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## Age Related Shift in Visceral Fat

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### Abstract

Fat distribution, especially increased visceral fat, may be as important as overall obesity in increasing risk of heart disease, type 2 diabetes and certain cancers. Risk of disease, as well as visceral fat, increases dramatically with age. Cross-sectional data suggests that increased risk of disease may be largely prevented if the age related increase in visceral fat does not occur. The objective of this short review is to present data that shows visceral fat increasing over 200% in men and 400% in women between the 3<sup>rd</sup> and 7<sup>th</sup> decades, show that a combination of weight gain, loss of muscle, and a shift from peripheral to central fat patterning contributes to this increase, and identify hormones that may be responsible for the shift. Finally, the review will show how participation in exercise can slow the age related shift in visceral fat.

### Keywords

fat distribution; resistance training; aerobic training; weight gain; obesity

### Introduction

The purpose of this short review is to identify an important age related factor that contributes to the increasing risk of disease, increased visceral adiposity. The review is structured as follows: 1) Establishing link between visceral fat and risk of disease; 2) Showing that visceral fat and risk increase dramatically with age; 3) Show that weight gain, muscle loss, and shift in fat distribution all contribute to the increase in visceral fat; 4) Demonstrate that the hormone milieu may be affecting fat distribution; 5) Show that exercise may be important for slowing the age related shift in fat distribution.

### Visceral fat and risk

Obesity continues to be one of our nation's most serious health problems <sup>1</sup> with weight gain associated with increased risk of colon cancer <sup>2</sup>, breast cancer <sup>3</sup>, diabetes <sup>4;5</sup>, and cardiovascular disease <sup>6</sup>. However, the distribution of body fat may be more important to health than the classification of obesity or the total amount of body fat. Fat distributed in the trunk and especially visceral adipose tissue (VAT) is related to the development of diabetes, heart disease and several cancers, as well as mortality <sup>7;8;9;10;11</sup>. In contrast, fat in the legs appears to impose little or no risk <sup>10;11;12</sup>.

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Why fat stored in the viscera is more harmful than fat stored under the skin is not known. However, proinflammatory cytokines may play a role. Chronic subclinical inflammation is associated with type 2 diabetes and heart disease<sup>13;14</sup>. Although the actual mechanisms are unclear, inflammation probably affects disease through multiple mechanisms. Increased visceral fat is associated with increased inflammation, especially in European Americans<sup>15</sup>. Preadipocytes (which give rise to new fat cells) and macrophages seem to be the primary producer of pro-inflammatory cytokines. In addition, excess VAT can lead to subcutaneous fat tissue dysfunction, compromising the ability of the dysfunctional subcutaneous fat tissue to store energy. This in turn could lead to the expansion of VAT organ dysfunction and metabolic disease, both of which occur more frequently in old age<sup>16</sup>. Whatever the causes, it is well accepted that increased VAT is harmful for metabolic health.

Visceral fat is difficult to measure since it is contained in the abdominal cavity under the surrounding abdominal and back musculature. Imaging techniques such magnetic resonance imaging or computed tomography can be used to measure it accurately. Rough estimates of visceral adiposity can also be obtained from measurement of waist circumference.

**Increased Risk with Age**—Risk for metabolic disease increases with age, with age consistently associated with a worsening blood lipid profile in both men<sup>11</sup> and women<sup>17;18</sup>. In addition, increasing age is associated with increased accumulation of visceral fat. This increase is dramatic in women, as shown in Figure 1, almost quadrupling between the ages of 25 and 65 years, adapted from Hunter et al<sup>19</sup>. The increase in men is similar in absolute terms but not so dramatic proportionately, slightly more than doubling during that time period since the men have over 70 cm<sup>2</sup> visceral fat in their 3<sup>rd</sup> decade compared to slightly more than 30 cm<sup>2</sup> for women. It is difficult to know exactly how much visceral fat is too much. However, the majority of men and women in their 7<sup>th</sup> decade exceed even the most conservative estimates of visceral fat needed for increased risk, about 110 cm<sup>2</sup> for women<sup>20</sup> and 130 cm<sup>2</sup> for men<sup>21</sup>.

This age related increase in visceral fat is probably the cause of at least some of the increased risk for metabolic disease in older adults, since the relationship disappears when adjustments for visceral fat are made<sup>11;17;18</sup>. In fact, some variables such as HDL cholesterol<sup>17</sup>, insulin, and insulin sensitivity<sup>18</sup> actually show improved risk with age, i.e. increased age is associated with improved HDL cholesterol, insulin, and insulin sensitivity when the relationship is adjusted for visceral fat<sup>17;18</sup>. Although caution should be taken in interpretation since existing data are cross-sectional rather than longitudinal, the results are suggestive that increased risk of chronic metabolic disease with age may be greatly reduced if visceral fat gain is eliminated, or at least decreased.

### **Weight gain contributes to visceral fat gain**

Prevention of visceral fat gain with age, however, appears to be a daunting task. Three factors are likely responsible for the age-related increase in VAT. First, most adults in industrial countries tend to gain weight between the ages of 20 and 70 years. Kuczmarski et al<sup>1</sup> using data from the third Nutritional Examination Survey (NHANES III) offers national estimates of weight between 1960–1991. Estimated weight calculated from the reported

BMI measures, yields average weight increases of 14.1 pounds for men and 19.2 pounds for women. These modest weight gains, 8% gain for the men and 13.2% for the women, do not fully account for the dramatic increases in visceral fat of over 200% in the men and 400% in the women for this same time period.

### **Muscle loss also contributes**

Another factor that most assuredly contributes to the age related increase in visceral fat is loss of muscle. Estimates of muscle or fat free mass (FFM) loss between the ages of 25 and 65 years are even more difficult to obtain. However, measurements from over 200 subjects show that 60–69 year old men have approximately 14 pounds less FFM than a group of men 20–29 years old, despite being over 8 pounds heavier <sup>22</sup>. In another study with over 220 women <sup>19</sup>, 60–69 year old women have over 13 pounds less FFM than a group of 20–29 year old women even though the older women are almost 12 pounds heavier. It would be presumed that the majority of the FFM loss was muscle. Of course the calories that were contained in the FFM were not lost from the body unless a period of negative energy balance occurred. Since increases in weight are observed, it is obvious that significant energy deficits do not normally occur, rather the extra calories (previously contained in FFM) must be stored as fat mass. Thus weight gain and muscle loss would have a cumulative affect on fat mass gain with the older men and women increasing fat mass by 22 pounds <sup>19;22</sup>, a 75% increase for the women and a 71% increase for the men. Even this fat mass gain does not come close to accounting for the 200–400% increase in visceral fat. Obviously some other factor/factors must also be contributing to the dramatic increase in visceral fat.

### **Factors that affect fat distribution**

Obviously a shift in fat distribution is necessary to account for the dramatic increase in visceral fat. Aging is therefore associated with a shift of fat from the periphery, i.e. face, arms, and legs, to a more central fat deposition, especially the viscera. Little is known concerning reasons for this shift. Likely it is caused by multiple factors. Several conditions seem to be associated with increased distribution of fat in the viscera. Alcohol consumption <sup>23</sup> and smoking have both been linked to visceral fat accumulation in correlational studies. In addition use of protease inhibitor therapy in HIV patients is accompanied by dyslipidemia, peripheral fat loss, and marked increase in VAT.

### **Hormonal environment and shift**

Women with a history of bulimia nervosa have more visceral fat and increased adrenal gland volume than women matched for age, BMI, weight and muscle mass who are non bulimic <sup>24</sup>. Consistent with the hypothesis that the adrenal gland could be playing a role, patients with Cushing's Syndrome have elevated visceral fat as well as chronically elevated cortisol levels <sup>25</sup>.

Other hormones may also be having an affect. Parity is associated with a disproportionate deposition of fat in the viscera that is independent of total body fat and physical activity <sup>26;27</sup>. It is well documented that pregnancy is associated with reduced insulin sensitivity and several studies have shown that peripheral fat cells are particularly dependent

on insulin action to acquire lipid. One possibility for explaining the disproportionate gain in visceral fat during pregnancy could be that the decreased insulin sensitivity retards peripheral fat acquisition causing the visceral fat cells, which are less dependent on insulin action, to acquire increased amounts of fat<sup>27</sup>. It is therefore possible that an age related increase in insulin resistance could be partially responsible for the shift in fat toward the viscera in older adults. A large body of literature supports the role of gonadal hormones in directing fat distribution. Gonadal hormones decline with age in both men and women<sup>28</sup>, with women experiencing a sharp decrease during the menopause transition. In men, low levels of testosterone are associated with increased visceral fat<sup>29-31</sup>, whereas in women, the decline in estrogens and progesterone associated with menopause results in increased visceral fat<sup>32;33</sup>. Use of postmenopausal hormone replacement therapy is associated with less visceral fat<sup>34</sup>. Women who undergo oophorectomy and androgen treatment in conjunction with transsexual surgery experience a 30% increase in the proportion of adipose that is VAT after 12 months, whereas men who undergo treatment with estrogen and anti-androgens demonstrate a 26% decrease in the proportion of abdominal adipose as visceral fat, and a concomitant 66% increase in thigh fat<sup>35</sup>. These observations support the hypothesis that the decline in gonadal hormones with age contributes to the increase in visceral fat in both men and women.

Taken together these studies suggest strongly that fat distribution is markedly affected by several hormones and it is probable that age induced changes in the hormone environment contributes to this age related unfavorable shift in fat distribution

### **What can be done to prevent the age related increase?**

What if anything can be done to prevent or at least slow the increase in visceral fat with increasing age? Obviously, as difficult as it may be, prevention of weight gain has some affect. In fact, at least for overweight and borderline overweight young adults, a strong argument can be made for loss of weight between the 3<sup>rd</sup> and 7<sup>th</sup> decades<sup>36</sup>. Since weight gain typically accounts for less than 25% of the increase, other strategies are necessary. Loss of muscle between the 3<sup>rd</sup> and 7<sup>th</sup> decade probably accounts for another 25% of the visceral fat gain. High intensity resistance training can slow the loss of muscle<sup>37</sup>, although can not prevent it. Estimates of how much muscle can be spared across this 40 year time span are difficult to make. However, it is probable that over 50% of the muscle loss may be prevented. In addition, it is not unusual to see highly trained men and women in their 7<sup>th</sup> decade with FFM, strength, and function similar to untrained men and women in their 3<sup>rd</sup> decade. Resistance training can also increase resting energy expenditure<sup>38-40</sup>, improve function/maintain function<sup>41</sup>, and increase participation in free living energy expenditure<sup>42</sup>, suggesting resistance training may have an affect on helping to prevent weight gain. In fact, a recent paper shows that resistance training following a diet induced weight loss decreases the subsequent one year weight regain by 40% compared to non exercisers who lost weight<sup>36</sup>.

Since the biggest increase in visceral fat with age seems to be caused by the shift in fat distribution, and probably accounts for at least 50% of the increase in visceral fat between 25 and 65 years, strategies for preventing this shift are important. As indicated above, only

speculation concerning its cause and recommendations for remedies to prevent it are primarily speculation at this time. However, based on the cited relationships between VAT and different hormones, interventions that positively affect the hormone environment of aging adults might be beneficial. Exercise training affects the hormone environment and holds some promise for at least slowing the increase in VAT. Exercise training is associated with loss of body fat, particularly visceral fat<sup>43–46</sup>. In addition, we have shown recently that both resistance or aerobic training not only slow weight regain for one year following weight loss, but prevents regain of any visceral fat, demonstrating in effect a redistribution of body fat away from the viscera<sup>36</sup>. Further, supporting the idea that participation in exercise training or physical activity may lead to a more favorable distribution of fat, several studies have shown in both young and older adults that physical activity is related to either reduced waist circumference<sup>47–49</sup> or reduced visceral fat independent of percent body fat<sup>11;17;27</sup>. In fact the age – visceral fat relationship disappeared when adjustments for parity, percent fat, aerobic fitness, and physical activity were made in women<sup>27</sup>. This study suggests being fit and participating in large amounts of physical activity may be protection from the age related shift in body fat distribution. However, the age range for this study was only a little over 25 years(20–48 years)<sup>27</sup>. Figure 3 compares unadjusted visceral fat changes across age with visceral fat changes adjusted for physical activity, parity and percent fat in a group of subjects who have a much larger age range (over 50 years). As can be seen, the increase in visceral fat with age does not seem to occur until the 7<sup>th</sup> decade, and is decreased greatly between the 6<sup>th</sup> and 7<sup>th</sup> decades. Although the data from these two studies are cross-sectional, it is suggested that a shift in fat distribution may be prevented to about 60 years of age and slowed even in the 7<sup>th</sup> decade if weight gain is prevented and activity levels are maintained high.

Too little research is available to be able to identify what the optimal exercise program would be for preventing an age related increase in visceral fat. However, an argument can be made for resistance training being included in such a program. As little as 30–40 minutes of high intensity resistance training will help to conserve muscle (preventing shift of calories contained in the muscle to fat), maintain function in activities of daily living, and thus increase the likelihood that older individuals are going to feel like being more physically active and maintain high free living energy expenditure. Aerobic training also has added benefits, including reduced blood lipids, increased energy expenditure, and improved insulin sensitivity. Therefore, it can be argued that a combined program of aerobic and resistance training would be valuable for enhancement of fat distribution, decreasing risk of diabetes, heart disease and some cancers, as well as maintaining a high quality of life.

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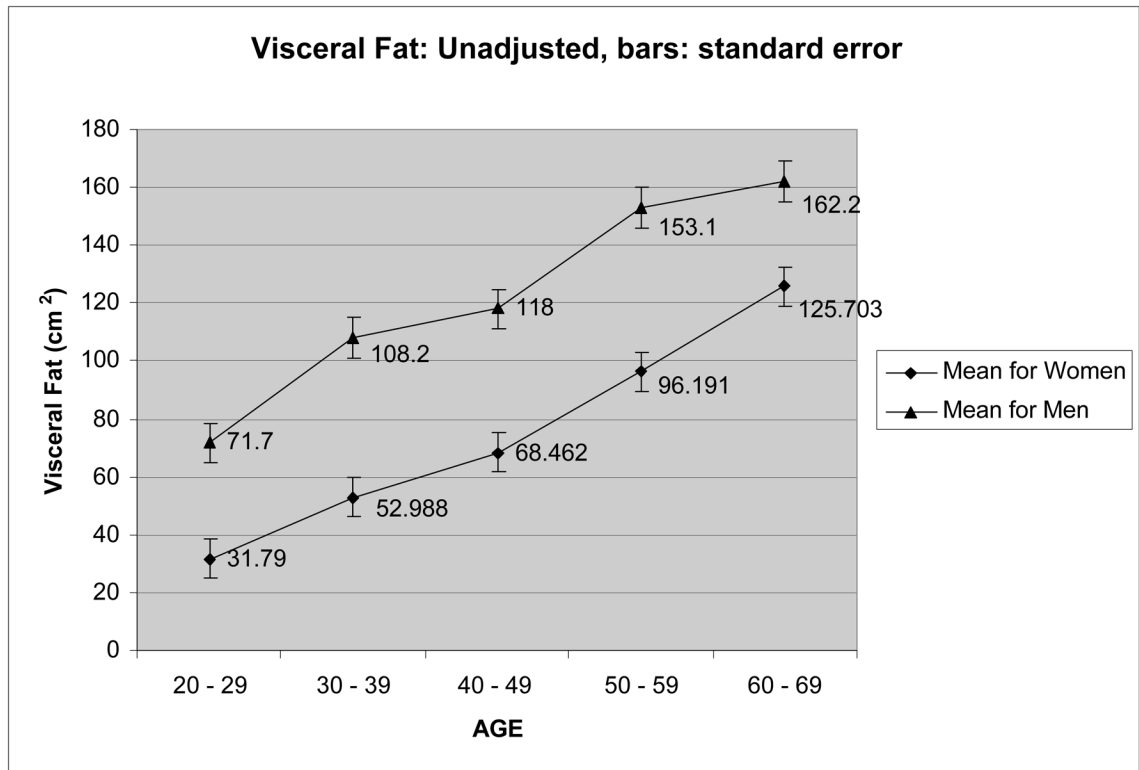
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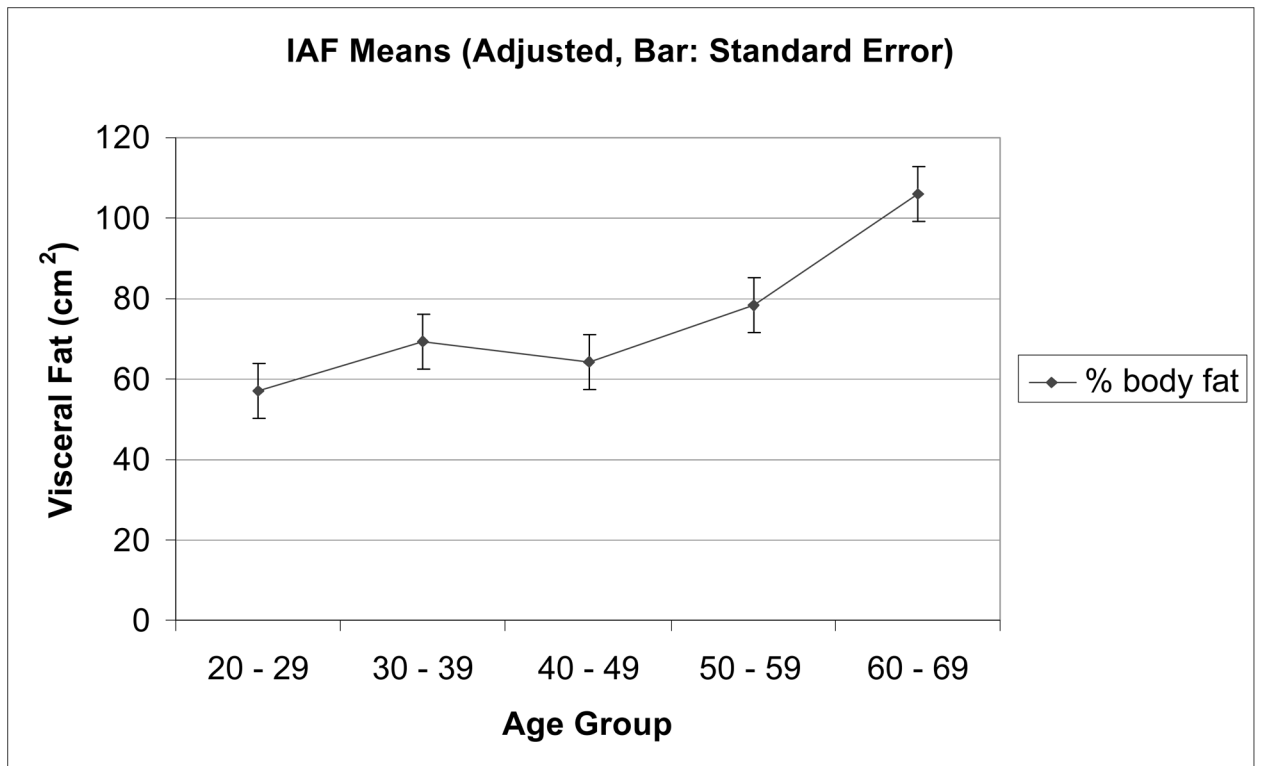
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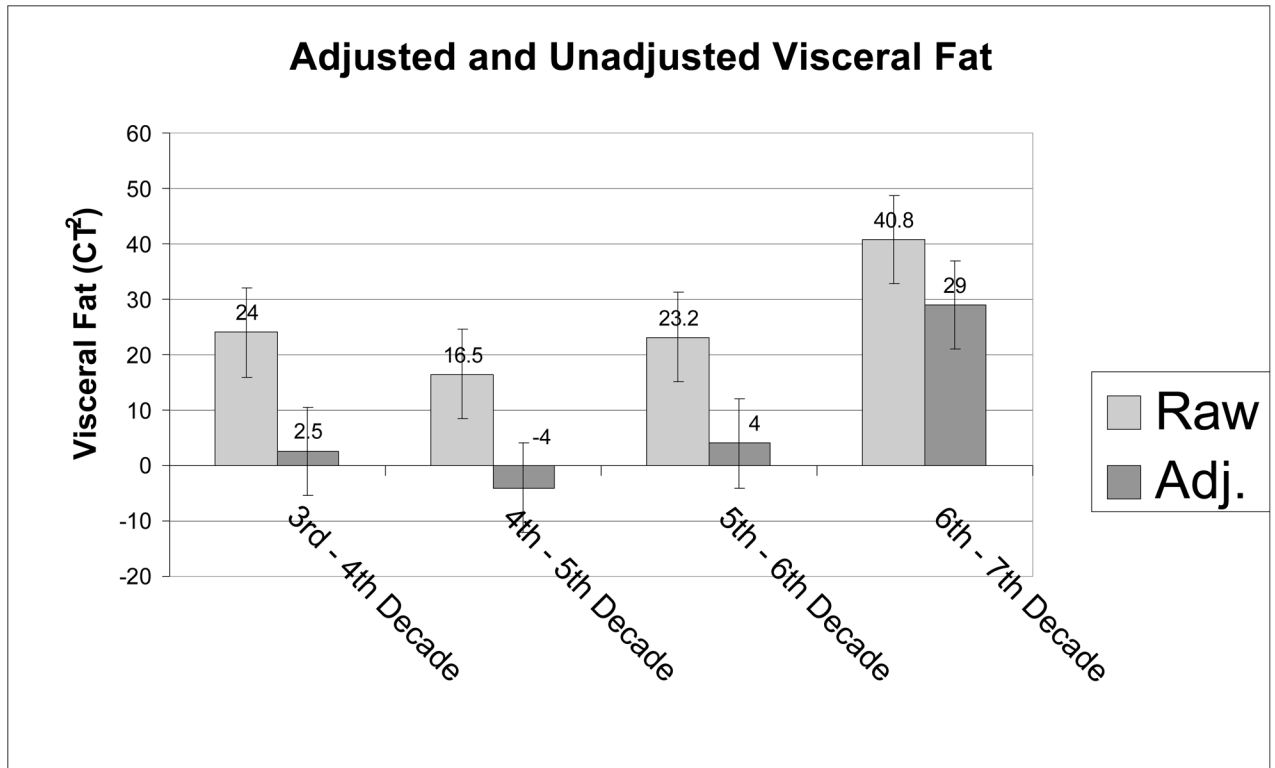




**Figure 1.**  
Visceral fat across different ages for 203 men and 220 women.



**Figure 2.**  
Visceral fat adjusted for percent fat across different ages for 220 women.



**Figure 3.**  
Change in visceral fat unadjusted and adjusted for percent fat, parity, and physical activity