Age-Related Changes in Gait Velocity and Leg Extension Power in Middle-Aged and Elderly People

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To prevent a decline in gait with age, it is necessary to investigate age-related changes in gait performance and detect related factors. The purpose of this study was to assess the association between gait ability and leg extension power among middle-aged and elderly people. Height, weight, maximum gait velocity (MGV) and leg extension power (LEP) were measured in 752 males and females who participated in the National Institute for Longevity Sciences, Longitudinal Study of Aging (NILS-LSA). Age-related changes in MGV and LEP and the association between MGV and LEP were assessed. There were significant decline trends in height, weight, MGV and LEP with advancing age (p<0.001). MGV showed a significantly positive correlation with LEP (in males: r=0.48 p<0.001, in females: r=0.47; p<0.001). Subjects aged 60yrs and over showed a significantly higher correlation than those under 60yrs in males, but not in females, after adjustment for height and weight. Although the relationships between MGV and LEP were different by age and gender, LEP may be one of the important factors in maintaining gait ability.


maximum gait velocity, leg extension power, middle-aged and elderly people

INTRODUCTION

The National Institute for Longevity Sciences has conducted a multidisciplinary longitudinal study on aging, called the NILS-LSA (National Institute for Longevity Sciences, Longitudinal Study of Aging). In this project, the normal aging process has been assessed by detailed questionnaires and examinations including clinical evaluations, blood chemical tests, anthropometry measurements, physical function tests, nutritional analysis, and psychological tests 1). Although gait is an essential part of daily living throughout life, many studies have reported an age-related decline in gait ability 2-6). Thus, in the NILS-LSA, gait has been one of the main research items, and gait step length, pitch, velocity, leg strength, leg extension power (LEP) and static balance have been measured in the gait assessment.

Since maximum performance is considered to indicate the capacity for physical ability, maximum gait velocity (MGV) is regarded as one of the most important measurements of gait ability 2). On the other hand, muscle strength generates the force to move. It was reported that leg strength 7-9) and leg extension power 10) were profoundly related to gait performance. However, in Japan, attempts to measure and study MGV and LEP at the same time among community dwelling adults have been rare. Therefore, we have paid attention to MGV and LEP among the participants in the NILS-LSA.

The purpose of this study was to investigate MGV, LEP, and their association among middle-aged and elderly people in the NILS-LSA. The effect of age on this association with controlling for anthropometry measurements was also examined.

MATERIAL AND METHODS

Subject

The data for this study was derived from baseline data collected as part of the NILS-LSA 1). The subjects consisted of

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362 males and 390 females aged 40-79 years who could walk for 10m independently.

**Maximum Gait Velocity**

MGV was measured with the walking analysis system (YW-3, Yagami Co., Japan) \[^{11}\]. Subjects walked in comfortable shoes. Subjects were asked to walk a distance of 10m along a walkway steadily, with about 1 meter before and after the test distance for acceleration and deceleration. They were required to walk as fast as they could without running for the maximum velocity measurement. To check the start and end point, light sensors were used. The time taken for a 10m walk was recorded.

**Leg Extension Power**

LEP was measured with the help of a sledge ergometer in a sitting position (Leg Power, Takei Co., Japan) \[^{10}\]. The acceleration of the sledge was 0.73m/sec and the sledge stroke was 0.79m. Subjects were fastened by a seat belt to the chair. In the starting position, the feet were placed on a footplate attached perpendicularly to a rail. The hip and the knee angle was adjusted to less than 90°. Subjects were advised to extend their legs as quickly and powerfully as possible, so that the footplate started sliding horizontally on the rail. The highest result of eight trials was taken as the measurement result.

**Statistical Analysis**

All values were given as means ± S.D. and compared by decade of age and gender. Statistical testing was performed using the t-test, analysis of variance, Tukey's method for multiple comparison analysis and a trend test using the Statistical Analysis System (SAS, release.6.12.) \[^{13}\]. Relationships among variables were examined with Pearson's correlation. Partial correlation of LEP with MGV adjusted for height and weight was also calculated and the differences were analyzed between the younger group (less than 60yrs) and older group (60yrs and over).

Significant differences in gait performance between males and females have been reported \[^{4}\]. Therefore, all values were analyzed by gender.

**RESULTS**

Table 1 summarizes the height and weight of the subjects by decade of age and gender. There were significant declines with advancing age in height and weight in both genders (Trend: p<0.001).

Figure 1 shows the results of MGV by decade of age and gender. For MGV, there were significant declines with age for both genders (p<0.001). Females in their 70s showed extremely low velocities.

The results of LEP are shown in Figure 2. LEP in males was significantly stronger than that in females among all age groups (p<0.001). In both genders, there were significant declines in LEP with age (Trend: p<0.001).

The correlation coefficients were examined among age, height, weight, MGV and LEP in both genders (Table 2). Regarding to MGV, age was negatively correlated with MGV in both genders (in males: r=-0.43, in females: r=-0.54, p<0.001). MGV showed a positive correlation with height (r=0.40, 0.39) and LEP (r=0.48, 0.47) in both genders. Weight showed a positive correlation with MGV in males (r=0.28), but no significant correlation with MGV in females. LEP showed

Table 1. Anthropometry of subjects sorted by decade of age and gender.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Height** (cm)</th>
<th>Weight** (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40s</td>
<td>84</td>
<td>168.7 ± 5.6</td>
<td>66.9 ± 9.9</td>
</tr>
<tr>
<td>50s</td>
<td>85</td>
<td>166.1 ± 5.8</td>
<td>61.9 ± 8.2</td>
</tr>
<tr>
<td>60s</td>
<td>94</td>
<td>163.2 ± 5.4</td>
<td>60.9 ± 7.6</td>
</tr>
<tr>
<td>70s</td>
<td>88</td>
<td>160.5 ± 5.3</td>
<td>57.0 ± 8.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40s</td>
<td>89</td>
<td>153.8 ± 4.8</td>
<td>53.9 ± 7.6</td>
</tr>
<tr>
<td>50s</td>
<td>113</td>
<td>153.3 ± 4.8</td>
<td>53.2 ± 7.1</td>
</tr>
<tr>
<td>60s</td>
<td>90</td>
<td>150.2 ± 5.4</td>
<td>52.1 ± 7.7</td>
</tr>
<tr>
<td>70s</td>
<td>98</td>
<td>147.2 ± 6.1</td>
<td>50.3 ± 9.0</td>
</tr>
</tbody>
</table>

Values are means ± S.D.  \(^{**}\) Trend in males and females: p<0.001

![Figure 1. Maximum gait velocity (MGV) by decade of age and gender.](image)
the highest correlation among all variables, with MGV in males, and there was also a positive correlation in females. As it appeared that there were age and gender differences in the association among MGV and other variables, the correlation of LEP with MGV, after controlling for height and weight, was examined by age group (Table 3). The correlation was significant in older males, younger females and older females but not in younger males. The correlation coefficients were compared between the younger group and older group. Although the older group showed a higher correlation than the younger group in both genders, a significant difference between two age groups was found only in males.

DISCUSSION

In this study, MGV declined significantly with advancing age in both genders, as reported in previous studies. Bohannon et al. showed gait velocity can be expected to reduce in individuals of greater age, lower height and lower extremity muscle strength in subjects aged 20-79 years. Our results were in agreement with theirs. Cunningham et al. reported anthropometric variables like height and weight had a relationship with gait and self-selected walking pace. In our study, the subjects' heights and weights decreased with aging. The age-related decline in MGV may be due to these anthropometric changes. However, we have confirmed the decline in gait velocity with aging after controlling for anthropometric variables. It is possible that there were other physiological functions, as well as anthropometric variables, which influenced the age-related decline in this study.

LEP showed a significant decline with advancing in age for both genders. Many previous studies reported that age-related declines were observed in muscle strength and muscle power. Vito et al. discussed that age-related decrement in muscle power were accompanied by muscle quality changes, such as a change in the ability of the nerve system, myosin heavy chain II (MHC-II) reduction or Type II fiber reduction. Although the cause of age-related muscle power changes are still unclear, a change in muscle quality may bring
on a decline in LEP. In this study, we assessed the relationship between MGV and LEP, and LEP was positively correlated with MGV with statistical significance. Rantanen et al. 10 found a similar trend in their study. LEP may thus be one of the most important factors regarding gait ability.

In the present study, the correlation between MGV and LEP was significant among females and older males, even after controlling for anthropometry measurements. These results suggested an increase in power improved gait velocity in these groups. They may be situated within the critical power range for walking. While, LEP did not correlate with MGV significantly among younger males. In this group, LEP was probably not a limiting factor for gait velocity.

Our results showed that the correlation between MGV and LEP was higher in older groups than in younger groups, especially among males. These results suggested that the relationship between MGV and LEP might be non-linear. Buchner et al. reported that the relationship between walking speed and leg strength was non-linear and that there was a threshold in leg strength needed to maintain gait velocity 20. Buchner et al. also insisted that the non-linear relationship between gait velocity and leg strength represented a mechanism by which small changes in physiological capacity may produce relatively large effects on performance in frail adults, while large changes in capacity have little or no effect on daily function in healthy adults. Our study supports their results, and suggests the importance of maintaining muscle function for gait.

A decline in gait ability can lead to a restriction in activities of daily living and, subsequently a loss of quality of life. Therefore, it is obviously important to investigate the mechanism and correlates of gait performance and to find useful strategies to prevent the decline in gait ability. As the NILS-LSA is a multidisciplinary longitudinal study, many variables including physical, psychological and medical measurements have been assessed recurrently. We intend to analyze the relationships between gait ability and those other factors longitudinally.

ACKNOWLEDGEMENTS

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REFERENCE


