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Age-and Gender-related Differences in Physical Functions of the Elderly following 1-year Regular Exercise Therapy: Comparison with Standard Values

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Abstract Only limited data are available regarding the physical functions of elderly patients during the maintenance period after suffering from cardiac or other serious diseases. This study aimed to clarify age- and gender-related differences in the elderly physical functions by mainly comparing data from elderly subjects during the maintenance period with nationwide physical fitness data of healthy elderly subjects collected by the Japanese Ministry of Education. One hundred and sixty-seven elderly individuals who participated in a regular exercise therapy program twice a week participated in this study. Grip strength, 10-m obstacle walking time, one-legged balance with eyes open, sit-ups, sitting trunk flexion, and 6-min walking were selected as the physical function tests. In the gender and age groups considered, compared with the standard value, grip strength, sit-ups, and sitting trunk flexion were lower; 10-m obstacle walking time was similar or higher; and 6-min walking data were similar. One-legged balance with eyes open was lower in subjects, except for males in the young elderly group. Grip strength was significantly higher in females than in males; however, the results from the 10-m obstacle walking time, one-legged balance with eyes open, sit-ups, and 6-min walking tests did not show any significant difference between genders. The young old elderly groups performed better in all tests, except for sit-ups and one-legged balance with eyes open (females), in both genders compared with the old elderly groups. In conclusion, during the maintenance period, the elderly subjects who participated in group sports and exercise therapy performed similarly or better in the 10-m obstacle walking time and 6-min walking tests than the healthy elderly individuals of the same age group; however, they performed worse in grip strength, sit-ups, and sitting trunk flexion. However, our results suggest that the effect of performing sports and exercise therapy may differ between genders.

Keywords: *physical function, exercise therapy, standard value*

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1. Introduction

In old age, the level of physical activity decreases with decrease in physical function and worsens with disuse atrophy [1,2]. According to the white paper on aging society [3], approximately half of the elderly aged >65 years suffer from health problems and nonspecific symptoms. Even if elderly with serious diseases have a longer life expectancy than healthy elderly individuals, the remarkable health-related discontent they experience often make them feel that they have nothing to live for [4], highlighting the importance of facilitating a fulfilling life with adequate quality of life [5]. Thus, cooperation among local authorities is necessary to extend the healthy life expectancy of the elderly and to enhance their quality of life through rehabilitation and the provision of public health services of the elderly during the maintenance period (independent elderly people without requiring nursing care after a serious disease including cardiac disease).

Until now, several policies have been implemented, mainly to ensure the primary prevention of 3 major diseases affecting the elderly in Japan, i.e., malignancies, cardiac diseases, and stroke. However, adequate policies factoring in the elderly during the maintenance period (tertiary prevention) have not been implemented, and information regarding their physical function is poor [6]. Exercise therapy may include activities such as group sports; aerobic exercises such as bicycle ergometer or walking; or table tennis, soft tennis, and tai chi, which need the participation of another individual [7]. It has been reported that the general elderly population as well as the elderly in the maintenance period can improve their

physical function by participating in exercise therapy [6,8]. Adequately improving their physical function is important to prevent disease and fall incidence; however, for safety reasons, elderly individuals with cardiac disease or other serious diseases are often excluded from studies evaluating physical function, and thus, their physical functions have not been adequately evaluated yet [9].

Sugimoto et al. [10] examined age and gender differences in physical functions in the elderly during the maintenance period and reported that physical function differs between genders, with the males presenting greater muscle strength, muscle endurance, whole-body endurance, and walking ability. On the other hand, females are generally more flexible than males. The older elderly scored lower in all the physical functions measured, except muscle endurance; however, how these differences compare with the physical function of healthy elderly individuals has not been comprehensively clarified. Maruyama et al. [11] compared regional data on the physical functions of active healthy elderly individuals with the standard values published by the Ministry of Education. In this case, the report did not examine gender- and age-related differences with standard values and only targeted elderly subjects in the maintenance period. Effective exercise therapy programs are important to understand how physical functional elements of the elderly in the maintenance period compare with healthy subjects (standard value) and how these differences vary with age and gender.

In this study, the following hypothesis was proposed: 10-m obstacle walking time, 6 min walking, grip strength, sit-ups, and sitting trunk flexion vary with gender and age and are lower in elderly subjects in the maintenance period than in healthy elderly subjects (standard values). This study aims to understand age- and gender-related differences in physical functions, compared with the standard values, in elderly participating in a 1-year regular exercise therapy program in the maintenance period.

2. Method

2.1. Subjects

In this study, 167 elderly individuals in the maintenance period were divided into 4 groups according to gender and age: the young elderly group (aged 65–74 years), which consisted of a male group (MYG; n = 29) and a female group (FYG, n = 45), and the old elderly group (aged ≥75 years), which consisted of a male group (MOG; n = 49) and a female group (FOG; n = 44). In this study, the elderly with maintenance periods were defined as those >65 years who live independently >7 months from the onset of symptoms, such as cardiac disease, macrovascular disease, malignant tumor, cerebrovascular disease, and diabetes and those who do not require nursing care because of stable disease. During the study period between April 2008 and December 2012, we enrolled subjects who participated in a regular exercise therapy program twice a week for a minimum of 1 year. They undertook physical function tests toward the end of the regular exercise program.

The mean and standard deviation values of age, height, and weight were as follows: MYG: 70.4 years (3.3 years), 162.4 cm (6.6 cm), and 56.3 kg (6.9 kg), respectively; FYG: 71.9 years (2.2 years), 155.5 cm (5.4 cm), and 52.4 kg (5.5 kg), respectively; MOG: 80.2 years, (3.8 years), 161.3 cm (5.0 cm), and 59.6 kg (7.5 kg), respectively; and FOG: 79.1 years, (3.2 years), 150.4 cm (3.7 cm), and 52.6 kg (8.4 kg), respectively. Statistical analysis showed significant gender difference between age of MYG and FYG; however, the difference was small (ES = 0.01). The males were significantly taller than the females in both age groups, and the FYG subjects were taller than the FOG subjects. The male subjects were significantly heavier than the female subjects. The details of the main illness at onset and the number of days of participation in the year-long exercise program of the subjects included in the present study have been previously reported by Sugimoto et al. [10]. Exercise was not contraindicated in any subject. The purpose of this study, the measurements taken, and safety procedures, as well as the voluntary nature of the study and the right of subjects to refuse participation in the survey and the tests was explained to all subjects. All subjects provided written informed consent prior to initiation of the study and performance of the tests.

The study was approved by the Ethics Committee on Human Experimentation of Faculty of Human Science, Kanazawa University (2012-27).

2.2. Standard Values

The Japanese Ministry of Education recently published the results of a new physical fitness test battery targeted at healthy elderly individuals on a nationwide scale. The battery includes the following test items: grip strength, 10-m obstacle walking time, one-legged balance with eyes open, sit-ups, sitting trunk flexion, and 6-min walking. In this study, the mean values of these tests are assumed to be the standard values for Japanese healthy elderly individuals [12].

2.3. Exercise Therapy Program

The exercise therapy program was aimed to prevent illness recurrence and need for care, to improve QOL, and to extend the healthy life expectancy in the maintenance period in elderly individuals who had suffered serious diseases. This therapy is recommended for elderly individuals throughout their lifetime. A typical exercise program lasted 80 min and included a 15-min warm-up, 6-min walking, 40-min main exercise (table tennis, soft tennis, or bicycle ergometer) with 5-min rest time, and 10-min cooling down.

2.4. Physical Function Tests

The following 6 physical function tests were performed: grip strength (muscle strength), 10-m obstacle walking time (walking ability), one-legged balance with eyes open (balance ability), sit-ups (muscle endurance), sitting trunk flexion (flexibility), and 6-min walking (endurance). Grip strength of the right and left hands was measured twice, with the subject standing up, using a Smedley hand dynamometer (TKK5401, Takei Scientific Instruments Co., Ltd., Japan), and the average maximum value was used as the representative value. A 10-m obstacle walking test was used to measure the time that subjects required to

step over six obstacles twice, and a shorter time value was used for analyses. One-legged balance with eyes open was measured twice when subjects could stand using only the supporting leg with both hands at the waist, and a higher time value was used for analyses. Sit-ups were counted as per the following repeating motion for 30 s: subjects performed sit-ups from the supine posture on the floor with arms crossed over on the front chest and both their knees at 90° until they touched both elbows to both knees. Sitting trunk flexion was measured twice using a trunk flexion measurement device (EKJ091, EVERNEW Co., Ltd., Japan), and a higher value was used for analyses. The 6-min walking test measured the distance for which the subjects walked for 6 min at the usual speed in gymnasiums. The measurements were performed on the basis of the implementation guide published by the Ministry of Education [9].

2.5. Measurement Procedures

The survey and all the measurements were conducted after sufficiently explaining the content to each subject in advance. All subjects were instructed not to participate in any test if they found it difficult because of their underlying disease. Fourteen subjects declined to participate in the 6-min walking test, and 3 subjects refused to perform the sit-ups because of poor health condition. After confirming that none of the subjects had any particular physical problem or blood pressure issues (systolic and diastolic) following the 15-min warm-up comprising stretching exercises, the subjects undertook the physical function tests.

2.6. Statistical Analysis

Statistical analyses were performed using SPSS 11.5J for Windows (SPSS Inc., Tokyo, Japan). The values measured for each subject were converted into personalized ratios with the standard value (i.e., measured value/standard value), and the means and standard deviations were calculated according to gender and age. Two-way analysis of variance (ANOVA) with unpaired measures was used to test for significant mean differences (gender × age) between the personalized ratios for each of the physical function test. When a significant interaction or main effect was found, the post hoc Tukey test for multiple comparison was conducted. An alpha level of 0.05 was considered significant for all tests.

3. Results

Table 1 shows the means and standard deviations of each variable according to gender and age (YG and OG) and standard values on the actual measurements in physical function tests. Sugimoto et al. [10] previously reported their results of two-way ANOVA and the multiple comparison test according to gender and age. Table 2 shows the means and standard deviations of the personalized ratios grouped by gender and age (YG and OG) and the results of the two-way ANOVA and the multiple comparison test. The two-way ANOVA showed that the results on grip strength (gender: $F = 14.04$, $p < 0.05$, age: $F = 5.49$, $p < 0.05$) and the sitting trunk flexion (gender: $F = 5.84$, $p < 0.05$, age: $F = 4.27$, $p < 0.05$) were significantly influenced by gender and age. It also showed that ratios in females were significantly higher than those in males. In addition, the ratios in YG were higher than those in OG. The 10-m obstacle walking time ($F = 14.52$, $p < 0.05$) and the 6-min walking ($F = 5.40$, $p < 0.05$) was significantly influenced by age alone. YG showed significantly higher values than OG. The one-legged balance with eyes open ($F = 4.10$, $p < 0.05$) was significantly influenced by the interaction between age and gender. The results of the multiple comparison test showed that the time was lower in OG than in YG, but only in males. The sit-ups were not significantly influenced by either gender or age.

Table 1. Means, standard deviations and standard value of physical function tests by gender and age-level

	Young elderly		Old elderly		Standard value
	Mean	SD	Mean	SD	(Young/Old)
Grip strength (kg)					
Male	33.3	5.5	29.1	3.7	(37.2/35.2)
Female	22.9	4.5	20.3	3.5	(23.5/21.9)
Ten-meter obstacle walking time (sec)					
Male	5.9	1.2	7.4	2.0	(6.6/7.0)
Female	6.9	1.2	8.3	1.7	(7.4/8.2)
One-legged balance with eyes open(sec)					
Male	85.7	41.5	41.6	42.9	(71.3/57.0)
Female	60.9	47.7	45.4	43.6	(67.8/50.2)
Sit-ups (point)					
Male	7.5	5.8	6.4	5.0	(12.7/10.8)
Female	4.2	5.1	4.8	4.8	(7.6/6.7)
Sitting trunk flexion (cm)					
Male	28.4	8.4	25.7	10.2	(35.9/35.2)
Female	35.8	8.3	30.8	7.5	(39.9/38.2)
Six minutes walking (m)					
Male	59.1	77.3	539.5	60.3	(592.9/565.9)
Female	562.8	58.0	502.9	73.4	(555.0/516.8)

M: Mean, SD: standard deviation, Standard values of the young elderly group/old elderly group.

Table 2. Means and standard deviations of the personalized ratios of physical function test parameters grouped by gender and age, along with the results of 2-way analysis of variance and the multiple comparison test

	Young elderly		Old elderly		Two-way ANOVA					Multiple comparison	
	Mean	SD	Mean	SD	Factor	df	F value		p value	η^2	Gender	Age level
Grip strength (kg)					Gender	1	14.04	*	0.01	0.01		
Male	0.89	0.15	0.83	0.11	Age level	1	5.49	*	0.02	0.03		
Female	0.97	0.19	0.93	0.16	Interaction	1	0.21		0.65	0.00		
					Error	163						
Ten-meter obstacle walking time (s)					Gender	1	0.20		0.66	0.00		
Male	1.17	0.26	1.00	0.21	Age level	1	14.52	*	0.01	0.08		
Female	1.11	0.17	1.03	0.20	Interaction	1	2.31		0.13	0.01		
					Error	163						
One-legged balance with eyes open (s)					Gender	1	0.31		0.58	0.00	Young: ns	Male: Young>OM
Male	1.20	0.58	0.73	0.75	Age level	1	3.93	*	0.05	0.02	Old: ns	Female: ns
Female	0.90	0.70	0.90	0.87	Interaction	1	4.10	*	0.04	0.03		
					Error	163						
Sit-ups (point)					Gender	1	0.15		0.70	0.00		
Male	0.59	0.45	0.59	0.46	Age level	1	0.72		0.40	0.00		
Female	0.55	0.67	0.71	0.72	Interaction	1	0.72		0.40	0.00		
					Error	161						
Sitting trunk flexion (cm)					Gender	1	5.84	*	0.02	0.04		
Male	0.79	0.23	0.73	0.29	Age level	1	4.28	*	0.70	0.03		
Female	0.90	0.21	0.81	0.20	Interaction	1	0.15		0.70	0.00		
					Error	163						
Six-minute walking (m)					Gender	1	0.59		0.44	0.00		
Male	1.00	0.13	0.95	0.11	Age level	1	5.40	*	0.02	0.04		
Female	1.01	0.10	0.97	0.14	Interaction	1	0.06		0.81	0.00		
					Error	149						

M: Mean, SD: standard deviation, df: degree of freedom, η2: effect size, *: $p < 0.05$
Young >Old: The young elderly group shows significantly higher values than the old elderly group.
ns: not significant.

4. Discussion

Because of the physical burden imposed by the physical function tests on the elderly subjects in the maintenance period, data regarding these tests in this population is not available; in addition, reports regarding the physical functions in this population are very limited [8]. This study aimed to clarify age- and gender-related differences in physical function in the elderly during the maintenance period. To this end, we compared the data from elderly who participated in the exercise therapy for 1 year with nationwide standard values obtained from healthy elderly.

4.1. Comparison with Standard Values

The results for sit-ups in YG were <60% of the standard values; however, the results for grip strength, sitting trunk flexion, and one-legged balance with eyes open (except for males) were only slightly lower (within the 79%–97% range) than the standard values. The values for the 6-min walking tests were similar to the standard values, and the 10-m obstacle walking time was slightly higher than the standard values (111%–117%) for both genders in YG. In OG, the results for sit-ups was <71% of the standard values; however, the values for the 6-min walking tests and the 10-m obstacle walking time were almost equal to the standard values. However, the results from all other tests were slightly lower (within the 73%–93% range) in both genders. In brief, in the subjects of this study, compared with the standard values, the results for sit-ups, grip strength, sitting trunk flexion, and one-legged balance with eyes open (except for MYG) were lower; the 6-min walking was similar, and the 10-m obstacle walking time test was higher. Kurose et al. [8] compared the standard values with the values obtained for elderly subjects of the same age in the maintenance period. They showed that >50% of the elderly in the maintenance period exceed the standard value in the 10-m obstacle walking time test and nearly 25% subjects exceed the grip strength standard value. Maruyama et al. [11] compared the standard values to physical function measurements obtained from elderly subjects who participated in a training workshop arranged by their local old elderly club. The reported 6-min walking and one-legged balance with eyes open were higher than the standard values, but the results for grip strength, sitting trunk flexion, and 10-m obstacle walking time were similar to the standard values for all age groups and for both genders. The 10-m obstacle walking time and 6-min walking in the subjects of the present study are similar to those reported by Kurose et al. [8] and Maruyama et al. [11], demonstrating that the physical function of elderly subjects in the maintenance period is not necessarily inferior to that of the general elderly population. The subjects of this study performed the 6-min walking included in the exercise program for an entire year; thus, it can be considered that walking ability and endurance of the elderly in the maintenance period improved through this activity to reach the same level as the general elderly individuals. On the other hand, muscle strength in the elderly individuals has been reported to improve through resistance exercise training [13]. In this study, resistance exercise training was not considered part of the exercise program; therefore, it is inferred that the results did not relate to improvement in muscular power. Sit-ups have been suggested as an indicator of muscle endurance, which is known to decrease with age and muscle strength [14, 15]. Murata et al. [16] reported that

subjects who cannot perform sit-ups were significantly inferior in sitting trunk flexion to those who can do it even in the healthy elderly. The present results demonstrated the same relationship between both tests.

Balancing ability declines markedly with age compared with other physical functions [17]. Kimura et al. [18] reported that individual differences in the one-legged balance with eyes open test are large, suggesting that it is a fairly unreliable test. Half of the subjects could successfully complete 120 s of the one-legged balance with eyes open test and managed to do it for only ≤10 s. In other words, we found large individual differences in the present study population as well. Hess et al. [19] reported that elderly individuals with suboptimal balance can improve the 1-legged stance by practicing high intensity resistance exercises and balance exercises. Similar to resistance exercise training, we did not incorporate specific exercises for improving balancing ability into the training programs in this study; thus, future studies should examine the effect of including such exercises into the therapy program to prevent decrease in the balancing ability associated with increasing age in elderly subjects.

From our results, it can be inferred that elderly subjects in the maintenance period present similar 10-m obstacle walking and 6-min walking compared with healthy elderly individuals of the same age in both genders but show lower grip strength, sit-ups, and sitting trunk flexion results than healthy elderly individuals in both age groups.

4.2. Gender and Age-related Differences in Physical Function of the Elderly in the Maintenance Period

Our results regarding age-related differences in physical function compared with the standard values follow those previously reported by Sugimoto et al. [10]. We found similar gender-related differences for the results of sitting trunk flexion and one-legged balance with eyes open (old elderly group) tests, but our results differed with regard to grip strength, 10-m obstacle walking time, one-legged balance with eyes open (young old elderly), sitting trunk flexion, and 6-min walking tests. These tests showed higher values in males than in females compared with the values measured previously [10]. Thaweewannakij et al. [20] reported that healthy elderly males perform better in the 10-m obstacle walking time, Berg balance scale, and 6-min walking tests than females for all age groups. Males generally perform better in grip strength, while females perform better in the sitting trunk flexion test [21,22]. Similar gender differences are also found in the standard values, because the results for grip strength, 10-m obstacle walking time, one-legged balance with eyes open test, sit-ups, and 6-min walking tend to be higher in males whereas those for sitting trunk flexion values are higher in females (see Table 1). Here, the ratios in females were higher than those in males for grip strength, but no gender differences were found for the 10-m obstacle walking time, one-legged balance with eyes open, sit-ups, and 6-min walking. It is considered that the elderly females in the maintenance period developed their grip strength during this study, showing only slight differences with the standard value for females of the same age (MYG and MOG having 89% and 83% compared with corresponding standard values, whereas FYG and FOG having a score of 97% and 93% compared with the corresponding standard values). For the 4 items that did not show any gender difference, it is believed that the physical function of the study subjects is at the same level as that of healthy subjects from the same age group, except for sit-ups. Our results agree with those of Rantanen et al. [23], who reported that grip strength is an indicator of muscle strength of the whole body and is closely related to leg strength as well as walking and movement ability.

In this study, the physical function of female subjects in the maintenance period was similar to that of the general elderly population of the same age, except for sitting trunk flexion and sit-ups. In fact, the exercise intensity used in this study was suited for females rather than for males, and therefore, may have been more effective in females, an issue that should be further examined based on longitudinal data in future.

In this study, the subjects were specifically selected in relation to a specific exercise program; thus, further studies are necessary to compare the effects of different exercise programs and to increase the sample size.

5. Conclusion

In conclusion, elderly individuals in the maintenance period perform equally or better than healthy subjects of the same age in 10-m obstacle walking time and 6-min walking tests; however, their results are lower with regard to grip strength, sit-ups, and sitting trunk flexion. In this study, the intensity of the group exercise might be better suited for females than males; therefore, there is a possibility that the effect of this exercise intensity may differ by gender.

References

[1] Guccione, A.A., Felson, D.T., Anderson, J.J., Anthony, J.M., Zhang, Y., Wilson, P.W., Kelly-Hayes, M., Wolf, P.A., Kreger, B.E. and Kannel, W.B, "The effects of specific medical conditions on the functional limitations of elders in the Framingham study," *Am J Public Health*, 84.351-358. 1994.

[2] Paterson, D.H., Govindasamy, D., Vidmar, M., Cunningham, D.A. and Koval, J.J, "Longitudinal study of determinants of dependence in an elderly population," *J Am Geriatr Soc*, 52.1632-1638. 2004.

[3] Cabinet Office, "Aged society white paper (Heisei 25 edition)." Printing mail order Publisher, Tokyo, 2013, 14.

[4] Penninx, B.W., Beekman, A.T., Honig, A., Deeg, D.J., Schoevers, R.A., van Eijk, J.T. and van Tilburg, W, "Depression and cardiac mortality: results from a community-based longitudinal study," *Arch Gen Psychiatry*, 58.221-227. 2001.

[5] Suzuki Takao, Preventive care perfection manual Continued, Tokyo welfare health foundation, Tokyo, 2011.

[6] Joint study group report of Japanese Circulation Society, Guidelines for rehabilitation in cardiovascular disease (JCS 2012), Japanese Association of Cardiac Rehabilitation, Tokyo, 2012, 50-54.

[7] Hamazaki, H. and Shimomura, M, "Examination about amount of activities and intensity in sports cardiac rehabilitation," *Japanese Society for Adapted Physical Education and Exercise*, 3. 48-56. 2005.

[8] Kurose, S., Imai, M., Kagitani, K., Shithino,Y., Yamashita, M., Uenishi, K., Hamamithi, S., Masuda, I. and Hashimoto, T, "Comparison physical fitness in patients with or without cardiac disease during a maintenance phase of cardiac rehabilitation," *Japanese Association of Cardiac Rehabilitation*, 14. 263-268. 2009.

[9] Ministry of Education, Science, Sports and Culture. New physical fitness test for meaningful use, Gyousei. Publishers, Tokyo, 2000.

[10] Sugimoto, H., Demura, S. and Nagasawa, Y, "Age and gender-related differences in physical functions of the elderly following one-year regular exercise therapy," *Health*, 6.792-801.April.2014.

[11] Maruyama, Y., Furukawa, M. and Takei, M, "Aging and physical strength change in the senior citizens' club officers of participation leader training session," *J Health Sports Sci Juntendo*, 8. 43-47. 2004.

[12] Ministry of Education, Science, Sports and Culture, Physical strength and athletic ability investigation, 2012. [Online]. Available: http://www.mext.go.jp/b_menu/toukei/chousa04/tairyoku/1261241.htm.[Accessed May. 2, 2014].

[13] Martins, W.R., de Oliveira, R.J., Carvalho, R.S., de Oliveira Damasceno, V., da Silva, V.Z. and Silva, M.S, "Elastic resistance training to increase muscle strength in elderly: a systematic review with meta-analysis," *Arch Gerontol Geriatr*, 57.8-15. 2013.

[14] Ota, M., Ikezoe, T., Kaneoka, K. and Ichihashi, N, "Age-related changes in the thickness of the deep and superficial abdominal muscles in women," *Arch Gerontol Geriatr*, 55. 26-30. 2012.

[15] Kanehisa, H., Miyatani, M., Azuma, K., Kuno, S. and Fukunaga, T, "Influences of age and sex on abdominal muscle and subcutaneous fat thickness" *Eur J Appl Physiol*, 91. 534-537. 2004.

[16] Murata, S., Otao, H., Murata, J., Horie, J, Miyazaki, J., Yamazaki, S. and Mizota, K, "Relationships between Ability to Raise the Upper Body and Physical and Psychological Functions of Community-Dwelling Elderly, *J Phys Ther Sci*, 25.115-119. 2010.

[17] Cooper, R., Hardy, R., Aihie Sayer, A., Ben-Shlomo, Y., Birnie, K., Cooper, C., Craig, L., Deary, I.J., Demakakos, P., Gallacher, J., McNeill,G., Martin, R.M., Starr, J.M., Steptoe, A. and Kuh, D, "Age and gender differences in physical capability levels from mid-life onwards: the harmonisation and meta-analysis of data from eight UK cohort studies," *PLoS One*, 6. e27899. 2011.

[18] Kimura, M., Hirakawa, K., Okuno, T., oda, Y., Morimoto, T., Kitani, T., Fujita, D. and Nagata, H, "An analysis of physical fitness in the aged people with fitness battery test," *Jpn J Phys Fitness Sports Me*d, 38.175-185. 1989.

[19] Hess, J.A. and Woollacott, M, "Effect of high-intensity strength-training on functional measures of balance ability in balance-impaired older adults," *Manipulative Physiol Ther*, 28. 582-90. 2005.

[20] Thaweewannakij, T., Wilaichit, S., Chuchot, R., Yuenyong, Y., Saengsuwan, J., Siritaratiwat, W. and Amatachaya, S, "Reference values of physical performance in Thai elderly people who are functioning well and dwelling in the community," *Phys Ther*, 93. 1312-1320. 2013.

[21] Nagasawa, Y., Demura, S. and Hamazaki, H, "Age and sex differences of controlled force exertion measured by a computer-generated quasi-random target-pursuit system, *J Musculoskelet Neuronal Interact*, 10.237-244. 2010.

[22] Riemann, B.L., DeMont, R.G., Ryu, K. and Lephart, S.M, "The effects of sex, joint angle, and the gastrocnemius muscle on passive anklejoint complex stiffness," *J Athlete Training*, 36. 369-377. 2001.

[23] Rantanen, T., Era, P. and Heikkinen, E, "Maximal isometric strength and mobility among75-year-old men and women," *Age Ageing*, 23. 132-137. 1994.