Journal of
Nutritional Medicine and Diet Care

Short Note: Open Access

Should We Use Various Obesity Measures Interchangeably?

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In clinical setting or clinical research studies, convenient obesity measures such as body weight and body mass index (BMI) are commonly used to quantify obesity status of patients or research participants. Although these obesity data are easy and cheap to collect, they may have problems as compared to other obesity measures.

Obesity is a complex medical condition that excess amount fat has accumulated in the human body. Obesity represents a major public health burden as it is highly prevalent throughout the world. Worldwide, over 200 million men and 300 million women have obesity, which has increased more than two-fold since 1980 [1]. In the U.S., around 33% of adults aged 20-74 years are obese [2]. The prevalence of obesity in the globe will increase dramatically because of unhealthy diets and physically inactive lifestyles [3]. The direct costs of obesity account for 5.7% of National Health Expenditure in the U.S. [4].

Obesity can be quantified via various methods. BMI is body weight (kg) divided by body height (meter) squared, and is commonly used to quantify obesity in clinical setting. Besides BMI, other similar obesity measures including waist/hip circumference, waist-to-hip ratio, skin fold thickness and bioelectrical impedance are useful in clinical and research settings. Recently, more sophisticated methods such as magnetic resonance imaging (MRI) or dual energy X-ray absorptiometry (DXA) become available. They are able to directly measure total body, trunk, abdominal, appendicular, visceral and subcutaneous fat. Due to limited clinical resources, applying imaging measures to assess obesity is of difficulty.

Although the correlations between different obesity measures are high ($r \geq 0.7$ and $p<0.001$) [5], they should not be used interchangeably. Several reasons can explain this:

First, they measure different aspects of obesity. BMI, waist/hip circumference, waist-to-hip ratio, skin fold thickness and bioelectrical impedance are not a direct measure of fatness; they can only provide an estimate of fat. Whereas, fat measured by MRI or DXA is an absolute scale of measurement of fat mass. These obesity measurements are reliable and accurate, but are also inconvenient and relatively expensive to measure. In addition, BMI or total body fat measured by DXA reflect total body obesity. Some other obesity measures such as appendicular fat, waist/hip circumference and skin fold thickness only assess regional obesity, which may not highly correlate with total body obesity.

Second, they have different associations with various obesity related outcomes. It has been proved that abdominal fat is more strongly associated increased risk of hypertension, CVDs, type-2 diabetes and insulin resistance than total body obesity measures [6-8]. This has also been confirmed by one of my recent papers suggesting that hip circumference was the most important obesity measure in relation to bone mineral density in the National Health and Nutritional Examination Survey, 2005-2006 [5]. Future research is required to find the best obesity measure for certain obesity related diseases. This will help us to accurately assess the magnitude of the relationship between obesity and its consequent diseases.

Third, there is a statistical issue when a ratio of two obesity measures is used to predict obesity related diseases. Percentage of fat mass and waist-to-hip ratio are two typical examples. The problem is that both obesity measures are a ratio of highly correlated variables. In both obesity measures, body weight and hip circumference are not appropriate denominators to assess body size as they are highly correlated with total body fat mass and waist circumference. In statistics, a ratio of highly correlated variables gives an error called "multicolinearity", and leads to misleading results [9,10]. This is similar to a study that percentage of fat was used to investigate the association between fat mass and bone mineral density [11]. It is still unclear whether these ratios directly reflect obesity or other things. Instead of highly correlated variables, body height which is not highly correlated with these obesity measures is recommended to quantify body size. That is why BMI or total body fat mass index are preferred.

In conclusion, we should not use various obesity measures interchangeably because they measure obesity at different aspects, have different importance in relation to obesity related outcomes and may be subject to certain statistical errors when a ratio of two highly correlated obesity measures is used.

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Citation: Yang S (2015) Should We Use Various Obesity Measures Interchangeably?. J Nutri Med Diet Care 1:005

Received: June 29, 2015: **Accepted:** August 14, 2015: **Published:** August 18, 2015

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