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Changes in the muscle strength and functional performance of healthy women with aging

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Abstract

Background: Lower limbs antigravity muscles weakness and decreased functional ability have significant role in falling. The aim of this study was to find the effects of aging on muscle strength and functional ability, determining the range of decreasing strength and functional ability and relationship between them in healthy women.

Methods: Across-section study was performed on 101 healthy women aged 21-80 years. The participants were divided into six age groups. The maximum isometric strength of four muscle groups was measured using a hand-held dynamometer bilaterally. The functional ability was measured with functional reach (FR), timed get up and go (TGUG), single leg stance (SLS), and stairs walking (SW) tests.

Results: Muscle strength changes were not significant between 21-40 years of age, but decreased significantly thereafter. Also, there was a significant relationship between muscle strength and functional ability in age groups.

Conclusion: Both muscle strength and functional ability is reduced as a result of aging, but the decrease in functional ability can be detected earlier.

Keywords: Aging, Dynamometer, Functional performance, Muscle strength.

Introduction

Muscle strength is known to indicate habitual and cultural physical activity (1). Age-related deterioration of muscular strength and balance control mechanisms has been associated with reduced performance on functional tasks (2,3,4). Based on the obtained information, 18 percent of the populations above 65 years of age are dependent upon others in performing one or more daily activities(5)and about 30% of people aged 60 and older will fall in any 12-month period(6). The changes that are related to age are observed in active healthy adults usually after the age of 50 (7).The loss of strength begins sooner in women than men, when comparing isometric strength levels of the same muscle group(8). It is reported that women are weaker than men in absolute strength of various muscle groups in all stages of life. Thus it's suggesting that women should be the first target group in musculoskeletal evaluation and rehabilitation (9). Although women have longer life spans, the prevalence of disability among women is more than men and it is marked with advancing age (10).

Important factors including use of sensory inputs (visual, somatosensory, vestibular) are involved in controlling and retaining the balance and position sensation. They stimu-

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late positional muscles appropriately by activating consolidated synergy so that the person can defend against balance-impairing factors (11).The muscle weakness is a risk factor for falls, so that some studies have shown that lower extremity weakness is a clinically important and statistically significant risk factor for falls (12,13). Awareness of the effects of aging on the musculoskeletal performance and strength seems to be important for health specialists to improve the quality of life (14). It has been reported that exercise training (including balance training) may help to prevent falls, although the evidence is inconclusive (15). Different studies show that the muscles of the lower limbs are necessary to perform functional activities in older people (16,17).Functional ability is a key factor for elderly individuals both to maintain independent living and to participate in family and community activities (18).The proximal muscles of the lower extremities are more affected by strength losses than those of the upper extremities, which in older people has been attributed to a decreasing use of lower compared with upper limb muscles(9, 19) Muscular strength can be assessed by means of isokinetic and hand-held dynamometers (HHD) both in research settings and in clinical practice settings. HHD is a portable and inexpensive device to assess muscle strength (20,21,22). This device provides quantification of muscle strength, and is more sensitive to change in muscle strength than simple manual muscle tests (23,24). Evidence of the validity and reliability of HHD has been provided in several studies (17, 22,25).

There are many contradictions regarding the time of muscular strength decrease and patterns of changes in the functional ability and strength of the individuals with aging(1,14). Therefore several study should be design to better elucidate the role of aging on skeletal muscle and effects of physical activity on it (26).

Considering the importance of balance and strength in the elderly, it seems necessary to study the effect of aging on muscular strength and functional ability in order to determine the age at which the decrease in muscular strength begins. Therefore the aim of this study was to find the effects of aging on muscle strength and functional ability.The study of changes in the two factors of strength and balance along with the increase in age and also the relationship between the two in healthy women with age groups of 21 through 80 can provide us with the resulted changes as a criterion to evaluate the elderly in order to devise more precise evaluation and more useful rehabilitation programs as well as to take necessary steps to prevent or decrease falling accidents.

Methods

This study was performed on 101 women using the simple convenience non-probability sampling method. The participants were divided into six groups of 21 to 80 years of age, each group consisting of 15-20 individuals. The participants were healthy non-athletes with no known cardiac, vascular, musculoskeletal damage. They were capable to fallow commands and did not have a history of falling during the past year.

Muscular strength measurement method: Maximum isometric strength tests, known as make tests, of four muscle groups was measured using a hand-held dynamometer bilaterally. These muscles included hip abductor and extensor muscles, knee extensor muscle and ankle dorsiflexor muscles on the right and left sides. This hand-held digital system is portable and of load-cell kind known as "Track II Commander TM strength" made by J Tech Medical Company in the United States. Generally, muscular groups were tested for the middle part of the joint range of motion. The dynamometer was placed vertically on the desired organ in all cases (27, 28). The system was regulated so that it recorded the maximum contraction. For any group of muscles, the duration of 5 seconds was determined to measure maximum isometric contraction of each muscle group. Before performing any test, a sample test was performed once for better understanding. The average of three contraction trials was recorded as the final number, and 2 minutes of rest was given between every contraction to avoid a decline in strength across trials due to fatigue. Oral encouragement was given during all muscle strength tests. During testing the person holds on to the sides of the table with both hands to self-stabilization. Evaluation of hip extensor muscles strength was performed in the prone position with the hip in neutral position. To perform the test, the pad of the dynamometer system was placed 5 cm above the proximal edge of the medial malleolus, at the posterior aspect of the leg and the person being tested exerted a maximum effort against the dynamometer .The muscular strength of the hip abductor muscles was measured by placing the participant in the supine position while the hip joint was in neutral position. The dynamometer pad was placed on a 5 cm above the proximal edge of the lateral malleolus, against hip abduction (22,29). The evaluation of knee extensor muscle was performed in the sitting position. The tester placed one of his hands above the knee in the distal of the thigh and placed the other hand on the dynamometer pad on the bottom of anterior surface of the leg just proximal to the malleolus. Evaluation of the dorsiflexor strength of the ankle was performed by placing the tested person in the supine position with the hip and knees straight. The bottom of dynamometer pad was placed on the foot higher than the metatarsophalangeal joints (4, 22).

Functional performance testing: For assessment of functional abilities, four balanced tests, including FR, TGUG, SLS and SW tests, were performed.

FR: The participant stood on her two lower limbs and raised her upper limbs from the shoulder to 90-degree flexion and fisted her hand. Then, the participant, without losing the body balance, moved forward as far as possible. The distance between places of the third metacarpal was recorded before and after movements (1,30).

TGUG: The participant stood up from a hand held chair by an approximate height of 46cm and travelled a distance of 3m along in a direct line and then returned to the original place on the chair. The time spent recorded with a hand chronometer which was capable of measuring one-hundredth of a second (1, 2, 31,32).

SLS: This test included standing on the dominant lower limb without shoes and socks while the participant has placed his hands crossed on the chest (1,33).

SW: The individuals were requested to walk up three 20cm stairs upon hearing an agreed upon command in a convenient and suitable speed and then to go down (1). All functional ability and strength tests were performed by resting intervals in one session. The instructions for all the testes were the same and all the tests were performed by female physiotherapist and in a definite time during day-time.

Analysis: For statistical analysis, SPSS software (version 17) was used. A kolmogorov-smirnov (K-S) test demonstrated a normal distribution of each variable and parametric tests were applied. One Way Analysis of Variance (ANOVA) was used to determine the difference between the groups and upon detecting a statistical difference; the post hoc test was employed. To study the kind of relationship between the variables in each group and among groups, linear regression analysis was used. Statistical significance for all tests was accepted below the level of 0.05. An intraclass correlation coefficients ($ICC_{3,2}$) was calculated to determine reliability of angle measurement method.

Ethics: The study has been approved by The School of Rehabilitation Ethics Committee for Medical Research (171).

Results

The Mean age, height, weight and Body Mass Index (BMI) of the participants in the six study groups are presented in Table 1. In order to investigate the reliability of study variables, the result of three tests was recorded. $ICC_{3,2}$ was 83% for muscle strength parameters and mean $ICC_{3,2}$ for functional

Table 1. Mean age, height, weight and BMI of The participants in the six study groups [values are presented as mean ± Standard deviation (SD)].

Group (yr)	No	age	weight	height	BMI
1(21-30)	20	23±5	58±4	161±4	22.3
2(31-40)	18	36±4	65±6	162±6	25.1
3(41-50)	18	43±8	63±9	160±4	24.8
4(51-60)	15	55±5	69±5	160±8	26.9
5(61-70)	15	65±6	75±8	158±11	30
6(71-80)	15	74±5	62±4	153±6	26.3

Table 2. The mean strength of different muscle groups [values are presented as mean ± Standard deviation (SD)]

Group(yr)	HE (N)		HA(N)		KE(N)		AD(N)	
	Rt	Lt	Rt	Lt	Rt	Lt	Rt	Lt
1(21-30)	93±13	91±13	88±10	84±9	86±9	83±9	84±8	85±10
2(31-40)	86±10	84±6	83±6	83±8	88±12	88±11	81±5	79±7
3(41-50)	81±11	78±12	81±9	80±8	80±10	75±10	74±9	71±6
4(51-60)	67±5	66±6	68±7	69±8	70±6	67±7	61±5	59±5
5(61-70)	61±7	62±9	61±4	60±7	63±11	62±8	53±4	52±4
6(71-80)	54±7	52±3	55±7	54±6	53±6	53±7	51±5	50±4

Hip Extensor= HE, Hip Abductor=HA, Knee Extensor =KE, Ankle Dorsiflexor = AD, Newton=N, Right= Rt, Left=Lt, yr=Year

performance parameters was 86.4.

The results obtained from strength assessment tests showed that the average of the decrease in strength in different muscular groups from group six to group one was 38.72%. Results of the correlation test represented a significant correlation between the research variables and the age ($p<0.0001$, $r=-0.871$). The linear regression test showed that there was a significant relationship ($p<0.0001$) between the age and the maximum assessed muscular strength ($r^2=0.67$ to 0.73) in a way that by aging, the maximum muscular strength decreased (Table 2).

There was a progressive decrease in the strength of the muscle groups by aging but this event emerged in different muscular strengths by a slight difference, so that there were no significant changes between mean muscular strength of hip extensor and ankle dorsiflexor muscles until the forth decade of life but decreased significantly thereafter ($p<0.0001$). There were no significant changes in mean muscular strength of the knee extensor and hip abductor muscles until the fifth decade but a significant decrease was noted thereafter ($p<0.0001$).

There were no significant changes in mean TGUG test results until the fifth decade of life but they decreased significantly thereafter ($p<0.0001$). Also, there was no significant difference between mean FR test result in Group 1 and Group 2 ($p=0.07$), but there was a significant difference when compared with other groups ($p<0.0001$). The results obtained for SLS and SW tests indicated a significant difference in mean results in these tests between group 1 and all other groups ($p<0.0001$) (Table 3) .

Discussion

The results of this study demonstrated a progressive decrease in the strength and functional ability in the research groups with aging, but this trend showed a slight difference in various muscle strengths in such a way that mean strengths of the hip extensor muscles and ankle dorsiflexor muscles decreased significantly after the fourth decade. However, mean strengths of the knee extensor and hip abductor muscles decreased significantly after the fifth decade. This decrease in the strength and functional ability can be the result of changes which occur normally in the process of aging; also, the role of the individuals' lifestyle and their

Table 3. Mean of functional tests measures of participants in six study groups.
[Values are presented as mean ± Standard deviation (SD)]

Group(yr)	TGUG	SLS	FR	SW
1(21-30)	3.7±.5	392±22	25±3.5	2.1±.28
2(31-40)	3.8±.6	208±24	23±2.5	2.7±.4
3(41-50)	4.4±.5	169±24	21±2.2	3.4±.4
4(51-60)	6.5±.7	68±26	19±2.4	4.5±.5
5(61-70)	8.2±1.5	56±26	17±3	5.2±.7
6(71-80)	9±2	19±27	13±2	9.8±1.7

Time get up and go = TGUG, Single leg standing =SLS, Functional reach = FR, Stair walking test = SW, yr=Year.

physical and recreational activities should not go unnoticed (1). Nonetheless, in the present study, it could not be specifically mentioned which of the above-mentioned factors influenced the decrease in the strength and functional ability with aging, but the significant correlation between the age and muscular strength and functional ability pointed to the role of age as an effective factor.

Also, the difference in the pattern of decrease in the strength of the lower limb muscles can be due to different uses of these muscles during daily activities. On the other hand, muscles which are more often used during the day will weaken later. Our findings are in agreement with the reports of multiple studies such as Cayley which noted that muscular strength increased until the age of 30 and, remained constant without change until about the age of 50 and then decreased by about 30% between the ages of 50-70 (14). Thompson reported that increase in age is followed by a progressive decrease in muscular mass and strength conditions (7). Lord et al. identified muscular weakness of lower extremities as an important factor in falling of the elderly individuals and concluded that muscular strength and balance decreased by aging (34). Abdulwahab considered the effects of the old age on muscular strength and functional capability of healthy men as significant in such a way that after the age of 40, a significant loss in muscular strengths and functional ability emerged (1). Doherty et al. found that the maximum intentional isometric contraction in healthy women aged 60 through 80 was 20-40 percent less than younger people, which even decreased to 50 percent or more in older individuals (35).On the other hand, Morse et al. reported that the maximum intentional muscular contraction in elder people was 39% less in comparison with that of the young individuals (36). In the present study, mean decrease in muscular strength was 38.72 percent when the third decade of life was compared with the eighth decade of life; the results were in line with the report of Doherty et al. (37), but differed a little with the percentage reported by Morse et al.(36).This difference can be due to the muscular group in the present study in which four muscular groups in any of the lower extremities were evaluated while in Morse's study, only the planter flexor muscles were evaluated which showed a decrease of 19%. However, in the present study, strength loss in the four studied groups was different in such a way that strength loss in the muscle groups of hip and knee extensors was 41.54 percent and 36.89 percent, respectively. Consequently, it can be said that the decrease in the strength in different muscular groups are different. The obtained results showed that mean results of the individuals' TGUG test had no significant change until the fifth decade which means that the ability to perform this test decreases after the age of 50. The TGUG test provides a measure of functional mobility in older adults (37). The ability to perform this test depended on antigravity strength of the lower extremity muscles, especially the quadriceps muscle. Since the decrease in the strength experiences a steeper slope from the fifth decade, it is expected that the time to perform TGUG test increase after the fifth decade. Our findings regarding SLS and SW tests indicated a significant increase in mean time to perform these tests after the third decade. Bohannon et al. reported that the time of standing on a single limb has a strong correlation with age (33). Researchers reported the postural control began to decrease after the third decade which continues during everyone's life (38, 39). Also, the average of the results of the FR test after the age of 40 significantly decreased. Probably, in these tests, in addition to the important role of muscular strength, coordination among different systems enjoys a high importance.

Since the subjects of this study were selected with a simple convenience non-probability sampling method, it is better to caution in generalizing the results to the whole population.

Conclusion

Although reduced muscular strength and the functional ability both emerge as a result of aging, the decrease in the functional ability can be identified earlier. Onset of muscle strength decrease in lower limb is not the same among different muscle groups with aging. Therefore planning of the suitable physical activities among all age groups especially population with high risk of falling is necessary. Perfect performance of exercise therapy may prevent balance disorders and falling among the elder population.

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