Body Mass Index Misclassification of Obesity Among Community Police Officers

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RESEARCH ABSTRACT

Occupational health nurses are at the forefront of obesity assessment and intervention and must be aware of potential inaccuracies of obesity measurement. The purpose of this study was to identify the prevalence of obesity among a sample of 84 male police officers 22 to 63 years old and determine the accuracy of body mass index (BMI) in estimating obesity compared to body fat percent (BF %). BMI identified 39.3% of the participants as obese, compared to 70.2% by BF %. BMI misclassified normal-weight officers as obese or overweight and obese officers as normal 48.8% ($n = 41$) of the time. The two misclassified groups had similar average BMIs but significantly different BF %. BMI was not an accurate measure of obesity among adult males. BMI underestimated the true prevalence of obesity and could represent a missed opportunity for early intervention and disease prevention.

The global epidemic of obesity affects all age, ethnic, and socioeconomic groups (Basham & Luik, 2008; Ford & Mokdad, 2008). Because obesity increases the risk of cardiovascular disease (CVD), Type II diabetes, metabolic syndrome, and other chronic health conditions, it carries a substantial economic burden affecting both obese individuals and society as a whole. Indeed, health problems associated with obesity cost the U.S. health care system an estimated $99.2 billion annually (Bungum, Satterwhite, Jackson, & Morrow, 2003). Adding to that cost, obese workers use more sick days, are more likely to take a leave of absence, and retire earlier than non-obese workers (Bungum et al., 2003; Harvey et al., 2010; Houston, Cai, & Stevens, 2009; Ostbye, Dement, & Krause, 2007).

Emergency responders, including police officers, are expected to be more physically fit than average workers because they must perform strenuous duties without compromising the safety of themselves, their colleagues, or the community (Ramey, Downing, & Knoblauch, 2008). When hiring police officers, weight and physical strength are considered essential criteria to ensure that recruits are capable of performing physically demanding duties. However, contrary to this expectation, evidence suggests that although law enforcement officers are more physically active than the general public, they are also more likely to be obese or suffer from obesity-related diseases (Franke, Ramey, & Shelley, 2002; Ramey, 2003; Ramey et al., 2008). When gauged by body mass index (BMI), as many as 83% of law enforcement officers are classified as obese or overweight (Kales, Tsismenakis, Zhang, & Soteriades, 2009; Nabeel, Baker, McGrail, & Flottemesch, 2007; Ramey et al., 2008; Violanti et al., 2006).

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The authors disclose that they have no significant financial interests in any product or class of products discussed directly or indirectly in this activity, including research support.

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Received: April 28, 2011; Accepted: July 13, 2011; Posted: October 24, 2011.
doi:10.3928/08910162-20111017-01

Applying Research to Practice

Obesity is a global epidemic affecting all age, racial, and socioeconomic groups. Occupational health nurses are at the forefront of obesity assessment in the workplace. With precise obesity estimation measures, occupational health nurses can assist in detecting obesity prevalence among working populations and prevent and reduce obesity and related health problems.

However, BMI may not be an accurate way to measure obesity in police officers. Although convenient, this calculation is known to overestimate obesity in those with more muscle mass (e.g., athletes) and underestimate obesity in those with less muscle mass (e.g., the elderly) (Ode, Pivarnik, Reeves, & Knous, 2007; van den Ham et al., 2000). This problem arises because BMI measures fatness indirectly—estimating fatness solely based on height and weight. In contrast, calculations of body fat percent (BF %) estimate obesity more precisely. Nevertheless, neither method accounts for the abdominal distribution of fat, which can compromise both indicators as predictors of obesity-related health risks (Gelber et al., 2008; Leslie, Ludwig, & Morin, 2010; World Health Organization, 1995). Indeed, overall fatness, regardless of how it is measured, is just one indicator of health risk. The distribution of fat in the abdominal region, in the form of visceral adipose tissue, is a key indicator of risk because visceral adipose tissue generates low-grade chronic inflammatory cytokines and the inflammatory marker C-reactive protein (CRP) and reflects a pro-atherogenic phenotype (Faria, Ribeiro Filho, Gouveia Ferreira, & Zanella, 2002; Forouhi, Sattar, & McKeigue, 2001; Giltay et al., 1998).

Obesity-related diseases are of particular concern for police departments because law enforcement officers are 1.7 times more likely than their civilian peers to develop CVD (Ramey, Downing, & Franke, 2009): 38% have hypertension and 33% have hypercholesterolemia (Franke et al., 2002; Ramey, 2003). Still, some researchers have argued that previous studies exaggerate the problem of obesity in police departments because officers' relatively high BMIs actually reflect the officers' tendency toward more lean mass, not higher fat mass (Violanti et al., 2006). Only one study actually compared obesity rates simultaneously measured by both BMI and BF % (Bureau of Justice Statistics, 2009). Although that study supported the contention that BMI overestimates obesity for police officers because officers tend to have more lean mass, the true levels of obesity were not accurately reflected because only about 10% (42 females and 58 males) of the departments' 932 members participated. Moreover, the study excluded individuals with select health problems (e.g., CVD) that are more common in overweight individuals (Bureau of Justice Statistics, 2009).

Accurate estimates of obesity and intermediate disease risks are essential in working populations for which performance evaluations and health insurance benefits may be influenced by physical criteria and in populations for which early identification of risks could substantially reduce disease. Occupational health nurses, who are often at the forefront of obesity assessment and intervention, must be aware of inaccurate methods for measuring obesity to avoid incorrectly labeling workers as obese, and to correctly identify obese workers to provide timely preventive interventions. Accordingly, the purposes of this study were to (a) determine the prevalence of obesity among police officers in three community police departments, using BF % to define obesity; (b) compare the accuracy of BMI and BF % in measuring obesity; and (c) determine how BMI misclassification of obesity relates to CRP, a risk indicator for CVD and metabolic syndrome.

DESIGN AND METHODS

Data were collected as part of a cross-sectional study of police officers that evaluated the relationships among occupational stressors, cortisol, obesity, and CRP. The study sample included 84 male police officers between 22 and 63 years old, representing 73% of all male officers employed by three community police departments. The study was approved by the University of Iowa Institutional Review Board and all participating officers provided written informed consent.

Body composition (i.e., lean mass, fat mass, and bone mass) was measured using dual energy X-ray absorptiometry (DXA; GE Lunar Prodigy, Madison, WI). DXA exposes the region of interest to a low-intensity energy source emitted from an X-ray tube. Any residual energy that passes through the body is detected by a sodium iodide scintillation counter. The energy intensity detected by the scintillation counter reflects the amount of energy attenuated by tissues of different density, enabling these scans to discriminate bone mass, fat mass, and non-bone lean mass, giving a cross-sectional density profile of each participant. Individuals lie flat on the scan table and are positioned visually, using a computer monitor, for lumbar spine, femoral neck, and total-body scans. The scanner was calibrated daily with a block supplied by the manufacturer. In addition, a calibration aluminum phantom was measured weekly.

BF % and fat distribution were determined from total-body scans. BF % was calculated as the total estimated body fat mass (kg) divided by the sum of lean mass, fat mass, and bone mass (Deurenberg et al., 2001; Deurenberg, Yap, Wang, Lin, & Schmidt, 1999; Jackson et al., 2002; Piers, Soares, Frandsen, & O'Dea, 2000). Abdominal fat distribution was determined by comparing the amount of fat in the android and gynoid regions. Android fat is the fat around the upper limbs and abdominal area, defined by the upper part of the pelvis and the lateral part of the chest wall (Aucouturier, Meyer, Thivel, Taillardat, & Duche, 2009), whereas gynoid fat is the fat around the lower limbs and the thighs, defined by the upper third of the femur (i.e., superior part of trochanter major) and the lateral part of the hip. The android/gynoid ratio (A/G ratio) was calculated as the amount of fat mass around the android area divided by the fat mass in the gynoid area.

The accuracy of DXA for measuring body composition has been established through high correlations with underwater weighing ($r = 0.97$) and with bio impedance analysis (0.85 to 0.95) (Boneva-Asiova & Boyanov, 2008; Going et al., 1993; Hendel, Gotfredsen, Hojgaard, Andersen, & Hilsted, 1996). The correlation between DXA and visceral adipose tissue, as determined by magnetic resonance imaging, was 0.853; it was 0.974 for total abdominal adipose tissue (Nindl et al., 2000; Nindl, Scoville, Sheehan, Leone, & Mello, 2002).

Participants were weighed on an electronic scale (Tanita Corporation, Arlington Heights, IL), without shoes and wearing as little clothing as possible. The scale was calibrated daily by comparing the actual scale value to a standard 50-pound weight. Height was measured using a standard stadiometer. BMI was calculated by dividing the weight in kilograms (kg) by the height in meters squared (m^2).

Blood was drawn at random times throughout the day. Sera were stored at -86°C and assayed in batches to determine high sensitive serum C-reactive protein (hsCRP) concentration. The hsCRP concentrations were determined in duplicate, using a high-sensitivity sandwich enzyme immunoassay (EIA; ALPCO Diagnostics, Windham, NH). Normal values for adults ranged from 0.3 to 8.2 mg/L; the sensitivity was approximately 0.05 mg/L. The intra- and inter-assay coefficient of variation averaged 6.0% and 11.6%, respectively.

Data Analyses

Obesity was classified according to World Health Organization criteria, which use BMI and BF %. Using BMI criterion, three groups were created: normal weight (BMI is greater than 18.5 kg/m^2 and less than 25 kg/m^2), overweight (BMI is greater than or equal to 25 kg/m^2 and less than 30 kg/m^2), and obese (BMI is greater than or equal to 30 kg/m^2). Consistent with other large, population-based studies, participants were also classified as obese if their BF % was greater than or equal to 25 (Deurenberg et al., 1999; Romero-Corral et al., 2008; World Health Organization, 1995). After cross-comparison of the BMI and BF % criteria, participants were classified into four groups. Two of the groups had been classified correctly by both BMI and BF %, as either normal or obese. In contrast, the other two groups had been incorrectly classified by BMI. In one group, BMI incorrectly classified individuals as obese when in fact they were normal by BF %; in these cases, BMI overestimated obesity. In the other group, BMI incorrectly classified individuals as normal or overweight when in fact they were obese by BF %; in these cases, BMI underestimated obesity.

Using standard formulas, the researchers calculated the sensitivity and specificity of the BMI when the BF % of 25 or more was used as the referent for true obesity. Sensitivity and specificity are used to describe the accuracy of any screening test. Sensitivity is defined as the ability of a screening test to correctly identify individuals with the disease or condition of interest. A low sensitivity indicates the screening test yields a high proportion of false-negative results. Specificity represents the ability of the screening test to correctly identify individuals without the disease or condition of interest. A low specificity indicates the screening test yields a high proportion of false-positive results (Gordis, 2009; Ridker, 2009). Officers were also classified into hsCRP risk groups, with hsCRP levels of 1 or less, 1 to 3, and greater than 3 mg/L denoting low, moderate, and high risk, respectively (Backes, Howard, & Moriarty, 2004). Descriptive analysis used means and standard deviations for the normally distributed variables, and medians and proportions for the non-normally distributed variables. Natural log transformations were applied to the hsCRP biomarker to normalize the distribution, before the analysis was performed.

RESULTS

Age, body composition, and hsCRP values are reported in Table 1. Table 2 shows the obesity classifications and CRP risk estimates. Using BMI as the standard, 39.3% ($n = 33$) of the officers were obese and another 40.5% ($n = 34$) were overweight; using a BF % of 25 or greater as the standard, 70.2% ($n = 59$) of the participants were obese. Using CRP values as an indicator of intermediate health risk, 27.4% ($n = 23$) had values of 3 or greater, placing them in the high-risk group, 28.6% ($n = 24$) were at average risk, and 44.1% ($n = 37$) were at low risk (Table 2).

BMI incorrectly classified obesity almost half of the time ($n = 41$, 48.8%; Table 3). The sensitivity and specificity of BMI were low, at 51.7% and 48%, respectively. In most instances of misclassification ($n = 29$, 70.1%), BMI incorrectly classified officers as normal or overweight when, according to BF %, they were actually obese. For 29.9% of the misclassified officers ($n = 12$), BMI incorrectly labeled them as obese when their BF % indicated they were normal. The officers who were incorrectly classified as obese were significantly younger than the officers in the other three groups ($p < .05$).

Not surprisingly, the four groups differed substantially by BMI, BF %, and fat and lean mass. The two groups that differed most were those correctly classified as either obese or normal weight by both BMI and BF %. Those correctly placed in the obese group were, on average, 32.1 kg heavier (108.3 vs. 77.2 kg; $p < .05$), had a BMI that was 10.5 kg/m^2 higher (34.0 vs. 23.5; $p < .05$), and had a BF % that was 16.1 greater than those correctly classified as normal weight. In addition, those in the obese group had 13.9 kg more fat mass, 7.8 kg more lean mass, and a larger A/G ratio than those in the normal-weight group ($p < .05$). Median hsCRP levels of those correctly classified as obese were more than 3 times greater than those of the officers correctly classified as normal weight and non-obese (3.88 vs. 0.74, respectively; $p < .05$).

For the two groups whose obesity status was incorrectly classified by BMI, Table 3 shows that they differed in body composition and hsCRP levels. Although the two groups had similar BMI values, 28.2 and 27.3 kg/

Table 1

Age, Body Composition, and High Sensitive Serum C-Reactive Protein Level of Male Officers in Three Community Police Departments

Variable	M	SD	*Median*	*Minimum*	*Maximum*
Age (years)	39.4	9.1	38.9	22.4	63.3
Height (cm)	179.9	7.0	179.6	167.6	200.7
Weight (kg)	94.6	15.0	94.8	69.5	136.1
Body mass index (kg/m²)	29.3	4.5	28.6	21.9	41.0
Lean mass (kg)	63.9	7.6	62.0	51.5	90.4
Fat mass (kg)	21.1	11.9	25.9	9.1	83.3
Bone mass (g/cm²)	3.7	0.5	3.7	2.8	4.8
Body fat %	29.6	7.7	29.0	11.2	48.0
Android/gynoid ratio	1.2	0.2	1.2	0.8	1.7
hsCRP (mg/L)	2.3	2.7	1.1	0.1	12.6

Note. *hsCRP = high sensitive C-reactive protein.*

m^2 ($p < .05$), placing them in the overweight category, one group was similar to the normal-weight group with a BF % of 21.3 and the other group was obese with a BF % of 30.2. The group incorrectly classified as obese by BMI had average lean mass levels that were approximately 8 kg greater and fat mass levels that were 8 kg lower than the group incorrectly classified as normal or overweight. Median hsCRP levels were in the lowest risk category for both incorrectly classified groups and not significantly different from the CRP values of the normal weight, non-obese group. No difference in A/G ratio existed between the two misclassified groups.

Table 2

Risk Classification by Body Mass Index, Body Fat Percent, and C-Reactive Protein Level

	Frequency	*%*
BMI (kg/m²)		
Normal weight (BMI < 25.0)	17	20.2
Overweight (BMI = 25.0 to < 30.0)	34	40.5
Obese (BMI ≥ 30.0)	33	39.3
BF %		
Non-obese (BF % < 25.0)	25	29.8
Obese (BF % ≥ 25.0)	59	70.2
hsCRP level (mg/L)		
Low risk (< 1)	37	44.1
Average risk (1 to 3)	24	28.6
High risk (> 3)	23	27.4

Note. *BMI = body mass index; BF % = body fat percent; hsCRP = high sensitive C-reactive protein.*

DISCUSSION

The researchers used DXA to measure the body composition of community police officers. The resulting data showed that the prevalence of obesity, when defined as a BF % of 25.0 or greater, is high (70.2%) and obesity is substantially more prevalent than when estimated by BMI, which classified only 39% of the officers as obese. One explanation for the discrepancy between BMI- and BF %-defined obesity is that BF % does not have an "overweight" category. In fact, when the two BMI classifications were combined, 80% of the officers in this study were either overweight or obese. The study findings confirm concerns that obesity and overweight are common in a profession with selection criteria and work responsibilities often requiring a high level of fitness (Franke et al., 2002; Ramey, 2003).

If the overweight and obese categories of the BMI scale are combined, BMI more closely approximates the prevalence of BF %-defined obesity in this population of police officers; however, this does not remedy the finding that BMI introduces inaccuracies and misclassification. In this study, BMI was not an accurate measure, incorrectly classifying the obesity status of officers almost half the time. Most of these misclassifications were among officers in the overweight category (i.e., BMI greater than 25.0 and less than 30.0). The researchers expected that this sample of officers might include a higher proportion of very fit, non-obese men who were misclassified as overweight because of their high muscle mass, causing an overestimation of the prevalence of obesity. Nevertheless, the opposite was found to be true. Using BMI underestimated the true prevalence of obesity by about 30%.

The only other study to use both BMI and BF % to measure obesity in law enforcement officers found that

Table 3

Misclassification of Obesity by Body Mass Index for Male Police Officers

	Correctly Classified Normal (A) BMI BF % (n = 13)		*Incorrectly Classified: (B) Overweight by BMI Normal by BF % (n = 12)*		*Incorrectly Classified: (C) Normal or Overweight by BMI Obese by BF % (n = 29)*		*Correctly Classified Obese (D) BMI BF % (n = 30)*	
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
Age (years)[d,e]	37.4	7.5	32.6	7.2	40.7	9.0	41.8	9.3
Height (cm)	181.2	9.4	178.0	5.4	181.7	7.6	178.4	5.3
Weight (kg)	77.2	2.0	89.4	3.1	90.0	1.5	108.3	2.2
BMI (kg/m^2)[c,d,f]	23.5	1.1	28.2	2.4	27.3	1.9	34.0	3.0
BF %[b,c,d,e,f]	20.0	3.4	21.3	4.5	30.2	3.6	36.1	5.5
Lean mass (kg)[a,c,d,f]	59.6	5.3	68.3	8.3	60.6	5.9	67.2	7.4
Fat mass (kg)[b,c,d,e,f]	15.1	3.6	18.6	4.8	26.3	4.2	38.9	11.4
	Median	***Range***	***Median***	***Range***	***Median***	***Range***	***Median***	***Range***
Android/gynoid ratio[b,c]	1.0	0.8-1.6	1.1	0.8-1.7	1.2	0.9-1.5	1.2	1.0-1.5
hsCRP[c,e,f]	0.7	0.2-2.9	0.6	0.2-1.6	0.9	0.1-6.8	3.9	0.3-12.6

Note. BMI = body mass index; BF % = body fat percent; hsCRP = high sensitive C-reactive protein. [a]A versus B ($p < .05$). [b]A versus C ($p < .05$). [c]A versus D ($p < .05$). [d]B versus C ($p < .05$). [e]B versus D ($p < .05$). [f]C versus D ($p < .05$).

BMI overestimated the prevalence of obesity because the officers tended to have higher levels of lean mass (Violanti et al., 2006). In that study, the officers' BMI averaged 29.8 kg/m^2, placing them in the overweight category, just under the 30 kg/m^2 that defines obesity. However, their mean BF % was 23.4, placing them in the normal, non-obese category. The reason for differences between these studies is not completely clear but may reflect differences in characteristics or work demands of officers who are employed in large urban departments (Violanti et al., 2006) versus those in the current study, who worked for smaller community police departments. Conflicting findings might also arise from differences in sampling strategies. This study included 73% of all officers, regardless of health problems; the previous study included just 10% of the work force and excluded officers if they had diseases such as CVD, thereby potentially excluding the heaviest workers.

In screening for obesity, the researchers found that using BMI was neither sensitive nor specific, meaning that the rate of false-negative (sensitivity) and false-positive (specificity) results was unacceptably high. This inadequacy of the BMI in detecting true obesity in a variety of population groups is well documented (Blew et al., 2002; Mullie, Vansant, Hulens, Clarys, & Degrave, 2008; Romero-Corral et al., 2008). Nevertheless, the clinical and practical ramifications of this misclassification are not completely appreciated. In this study, more than one third of the officers were classified as obese by BF % but not by BMI (false negative). Failing to identify obese individuals could represent a missed opportunity to intervene early and prevent obesity-related disease. This finding is particularly important for police officers, who may be at higher risk for developing CVD than their civilian peers (Ramey et al., 2009) and have documented higher rates of hypertension and hypercholesterolemia (Franke et al., 2002; Ramey, 2003).

The researchers also found that 14.3% of the officers were incorrectly classified by BMI as obese when their BF % classified their weight as normal (false positives). This misclassification can jeopardize police officers, whose performance evaluations and health insurance benefits may be highly influenced by obesity. It may also trigger unhealthy and unnecessary weight-loss behavior.

This study is unique in that it used hsCRP to assess intermediate disease risks in this population of police officers. The researchers found more than 1 in 4 officers had hsCRP levels greater than 3—the highest risk group; hsCRP, which is produced in the liver and adipose tissue (Bokor, Amouyel, & Dallongeville, 2009; Ouchi et al., 2003), is used as a biochemical marker of inflammation. An elevated hsCRP level is linked to glucose intolerance, CVD, and ischemic heart disease, and is recognized as a predictor of death from CAD (Haffner, 2006; Pepys &

Hirschfield, 2003; Ridker, 2001). Furthermore, hsCRP adds prognostic information to the Framingham risk score (i.e., a self-report, CVD risk-assessment tool) (Ridker, 2009; Ridker, Rifai, Rose, Buring, & Cook, 2002). Currently, measuring hsCRP is not a standard component of risk screening in occupational settings; however, in the future, this method may be a feasible way to identify high-risk groups who would benefit from interventions. The hsCRP may be a particularly valuable screening tool for police officers, given that CVD events account for about 22% of on-duty deaths (Kales et al., 2009).

The observation that hsCRP levels were highest in the officers correctly classified as obese supports the research finding that obese officers are indeed at greater risk of CVD. Contrary to the researchers' expectation, hsCRP levels were not useful in distinguishing risks between the two misclassified groups, despite differences in BF %. The explanation for this is not clear.

APPLICATION AND IMPLICATIONS

Nearly 18,000 criminal justice agencies in the United States employ more than 732,000 sworn officers in local, state, and federal venues (Boneva-Asiova & Boyanov, 2008). This study demonstrates that obesity is prevalent in community police forces and highlights the need for work force interventions designed to prevent or reduce obesity. Worksite programs span a wide range of educational and behavioral interventions directed toward physical activity, nutrition, and stress reduction, as well as environmental modification and policy changes. The Task Force on Community and Preventive Services found strong evidence to support worksite health promotion interventions that prevent or reduce obesity (Anderson et al., 2009; Task Force on Community Preventive Services, 2009), which should minimize the cost and reduce the health consequences of obesity. Detailed intervention strategies including both informational and behavioral components can be accessed via www.thecommunityguide.org/obesity/workprograms.html.

Occupational health nurses can play a key role in identifying officers who are at high risk for obesity-related disease, but only if they have a reliable classification method. BMI is the most commonly used method of screening for obesity, but BMI has limitations. Other methods can discriminate fat and lean mass and are simple, noninvasive, portable, and reasonably inexpensive (e.g., bio impedance analysis) (Gagnon et al., 2010; Kyle et al., 2004). Incorporating this instrumentation in place of, or along with, estimating BMI should be considered to more accurately determine obesity. Occupational health nurses can advocate for and implement these newer technologies.

LIMITATIONS

Although this study has many strengths, including a high response rate and accurate body composition measurement, some limitations remain. First, the sample was exclusively male, predominantly White, and primarily employed by small community police departments, preventing generalizability to females, other racial and ethnic groups, and other locations or work environments. Second, experts have not set a BF % level for obesity. The researchers chose 25, congruent with the World Health Organization recommendation for men, and to be consistent with other large, population-based reports (Romero-Corral et al., 2008; World Health Organization, 1995).

CONCLUSION

More than 70% of police officers in this study were obese, as defined by a BF % of 25 or more, suggesting that this work sector is not immune to obesity and would benefit from work-related obesity prevention interventions. BMI was not an accurate method of screening for obesity in this population. It led to underestimating and overestimating obesity and missed opportunities for early prevention or treatment. It also potentially jeopardized police officers, whose performance evaluations and health insurance benefits may be highly influenced by obesity.

REFERENCES

Anderson, L. M., Quinn, T. A., Glanz, K., Ramirez, G., Kahwati, L. C., Johnson, D. B., et al. (2009). The effectiveness of worksite nutrition and physical activity interventions for controlling employee overweight and obesity: A systematic review. *American Journal of Preventive Medicine, 37*(4), 340-357.

Aucouturier, J., Meyer, M., Thivel, D., Taillardat, M., & Duche, P. (2009). Effect of android to gynoid fat ratio on insulin resistance in obese youth. *Archives of Pediatrics & Adolescent Medicine, 163*(9), 826-831.

Backes, J., Howard, P., & Moriarty, P. (2004). Role of C-reactive protein in cardiovascular disease. *The Annals of Pharmacotherapy, 38*(1), 110.

Basham, P., & Luik, J. (2008). Is the obesity epidemic exaggerated. *British Medical Journal (Clinical Research Ed.), 336*(7638), 244.

Blew, R., Sardinha, L., Milliken, L., Teixeira, P., Going, S., Ferreira, D., et al. (2002). Assessing the validity of body mass index standards in early postmenopausal women. *Obesity Research, 10*(8), 799-808.

Bokor, S., Amouyel, P., & Dallongeville, J. (2009). Which measure of adiposity for primary care? *International Journal of Clinical Practice, 63*(9), 1270-1272.

Boneva-Asiova, Z., & Boyanov, M. A. (2008). Body composition analysis by leg-to-leg bioelectrical impedance and dual-energy X-ray absorptiometry in non-obese and obese individuals. *Diabetes, Obesity & Metabolism, 10*(11), 1012-1018.

Bungum, T., Satterwhite, M., Jackson, A. W., & Morrow, J. R. (2003). The relationship of body mass index, medical costs, and job absenteeism. *American Journal of Health Behavior, 27*(4), 456-462.

Bureau of Justice Statistics. (2009, February 26). *State and local law enforcement statistics*. Retrieved from www.ojp.usdoj.gov/bjs/sandlle.htm

Deurenberg, P., Andreoli, A., Borg, P., Kukkonen-Harjula, K., de Lorenzo, A., van Marken Lichtenbelt, W. D., et al. (2001). The validity of predicted body fat percentage from body mass index and from impedance in samples of five European populations. *European Journal of Clinical Nutrition, 55*(11), 973-979.

Deurenberg, P., Yap, M. D., Wang, J., Lin, F. P., & Schmidt, G. (1999). The impact of body build on the relationship between body mass index and percent body fat. *International Journal of Obesity, 23*(5), 537-542.

Faria, A. N., Ribeiro Filho, F. F., Gouveia Ferreira, S. R., & Zanella, M. T. (2002). Impact of visceral fat on blood pressure and insulin sensitivity in hypertensive obese women. *Obesity Research, 10*(12), 1203-1206.

Ford, E. S., & Mokdad, A. H. (2008). Epidemiology of obesity in the western hemisphere. *The Journal of Clinical Endocrinology and Metabolism, 93*(11 Suppl. 1), S1-S8.

Forouhi, N. G., Sattar, N., & McKeigue, P. M. (2001). Relation of C-reactive protein to body fat distribution and features of the metabolic syndrome in Europeans and South Asians. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity, 25*(9), 1327-1331.

Franke, W. D., Ramey, S. L., & Shelley, M. C. (2002). Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. *Journal of Occupational and Environmental Medicine, 44*(12), 1182-1189.

Gagnon, C., Menard, J., Bourbonnais, A., Ardilouze, J. L., Baillargeon, J. P., Carpentier, A. C., et al. (2010). Comparison of foot-to-foot and hand-to-foot bioelectrical impedance methods in a population with a wide range of body mass indices. *Metabolic Syndrome and Related Disorders, 8*(5), 437-441.

Gelber, R. P., Gaziano, J. M., Orav, E. J., Manson, J. E., Buring, J. E., & Kurth, T. (2008). Measures of obesity and cardiovascular risk among men and women. *Journal of the American College of Cardiology, 52*(8), 605-615.

Giltay, E. J., Elbers, J. M., Gooren, L. J., Emeis, J. J., Kooistra, T., Asscheman, H., et al. (1998). Visceral fat accumulation is an important determinant of PAI-1 levels in young, nonobese men and women: Modulation by cross-sex hormone administration. *Arteriosclerosis, Thrombosis, and Vascular Biology, 18*(11), 1716-1722.

Going, S. B., Massett, M. P., Hall, M. C., Bare, L. A., Root, P. A., Williams, D. P., et al. (1993). Detection of small changes in body composition by dual-energy x-ray absorptiometry. *The American Journal of Clinical Nutrition, 57*(6), 845-850.

Gordis, L. (2009). *Epidemiology* (4th ed.). Philadelphia, PA: Saunders, Elsevier.

Haffner, S. (2006). The metabolic syndrome: Inflammation, diabetes mellitus, and cardiovascular disease. *The American Journal of Cardiology, 97*(2A), 3A-11A.

Harvey, S. B., Glozier, N., Carlton, O., Mykletun, A., Henderson, M., Hotopf, M., et al. (2010). Obesity and sickness absence: Results from the CHAP study. *Occupational Medicine (Oxford, England), 60*(5), 362-368.

Hendel, H. W., Gotfredsen, A., Hojgaard, L., Andersen, T., & Hilsted, J. (1996). Change in fat-free mass assessed by bioelectrical impedance, total body potassium and dual energy X-ray absorptiometry during prolonged weight loss. *Scandinavian Journal of Clinical and Laboratory Investigation, 56*(8), 671-679.

Houston, D. K., Cai, J., & Stevens, J. (2009). Overweight and obesity in young and middle age and early retirement: The ARIC study. *Obesity, 17*(1), 143-149.

Jackson, A. S., Stanforth, P. R., Gagnon, J., Rankinen, T., Leon, A. S., Rao, D. C., et al. (2002). The effect of sex, age and race on estimating percentage body fat from body mass index: The heritage family study. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity, 26*(6), 789-796.

Kales, S. N., Tsismenakis, A. J., Zhang, C., & Soteriades, E. S. (2009). Blood pressure in firefighters, police officers, and other emergency responders. *American Journal of Hypertension, 22*(1), 11-20.

Kyle, U. G., Bosaeus, I., De Lorenzo, A. D., Deurenberg, P., Elia, M., Gomez, J. M., et al. (2004). Bioelectrical impedance analysis: Part I. Review of principles and methods. *Clinical Nutrition, 23*(5), 1226-1243.

Leslie, W. D., Ludwig, S. M., & Morin, S. (2010). Abdominal fat from spine dual-energy x-ray absorptiometry and risk for subsequent diabetes. *The Journal of Clinical Endocrinology and Metabolism, 95*(7), 3272-3276.

Mullie, P., Vansant, G., Hulens, M., Clarys, P., & Degrave, E. (2008). Evaluation of body fat estimated from body mass index and impedance in Belgian male military candidates: Comparing two methods for estimating body composition. *Military Medicine, 173*(3), 266-270.

Nabeel, I., Baker, B. A., McGrail, M. P. Jr., & Flottemesch, T. J. (2007). Correlation between physical activity, fitness, and musculoskeletal injuries in police officers. *Minnesota Medicine, 90*(9), 40-43.

Nindl, B. C., Harman, E. A., Marx, J. O., Gotshalk, L. A., Frykman, P. N., Lammi, E., et al. (2000). Regional body composition changes in women after 6 months of periodized physical training. *Journal of Applied Physiology, 88*(6), 2251-2259.

Nindl, B. C., Scoville, C. R., Sheehan, K. M., Leone, C. D., & Mello, R. P. (2002). Gender differences in regional body composition and somatotrophic influences of IGF-I and leptin. *Journal of Applied Physiology, 92*(4), 1611-1618.

Ode, J., Pivarnik, J., Reeves, M., & Knous, J. (2007). Body mass index as a predictor of percent fat in college athletes and nonathletes. *Medicine and Science in Sports and Exercise, 39*(3), 403-409.

Ostbye, T., Dement, J. M., & Krause, K. M. (2007). Obesity and workers' compensation: Results from the Duke health and safety surveillance system. *Archives of Internal Medicine, 167*(8), 766-773.

Ouchi, N., Kihara, S., Funahashi, T., Nakamura, T., Nishida, M., Kumada, M., et al. (2003). Reciprocal association of C-reactive protein with adiponectin in blood stream and adipose tissue. *Circulation, 107*(5), 671-674.

Pepys, M. B., & Hirschfield, G. M. (2003). C-reactive protein: A critical update. *The Journal of Clinical Investigation, 111*(12), 1805-1812.

Piers, L. S., Soares, M. J., Frandsen, S. L., & O'Dea, K. (2000). Indirect estimates of body composition are useful for groups but unreliable in individuals. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity, 24*(9), 1145-1152.

Ramey, S. (2003). Cardiovascular disease risk factors and the perception of general health among male law enforcement officers: Encouraging behavioral change. *AAOHN Journal, 51*(5), 219-226.

Ramey, S. L., Downing, N. R., & Franke, W. D. (2009). Milwaukee police department retirees: Cardiovascular disease risk and morbidity among aging law enforcement officers. *AAOHN Journal, 57*(11), 448-453.

Ramey, S. L., Downing, N. R., & Knoblauch, A. (2008). Developing strategic interventions to reduce cardiovascular disease risk among law enforcement officers: The art and science of data triangulation. *AAOHN Journal, 56*(2), 54-62.

Ridker, P. (2009). C-reactive protein: Eighty years from discovery to emergence as a major risk marker for cardiovascular disease. *Clinical Chemistry, 55*(2), 209.

Ridker, P. M. (2001). High-sensitivity C-reactive protein: Potential adjunct for global risk assessment in the primary prevention of cardiovascular disease. *Circulation, 103*(13), 1813-1818.

Ridker, P., Rifai, N., Rose, L., Buring, J., & Cook, N. (2002). Comparison of C-reactive protein and low-density lipoprotein cholesterol levels in the prediction of first cardiovascular events. *The New England Journal of Medicine, 347*(20), 1557.

Romero-Corral, A., Somers, V. K., Sierra-Johnson, J., Thomas, R. J., Collazo-Clavell, M. L., Korinek, J., et al. (2008). Accuracy of body mass index in diagnosing obesity in the adult general population. *International Journal of Obesity, 32*(6), 959-966.

Task Force on Community Preventive Services. (2009). A recommendation to improve employee weight status through worksite health promotion programs targeting nutrition, physical activity, or both. *American Journal of Preventive Medicine, 37*(4), 358-359.

van den Ham, E. C., Kooman, J. P., Christiaans, M. H., Leunissen, K. M., & van Hooff, J. P. (2000). Posttransplantation weight gain is predominantly due to an increase in body fat mass. *Transplantation, 70*(1), 241-242.

Violanti, J. M., Burchfiel, C. M., Miller, D. B., Andrew, M. E., Dorn, J., Wactawski-Wende, J., et al. (2006). The Buffalo cardio-metabolic occupational police stress (BCOPS) pilot study: Methods and participant characteristics. *Annals of Epidemiology, 16*(2), 148-156.

World Health Organization. (1995). *Physical status: The use and interpretation of anthropometry. Report of a WHO expert committee* (World Health Organization Technical Report Series, 854, 1). Geneva, Switzerland: Author.