Introduction
Obesity has been associated with several diseases and health problems such as metabolic syndrome, cardiovascular disease (CVD) and certain cancers (colon, prostate and breast cancer). Recent research suggests that fat distribution may differently affect the development of those diseases.

When we look at the evaluation of anthropometric measures and their association to mortality and morbidity risk, underwriting guidelines seem to be running behind medical research findings. The life insurance industry has used BMI in the risk selection process for quite some time. However, BMI has several limitations which could lead underwriters to make decisions that less accurately reflect risks. We as underwriters should be aware of these limitations because we all use build (i.e., height and weight) in our risk assessment. What can we do?

During the last several years, many simple tools have been proposed by scientists and physicians to improve the evaluation of risk for obesity-related diseases and premature death. Perhaps you may already have read about waist circumference, hip circumference, body shape index and so on. These measures could be new and better ways to evaluate obesity and disease risk factors. Their use may one day be part of a complete risk assessment and help the industry improve mortality and morbidity experience. Should the life insurance industry, therefore, use these new measures in evaluating anthropometric risk for mortality and morbidity? Let’s explore.

Body Mass Index
As mentioned, the use of body mass index (BMI) as a marker of obesity and mortality/morbidity risks is widely accepted in the insurance industry. It is calculated as:

\[
BMI = \frac{\text{Weight in Kilograms}}{(\text{Height in Meters})^2}
\]

Previous mortality studies show a U-Shape curve: mortality rate being higher for the low and high BMI ranges, while mortality is lower for normal BMI. Underwriters are familiar with this. Some studies show that a 0.5 standard deviation increment in BMI was associated with a 20-30% prevalent odds ratio of diabetes. Other studies also show that BMI demonstrates a strong connection with colon cancer (CCa) in men and young women.

Although BMI is the most commonly used fat-related risk index, it was found that BMI’s connection to metabolic syndrome (MetS) disorders is not as strong compared to that of other measures, which will be introduced later.

Nonetheless, BMI does a satisfactory job as a prognostic indicator of diabetes, CCa and, to some extent, MetS. However, BMI has its limitations:

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**Executive Summary**

Body mass index (BMI) has been used by the insurance industry for years as a marker of obesity. Despite being widely recognized as a prognostic indicator of cardiometabolic diseases and premature death, BMI has a number of limitations. This article proposes new anthropometric measures that scientific studies demonstrate to be better predictors of morbidity and mortality risk compared to BMI. These measures include waist circumference, waist-to-hip ratio, waist-to-height ratio and body shape index.
• It does not distinguish between muscle and fat accumulation. There is evidence that higher fat mass is associated with greater risk of premature death on the one hand, and high muscle mass reduces that risk on the other hand. Thus, a person with relatively more muscle mass could still have a higher BMI but ironically classified as “higher” risk.

• It also does not distinguish between fat locations, when abdominal fat deposition is proven to have negative consequences.

The theory is that abdominal obesity, rather than total obesity (as implied in BMI), has adverse consequences on mortality and morbidity. Therefore, the medical and scientific community proposed the use of several measures of abdominal obesity: waist circumference, body shape index, waist-to-hip ratio and waist-to-height ratio, among others. Extensive research has been done for each of these measures to prove this theory and we will discuss these indices as follows.

Waist Circumference
Waist circumference (WC) is simply the measured circumference of a person’s waist. Along with waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) and body shape index (ABSI) which will be discussed later, WC is a measure of abdominal obesity. It is thought that cardio-metabolic risk associated with abdominal obesity is attributed with the presence of visceral adipose tissue (VAT), which promotes insulin resistance, dyslipidemia and hypertension.

According to several studies, WC:
- Is strongly associated with the presence of VAT.
- Has a stronger association with diabetes (40% for WC vs. 20-30% for BMI).
- Has been widely demonstrated to be a predictor of CVD in both genders.
- Predicted mortality risk better than BMI.
- Demonstrates that an increase of 5.04 cm is associated with an increase of 10% relative risk (RR).

Recent evidence suggests that the increasing prevalence of Type II diabetes and CVD in Asian countries is occurring at levels of BMI much lower than the “normal” cut-off point of 25.0 kg/m². Studies point out the growing problem among Asian populations where individuals may exhibit a normal BMI but have disproportionately large WC. This brings us to yet another limitation of BMI: for a given BMI, central adiposity can be substantially different among various ethnic groups. Therefore, the current BMI cut-off values may not be universally applied to all ethnicities.

The World Health Organization (WHO) emphasizes the importance of WC in Table 1 by showing how BMI and WC are associated to disease risk.

### Table 1

<table>
<thead>
<tr>
<th>Body mass index</th>
<th>Obesity class</th>
<th>Disease risk (relative to normal weight and waist circumference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
<td>Men &lt; 102 cm Women &lt; 85 cm</td>
</tr>
<tr>
<td>Normal</td>
<td>18.5-24.9</td>
<td>Normal</td>
</tr>
<tr>
<td>Overweight</td>
<td>25.0-29.9</td>
<td>Increased</td>
</tr>
<tr>
<td>Obesity</td>
<td>30.0-34.9</td>
<td>High</td>
</tr>
<tr>
<td>Extreme obesity</td>
<td>&gt;35.0</td>
<td>Very high</td>
</tr>
</tbody>
</table>

Body Shape Index
An index that was developed using both WC and BMI is a body shape index (ABSI). It was created with the goal of combining the individual strengths of WC and BMI. The formula to calculate for ABSI is:

$$\text{ABSI} = \frac{\text{WC}}{\text{BMI}^{1/3} \times \text{height}^{1/2}}$$

Since it uses WC, BMI and height in calculating ABSI, it means that at a given height and weight, a high ABSI may correspond to a greater fraction of visceral (abdominal) fat compared to peripheral tissue. As estimated from 3D X-ray scans in certain studies, ABSI was found to be positively correlated to trunk fat mass, but negatively correlated to limb lean mass.

An interesting study conducted by Malara, Keska Tkaczyk and Luoslawska (2015) showed that ABSI was significantly correlated with plasma levels of insulin, total cholesterol, LDL-C and non-HDL-C, whereas BMI was correlated only with triglycerides. Thus, ABSI is said to have a closer association to metabolic risk factors than BMI does. Since WC forms part of the formula for ABSI, this supports the notion that abdominal fat is a strong risk factor for MetS, diabetes and CVD. (See Table 2, next page.)

Another study by Krakauer & Krakauer (February 2014) illustrates that while BMI shows a U-curve relation to mortality risk, ABSI depicts an increasing curve, suggesting that lower quintiles of ABSI had significantly reduced mortality hazard, while the...
top quintile showed elevated mortality hazard by a similar degree.

To evaluate the long-term mortality predictability of ABSI, this study used the British Health and Lifestyle Survey (HALS) with a sample of 7,011 individuals spanning a follow-up period of 24 years. In the end, the study established that ABSI was stronger than BMI as a predictor of mortality risk over a long period of time.

**Waist-to-Hip Ratio**

As we have said, body fat distribution could have a strong impact on disease development. Researchers have pushed further this thinking and found that some accumulation of fat at some places is better for one’s health than others. As discussed in the WC and ABSI indices, fat accumulation at waist level is a good indication of higher mortality and morbidity. On the other hand, one specific place that has been identified as beneficial is at the hip level. Theoretically, gluteofemoral fat may benefit health by removing free fatty acids from the bloodstream. Moreover, increased hip circumference is associated with greater subcutaneous fat in the hip region, increased gluteal muscle and total leg muscle mass. More leg muscle mass often suggests greater physical activity which we know is inversely related to several chronic diseases. With this in mind, a new ratio was created: waist-to-hip ratio (WHR).

Previous articles in *ON THE RISK* have already placed emphasis in paying attention to WHR in underwriting. More research has been done since that time, and according to more recent scientific studies, WHR:

- Is associated with CVD and the development of cardio-metabolic risk factors as well as breast and colorectal cancer risk.
- Has better sensitivity to diabetes (40% for WHR vs. 20-30% for BMI).
- Has better predictive value for mortality than BMI.
- **Relative risk (RR) increases by 5% for every 0.01 increase in WHR.**

As a result, it has been suggested that WHR be incorporated into CVD risk assessment (like age, cholesterol, blood pressure, etc.). According to the WHO, the cut-off WHR points for the risk of metabolic complications are ≥0.90 for men and ≥0.85 for women. Above these values, the risk of mortality and morbidity is substantially increased. Table 3 below illustrates the level of metabolic risk at various cut-off points for WC and WHR.

It is, however, important to remember that WHR is a ratio. Theoretically, it is possible for both obese and lean individuals to have equal values of WHR. This means that if we use WHR alone without cross-referencing to height, WC or BMI, it may be difficult to properly evaluate overall risk.

**Waist-to-Height Ratio**

It has been shown that short people have higher metabolic risks than tall people with similar WC. Unfortunately, WC and WHR do not use body height. To take into account the height while incorporating central obesity, another ratio has been studied for several years in various scientific articles: waist-to-height ratio (WHtR). It is calculated as:

\[
\text{Waist-to-height ratio} = \frac{\text{waist circumference (cm or in)}}{\text{height (cm or in)}}
\]

First, WHtR has been strongly correlated with abdominal fat. WHtR has shown to have a better CVD predictivity than BMI and WC, and a high correlation with Type II diabetes and high blood pressure. Simply put, it is a good diagnostic predictor for diseases that we often see in underwriting. According to WHO, WHtR has a “convincing” relationship with overall mortality risk. A review of several studies about WHtR concluded that:

- A WHtR boundary value of 0.5 indicates increased risk for men and women.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Cut-off points</th>
<th>Risk of metabolic complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference</td>
<td>&gt;94 cm (M); &gt;80 cm (W)</td>
<td>Increased</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>&gt;102 cm (M); &gt;88 cm (W)</td>
<td>Substantially increased</td>
</tr>
<tr>
<td>Waist-hip ratio</td>
<td>≥0.99 cm (M); ≥0.85 cm (W)</td>
<td>Substantially increased</td>
</tr>
</tbody>
</table>

**Table 2: Biochemical variables in young healthy men according to lower and upper quartiles of BMI and ABSI.**

<table>
<thead>
<tr>
<th>Variable (mean)</th>
<th>Insulin</th>
<th>TG</th>
<th>TC</th>
<th>HDL-C</th>
<th>LDL-C</th>
<th>Non-HDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSI Quartile I (0.069 +/- 0.001)</td>
<td>7.2</td>
<td>0.9</td>
<td>4.3</td>
<td>1.4</td>
<td>2.4</td>
<td>2.9</td>
</tr>
<tr>
<td>ABSI Quartile IV (0.077 +/- 0.002)</td>
<td>13.8</td>
<td>0.9</td>
<td>4.8</td>
<td>1.3</td>
<td>3.1</td>
<td>3.5</td>
</tr>
<tr>
<td>BMI Quartile I (BMI: 20.0 +/- 0.9)</td>
<td>4.8</td>
<td>0.8</td>
<td>4.5</td>
<td>1.4</td>
<td>2.7</td>
<td>3</td>
</tr>
<tr>
<td>BMI Quartile IV (BMI: 28.2 +/- 2.8)</td>
<td>5.1</td>
<td>1.2</td>
<td>4.5</td>
<td>1.3</td>
<td>2.7</td>
<td>3.2</td>
</tr>
</tbody>
</table>
- WHtR may allow the same boundary value for children and adults as well as different ethnic groups.
- WHtR’s sensitivity is greater than BMI’s as early warning for health risks.
- WHtR is less expensive and easier to measure and calculate than BMI (no need for scales).

With these findings, shouldn’t WHtR be used as another better screening tool than BMI?

**Conclusion**

While measures of central obesity are said to have a strong association to mortality and morbidity risk, there are issues with respect to these ratios. First, there are difficulties in achieving measurement uniformity. Cited sources of these problems include instrument imprecision and differences in rules as well as human inconsistencies. Current studies show excellent reproducibility for body height, weight and derived BMI, but less satisfactory reproducibility for WC and WHR. Also, certain subjects may have objections to having their measurements taken. Furthermore, as mentioned, an obese person may have the same ratio (WHR) as a non-obese person. Finally, differences exist among various ethnic groups, and therefore the cut-off values for each index must be established differently except for WHtR.

Despite these, many studies demonstrate that WC, WHR, WHtR and ABSI have better association to mortality and morbidity than BMI does. Additionally, body fat distribution may also affect the development of diseases. Adipose tissue in the thigh has protective value, while a high ratio of abdominal to thigh fat is most predictive of cardio-metabolic diseases. Research has shown that abdominal fat has been implicated as a major risk factor for metabolic syndrome, certain cancers, dyslipidemia, type II diabetes, hypertension, CVD and overall risk of death. Table 4 below from WHO summarizes the associations of various indices discussed to certain diseases.

It is also important to note that no additional cost will be incurred to have these measures taken with clients during standard paramedical examinations.

If we are to use these measures in the future, more
research will be needed using relative risk, odds risk, hazard ratios and other mortality statistical studies in order to establish concrete underwriting guidelines and tables.

One thing is certain, there are other ways to underwrite the risk of obesity-related diseases, and the underwriter should be aware of what we have discussed. Historically, the life insurance industry has been among the first to show the association between obesity and mortality, so why should we wait this time around?

References

Malara et al., Body shape index versus body mass index as correlates of health risk in young healthy sedentary men, Journal of Translational Medicine 2015.
Lucy M. Browning et al., A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0.5 could be a suitable global boundary value, Nutritional Research Reviews, 23, 247-269, 2010.

About the Authors
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