Comparison of Serum Iron, Total Iron Binding Capacity and hemoglobin A1c level according to Obesity in South Korean Adult

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Abstract

The purpose of this study was to investigate the difference in serum Iron, total iron binding capacity (TIBC) and hemoglobin A1c (HbA1c) according to the body mass index (BMI) of South Korean adults. This study analyzed The Fifth Korea National Health and Nutrition Examination Survey, and classified in normal weight G (43.3%), Overweight G (24.8%) and obesity G (31.9%), then analyzed survey and blood test of total of 4485 subject. Data were analyzed using descriptive statistics, χ²-test, ANOVA, Scheffe’s test Pearson correlation coefficient and multiple regression analysis (SPSS 24.0).

The major findings of this study were as follows. First, The age was the highest in the overweight G (52.66y), followed by the obesity G (50.89y) and the lowest in the normal weight G (46.67y). Obesity and Overweight G showed more female than male. Second, There was no significant difference in serum iron (μg/ dL) between normal weight G (111.80), overweight G (115.13) and obesity G (115.93), TIBC (μg/ dL) was the highest in the obesity G (319.93), followed by the overweight G (312.30) and the lowest in the normal weight G (312.13).

HbA1c(%) was the highest in the obesity G (5.97), followed by the overweight G (5.83) and the lowest in the normal weight G (5.64). Third, BMI was not correlated with serum iron, and positive correlated with TIBC and HbA1c. In addition, TIBC and HbA1c appeared to be a factor affecting the BMI. We want to provide a basis data for the prevention and management of obesity intervention program for Korean adult.

Keywords: Adult, Body mass index, Serum iron, Total iron binding capacity, HbA1c

INTRODUCTION

The global incidence of obesity has increased dramatically over the past 50 years. Currently more than 1 billion people are thought to have a BMI of more than 30kg/m²[1]. Obesity is a condition in which fat tissue accumulates excessively in the body and causes health problems[2]. Obesity is is recognized as a major risk factor for chronic diseases[3]. In order to prevent and effectively manage obesity, it is essential to accurately assess obesity[4].

Obesity and related complications as well as iron deficiency (ID) are major issues that affect significant proportions of the global population[5]. The association between iron status and obesity is one that should be explored further[6]. Type 2 diabetes mellitus is expected to affect nearly 10% of the world’s population by 2030[7]. More than 25% of the U.S. population aged 65 years has DM[8]. The epidemic of type 2 diabetes is linked to increasing rates of overweight and obesity in the population[9].

The obesity may be associated with changes in the iron parameters, including TIBC. Obesity-related inflammation is expected to result in reduced serum iron levels in obese adults. Low iron levels were present in 38.8%, 12.1%, and 4.4% of obese, overweight and normal-weight subject[10]. Iron plays a major role not only for hemoglobin synthesis alone, but also for oxidative metabolism and energy production[11].

The low iron levels in overweight and obese subjects are most probably caused by the inflammatory mechanisms, which arrest iron in the reticuloendothelial system by releasing different inflammatory mediators like cytokines and so forth[12]. Association of ID with obesity doubles the ill health effects of the obesity itself. Though chronic inflammation caused by excess adipose tissue, rather than dietary factors, offers a plausible explanation for ID in obese people[13]. Iron deficiency is associated with concurrent decreased serum iron and increased TIBC levels, so that iron divided by TIBC, also known as iron saturation ratio, is usually quite low[14]. There is a relative scarcity of more specific test for the diagnosis of ID or IDA like TIBC and so forth[15].

Obesity is associated with chronic, low grade, systemic inflammation, the inflammatory state plays a causal role in the development of insulin resistance[16] and obesity is one of the modifiable risk factors of type 2 diabetes[17]. The HbA1c helps in detecting undiagnosed diabetes, especially in high risk individuals[18]. The earliest diagnostic marker for diabetes is elevated plasma glucose levels, HbA1c gives information on the long term control of diabetes[19], HbA1c may serve as a better indicator for glucose control in diabetic patients than fasting blood sugar levels[20]. In 2011, the
World Health Organization and the American Diabetic Association accepted HbA1c≥6.5% as a diagnostic criterion for DM and HbA1c 5.7%~6.4% as a high-risk DM[21]. WHO classifies BMI over 25kg/m² as overweight and over 30kg/m² as obesity[22]. However, it is not appropriate to apply it to Asians because it was developed based on the results of research on westerner[23]. World Health Organization Western Pacific Region[24] defines obesity as over 25kg/m² and this criterion is applied in this study as well. In order to rule out the effects of DM and iron deficiency anemia(IDA), subjects who were diagnosed with DM and IDA were excluded. we tried to suggest a fundamental data of adult obesity prevention and management program by checking a correlation of BMI, serum Iron, TIBC and HbA1c, targeting a adult.

METHODS

Research Design
This study is a descriptive survey study which attends a secondary analysis of The Fifth Korea National Health and Nutrition Examination Survey's raw data to check the differences of serum Iron, TIBC and HbA1c depends on Korean adults' obesity degree.

Samples and setting
The subject of this study is adult and data is based on ‘The Fifth Korea National Health and Nutrition Examination Survey (KNHANES V-3), 2015’ which Ministry of Health and Welfare and Korea Centers for Disease control and prevention conducted.

The total number of subjects in the Fifth Korea National Health and Nutrition Examination Survey was 8058, subjects who were diagnosed with DM, IDA, under19 years old and non-responders were excluded. The 4485 adults analyzed as final data of this study.

Measuring methods

BMI
The Height and weight were measured after overnight fasting with participants shoeless and wearing a lightweight gown. BMI was calculated as weight(kg) divided by the square of the height(m). Based on this, the BMI weight status categories are Normal weight(BMI<23kg/m²), Overweight(23≤BMI<25kg/m²), and Obese (BMI≥25kg/m²)[25]. The representative method to measure obesity is BMI, and the way to change BMI into clinical obesity category has slight difference following weight distribution of west and east[26]. This study classified subject’s in normal weight G 1941 (43.3%), Overweigh G, 1112(24.8%) and obesity G 1423(31.9%), then analyzed survey and blood test of total of 4485 subject.

Serum iron, TIBC and HbA1c measurement
The blood sampling was performed in the morning after fasting for 8 hours or more, and cubital vein was punctured using a vacutainer needle and blood was drawn into a vacuum tube. Measurement of the serum iron Bathophenanthroline direct method, reagent was L-Type Fe(Wako/Japan) and it is analyzed by equipment; Hitachi Automatic Analyzer 7600(Hitachi/Japan). Measurement of the TIBC was Calculation, reagent was IRON+UIBC and it is analyzed by equipment; Hitachi Automatic Analyzer 7600(Hitachi/Japan). High Performance Liquid Chromatography; HLC-723G7 HbA1c (Tosoh/Japan) was used for measuring HbA1c and it is analyzed by the equipment; HLC-723G7 (Tosoh/Japan).

Data analysis
The collected data was analyzed by SPSS WIN 24.0 program(SPSS Inc. Chicago, IL, USA). The general characteristic of subjects was analyzed by descriptive statistics. The serum iron, TIBC and HbA1c differences according to BMI levels were analyzed by χ²-test, ANOVA and Scheffe's test. The relationship between BMI, serum iron, TIBC and HbA1c was analyzed by Pearson correlation coefficient. Factors influencing BMI were multiple regression analysis. When the value of p is under 0.05, it is statistically meaningful.

Ethical consideration
The Korea National Health and Nutrition Examination Survey which is used in this study was reviewed from Korea Centers for Disease control and Prevention and Institutional Review Board(2012-01EXP-01-2C), and subject's anonymity and confidentiality were guaranteed by collecting their private information in serial number which is unable to distinguish and we pactionally conducted a 2012 annual survey(48weeks a year).

RESULTS
General characteristics of subject
The mean age of the subjects was 49.50, 43.3% for male and 56.7% for female. Subjective figure recognition were skinny 16.3%, normal 41.2%, and obese 42.3%. Weight change over the past year showed no change(within 0-3Kg) 66.7%, weight loss 13.4% and weight gain 19.6%. The mean variables of the subjects were BMI 23.75kg/m², serum iron 119.25μg/dL, TIBC 314.66μg/dL and HbA1c 5.79%(Table 1).
Table 1: General characteristics of subject
(N=4,485)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Category</th>
<th>Mean±SD n(%)</th>
<th>Acquired score range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(yrs)</td>
<td></td>
<td>49.50±16.18</td>
<td>19~88</td>
</tr>
<tr>
<td></td>
<td>19~29</td>
<td>569(12.7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30~39</td>
<td>835(18.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40~49</td>
<td>807(18.0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50~59</td>
<td>915(20.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60~69</td>
<td>758(16.9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Over 70</td>
<td>601(13.4)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>1940(43.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2545(56.7)</td>
<td></td>
</tr>
<tr>
<td>Subjective figure recognition</td>
<td>Skinny</td>
<td>729(16.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>1847(41.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obese</td>
<td>1896(42.3)</td>
<td></td>
</tr>
<tr>
<td>Weight change over the past year</td>
<td>No change(within 0 -3Kg)</td>
<td>2991(66.7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight loss</td>
<td>601(13.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight gain</td>
<td>874(19.5)</td>
<td></td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td></td>
<td>23.75±3.35</td>
<td>14~43</td>
</tr>
<tr>
<td></td>
<td>Normal weight (BMI&lt;23.0)</td>
<td>1941(43.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overweigh (23≤BMI&lt;25)</td>
<td>1112(24.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obesity(BMI≥25)</td>
<td>1432(31.9)</td>
<td></td>
</tr>
<tr>
<td>Serum iron(µg/dL)</td>
<td></td>
<td>119.25±46.59</td>
<td>6~395</td>
</tr>
<tr>
<td>TIBC(µg/dL)</td>
<td></td>
<td>314.66±41.83</td>
<td>157~637</td>
</tr>
<tr>
<td>HbA1c(%)</td>
<td></td>
<td>5.64±0.55</td>
<td>4~15</td>
</tr>
</tbody>
</table>

Differences in Serum iron, TIBC and HbA1c according to subject's BMI

The Serum iron(µg/dL) was not significantly different between the normal G (mean=111.80), overweight G(mean=115.13) and obesity G(mean=115.93)(F=1.732, p=0.177).

The TIBC(mg/dL) was higher in the obesity G(mean=319.93) than overweight G(mean=312.30) and normal weight G(mean=312.13)(F=16.787, p<0.001). The HbA1c(%) was the highest in the obesity G(mean=5.97%) followed by the overweight G(mean=5.83%) and the lowest in the normal weight G(mean=5.64%)(F=102.602, p<0.001)(Table 2).

Correlation between subject's BMI, Serum iron, TIBC and HbA1c

There was a significant positive correlation between the subject's BMI and TIBC(r=0.085, p<0.001), HbA1c(r=0.224, p<0.001)(Table 3).
Table 2: Differences in Serum iron, TIBC and HbA1c according to subject's BMI
(N=4,485)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Category</th>
<th>Normal weigh G¹ n=1941(43.3%)</th>
<th>Overweigh G² n=1112(24.8%)</th>
<th>Obesity G³ n=1432(31.9%)</th>
<th>F/χ² (p value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean, yrs)</td>
<td></td>
<td>Mean±SD n(%)</td>
<td>Mean±SD n(%)</td>
<td>Mean±SD n(%)</td>
<td>57.624 (0.001)</td>
</tr>
<tr>
<td>19~29</td>
<td></td>
<td>46.67±17.04 (18.5)</td>
<td>52.66±15.11 (7.9)</td>
<td>50.89±15.14 (8.5)</td>
<td></td>
</tr>
<tr>
<td>30~39</td>
<td></td>
<td>416(21.4)</td>
<td>165(14.8)</td>
<td>254(17.7)</td>
<td></td>
</tr>
<tr>
<td>40~49</td>
<td></td>
<td>344(17.7)</td>
<td>181(16.3)</td>
<td>282(19.7)</td>
<td>178.884 (&lt;0.001)</td>
</tr>
<tr>
<td>50~59</td>
<td></td>
<td>333(17.2)</td>
<td>267(24.0)</td>
<td>315(22.0)</td>
<td></td>
</tr>
<tr>
<td>60~69</td>
<td></td>
<td>241(12.4)</td>
<td>248(22.3)</td>
<td>269(18.8)</td>
<td></td>
</tr>
<tr>
<td>Over 70</td>
<td></td>
<td>248(12.8)</td>
<td>163(14.7)</td>
<td>190(13.3)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>714(36.8)</td>
<td>526(47.3)</td>
<td>700(48.9)</td>
<td>58.999 (&lt;0.001)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1227(63.2)</td>
<td>586(52.7)</td>
<td>732(51.1)</td>
<td></td>
</tr>
<tr>
<td>Subjective figure recognition</td>
<td>skinny</td>
<td>655(33.7)</td>
<td>51(4.6)</td>
<td>23(1.6)</td>
<td>1929.252 (&lt;0.001)</td>
</tr>
<tr>
<td></td>
<td>normal</td>
<td>1044(53.8)</td>
<td>574(51.6)</td>
<td>229(16.0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>obese</td>
<td>238(12.3)</td>
<td>481(43.3)</td>
<td>1177(82.2)</td>
<td></td>
</tr>
<tr>
<td>Weight change over the past year</td>
<td>No change (within 0-3Kg)</td>
<td>1384(71.3)</td>
<td>770(69.2)</td>
<td>837(58.4)</td>
<td>149.610 (&lt;0.001)</td>
</tr>
<tr>
<td></td>
<td>Weight loss</td>
<td>301(15.5)</td>
<td>129(11.6)</td>
<td>171(11.9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight gain</td>
<td>249(12.8)</td>
<td>206(18.5)</td>
<td>419(29.3)</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td>20.80±1.62</td>
<td>23.98±0.56</td>
<td>27.58±2.51</td>
<td>6171.819 (&lt;0.001)</td>
</tr>
<tr>
<td>Serum iron (µg/dL)</td>
<td></td>
<td>111.80±49.32</td>
<td>115.13±46.89</td>
<td>115.93±46.40</td>
<td>1.732 (0.177)</td>
</tr>
<tr>
<td>TIBC (µg/dL)</td>
<td></td>
<td>312.13±42.12</td>
<td>312.30±42.15</td>
<td>319.93±40.71</td>
<td>16.787 (&lt;0.001)</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td></td>
<td>5.64±0.75</td>
<td>5.83±0.78</td>
<td>5.97±0.89</td>
<td>102.602 (&lt;0.001)</td>
</tr>
</tbody>
</table>

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Factors affecting BMI in the adult subjects

In order to confirm the relative influence of factors influencing BMI, we conducted a hierarchical regression analysis (Table 4) after controlling the age, gender, Subjective figure recognition, Weight change over the past year that could affect the subject's BMI. In the model I, the control variable was used. In model II, the model I was used as the independent variable Serum iron, TIBC and HbA1c.

Model I indicates the degree of influence of the control variables on the subject's BMI. The regression model fit was statistically significant at 1099.082 (<0.001). Age(β=0.167, p<0.001), Gender(β=-0.194, p=0.001), Subjective figure recognition(β=0.697, p<0.001) and Weight change over the past year(β=0.175, p<0.001) were found to affect the BMI of the subjects.

The regression model fit of model II was 890.776 (<0.001), TIBC(β=0.052, p<0.001) and HbA1c(β=0.107, p<0.001) was added as a variable that affected the subject's BMI. The explanatory power was improved by 7.3% over the model I.

DISCUSSION

The study was to investigate the relationship between serum iron, TIBC and HbA1c according to BMI in Korean adults.

In this study, the age was found to be higher in the overweight and obese G than in the normal G and overweight, obesity G showed more female than male. Obesity reports issued in 2014, from among 109 billion overweight adults over the age 18,600 million were obese[27]. The studies, overweight and obese G were older than normal[28], the results of this study are the same. As get older, your basic metabolism decreases and your weight gradually increases, with an average increase of 250g per year[29]. This is more common in women and is being considered as the most serious threat to human health by different authorities[30]. The body weight is increased
before and after menopause. Basal metabolic rate, which is the main factor of energy expenditure, gradually decreases from 50 years old, but decreases by 2~3% in 10 years[31].

Overweight individuals are at higher risk of iron deficiency than normal-weight individuals[32]. The study found that both normal and obese female subjects had lower iron and hemoglobin levels than male[33]. Elevated BMI is associated with lower iron. These findings may be explained by the chronic inflammation of obesity and may contribute to obesity-related co-morbidities[34]. The supported the results of this study.

In this study, BMI was not correlated with serum iron, serum iron had no significant difference in obesity G, overweight G, and normal weight G. Serum iron had no significant difference in obesity G, overweight G, and normal weight G[28]. It shows similar results with this paper. However, the study, overweight and obesity were defined as 25≤BMI<30 and BMI≥30[28], which is different from the obesity classification criteria of this study. There is a need to study the standardized obesity assessment method in relation to obesity and serum iron.

On the other hand, obesity and ID are the most common nutritional disorders worldwide[35]. Iron plays a vital role in hemoglobin production and erythrocyte maturation[34]. Iron homeostasis in the body is controlled by a very complex mechanism, the main components of which are erythropoietic activity, hypoxia, iron stores, and inflammation[36]. In adult study, found significantly lower levels of serum iron in obese people when compared to non-obese adults[37]. They reported that the obese and the non-obese subjects did not differ in daily iron consumption but that fat mass was a significant negative predictor of serum iron[38]. The low-grade inflammation induced by the aforementioned cytokines may contribute to the development of obesity-associated anemia[39]. This study, which showed no difference in serum iron according to BMI, was different from the general study results. After that, repeated studies that control racial background, regional differences, socioeconomic level, lifestyle, and age are necessary.

In this study, BMI and TIBC were positive correlations, TIBC showed higher obesity G than overweight G and normal weight G. In addition, TIBC appeared to be a factor affecting the BMI of the subjects. Obesity is characterized by the presence of low-grade inflammation and the risk of developing a number of chronic diseases such as impaired glucose tolerance, and type 2 diabetes[16]. Increased BMI among adults with DM reflected better HbA1c[41]. HbA1c is a form of hemoglobin that is measured in order to identify the average concentration of plasma glucose over the relatively long term period of two to three months prior to the 366(9492),pp.1197-209.

CONCLUSION

In this study, BMI of Korean adults was significantly positive correlated with TIBC and HbA1c. The TIBC and HbA1c are influencing factor of BMI, and TIBC and HbA1c were the highest in the obese G.

In conclusion, adult obesity prevention and management programs should include serum iron, TIBC and HbA1c.

ACKNOWLEDGEMENTS

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REFERENCES


