 249 lb
Obese Class II	from 35 to 40	Between 250 and 286 lb
Obese Class III	over 40	Over 290 lb

The World Health Organization 2008 projections indicate that globally:

- approximately 1.5 billion adults over the age of 20 were overweight;
- of these, more than 200 million men and nearly 300 million women were obese.
- WHO further projects that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese.

During the past two decades there has been a marked increase in obesity in the United States. In 2009, only Colorado and the District of Columbia had a prevalence of obesity less than 20% (CDC, 2009). Thirty-three states had prevalence equal to or greater than 25%; nine of these states (Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Missouri, Oklahoma, Tennessee, and West Virginia) had a prevalence of obesity equal to or greater than 30% (CDC, 2009). Figure 2 shows the shift in United States obesity prevalence from 1985 to 2009.

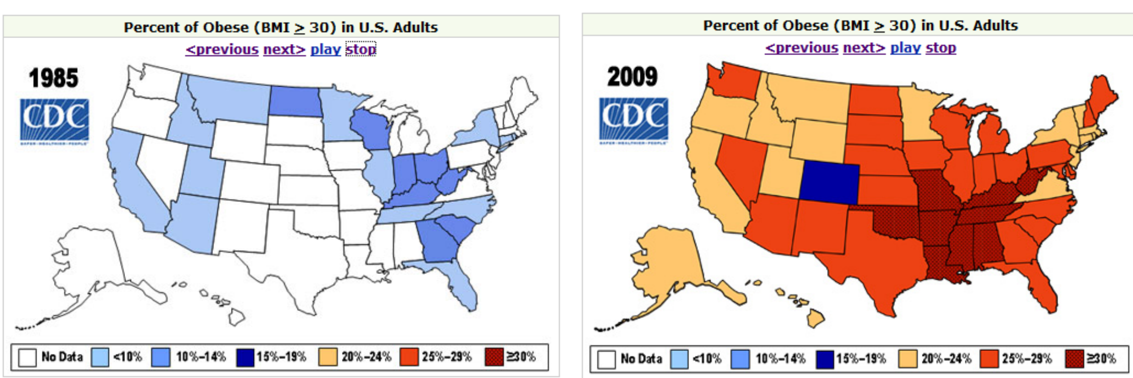

Figure 2: U.S. obesity prevalence in 1985 versus 2009 (*Source: CDC, 2009*)

BMI as an Indicator for Obesity…A Good Measure?

The popularity of using BMI as an indicator for obesity stems from research conducted in the 1970's. Keys et al. (1972) found BMI to be the "best proxy for body fat percentage among ratios of weight and height" and explicitly cited BMI as being appropriate for population studies, and inappropriate for individual diagnosis. However, due to the simplicity of the equation, BMI has since become the "norm" to measure a person's "fatness" or "thinness" and has been widely adopted in individual diagnoses.

In more recent years, BMI has come under scrutiny and is a controversial topic amongst researchers and health care professionals. Sample articles and key points include:

- CNN Health: "Can Neck Measure Indicate Body Fat Better Than BMI?" (2010)
  - Article based on research by Olubukola et al (2010) published in the journal *Pediatrics*.
  - A wide neck circumference is associated with obesity-related conditions such as sleep apnea, diabetes and hypertension. Neck circumference has been explored in studies for potential obesity and heart problems in adults.
  - One of BMI's shortcomings is that it "does not accurately define central body fatness".
  - Studies have shown that regional adiposity, fat collected around the midsection, is often a good indicator for obesity-related complications, including hypertension, diabetes and heart disease. The correlation between regional adiposity and a high neck circumference was found to be strong.

- National Public Radio (NPR): "Top 10 Reasons Why The BMI Is Bogus" (2009)
  - Keith Devlin of Stanford University suggests any obesity findings based on BMI should be taken with a grain of salt.
  - Quetelet said explicitly that it could not and should not be used to indicate the level of fatness in an individual.
  - There is no physiological reason to square a person's height in BMI. Moreover, it ignores waist size, which is a clear indicator of obesity level.
  - It makes no allowance for the relative proportions of bone, muscle and fat in the body.
  - A high BMI does not mean an individual is even overweight, let alone obese. It could mean the person is fit and healthy, with very little fat.

- Science Daily: "BMI Not Accurate Indicator Of Body Fat, New Research Suggests" (2007)
  - Article based on research published in the official journal of the *American College of Sports Medicine*.
  - A research team from Michigan State University and Saginaw Valley State University measured the BMI of more than 400 college students – some of whom were athletes and some not – and found that in most cases the student's BMI did not accurately reflect his or her percentage of body fat.
  - The problem is that BMI does not distinguish between body fat and muscle mass.

Causes and Consequences of Obesity

The primary cause of obesity and being overweight is an imbalance between calories consumed, and calories expended (WHO, 2009). According to WHO (2009), global increases are attributable to a number of factors including:

- A global shift in diet towards increased intake of energy-dense foods that are high in fat and sugars but low in vitamins, minerals and other micronutrients; and
- A trend towards decreased physical activity due to the increasingly sedentary nature of many forms of work, changing modes of transportation, and increasing urbanization.

The environment may also have an impact on obesity. There are several different environments that people interact with. In the home people may choose to do activities that do not lead to caloric expenditure, such as watching television and other sedentary behaviors. Schools also impact children; they dictate lunch menus and how much physical activity children get throughout the day. The type of work that a person does may affect the amount of physical activity, for instance sitting expends less than 720 calories over eight hours, whereas heavy work such as construction can expend around 2,400 to 3,600 calories over eight hours (Sanders, 1993). Finally, the community may affect people's choices about exercise and food. The availability of nutritious low-calorie food will influence the type of diet available for an individual.

Genes may also play a role in obesity. There is some scientific evidence that people may have a higher risk of becoming obese based on their family history (CDC, 2009). Many studies have been done on obese populations and obese families. In general, these studies have shown that a sizable portion of weight variation can be explained because of genetic factors. Narrowing these factors is the current challenge for researchers and scientists.

There are many health consequences for people classified as overweight or obese. Scientists have produced the first direct evidence that fat accelerates aging. Valdes et al (2005) found that obesity (BMI > 30) adds the equivalent of nearly nine years of age to a person's body. This can begin to explain why obese children are developing adult-onset Type 2 diabetes between ages 10 and 19 (as opposed to age 45 which has been the norm). Other health consequences include:

- Coronary heart disease
- Type 2 diabetes
- Certain cancers (endometrial, breast, and colon)
- Hypertension
- Dyslipidemia (high cholesterol, high triglycerides)
- Stroke
- Liver and gallbladder disease
- Sleep apnea and respiratory problems
- Osteoarthritis
- Gynecological problems (abnormal menses, infertility)

Physiological Effects of Obesity

Range of Motion (ROM)

Obesity, depending on the level and distribution of adipose tissue, can affect range of motion (Park et al, 2010). Overweight and obese individuals do not have as much flexibility in their hips or in their back. This means that obese individuals may have more trouble reaching objects. Park et al (2010) found significant differences between obese and non-obese groups; decreased range of motion for shoulder extension (~20 to 22%), shoulder adduction (~36 to 39%), trunk extension (22%), and trunk lateral flexion (~18 to 20%).

A person's abdomen may also be an obstruction, thereby limiting the reach distance at a work surface. This could also influence working postures because of the limited reach envelope the individual may have to compensate with other parts of their body (e.g., shoulder abduction, trunk flexion). It is important to note that these limitations exist for both seated and standing workstations.

Physiology

Excess fat increases the oxygen requirements for any given task that is being performed (Wood et al, 2010). Therefore there is a larger physiological deficit for those who are overweight or obese. This may reduce the endurance time for this segment of workers. Fatigued workers may show increases in quality defects or lower production rates. Resting heart rates are also higher for obese individuals which can affect physical work capacity. It can also lead to adverse cardiac outcomes in the long run, such as heart disease.

Key Workplace Design Guidelines

We can take a proactive approach to address some of the particular challenges obese workers face by keeping in mind the following design guidelines:

- **Keep things close.** For obese individuals, keeping things close (i.e., within arm's reach) becomes even more important since excess body weight can increase the forces and loads placed on the spine. Design workstations and processes to ensure items are placed within 16" from the edge of the work surface. If items must be placed further than the recommended 16", minimize the time spent in sustained postures at this distance.
- **Keep it in the comfort zone.** Obese individuals are more prone to back and knee injuries from excess body weight, so keeping all work tasks within the comfort zone (i.e., knees to shoulders) will help. Design workstations and processes to be height adjustable and minimize storing items on the floor; keep all items between 38" and 47" above the standing surface.
- **Provide appropriate equipment.** Ensure equipment and furniture are purchased and/or designed with expanded capacity in mind (e.g., office and industrial chairs). Most standard chairs have a weight rating between 225 and 275 lb. Chairs designed for the obese individual are more involved than just changing out the pneumatic cylinder with one rated for a higher weight; they are also designed to accommodate a larger profile (e.g., wider seat pan, swivel arm rests).

- **Promote variety at the workstation.** Standing workstations have been shown to increase energy expenditure by 40% versus seated workstations. Standing just 2.5 hours out of the day can result in 350 extra calories burned. Standing workstations can also have an impact on compressive force on intervertebral discs which can impact occurrence of low back pain.
- **Embrace 5S.** This lean manufacturing concept has been adopted by many companies and involves steps to ensure work spaces promote efficiency and productivity (i.e., Sort, Straighten, Shine, Standardize, and Sustain). Keeping the work area clean and reducing/eliminating clutter wherever possible will help obese individuals maneuver around their workstation more easily.

Closing

In traditional ergonomics programs, the primary goal is to adapt the workplace and tools to the capabilities of people. This goal does not change when considering obese workers. You need only make a slight shift to accommodate the limitations of obese individuals. Do exactly what you are doing today, just do it better, with more knowledge of the key performance differentiators within your workforce.

The obesity problem is not going to go away or resolve itself anytime soon. Although the obese individual must take ownership of their health and well-being, we, as professionals in the ergonomics, safety, and engineering realms, must also better understand the needs of this growing population and find solutions so that we can fit the job to all workers.

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