Lean Body Mass and Body Fat Distribution in Participants With Chronic Low Back Pain

Yoshitaka Toda, MD; Neil Segal, MD; Tamami Toda; Tadanobu Morimoto, MD; Ryokei Ogawa, MD

Background: Loss of muscle mass and central obesity progress with aging, but the effect of muscle loss on chronic low back pain has not been precisely evaluated.

Methods: Three hundred thirty Japanese persons aged 45 to 69 years, with a complaint of low back pain for longer than 3 months (n=203) and age- and sex-matched healthy control subjects (n=127), were enrolled in this study. Participants with chronic low back pain were classified into the following groups: (1) women with a positive straight leg raise test result, (2) women with a negative straight leg raise test result, (3) men with a positive straight leg raise test result, and (4) men with a negative straight leg raise test result. Controls were classified by sex into a female and a male group. Anthropometric data, consisting of body mass index, percentage body fat, waist-hip ratio, and lean body mass of the upper extremities, trunk, and lower extremities divided by body weight, were measured in participants with low back pain, and the results were compared with those of controls.

Results: The waist-hip ratio in women with a negative straight leg raise test result was significantly higher than those in the female control group (P<.001) and in the women with a positive straight leg raise test result (P=.04). The lean body mass of the trunk and lower extremities divided by body weight of women with a negative straight leg raise test result was significantly lower than that of female controls (P=.03 for the trunk and P<.001 for the lower extremities). However, no significant differences were detected between the female negative straight leg raise test result group and the female control group for lean body mass of the upper extremities divided by body weight or body mass index. There were no significant differences in anthropometric data between the male test and control groups or between the female positive straight leg raise test result group and the female control group.

Conclusion: Trunk and lower extremity loss of muscle mass and central obesity may be risk factors for chronic low back pain without a positive straight leg raise test result in women aged 45 to 69 years.

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PARTICIPANTS AND METHODS

PARTICIPANTS

In this study, Japanese participants, aged 45 to 69 years, with chronic low back pain were classified into the following groups: (1) women with a positive straight leg raise test result, (2) women with a negative straight leg raise test result, (3) men with a positive straight leg raise test result, and (4) men with a negative straight leg raise test result.

Subjects were defined as having chronic low back pain if either the duration of the current episode of pain was longer than 3 months or they presented with a recurrent history of disabling low back pain (causing absence from work or significant modification of activities of daily living). Two hundred three new outpatients with chronic low back pain, aged 45 to 69 years (mean age, 59.7 years; SD, 8.7 years), visiting the Toda Orthopedic Rheumatology Clinic, Osaka, Japan, in 1999 were enrolled in this study. Sciatic pain was defined as a positive straight leg raise test result.

Control participants, recruited from a community senior center, were defined as individuals without low back pain who denied having any problem with their lower back within 10 years. One hundred twenty-seven independently living, medically stable participants, aged 45 to 69 years (mean age, 57.6 years; SD, 8.7 years), were self-selected into the study. The control group was subdivided by sex into a female and a male group.

In the chronic low back pain and control groups, no participants had a history suggestive of congenital muscle, cardiovascular, cerebrovascular, or neurologic disease, and none had sustained a leg or an arm injury within the previous 10 years that had required immobilization of a joint for more than 1 week.

MEASUREMENTS

Body composition measurements and WHRs were obtained by segmental bioelectrical impedance using 8 tactile electrodes, according to the manufacturer's instructions (InBody 2.0; Biospace, Seoul, Korea). Participants stood barefoot on a platform with electrodes attached to their hands and feet. Thus, a pair of electrodes were attached to the surface of each hand and foot at the thumb, palm, fingers, ball of the foot, and heel. These electrodes were connected to current and voltage terminals from an impedance meter via electronic on-off switches, which were regulated by a microprocessor. The body was measured in 5 segments: right upper extremity, left upper extremity, trunk, right lower extremity, and left lower extremity. To measure the resistance of the right upper extremity segment, current terminals were connected to the right palm electrode and the right ball of the foot electrode, and voltage terminals were connected to the right thumb electrode and the left thumb electrode. While the current passed through R1, the resistance of the right upper extremity segment, the resistance of the trunk segment, the resistance of the right lower extremity segment, and R3, a different voltage was measured across R2, the resistance of the right upper extremity segment, and the resistance of the left upper extremity segment. In this way, only the voltage drop occurring in the right upper extremity was measured, where current pathway and voltage detection circuits were overlapped (Figure). By regulating these switches in the appropriate on or off position, a target segment could be measured selectively.

The chemical composition of lean body mass is assumed to be relatively constant, with a density of 1.1 kg/m³ at 37°C and a water content of 73%. Thus, the lean body mass of the upper extremities, trunk, and lower extremities was calculated by multiplying the values for water volumes of the upper extremities (a sum of right and left), trunk, and lower extremities (a sum of right and left) by 1.37. Each segmental lean body mass was divided by body weight to estimate segmental lean body mass per body weight. Height was measured to the nearest 1 cm using a stadiometer. Weight was measured with subjects standing erect, wearing only underwear and a robe, to the nearest 0.1 kg. The BMI was calculated as weight in kilograms divided by the square of height in meters.

STATISTICAL ANALYSIS

Differences in BMI, percentage body fat, lean body mass of the upper extremities, trunk, and lower extremities divided by body weight, and WHR between the chronic low back pain and control groups were tested using nonparametric analysis by the Kruskal-Wallis method. Statistical significance levels were considered to be P<.05.

RESULTS

The chronic low back pain and control groups were well matched for age, height, and weight. Disease duration did not significantly differ among male or female groups regardless of the results of the straight leg raise test (P=.19 and P=.88, respectively) (Table 1). Comparison of anthropometric data demonstrated no significant differences between the male control, male with a positive straight leg raise test result, and male with a negative straight leg raise test result groups (Table 2).
Comparison of anthropometric data for the female control, female with a positive straight leg raise test result, and female with a negative straight leg raise test result groups was presented in Table 3. Percentage body fat was significantly greater in the female with a negative straight leg raise test result group than in the female control group. The average BMI did not significantly differ among the 3 groups. The WHR in the female with a negative straight leg raise test result group was significantly higher than those of the female control group and the female with a positive straight leg raise test result group.

The lean body mass of the trunk and lower extremities divided by body weight measurements for women with a negative straight leg raise test result were observed between the female with a negative straight leg raise test result group and the female control group ($P = .65$). There were no significant differences in any anthropometric data between the female with a positive straight leg raise test result group and the female control group.

**COMMENT**

To our knowledge, this is the first study that has examined segmental body composition in patients with chronic low back pain. The results of this study demonstrate that women, aged 45 to 69 years, with chronic low back pain and a negative straight leg raise test result are characterized by an increased percentage of body fat and WHR and a reduced lean body mass of the trunk and lower extremities divided by body weight compared with a matched control cohort. However, the BMI and the lean body mass of the upper extremities divided by body weight do not appear to be independent risk factors for chronic low back pain with a negative straight leg raise test result in this cohort. This suggests that loss of muscle mass of the trunk and lower extremities and central obesity may be risk factors for chronic low back pain without sciatic pain in women in this age group.

Waist-hip ratio was shown to be significantly greater for women with low back pain with a negative straight leg raise test result than for participants in the control and positive straight leg raise test result groups. Waist-hip ratio is one of the most commonly used anthropometric measures to indicate a central obesity pattern. Past research has consistently demonstrated that adi-

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**Table 1. Characteristics of the Chronic Low Back Pain and Control Groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>MC (n = 44)</th>
<th>M− (n = 38)</th>
<th>M+ (n = 42)</th>
<th>FC (n = 83)</th>
<th>F− (n = 71)</th>
<th>F+ (n = 52)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>57.7 (9.8)</td>
<td>52.9 (8.6)</td>
<td>58.1 (8.3)</td>
<td>57.6 (8.1)</td>
<td>60.7 (8.2)</td>
<td>59.0 (10.3)</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>45-69</td>
<td>45-69</td>
<td>45-69</td>
<td>45-69</td>
<td>45-69</td>
<td>45-69</td>
<td></td>
</tr>
<tr>
<td>Height, cm</td>
<td>167.3 (6.1)</td>
<td>166.8 (8.4)</td>
<td>167.2 (5.2)</td>
<td>155.7 (6.4)</td>
<td>153.3 (6.4)</td>
<td>153.0 (6.6)</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>152-185</td>
<td>154-181</td>
<td>160-175</td>
<td>140-176</td>
<td>139-167</td>
<td>140-164</td>
<td></td>
</tr>
<tr>
<td>Weight, kg</td>
<td>67.6 (10.7)</td>
<td>64.4 (9.2)</td>
<td>68.1 (8.7)</td>
<td>54.8 (9.4)</td>
<td>54.0 (8.5)</td>
<td>52.4 (8.4)</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>43.4-103.9</td>
<td>46.6-86.7</td>
<td>48.0-85.9</td>
<td>36.0-84.8</td>
<td>37.0-82.0</td>
<td>41.0-78.0</td>
<td></td>
</tr>
<tr>
<td>Disease duration, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>4.2 (4.9)</td>
<td>6.3 (8.2)</td>
<td>3.9 (5.7)</td>
<td>3.0 (3.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0.4-20.0</td>
<td>0.4-30.0</td>
<td>0.4-21.0</td>
<td>0.4-12.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* $N = 330$. MC indicates male controls; M−, men with a negative straight leg raise test result; M+, men with a positive straight leg raise test result; FC, female controls; F−, women with a negative straight leg raise test result; F+, women with a positive straight leg raise test result; and ellipses, data not applicable.
pose tissue distribution, rather than absolute total fat, is associated with an increased risk of diabetes, hypertension, lipemia, and coronary artery disease. Thus, it is important to evaluate whether women, aged 45 to 69 years, with central obesity also possess a higher risk of degenerative disorders such as low back pain.

For BMI, there was no significant difference between participants with low back pain and healthy controls in either sex group. Although BMI is commonly used as a measure of obesity, it does not differentiate fat mass from lean body mass. Leboeuf-Yde et al reported that a positive association between BMI and low back pain did not hold in studies of monozygotic twins who were dissimilar in body weight classification. This suggests that assessment of BMI alone will not reveal the relation between obesity and low back pain.

In this study, the values for lean body mass of the trunk and lower extremities divided by body weight were significantly lower in women with low back pain with a negative straight leg raise test result than in the control cohort. It is believed that strengthening and stretching exercises are more clinically effective than traditional management of patients with low back pain. Thus, considering the relation between reduced segmental lean body mass and low back pain previously described, it is plausible that increasing the lean body mass of the trunk and lower extremities using exercises may improve symptoms of women with low back pain. As follow-up to this characterization of anthropometric risk factors, it will be important to study this therapeutic relation.

Chronic low back pain with a positive straight leg raise test result in male and female subjects was not significantly related to any anthropometric data, compared with age- and sex-matched controls. As indicated previously, in previous epidemiological studies, scientific evidence of the relation between obesity and low back pain remained unclear. Therefore, it was incumbent on us to evaluate the relation between obesity and low back pain, splitting the population of patients with low back pain by presence or absence of a positive straight leg raise test result. We believe that this study provides some useful information, and deems further characterization of the relation between obesity and low back pain, using the straight leg raise test results as grouping criteria.

In male participants, no significant relation was observed between chronic low back pain and the distribution of lean body mass or body fat content. There have

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### Table 2. Anthropometric Data of the Male Groups*  

<table>
<thead>
<tr>
<th>Group</th>
<th>% BF</th>
<th>BMI†</th>
<th>WHR</th>
<th>U-LBM/W</th>
<th>T-LBM/W</th>
<th>L-LBM/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC (n = 44)</td>
<td>Mean (SD)</td>
<td>22.3 (6.1)</td>
<td>23.9 (3.1)</td>
<td>90.5 (4.8)</td>
<td>8.3 (1.0)</td>
<td>34.2 (3.5)</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>9.9-32.7</td>
<td>17.6-33.0</td>
<td>82.0-100.0</td>
<td>6.2-10.8</td>
<td>28.0-43.0</td>
</tr>
<tr>
<td>M− (n = 38)</td>
<td>Mean (SD)</td>
<td>22.6 (5.7)</td>
<td>23.2 (2.4)</td>
<td>90.2 (4.4)</td>
<td>8.1 (0.8)</td>
<td>34.1 (2.9)</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>13.1-31.3</td>
<td>17.7-26.6</td>
<td>80.0-97.0</td>
<td>6.5-9.9</td>
<td>29.0-40.0</td>
</tr>
<tr>
<td>M+ (n = 42)</td>
<td>Mean (SD)</td>
<td>24.9 (4.4)</td>
<td>24.5 (2.2)</td>
<td>91.9 (4.0)</td>
<td>8.3 (0.8)</td>
<td>33.8 (3.4)</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>16.4-31.8</td>
<td>21.4-28.5</td>
<td>84.0-99.0</td>
<td>7.4-11.0</td>
<td>30.0-46.0</td>
</tr>
</tbody>
</table>

* n=124. BF indicates body fat; BMI, body mass index; WHR, waist-hip ratio; U-LBM/W, lean body mass of the upper extremity divided by body weight; T-LBM/W, lean body mass of the trunk divided by body weight; L-LBM/W, lean body mass of the lower extremity divided by body weight; MC, male controls; M−, men with a negative straight leg raise test result; and M+, men with a positive straight leg raise test result.

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### Table 3. Anthropometric Data of the Female Groups*  

<table>
<thead>
<tr>
<th>Group</th>
<th>% BF</th>
<th>BMI†</th>
<th>WHR</th>
<th>U-LBM/W</th>
<th>T-LBM/W</th>
<th>L-LBM/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC (n = 83)</td>
<td>Mean (SD)</td>
<td>27.9 (6.7)‡</td>
<td>22.7 (3.3)</td>
<td>86.5 (5.3)§</td>
<td>6.5 (0.8)</td>
<td>30.8 (2.9)‡</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>12.9-42.7</td>
<td>16.3-31.3</td>
<td>77.0-101.0</td>
<td>4.3-9.9</td>
<td>25.0-39.0</td>
</tr>
<tr>
<td>F− (n = 71)</td>
<td>Mean (SD)</td>
<td>30.5 (6.5)‡</td>
<td>23.1 (3.1)</td>
<td>90.8 (6.4)§</td>
<td>6.5 (0.9)</td>
<td>29.8 (3.1)‡</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>10.0-47.0</td>
<td>17.3-31.3</td>
<td>78.0-114.0</td>
<td>4.8-9.8</td>
<td>23.0-42.0</td>
</tr>
<tr>
<td>F+ (n = 52)</td>
<td>Mean (SD)</td>
<td>28.6 (7.0)</td>
<td>22.1 (3.6)</td>
<td>87.3 (6.3)‡</td>
<td>6.4 (0.6)</td>
<td>30.4 (3.1)</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>17.0-46.0</td>
<td>16.3-30.7</td>
<td>78.0-101.0</td>
<td>5.4-7.6</td>
<td>23.0-34.0</td>
</tr>
</tbody>
</table>

* n=206. BF indicates body fat; BMI, body mass index; WHR, waist-hip ratio; U-LBM/W, lean body mass of the upper extremity divided by body weight; T-LBM/W, lean body mass of the trunk divided by body weight; L-LBM/W, lean body mass of the lower extremity divided by body weight; FC, female controls; F−, women with a negative straight leg raise test result; and F+, women with a positive straight leg raise test result.

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been reports that physical demands, age, and family history, but not obesity, are risk factors for low back pain in Japanese men. Thus, chronic low back pain in men seems to better correlate with factors other than obesity. In this study, the number of female participants was greater than the number of male participants. In Japan, chronic low back pain is more prevalent in women than in men, and a matched number of participants was recruited for the control group. Therefore, a further study is indicated in which many male subjects are enrolled.

A sedentary lifestyle and consumption of food high in fat has become widespread, particularly among urban populations. This lifestyle will likely lead to a reduction in lower extremity and trunk lean body mass and an increase in body fat. This case-control study was based on observations made at only one point. Thus, it is important that we continue to further characterize the relation between reduction in segmental lean body mass and low back pain through longitudinal follow-up.

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REFERENCES