〔研究論文〕

女性高齢者における年齢と脊柱彎曲レベルによる筋力と QOL への影響

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INFLUENCE OF AGE AND SPINAL CURVATURE ON MUSCLE STRENGTH AND QUALITY OF LIFE IN ELDERLY WOMEN

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我々は高齢者の脆弱化指標の一つといえる脊柱彎曲に着目し、それらのレベルによる身体・心理・社会的機能の相違について基礎的資料を得るために、骨粗鬆症になりやすい女性高齢者を対象として筋力と QOL の相違を明らかにした。対象者は 60 歳以上の女性 68 名（平均年齢は 74.8 歳）で、年齢と脊柱彎曲レベル（20 度未満と 20 度以上）によって、以下の 6 群に分けた：L60VB（60 歳代で脊柱彎曲レベルは 20 度未満、15 名）、H60VB（60 歳代 20 度以上、6 名）、L70VB（70 歳代 20 度未満、10 名）、H70VB（70 歳代 20 度以上、14 名）、L80VB（80 歳以上 20 度未満、8 名）、H80VB（80 歳以上 20 度以上、15 名）。握力と大腿四頭筋では、L60VB が同年代の H60VB を含めた他群すべてよりも有意に高値で、脊柱彎曲を有する高齢女性はそうでない高齢女性よりも筋肉量や筋力の減少速度が速い可能性を示唆しうるものと考えられた。QOL の「身の回りのこと」「家事」「移動」「娯楽・社会的活動」でも、H80VB 群が他群すべてよりも有意に低く、日常生活動作の範囲が極端に限定されていることが明らかとなった。QOL の「転倒・心理的要素」では、どの年代においても脊柱彎曲レベル 20 度以上群が 20 度未満群よりも転倒に対する不安・恐怖心が強い傾向がみられた（ANOVA, p=0.0027）。以上より、脊柱彎曲のある女性高齢者は、そうでない高齢者よりも、筋力や QOL に悪影響を及ぼしている可能性が示唆された

キーワード：女性高齢者、脊柱彎曲、筋力、生活の質
Key words：elderly women，spinal curvature，muscle strength，quality of life (QOL)

Abstract

Spinal curvature caused by osteoporosis is believed to be common among elderly women. In the present study, we analyzed spinal curvature as an indicator of age-related change and determined the effect of age and spinal curvature on muscle strength and quality of life among 68 elderly women, in order to provide the basic data for understanding the physical, psychological, and social characteristics of elderly women. Subjects were 60 years or over, average, 74.8 years. Based on age (60-69; 70-79; 80+) and spinal curvature (<20 degrees; ≧ 20 degrees), subjects were classified into six groups. Grip strength and quadriceps femoris strength were significantly higher in those aged 60-69 with <20° spinal curvature than in other groups, including individuals of the same age with greater spinal curvature. These findings suggest that women in their 60's with marked spinal curvature experience accelerated loss of muscle mass and strength compared to those in the same age group without this deformity. In terms of QOL, the scores for "Personal appearance and hygiene", "Domestic chores", "Mobility" and "Recreational and social activities" for the H80VB group were significantly lower than those for the other groups, thus clarifying that elderly individuals in their 80's with spinal curvature of 20 degrees or higher have an extremely limited range of activities of daily living. As far as "fall and psychological factors" are concerned, in all three age groups, the level of fear and anxiety for falling was greater for women with spinal curvature of 20 degrees or higher (ANOVA, p=0.0027). These findings suggest the possibility that muscle strength and QOL are more adversely affected in elderly women with spinal curvature (kyphosis) than in those without it.

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INTRODUCTION

In Japan, the Long-term Care Insurance system was implemented in April 2000, and the number of users increased from 1.49 million in the first year to 4.14 million in 2004, an increase of 62%. In addition, the total cost of the system has rapidly increased from 3.6 to 5.5 trillion yen over the same period (Ministry of Health, Labor and Welfare of Japan, 2002 and 2005). In 2015, when the baby-boom generation (those born between 1947 and 1949) reaches the age of 65 years, there will be 32.77 million people over the age of 65 years, and the proportion of the elderly and very elderly in the population is expected to reach 26.0 and 12.5%, respectively. Since average life expectancy for Japanese women is increasing every year, the proportion of elderly Japanese women is anticipated to increase (Ministry of Health, Labor and Welfare of Japan, 2003).

Under these circumstances, the necessity for preventing the elderly from requiring care is an urgent political issue. It is seen as important for elderly people to lead high-quality independent lives, and in particular, the importance of preventing osteoporosis, a disease that is specific to the elderly, is well recognized. Osteoporotic individuals can easily sustain fractures from falling, and as a result, osteoporosis can cause elderly persons to become housebound or bedbound. Since bone mineral density decreases suddenly after menopause, the risk for osteoporosis is higher for women when compared to men (Orimo et al, 2001), and as a result, active prevention, including dietary and exercise therapy, is necessary.

In the present study, we analyzed spinal curvature (kyphosis) as an indicator of age-related change and clarified the effects of spinal curvature on the physical, psychological, and social functioning of elderly women. Spinal curvature is caused by degenerative thoracic or lumbar kyphosis, which results from remaining in one position for a long period of time, and compressive fracture of the spine due to osteoporosis. Spinal curvature caused by osteoporosis is believed to be common among elderly women (Mitta, 1998; Morii, 1999). Studies have clarified that digestive tract symptoms and pain associated with spinal curvature affect the activities of daily living in the elderly (Nakano, 2001; Taniguchi, 2000), but none have comprehensively analyzed muscle force and QOL (Aida et al, 2005). The present study is significant because it provides the basic data for understanding the physical, psychological, and social characteristics of elderly women with different degrees of spinal curvature.

PURPOSE

The purpose of this study was to determine muscle strength and quality of life (QOL) among 68 elderly women with respect to age and spinal curvature.

MATERIALS AND METHODS

1. Subjects

Subjects were 68 elderly women living in Tokyo metropolitan area, and were older than 60 years of age who were belonging to the following two ranks defined by the " Assessment Criteria for Independence in Activities of Daily Living for Disabled Elderly " (Ministry of Health, Labor and Welfare of Japan, 1991): Rank J (slight disability, but independence in activities of daily living is maintained; able to go out without assistance) or Rank A (mostly independent indoors, but unable to go outside without assistance). We excluded individuals with: respiratory diseases; physical paralysis caused by cranial neuropathies; or spinal diseases, besides other than osteoporosis, that could have affected spinal curvature, muscle strength or respiration. Average age of subjects was 74.8 years (SD: 9.2). The purpose of the study was explained individually to obtain written consent. The study was conducted in August 2003. <Table 1>

Subjects were divided into the following six groups with respect to age and spinal curvature: L60VB, L70VB, L80VB (spinal curvature $<$ 20 degrees, age = 60-69 years, 70-79 years, and $\geqq$ 80 years, respectively.), H60VB, H70VB, and H80VB (spinal curvature $\geqq$ 20 degrees, age = 60-69 years, 70-79 years, and $\geqq$ 80 years, respectively). Twenty degrees was selected as the cut-off value as spinal curvature was 17.2 degrees ((mean spinal curvature in 8 healthy female adults)+ 2SD; 15.8+1.4) and 20.6 $\pm$ 3.5 (mean $\pm$ SD) for the 68 subjects. Table 1 shows the characteristics and spinal curvature of the 68 subjects in the six groups.

2. Methods

Spinal curvature

Degree of spinal curvature has been assessed by quantifying posture, evaluating sagittal spinal alignment, and measuring pelvic inclination, and reliability and validity of these methods have been investigated (Suzuki, 1978; Burdett et al, 1986; Jackson & McManus, 1994; Bennell et al, 2000; Taniguchi et al, 2000; Harada et al, 2001). In the present study, as spinal curvature was assessed in the welfare center within certain time constraints, it was necessary to employ a technique that was easy to perform and minimize fatigue.

Figure 1 shows the method used to quantify degree of spinal curvature in the present study. With clothes on, each subject was asked to assume a natural standing position

Table 1 Characteristics and spinal angle for the 68 subjects with respect to age and spinal curvature

	L60VB (n=15)	H60VB (n=6)	L70VB (n=10)	H70VB (n=14)	L80VB (n=8)	H80VB (n=15)
Age (yr)	62.6±3.0	66.2±2.3	73.4±3.0	76.2±2.7	82.6±2.0	85.7±4.3
Independence in ADL						
Rank J	15 (100%)	5 (83.3%)	8 (80.0%)	11 (78.6%)	2 (25.0%)	2 (13.3%)
Rank A	0 (0.0%)	1 (16.7%)	2 (20.0%)	3 (21.4%)	6 (75.0%)	13 (86.7%)
Body Mass Index	21.6±2.6	24.3±4.0	23.1±3.3	23.2±3.0	21.4±3.0	22.4±2.4
Smokers	2 (13.3%)	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Osteoporosis	0 (0.0%)	1 (16.7%)	5 (50.0%)	5 (35.7%)	2 (25.0%)	0 (0.0%)
Past medical history of fracture	1 (6.7%)	0 (0.0%)	3 (30.0%)	2 (14.3%)	1 (12.5%)	1 (6.7%)
Exercise habits						
"exercise at least once a week and go out almost daily"	10 (66.7%)	1 (16.7%)	4 (40.0%)	5 (35.7%)	2 (25.0%)	2 (13.3%)
"do not exercise regularly but go out almost daily"	5 (33.3%)	3 (50.0%)	4 (40.0%)	6 (42.9%)	3 (37.5%)	2 (13.3%)
"do not exercise regularly and go out less than 3 days a week"	0 (0.0%)	2 (33.3%)	2 (20.0%)	3 (21.4%)	3 (37.5%)	11 (73.4%)
Degrees of spinal curvature	17.1±1.5	22.5±2.1	18.2±1.1	21.9±1.7	18.8±0.8	24.5±3.2
Range	15.0-19.5	20.5-25.0	16.0-19.5	20.0-25.5	17.5-19.5	21.5-33.5

Independence of ADL (Assessment Criteria for Independence in Activities of Daily Living for Disabled Elderly, Ministry of Health, Labor and Welfare of Japan, 1991): Rank J (slight disability, but independence in activities of daily living is maintained; able to go out without assistance) or Rank A (mostly independent indoors, but unable to go outside without assistance).

† Plus-minus values are means±standard deviation.
‡ Spinal curvature for groups L60VB, L70VB and L80VB (subjects aged 60-69, 70-79, and ≧80, respectively) was less than 20 degrees. Spinal curvature for groups H60VB, H70VB and H80VB (subjects aged 60-69, 70-79, and ≧80, respectively) was 20 degrees or greater.

facing forward. A red sticker was placed on the clinically determined center of gravity for the lower body, which was named“ Point G ”(the intersection between half the horizontal width of the thigh and one-third the length of the thigh (Fukui, 1997)). Subjects were then photographed from the left side using a digital camera. When instability was marked or risk of fall was apparent, subjects grasped a rail with the dominant hand. As shown in Figure 1, we established the following three points: the eyeball (Point E), Point G , and the most posterior point of the back (Point B). Therefore, as a measure of relative spinal curvature in the present study, spinal curvature (VB) was defined as the angle formed by points E, G and B. With this method, it was necessary to take into account the effect of body shape, thin or obese. However, since no significant intergroup differences were apparent in body shape or BMI, we just measured VB without calculating its ratio to the maximum width (length) of the upper body viewed from the left side. <Figure 1>

Muscle strength

The following three parameters were measured bilaterally using a dynamometer (Isoforce GT-300/305/310/315 OG GIKEN KK, Japan): pinch strength (strength of thumb/index finger pinch), grip strength, and quadriceps femoris strength. The accuracy of each device was as follows: controller GT-300 ± 1%FS, pinch force sensor GT-305 ± 1%FS (1 N/0.1 kgf), manual muscle force sensor GT-310 ± 1%FS (5 N/0.5 kgf), and micro grip strength sensor GT-315 ± 1%FS (6 N/0.6 kgf). When measuring quadriceps femoris strength, each subject was asked to sit in a chair with a backrest, and a muscle strength sensor was placed 5 cm proximal to the knee. On verbal command from a researcher, the subject was asked to raise the thigh as hard as possible against the sensor. As a general rule, duplicate measurements were taken on each side and the greatest was used.

Quality of life

Quality of life (QOL) was assessed using the QOL assessment questionnaire for osteoporosis patients developed by the Osteoporosis Patient QOL Study Group of the Japanese Society for Bone and Mineral Research (Takahashi, 2001). Subjects were asked to fill out the questionnaire on their own, but when this was not feasible, questionnaires were completed by a researcher at interview. The questionnaire consists of 14 questions about the subject ’ s characteristics and 39 that assess the following seven items:“ pain ” ,“ activities of daily

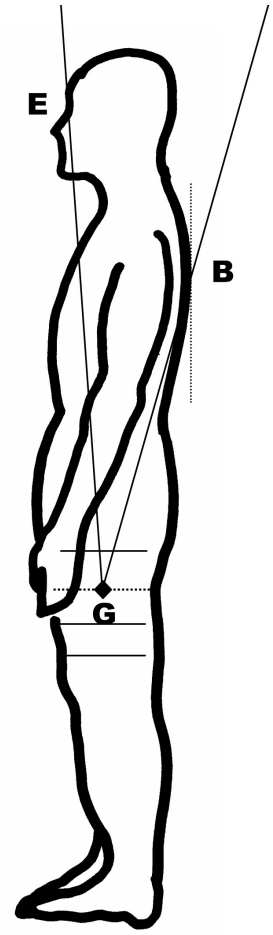


Figure 1. Measurement of spinal curvature in the present study

Subjects assumed a natural stance, facing forward. The clinically determined center of gravity for the lower body was named "Point G". We established three morphometric points and calculated the angle EGB of spinal curvature according to the spatial relationship between these points.

living ", " recreational and social activities ", " general health status ", " posture and body shape ", " fall and psychological factors ", and " overall. "Only" activities of daily living "had sub-items (1) personal appearance and hygiene, (2) domestic chores, and (3) mobility. Most questions were answered using a five-point scale; the higher the score, the better the QOL. The last four questions were answered using a three-point scale, and scores were reversed so that higher scores indicated better QOL. The one question regarding " overall " QOL was removed from the questionnaire as it is only relevant to individuals diagnosed with osteoporosis.

3. Statistical analysis

Statistical analysis was conducted using one-way ANOVA and Bonferroni tests to assess inter-group differences in means of muscle strength and QOL. All analyses were performed using Dr. SPSS II for Windows (with exact testing), with significance level set at < 5%.

4. Ethical considerations

In order to minimize physical and psychological stress on the elderly subjects, we employed measurement techniques that were convenient and not time-consuming; all necessary measurements were performed in around 30 minutes. The present study was designed in accordance with the standards established by the ethical review board of the university and the Helsinki Declaration. It was also reviewed and approved by the ethics committee of Tokyo Women ' s Medical University.

RESULTS

Figure 2 shows average pinch, grip, and quadriceps femoris strengths for each group. When compared to the L60VB group, these three strength parameters were significantly lower for the H70VB, L80VB, and H80VB groups. Grip and quadriceps femoris strengths were significantly higher in the L60VB group than in other groups, including the H60VB group (p=0.012, p=0.021). <Figure 2>

Figure 3 shows the results of an analysis of average QOL scores. For all items, higher scores indicated better QOL. On one-way ANOVA significant differences in the subscores for " Personal appearance and hygiene " (p=0.01), " Domestic chores " (p<0.0001), " Mobility " (p<0.0001), and " Recreational and social activities " (p=0.04) were observed, and a multiple comparison test showed that these were significantly lower in the H80VB group. Subscores for " Domestic chores " were significantly higher in the L80VB group than in the H80VB group (p=0.013). In all three age groups, the level of fear and anxiety related to falling (" fall and psychological factors ") was greater for women with

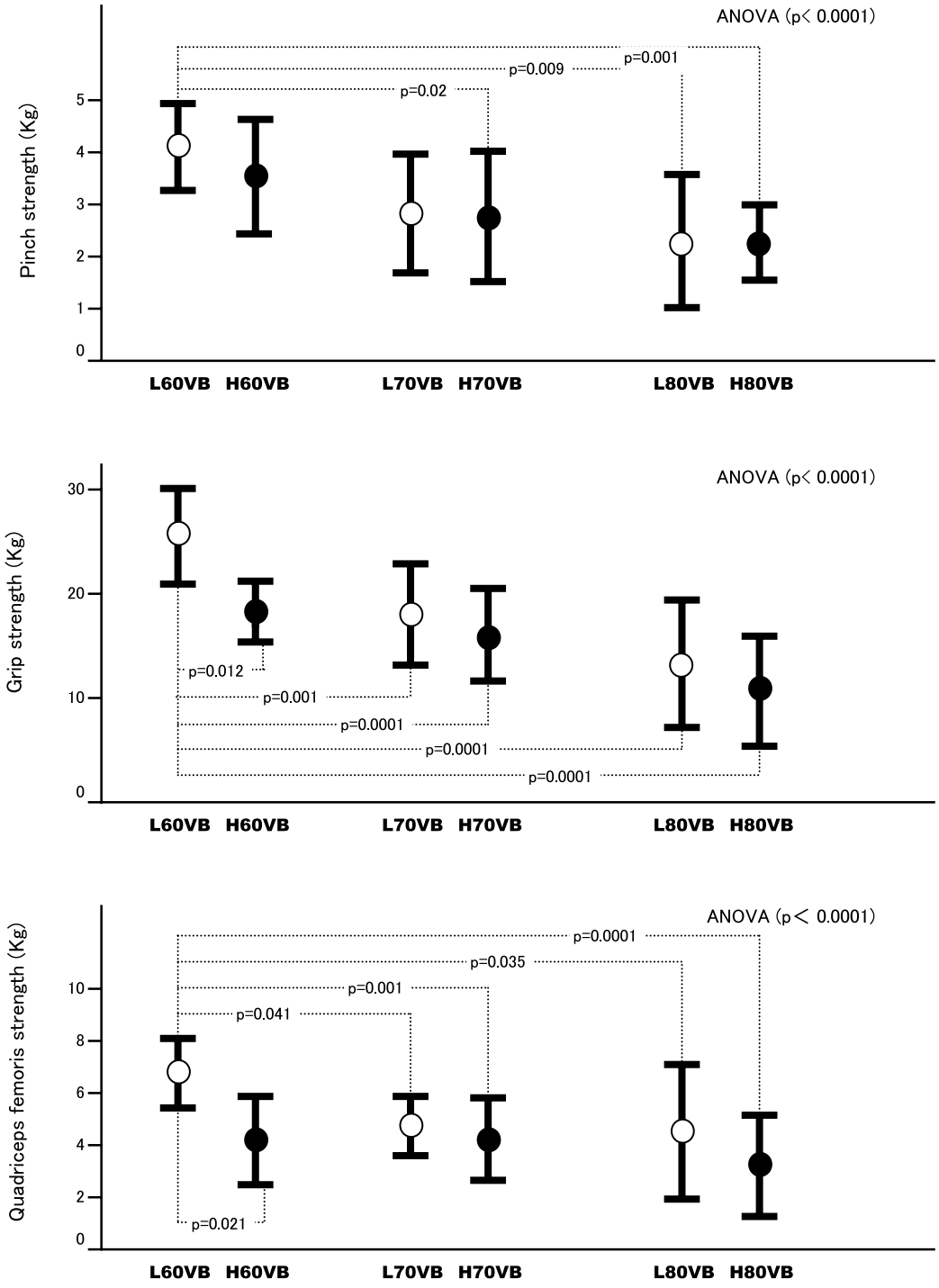
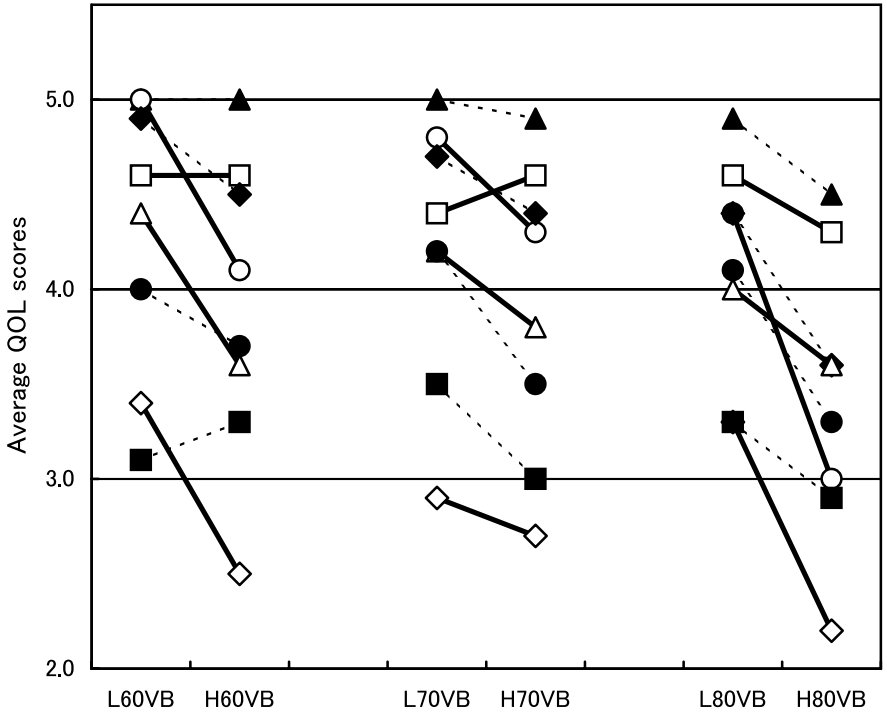


Figure 2. Intergroup comparison of muscle strength (mean±standard deviation)

† One-way ANOVA p values are displayed in the right upper corner of the figure.
‡ P values within the figure were obtained by a multiple comparison (Bonferroni) test.
§ Spinal curvature was ＜20 degrees for groups L60VB, L70VB, and L80VB (subjects aged 60-69, 70-79, and ≧80 respectively) and ≧20 degrees for groups H60VB, H70VB, and H80VB.



Items and sub-items of QOL	*p* values by one-way ANOVA	Bonferroni test †
Pain	ns	—
Personal appearance and hygiene	0.01	H80/L60, L70 (0.014, 0.042)
Domestic chores	< 0.0001	H80/L60, L70, H70, L80 (0.0001, 0.0001, 0.005, 0.013)
Mobility	< 0.0001	H80/L60, L70 (0.0001, 0.004)
Recreational and social activities	0.04	H80/L60 (0.035)
General health status	ns	—
Posture and body shape	ns	—
Fall and psychological factors	0.027	—

Figure 3. Intergroup comparison of mean QOL scores and results of one-way ANOVA and Bonferroni tests

† The Bonferroni test column shows results for group combinations exhibiting significant differences on multiple comparison test. For example, "H80/L60, L70 (0.01, 0.001)" indicates that the difference between the H80VB and L60VB groups was 0.01 and that between the H80VB and L70VB groups was 0.001.
‡ Average QOL score was calculated by determining the score per question for the six items (total score ÷ number of questions) for each group. The higher the QOL score, the better the QOL. For "Pain" and "Fall and psychological factors", the higher the score, the lower the pain and fear of falling.
§ Spinal curvature was <20 degrees for groups L60VB, L70VB, and L80VB (subjects aged 60–69, 70–79, and ≧80 respectively) and ≧20 degrees for groups H60VB, H70VB, and H80VB.

spinal curvature of ≧ 20 degrees (ANOVA, p=0.0027); however, multiple comparison tests did not detect a significant difference. <Figure 3>

DISCUSSION

In terms of muscle strength, grip strength, and quadriceps femoris strength, which are important for ADL, were significantly higher in the L60VB group than the other groups, including the H60VB group. According to the literature on age-related sarcopenia, muscle mass begins to decrease from the age of 25 years, even in healthy adults (Moulias et al, 1999). After age 40, muscle mass decreases by 0.5% every year and this accelerates from age 65, with 30-40% of muscle mass being lost by age 80 (Leeuwenburgh, 2003). As to muscle strength, it has been reported that 30-50% of muscle strength is lost between the ages of 30 and 80 years, although individual differences exist (Frischknecht, 1998). Annual loss in muscle strength is reported at 1% (Moulias et al, 1999). These findings suggest that women in their 60 ' s with marked spinal curvature experience accelerated loss of muscle mass and strength compared to those in the same age group without this deformity.

Spinal curvature causes complaints such as skeletal muscle pain, diaphragmatic hernia, and reflux esophagitis. Furthermore, due to fear of falling or worsening pain, the range of activities of daily living becomes limited, thus increasing the risk of immobility and disuse syndrome (Arai et al, 1995; Lexell et al, 1998; Mitta, 1998; Morii, 1999; Nakano & Tsurukami, 2001; Walker & Howland, 1991). As far as QOL is concerned, the results showed that anxiety and fear of falling (fall and psychological factors) were stronger for the women with ＜ 20 ° spinal curvature when compared to those with ≧ 20 ° curvature in all age groups. In particular, QOL of domestic chores for the H80VB group was significantly lower than that for the L80VB group, suggesting that spinal curvature has marked effects; not only on physical parameters, but also on psychological parameters and activities of daily living.

At present, to address physical fragility in the elderly, basic studies are being actively conducted to ascertain the effects of muscle strength training in improving mobility by alleviating disuse atrophy of the neuromuscular system (Takeuchi, 2002). However, methodologies of intervention approaches for disuse atrophy and sarcopenia (Moulias et al, 1999; Fulle et al, 2004) have varied and few cohort studies have been performed. As a result, there is no general consensus on exercise therapy (Moulias, 1999; Taffe & Marcus, 2000). In the future, it will be necessary to investigate and verify the exercise therapy, taking into account fragility and individual differences in the physical and psychological parameters of the elderly.

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