ANTHROBESITY: CHANGING GUIDLEINES FOR A CHANGING WORKFORCE

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ABSTRACT

The obesity "epidemic" has continued unabated for years. In 2011, 59% of Canadians are considered "overweight", including 23% who are considered obese (Ontario Medical Association, 2011). As ergonomists, we are charged with helping employers provide workplaces that safely accommodate the majority of the working population. As the population gets heavier, our design guidelines need to change so that we are accommodating larger workers in the workplace. Further, we need to account for the increasing demands on workers such as health care providers, who are required to interact with the general population. This paper reviews the anthropometric criteria that we, as ergonomists, need to consider when designing work spaces for a population that is increasing in size and weight. The paper combines research regarding trends in obesity with case studies, to demonstrate the effect of "anthrobesity" on workers in North America, both from the obese worker's perspective, and from the perspective of care providers.

Key words: Anthropometrics, Obesity, Occupational Design

INTRODUCTION

Ergonomics assessments and workplace design guidelines have continuously improved in terms of accuracy, reliability, and usability over the past four decades. The collection of fundamental tools, such as the *Liberty Mutual Manual Material Handling Tables*, provide both the male and female population percentages capable of performing manual material handling tasks without overexertion (Snook & Ciriello, 1991). These ergonomics tools allow workplaces to safely accommodate the majority of the working population. However, this working population is becoming larger and heavier, and this trend may alter how ergonomists approach accommodation strategies.

While published population data, such as the National Health and Nutrition Examination Survey (McDowell *et al.*, 2008) accurately and objectively reflect of population sizes and shapes, ergonomics design guidelines may not be keeping up with the changing physical characteristics of the working population. For example, a recently published textbook (Chengalur, Rodgers & Bernard, 2004) cites anthropometric data that was obtained in 1979-1981.

The purpose of this review is to evaluate how the anthropometry of larger workers, patients and clients may affect ergonomics assessment and design guidelines. For example, robust, “oversized” office seating is available to support a morbidly obese person in a seated position. However, the seat is only one component of the office work space that needs to be considered. Obese workers present unique design challenges due to their anthropometry; an ergonomist is challenged to keep items within reach, and clearance characteristics are more extreme than our “charts” would predict. Obese workers use more energy than healthy-weight workers, and therefore may have more difficulty under heat stress conditions, or during metabolically demanding tasks like climbing or manual handling. Policies may also be affected by obesity; e.g., since an obese person exerts more energy at work, s/he may require more rest breaks than a healthy-weight co-worker under heat stress conditions. The paper also describes how increasingly obese patients/clients increase the risk of musculoskeletal injury for those who are required to “handle” them; nurses, personal support workers, therapists, paramedics, and others who are required to position, transfer and generally assist people who can be significantly larger than themselves.

Most ergonomics assessment tools evaluate the risk of injury for an “average” worker, or for a majority of the population, based on the “limiting user”, who is the hypothetical worker who is most at risk. For overhead work, for example, the limiting user might be a small female, whereas for bending, the limiting user might be a larger male. When the risk is highest for the larger individual, our guidelines would use a published source of anthropometric data for the limited user, which may not be current enough to account for the obesity trend.

Similarly, recommendations that might mitigate risk for a healthy-weight population might be insufficient for an overweight population. For example, coaching to encourage workers to pull a load close before lifting it might help a healthy-weight worker, but “close” might not be close enough to help an obese worker.

ANTHROPOMETRICS AMENDED

Population Size Differences: Height and Weight

Comparison to historical population databases is necessary to drive change in both the ergonomics solutions to occupational concerns and the tools used to evaluate the concerns.

Comparison of similar populations in 1960-1962, 1976-1980, and 2003-2006 identifies large increases in mean adult waist circumference and body weight, while mean adult height has remained unchanged (Table 1).

Table 1: Comparison and measure of change for mean waist circumference and weight of adults in prior to 1980 and in 2003-2006

	Waist circumference (cm)			Weight (kg)		
	1960-1962*	**2003-2006****	**Increase** (cm, %)	**1976-1980*****	**2003-2006****	**Increase** (cm, %)
Male	88.9	100.8	11.9, 13.4	78.1	88.3	10.2, 13.1
Female	76.7	94.2	17.5, 22.7	65.4	74.7	9.3, 14.2

* from Stoudt *et al.* (1970)
**from McDowell *et al*. (2008)
*** from Najjar and Rowland (1987)

The anthropometric data cited in current ergonomics textbooks defines a "large" male (95th percentile) as 183 cm tall and 102.9 kg (Chengalur, Rodgers & Bernard, 2004). By comparison, an obese male can be defined as a 230 kg male, with similar stature (Lohmann, Neergaard & Vesterdorf, 2010).

Increased torso size increases the reach from the torso to the hands
Increased torso size has implications on shoulder work, whole body space requirements, and working reach, as it prevents the worker from keeping the elbows at the sides and the hands close to the body's centre of mass. Increased waist circumference and sagittal abdominal depth may "use up" functional workspace close to the torso. For example, a light assembly task was simulated in a 3D biomechanical analysis program (3DSSPP 6.0.2, University of Michigan, Ann Arbor, MI) for both a 50th percentile male worker (176.3 cm, 88.3 kg) and for a morbidly obese worker (176.3 cm, 230 kg, as described in Lohmann, Neergaard & Vesterdorf, 2010). The assembly task was performed in a seated posture, with both feet supported. The task involved manipulation of a 3.6 kg, 34.5 cm wide piece, performed with both hands directly in front of the torso, wrists in a neutral posture. For the 50th percentile worker, the upper limbs were set in a neutral posture (0° abduction and 0° flexion), and the elbows were set at 90° of flexion (Figure 1a). This assumes that the average male worker was able to adjust his working height and reach to allow work in a neutral posture. For the morbidly obese worker, the same task was performed. However, sagittal abdominal depth (77 cm) and seated elbow-to-elbow distance (80 cm) constraints were integrated, forcing the adjustment of the work location. (These dimensions were estimated based on Lohmann, Neergaard & Vesterdorf, 2010.)

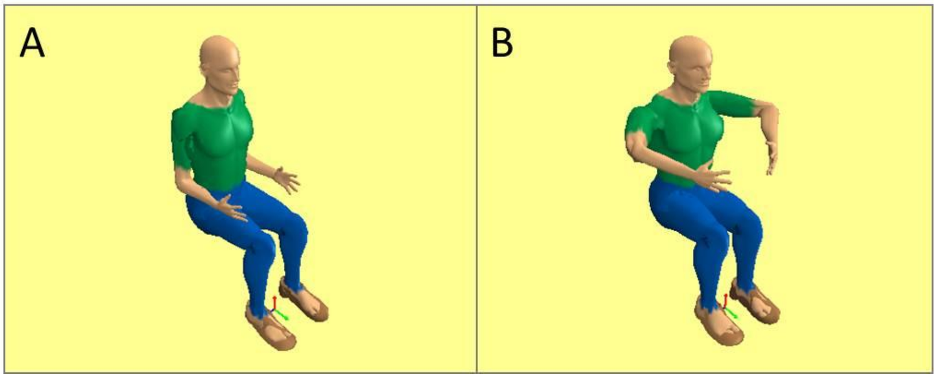

Figure 1: Biomechanical analysis comparison of average male (A) and morbidly obese male (B) workers performing an assembly task.

The 50th percentile worker required 20 % of maximum voluntary contraction (MVC) for both left and right shoulder abduction, whereas the morbidly obese worker required 50 % MVC. Note that this is a very conservative estimate for loading for the obese worker, as the biomechanical software would only allow the use of a 121.8 kg worker, rather than a 230 kg worker. The posture used by the obese worker was replicated, but the segment weights were not as great as a 230 kg worker would experience. Due to the sagittal abdominal depth and elbow-to-elbow distance required to accommodate his girth, the obese worker was required to work with 80° shoulder abduction and 43° shoulder flexion, even at a workstation that allowed adjustability to optimize working postures (Figure 1b).

Increased body size requires larger clearance allowances, which increases the reach for all workers

A lateral part transfer task and workspace were designed to allow clearance for a large male worker with an elbow-to-elbow width of 49.3 cm (Diffrient, Tilley & Harman, 1981). The worker transfers 1.5 kg parts from a belt conveyor (90 cm high) to a vertical monorail carrier, through a span of 116 cm (58 cm laterally from the centre of the torso). In order to accommodate a morbidly obese worker and allow the same torso clearance between the workstation and the torso of a large male worker, the workstation would have to be redesigned to allow an additional 30.7 cm of lateral clearance between the conveyor and the monorail. To assess the injury risk associated with this job, the ergonomist would typically evaluate the demands on a 50th percentile female worker. To illustrate the effect of accommodating morbidly obese workers at this work station, the 3D posture analysis for a 50th percentile female at the existing workstation is compared with the lateral reach that would be required to accommodate a large worker.

A) B)

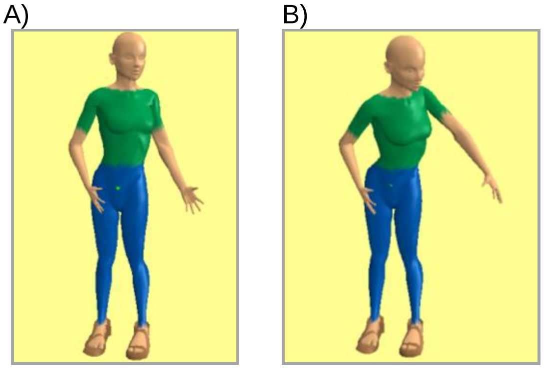

Figure 2: Average female working posture at the A) original workstation, and B) workstation adapted to allow clearance for an obese male

The existing design requires the average female to work at 17% MVC for the shoulder and 10% MVC for the back, to load a part to the monorail. The design adapted to allow clearance for an obese male requires the average female to work at 43% MVC for the shoulder and 41% MVC for torso rotation. Clearly, design to accommodate larger individuals has the potential to negatively impact other workers as well.

Heavier body segments add load to every lift for healthcare workers

Segment weights are heavier in an obese population. Increased segment loading is not only a concern for heavy individuals as workers, but also for professionals that treat these heavy individuals as patients or clients. Health care workers are often required to lift and hold or reposition patient legs. For a limb lifting task performed by a 50th percentile female health care practitioner at a 75 cm high hospital bed, the limb weight of an obese male (176.3 cm, 230 kg) drastically increases the risk of musculoskeletal injury compared to the same task performed on an average male (176.3 cm tall, 88.3 kg). The respective lower limb weights were 15.8 kg for the average male, and 37.0 kg for the obese male (Dempster & Gaughran, 1967). Assuming the same posture to lift the entire lower limb from the bed surface (Figure 3), the leg lift task requires the average female to work at 32% MVC for the shoulder, 27%

MVC for the elbow, and 25% MVC for the back. The same leg lift task with an obese patient requires the average female to work at 70% MVC for the shoulder, 61% MVC for the elbow, and 45% MVC for the back. These demands would place a higher risk of injury on the health care worker, particularly in an environment where the task was performed repetitively.

Figure 3: Lifting posture for a patient handling leg lift task performed by a 50th percentile female health care practitioner.

Heavier workers use more energy

Heat stress and other safety programs may use energy expenditure as safety criteria. For example, the ACGIH guidelines suggest limits for energy expenditure at various levels of heat stress. As the heat stress increases, workers need longer hourly rest breaks in order to prevent overexertion and heat-related illness. To assess the energy demands of a job, ergonomists use an energy expenditure prediction program (University of Michigan, 2002). For example, a light assembly job that requires a "large" (75th percentile, 98.2 kg male, McDowell *et al.*, 2008) worker to exert 3.16 kCal/minute would be classified as "light". However, a 230 kg worker would be working at a rate of 6.6 kCal/minute, which would be classified as "heavy". At temperatures that would require a company using a policy designed to accommodate 75% of male workers and more than 90% of females, to provide 15 minutes/hour of rest for "light work", the obese worker would need 45 minutes/hour of rest.

THE BIGGER PICTURE: AFFECTING THE FUTURE OF ERGONOMICS

Design guidelines and task analysis tools often focus on worker height, and biomechanical models, such as the University of Michigan's 3DSSPP, predict segment weight based on proportions recorded from a historic average population (values from 1975-78). As the anthropometry of the adult population changes, the emphasis on obtaining good data for worker weight and segment diameters and weights may need to increase. Workstations must accommodate a wider leg stance and clearance, seating and lean rails must support heavier loads, larger vehicle seating areas will be required, and wider doorways and access points are needed. If an overweight population was the only concern, such accommodation would be straight forward. The challenge to ergonomists, however, is that workstation design must consider smaller workers as well. Expanding seat clearances will increase reach distances, and enlarging workstation pathways will lengthen walking distances.

By 2015, it is expected that 75 % of adults and 24 % of children will be overweight or obese (Wang & Beydoun, 2007). Without a major intervention, these trends are likely to continue throughout the decades to come. These changes will continue to literally stretch the current ergonomic guidelines and require expanded worker accommodation strategies. Those who create occupational designs must be wary that, when adjusting standards to fit large workers, the small worker may be put at increased risk.

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