Effects of Age and Gender on the Power Generation Capabilities of Lower Limb Muscles in the Elderly

Toshio Yanagiya*, Hiroaki Kanehisa**, Masanobu Tachi***, Kazumi Takeshita****, Norihide Sugisaki***** , Taku Wakahara****, Koichiro Murata***** , Yusuke Takata******, Yasuo Kawakami******, Tetsuo Fukunaga**** and Shinya Kuno******

*School of Health & Sports Science, Juntendo University
1-1 Hiragagakuenndai, Inbamura, Inbagun, Chiba 270-1695 Japan
kazu.azuma@nifty.com

**Department of Life Sciences (Sports Sciences) University of Tokyo
3-8-1 Komaba, Meguro-ku, Tokyo 153-8902 Japan

***Japan Institute of Sports Sciences
3-15-1 Nishigaoka, Kita-ku, Tokyo 115-0056 Japan

****Faculty of Sport Sciences, Waseda University
2-579-15 Mikajima, Tokorozawa, Saitama 359-1192 Japan

*****Graduate School of Human Sciences, Waseda University
2-579-15 Mikajima, Tokorozawa, Saitama 359-1192 Japan

******Center for Tsukuba Advances Research Alliance (TARA), University of Tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki 305-8574 Japan

[Received May 20, 2005 ; Accepted November 4, 2005]

This study aimed to investigate the effects of age and gender on the power generation capabilities of lower limb muscles in the elderly aged from 65 to 79 yrs. In addition to isometric knee extension torque (KT) and leg extension power (LP), mechanical power during movements specific to maximal walking (WP) and running (RP) without arm movements were determined using a non-motorized treadmill in 140 men (71.3±4.0 yrs, mean ±SD) and 172 women (70.2±3.7 yrs). The measured variables were expressed as relative to body mass and then their percentages to mean values for the subjects aged 65 to 69 yrs of men and women, respectively, were calculated. The percentages of all measured variables except for KT in the women were negatively correlated to age in both men (r=-0.207 to -0.375, p<0.05) and women (r=-0.228 to -0.263, p<0.05). In the slope of regression line for the relationship between age and the percentage for each of LP, WP, and RP, no significant differences were found between the men and women and between the variables. In the sub-sample of the subjects, adjusted by their body height and mass, the men (n=31) showed significantly higher values than the women (n=34) in all variables except for WP, with a greater relative difference in LP and RP than in KT. The findings obtained here indicate that, at least in the elderly aged from 65 to 79 yrs, 1) the rate of age-related loss in the power generation capability of lower limb muscles is independent of gender and movement patterns, and 2) power development in the movement form of maximal walking is less influenced by gender as compared to that of maximal running as well as knee extension torque and leg extension power.

Keywords: movement power, non-motorized treadmill, knee extension torque

1. Introduction

Many studies have investigated the effects of gender on the age-related losses of muscle strength (Akima, et al., 2001; Frontera, et al., 1991; Kent-Braun & Ng 1999; Kwon, et al., 2001; Skelton, et al., 1994) and mechanical power developed by explosive or short-term maximal exercises (Bassey, et al., 1992; Bosco & Komi 1980; Meter, et al., 1997; Skelton, et al., 1994), and on the relationships between strength and/or power variables and physical performance (Bassey, et al., 1992; Kwon, et al., 2001; Skelton, et al., 1994). For the elderly, however, few studies have measured muscle strength and power in
the same subjects, and investigated the effects of age and gender on the two variables. To our knowledge, only two studies (Meter, et al., 1997; Skelton, et al., 1994) have given attention to the subject.

Most of our movements during daily life are accompanied with extremity velocity as well as force development, and their performance depends on the product of the two components, i.e., power. Hence, it is reasonable to assume that, for the elderly, power determination is important to assessing functional characteristics. Notably, measurement of the power generation capability of the lower limb muscles in elderly individuals may be useful in investigating their independencies for many basic activities in daily life and organizing effective rehabilitation programs (Bassey, et al., 1992). In most of the studies cited above, however, power determinations have been performed in maximal leg extension or cycling, in which the range of motion was restricted and the resistance loaded was controlled.

Recently, we developed a non-motorized treadmill to determine the mechanical power developed during movements specific to either walking or running (Funato, et al., 2001) and confirmed that this measurement system has been successfully applied to elderly individuals (Yanagiya, et al., 2004). Walking and running are the fundamental forms of most human movements. Walking is an important component of personal mobility and functional independence for elderly individuals (Kwon, et al., 2001). In addition to objective measurements of the strength and power of the lower limb muscles, therefore, power determinations for these forms in elderly populations of both genders may be useful to examine the age- and gender-related differences in the representative scales of functional capability in many routine activities of daily living and in the contribution of the function of limited muscle groups to them.

In the present study, we determined the mechanical power output during movements specific to maximal walking and running using the non-motorized treadmill in elderly men and women. In addition, the isometric knee extension strength and leg extension power were also determined. The purpose of this study was to examine the effects of age and gender on power generation capabilities of lower limb muscles, with a specific emphasis on their relations to the difference in exercise mode for power development.

2. Materials and methods

2.1. Subjects

A total of 312 men (n=140) and women (n=172) aged 65 to 79 yrs voluntarily participated in this study. The mean (±standard deviation, SD) for each of age, height and body mass for the subjects was 71.3 (±4.0) yrs, 162.4 (±5.7) cm and 62.4 (±7.4) kg, respectively, for the men and 70.2 (±3.7) yrs, 149.5 (±5.2) cm and 53.0 (±6.9) kg, respectively, for the women. The height and body mass of each subject were within the normal range of the corresponding age group in each of Japanese men and women. None of the subjects was or had been an athlete. Moreover, none were using sticks or other walking aids and all were functionally independent in daily life. This study was approved by the Office of the Department of Sports Sciences, University of Tokyo and was consistent with their requirements for human experimentation. The subjects were fully informed about the procedures to be used as well as the purpose of the study. Written informed consent was obtained from all the subjects.

2.2. Measurement of muscle strength

The torque output during maximal voluntary isometric knee extension was determined using an isometric torque measurement system (KND-005, VINE, Japan). To standardize the measurements and localize the action to the appropriate muscle group, the subject sat on an adjustable chair with support for the hips and back. In the torque measurements, the right ankle of the subject was fixed to the lever of the dynamometer with a knee joint angle of 90 degrees (full extension = 0 degrees). The rotation axis of the knee joint was aligned with that of the lever arm of the dynamometer.

Before maximal testing the subjects were asked to exert submaximal force isometrically at test position to familiarize themselves with the test procedure. After a process of warming-up and a rest period of 1 minute, the subjects were encouraged to exert maximal force two or three times with an interval of 30 seconds between the trials. The torque produced was recorded continuously, and the peak value of the torque curve was accepted at a given trial. The highest value among these trials was accepted for the subsequent analysis and referred to as KT.
2.3. Measurement of leg extension power

The subjects performed bilateral leg extensions using a constant-load leg extension apparatus (Anaeropress 3500, COMBI, Japan) in accordance with the procedure described in a prior study (Kawakami, et al., 1993). A schematic description of the apparatus has been given in the prior study (Kawakami, et al., 1993). This apparatus enables constant loading over the range of motion. The seat position of the subjects was adjusted so that the knee angle at the start of the push was 90 degrees. During the power measurements, the hips and back of the subject were held tightly in the seat using adjustable lap belts. The subjects, in a seated position on a chair with support for the hips and back, pushed an electrically braked footplate from the flexed position to full extension of the knee joints with maximal effort. The velocity of the movement was measured using a rotary encoder attached to a wheel that set constant loading to the footplate through a wire. The average mechanical power was calculated from the mechanical work, performed in translating the resistance set and in extending the footplate, divided by the time until the velocity peaked. In the maximal testing, the body mass of each subject was applied as a resistance.

Prior to the maximal testing, the subjects were asked to perform the leg extension movements with submaximal effort using test resistance setting to familiarize themselves with the test procedure. After a process of warming-up and a rest period of 1 minute, the subjects performed at least five single maximal voluntary exertions until no further improvements were seen, with rest intervals of 30 seconds between exertions. The highest recorded power output among these trials was taken as the representative value of leg extension power and referred to as LP.

2.4. Measurement of walking and running power

A non-motorized treadmill ergometer (Funato, et al., 2001) was used to measure the mechanical power developed during maximal walking and running. A schema of the apparatus and data acquisition system is shown elsewhere (Funato, et al., 2001). The ergometer was equipped with two force transducers (TR2001, Kyowa, Japan), mounted on the handlebar in order to detect the horizontal pushing force developed by the subject’s hands during locomotion on the belt. The bed of the treadmill was composed of 24 rolling bars under the belt, which allowed a reduction in the friction of the belt-bed. The axis of the front roller was connected to a flywheel, which enabled the smooth movement of the belt by counterbalancing the resistance of the moving belt. A pulse generator was attached to the flywheel to detect the revolution speed of the flywheel. During the test, the subject gripped the handlebar in front keeping both arms straight and horizontal. The height of the handlebar was adjusted to the height of the horizontally straightened arms when each subject performed on the belt. Electrical signals from the force transducers and pulse generator were amplified and fed into a personal computer (Macintosh PowerBook G3/233, Apple, U.S.A.) via an A/D converter (PowerLab/16sp, AD Instrument, Australia) at a rate of 200 Hz. The pulses produced by the pulse generator were converted to the displacement of the belt by multiplying by a conversion factor which was predetermined in a preliminary study on the relationship between the two variables. The instantaneous velocity of the belt was determined by differentiating the horizontal displacement of the belt. The horizontal pushing force and belt velocity were considered to be representing the propulsive force and velocity, respectively (Funato, et al., 2001). Multiplying the instantaneous velocity and propulsive force gave the instantaneous mechanical power in every step. In this study, the mean values of mechanical power in a period of time covering six steps, in which the belt velocity peaked and remained almost at a plateau during maximal walking and running, were calculated as representative scores of performances in the two maximal exercises, and referred to as WP and RP, respectively. The validity of the power measurements made with this ergometer was certified in a prior study (Funato, et al., 2001), in which a comparison was made between the mean horizontal pushing force on the handlebar and the mean horizontal ground reaction force recorded by the force platform during different speeds of walking or running and sprint running with maximal effort. In addition, WP and RP were negatively correlated to the time taken to walk 10 m (r=−0.820, p<0.05) and run 50 m (r=−0.683, p<0.05) with maximal effort, as the results of a preliminary study in which 10 young men were examined.

Prior to the test, the subjects had a warm up

A session of about 5 minutes, which consisted of several kinds of stretching exercise, and walking at their own comfortable speed and running with submaximal effort on the ergometer to familiarize themselves with the apparatus. After completion of the series of warm up exercise and a rest (more than five minutes), the subjects performed firstly the walking test and secondly the running test for about seven seconds two times, respectively. In each task, the subject started to walk or run from a standing position and accelerated as fast as possible. While doing the test, the subjects could monitor the belt velocity shown in a digital counter set in front of them. Firstly, the walking sessions were completed. A rest period of three minutes was taken between the two trials in each of the exercise tasks and between the walking and running sessions, respectively. A digital video camera (30Hz) was used to identify the existence of double support phase in the walking task and air phase in the running task. The higher value in the two trials was taken as a representative score of each of WP and RP.

2.5. Repeatability of torque and power measurements

The repeatability of KT, LP, RP and WP was tested on two separate days in a pilot study examining eight women and seven men. The intraclass correlation coefficient for the test-retest was \( r = 0.926 \) for KT, \( r = 0.948 \) for LP, \( r = 0.941 \) for RP and \( r = 0.872 \) for WP. The mean value for the coefficient of variation of the two measurements for every score was 6.6% for KT, 7.1% for LP, 6.8% for RP and 6.8% for WP. There was no significant difference between the mean values of the two tests in each of the four scores.

2.6. Statistical analyses

Descriptive data were presented as the mean and SD for each subject group. KT, WP, RP and LP were expressed as relative to body mass and referred to as \( \text{KT}\cdot\text{BM}^{-1} \), \( \text{WP}\cdot\text{BM}^{-1} \), \( \text{RP}\cdot\text{BM}^{-1} \) and \( \text{LP}\cdot\text{BM}^{-1} \), respectively. Furthermore, these variables were expressed as percentages of mean values for the subjects aged from 65 to 69 yrs of men and women, respectively, and were used to examine the correlations with age. Student’s t-test was used to test the significance of the difference between the means of the men and women. A simple linear regression analysis was used to calculate the correlation coefficients between age and each of the measured variables. The significance of the differences in the rates of age-related losses in strength and power variables between genders and between the measured variables were tested by regression analysis on the slope of the regression line for the relationship between age and measured variables. Since the men were significantly taller and heavier than the women, analyses of sub-sample matched for body height and mass were performed. Subjects were selected in accordance with a range of the value of mean – 1.5 SD in the men as the lowest and the value of mean + 1.5 SD in the women for body height and mass: from 153.8 to 157.3 cm for body height and from 51.0 to 63.4 kg for body mass. This sub-sample consisted of 31 men (age = 70.9 ± 4.3 yrs, body height = 156.2 ± 2.5 cm, body mass = 58.6 ± 6.6 kg) and 34 women (age = 70.6 ± 4.0 yrs, body height = 155.1 ± 2.7 cm, body mass = 56.5 ± 6.4 kg). In the sub-sample, there were no significant differences in age, body height and mass. Statistical significance was set at \( p < 0.05 \). In addition, statistical significance for the correlation coefficient in the non-selected sample was tested as that the number of the subject was \( \infty \) (\( r = 0.195 \) at \( p = 0.05 \)) (Vincent 1995).

3. Results

3.1. Basic data in the measured variables

Table 1 shows descriptive data obtained from the non-selected sample. The percentages of the mean values of torque and power variables for the women to those for the men were 57.6 to 77.6% in terms of the absolute value. The corresponding values increased to 74.0 to 91.8%, when the torque and power variables were expressed as relative to body mass. In both the absolute value and the value relative to body mass, the men showed significantly greater values than the women in all variables, with a tendency that the relative difference was largest in LP and smallest in WP.

3.2. Age-related changes in the measured variables

Figure 1 shows the relationship between age and each of KT\cdot\text{BM}^{-1}, WP\cdot\text{BM}^{-1}, RP\cdot\text{BM}^{-1} and LP\cdot\text{BM}^{-1}, respectively.
Gender-related Differences in Walking and Running Power

Table 1 Descriptive data on knee extension torque (KT), leg extension power (LP), walking power (WP) and running power (RP) in non-selected sample.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Men, n=140</th>
<th>Women, n=172</th>
<th>W/M (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KT, Nm</td>
<td>104.6±29.7</td>
<td>71.6±19.0</td>
<td>68.5</td>
</tr>
<tr>
<td>KT•BM⁻¹, Nm·kg⁻¹</td>
<td>1.68±0.46</td>
<td>1.36±0.37</td>
<td>81.0</td>
</tr>
<tr>
<td>LP, W</td>
<td>791.2±277.6</td>
<td>456.0±163.2</td>
<td>57.6</td>
</tr>
<tr>
<td>LP•BM⁻¹, W·kg⁻¹</td>
<td>12.7±4.3</td>
<td>9.4±3.1</td>
<td>74.0</td>
</tr>
<tr>
<td>WP, W</td>
<td>69.3±23.8</td>
<td>53.8±17.2</td>
<td>77.6</td>
</tr>
<tr>
<td>WP•BM⁻¹, W·kg⁻¹</td>
<td>1.11±0.36</td>
<td>1.02±0.30</td>
<td>91.8</td>
</tr>
<tr>
<td>RP, W</td>
<td>111.8±44.7</td>
<td>72.1±26.0</td>
<td>64.5</td>
</tr>
<tr>
<td>RP•BM⁻¹, W·kg⁻¹</td>
<td>1.80±0.73</td>
<td>1.37±0.48</td>
<td>76.1</td>
</tr>
</tbody>
</table>

Values are mean ± SD.
KT•BM⁻¹, KT relative to body mass; LP•BM⁻¹, LP relative to body mass; WP•BM⁻¹, WP relative to body mass; RP•BM⁻¹, RP relative to body mass; W/M(%), the percentage of the average value for the women to that for the men.
The average values for the men were significantly (p<0.05) greater than those for the women in all variables.

Figure 1 Relationship between age and each of knee extension torque (KT•BM⁻¹, left upper panel), leg extension power (LP•BM⁻¹, right upper panel), walking power (WP•BM⁻¹, left lower panel) and running power (RP•BM⁻¹, right lower panel), expressed as relative to body mass. The values were the percentages of mean values for the subjects aged 65 to 69 yrs of men and women, respectively.
BM$^{-1}$, expressed as percentages of mean values for the subjects aged 65 to 69 yrs of men and women, respectively. The all variables were negatively correlated to age in both men ($r$=-0.207 to -0.375, $p<0.05$) and women ($r$=-0.228 to -0.263, $p<0.05$), with an exception that the relationship between age and KT•BM$^{-1}$ for the women was insignificant ($r$=-0.138, $p>0.05$). For the men, the slopes of regression lines for the relationships between age and power variables were steeper than that between age and KT•BM$^{-1}$, but the $p$ values of regression analyses for the differences were not significant ($p=0.066$ to 0.235). In the slope of regression line for the relationship between age and each of WP•BM$^{-1}$, RP•BM$^{-1}$ and LP•BM$^{-1}$, too, there were no significant differences between the men and women and between the variables, indicating that the rates of the age-related losses in power variables are independent of gender and mode of the power development.

### 3.3. Gender-related differences in the measured variables of the selected-sample

Descriptive data obtained from the selected-sample are presented in Table 2. There were no significant differences between the men and women in WP and the value relative to body mass. In the other variables, however, the men showed significantly greater values than the women as observed in the non-selected sample.

### 4. Discussion

The main results obtained here were that 1) there were no significant differences between genders and between the measured variables in the rate of age-related losses in torque and power variables, and 2) power development during the movement form of maximal walking was less influenced by gender as compared to that of maximal running as well as knee extension torque and leg extension power.

Skelton et al.(1994) determined isometric knee extension strength and leg extension power in men and women aged from 65 to 89 yrs and examined whether the rates of age-related losses in these variables differs between genders. In their results, the decline of power was faster than that of strength in men, but not significantly so in women. From the findings of Metter et al.(1997), who examined age-related reductions in cranking power and isometric strength for the upper extremity, strength and power declined beginning by age 40 in both women and men. Thereafter, power declined about 10% more than strength in men, while no significant differences were found in women (Metter, et al., 1997). These findings contradict to the present results that only the men showed a significant loss across age in KT•BM$^{-1}$ and its rate of the age-related loss, based on the slope of regression line for the relationship with age, did not significantly differ from those in power variables. In addition, the

<table>
<thead>
<tr>
<th>Variables</th>
<th>Men, n=31</th>
<th>Women, n=34</th>
<th>W/M (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KT, Nm</td>
<td>89.8±27.5</td>
<td>71.2±17.6</td>
<td>79.3</td>
</tr>
<tr>
<td>KT•BM$^{-1}$, Nm•kg$^{-1}$</td>
<td>1.55±0.48</td>
<td>1.28±0.34</td>
<td>82.6</td>
</tr>
<tr>
<td>LP, W</td>
<td>695.5±291.6</td>
<td>443.4±160.5</td>
<td>63.8</td>
</tr>
<tr>
<td>LP•BM$^{-1}$, W•kg$^{-1}$</td>
<td>11.9±5.0</td>
<td>8.0±3.1</td>
<td>67.2</td>
</tr>
<tr>
<td>WP, W</td>
<td>60.8±22.3</td>
<td>54.2±16.0</td>
<td>89.1</td>
</tr>
<tr>
<td>WP•BM$^{-1}$, W•kg$^{-1}$</td>
<td>1.04±0.37</td>
<td>0.96±0.24</td>
<td>92.3</td>
</tr>
<tr>
<td>RP, W</td>
<td>92.8±37.3</td>
<td>71.5±23.7</td>
<td>77.0</td>
</tr>
<tr>
<td>RP•BM$^{-1}$, W•kg$^{-1}$</td>
<td>1.59±0.62</td>
<td>1.26±0.35</td>
<td>79.2</td>
</tr>
</tbody>
</table>

Values are mean ± SD.

KT•BM$^{-1}$, KT relative to body mass; LP•BM$^{-1}$, LP relative to body mass; WP•BM$^{-1}$, WP relative to body mass; RP•BM$^{-1}$, RP relative to body mass; W/M(%), the percentage of the average value for the women to that for the men.

The average values for the men were significantly ($p<0.05$) greater than those for the women in all variables except for WP•BM$^{-1}$.  

International Journal of Sport and Health Science Vol.4, 435-443, 2006
rates of the age-related losses in LP•BM⁻¹, WP•BM⁻¹ and RP•BM⁻¹ were independent of genders and measured variables. Reasons for the discrepancy are unknown but might involve the difference between the present and previous studies in the range of the ages in samples examined. Namely, the present study examined the subjects aged from 65 to 79 yrs. In the results of Skelton et al.(1994) and Metter et al.(1997), the loss of the age-related decline in power for men was more accelerated from 80 years of age. This resulted that men showed a greater difference between strength and power than other younger groups (Metter, et al., 1997). Taking these points into account, it may be assumed that the men examined here were not so older to show a significant difference between the age-related losses of strength and power, and consequently, it resulted in a similar rate of the age-related loss in power between the men and women.

In the findings of previous studies on elderly populations with a similar average age as that of the present subjects, the percentages of mean values for women in knee extension strength and leg extension power to those for men vary from 57 to 89% (Borges 1989; Skelton, et al., 1994; Kwon, et al., 2001) and 59 to 71% (Bassey, et al., 1994; Skelton, et al., 1994), respectively. The corresponding values observed here (69% for KT and 58% for LP) were ranked within the ranges mentioned above. In addition, the present result that the relative difference between men and women was greater in LP•BM⁻¹ than in KT•BM⁻¹ agrees with the finding of Skelton et al.(1994). In respect of gender differences in the torque and power generation capabilities of the lower limb muscles in 60- and 70-yr-olds, therefore, it is reasonable to assume that the subjects examined in this study have a similar profile as those in the prior studies.

It has been documented that knee extension strength or leg extension power is more closely correlated to performance scores in chair raise, stair climb or walking in elderly women than men (Bassey, et al., 1992; Kwon, et al., 2001; Ploutz-Snyder, et al., 2002; Rantanen and Avela, 1997). Bassey et al.(1994) reported that the performance measures for elderly women were on average all poorer, but considerably overlapped with those for men, in spite of a large difference in leg extension power. Moreover, Kwon et al.(2001) showed that there was a linear relationship between gait time and knee extensor strength only to a specific strength level, above which the relationship became plateau. In their results, a greater number of men were plotted in the plateau part of the relationship, but that of women in the linear part. These findings support the present result that WP•BM⁻¹ was less influenced by gender in spite of significant differences in KT•BM⁻¹ and LP•BM⁻¹.

With regard to the gender differences in WP and RP, no comparable data is available from previous studies. However, some researchers have assessed power generation capability during maximal walking or running in the elderly by the use of a stair climbing test (Margaria, et al., 1966; Bassey, et al., 1992), in which mechanical power was calculated as the product of body mass and the speed of vertical ascent. For example, Margaria et al.(1966) have reported an age-related change in mechanical power while subjects run up the stairs at maximal speed. In their results, however, the magnitude of the gender-related difference in the power for the elderly was not presented. Applying a similar procedure for power determination as presented by Margaria et al.(1966), Bassey et al.(1992) have calculated mechanical power while subjects walk up stairs at maximal speed and found no significant difference between elderly men and women in the stair climbing power. In the present study, the relative difference between the men and women was greater in RP•BM⁻¹ than in WP•BM⁻¹. In addition, as the result of sub-sample comparison, although RP•BM⁻¹ was still significantly higher in the men than the women, WP•BM⁻¹ was similar in the two genders. Hence, it is likely that, at least for the elderly population aged from 65 to 79 yrs, power development in the movement form of maximal walking is less influenced by gender as compared to that of maximal running.

We have no physiological and biomechanical data explaining the greater gender-related difference in RP than in WP. As the physiological backgrounds, however, the gender-related differences in the size of muscle fibers recruited and/or neuromuscular activities during multi joints explosive exercises might be involved. From the findings of Trappe et al.(2003), who examined the effects of gender and age on in vitro force-velocity properties of the vastus lateralis muscle, peak power of fast single muscle fiber for elderly women was significantly lower than that for elderly men, but the difference
became insignificant when the peak power was normalized to muscle cell size. In their results, there were no significant differences between elderly men and women in peak power and the value relative to muscle cell size for slow single fiber. In addition, Anton et al. (2004) indicated that, based on the comparison between weightlifting and powerlifting performances, the age-related rates of decline are greater in women than in men only in the events that require more complex and explosive power. These findings might be related to the present result that the gender difference was more apparent in RP as well as LP.

In summary, the findings obtained here indicate that, at least in the elderly aged from 65 to 79 yrs, 1) the rate of age-related loss in the power generation capability of lower limb muscles is independent of gender and movement patterns, and 2) power development in the movement form of maximal walking is less influenced by gender as compared to that of maximal running as well as knee extension torque and leg extension power.

Acknowledgements
This study was partly supported by financial aid from the Ministry of Education, Culture, Sports, Sciences and Technology (no.12480007) and the Basic Research for Life and Society, STA.

References
Name: Toshio Yanagiya

Affiliation: School of Health & Sports Science, Juntendo University

Address: 1-1 Hiragagakuenndai, Inbamura, Inbagun, Chiba 270-1695 Japan

Brief Biographical History:
2000-2002 Research Assistant, Department of Human Sciences, Waseda University
2003 Full-time Visiting Lecturer, Department of Sport Sciences, Waseda University
2004- Full-time Lecturer, School of Health and Human Sciences, Juntendo University

Main Works:

Membership in Learned Societies:
• Japanese Society of Biomechanics
• Japanese Society of Exercise and Sports Physiology
• The Japanese Society of Physical Fitness and Sports Medicine