Difference in Hamstring-to-Quadriceps Ratio and Dynamic Stability between Limbs in Elderly People

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Article info:
Received: 12 Oct. 2014
Accepted: 27 Jan. 2015

Keywords:
Elderly, Power, Strength, Postural balance

ABSTRACT

Purpose: previous studies have suggested that thigh muscle imbalance may be a risk factor for knee injury. The Present study aimed to compare Hamstring-to-Quadriceps (H:Q) Ratio and dynamic stability between the two lower limbs of elderly people.

Methods: This was a correlational study and by nonprobability sampling 19 healthy community doweling elderly (age=65.93±3.53 yrs.) participated in this study. Dynamic strength and power of knee extensor and flexor muscles and H:Q ratios of each lower limb were measured by isokinetic dynamometer. Dynamic stability was evaluated using the biodex balance system. Paired t test and Wilcoxon test were performed to compare power, strength, H:Q ratio, and balance index of 2 sides. Data analysis were conducted using SPSS software, version 19.

Results: Strength and power between two legs was significantly asymmetrical. There was no significant difference in H:Q strength ratios (P=0.057) between the two sides although this ratio was 14.42% greater in weaker leg. Antero-posterior stability index (APSI) was significantly different between two legs (P=0.03), however there is no significant difference in overall stability index (OSI) and medio-lateral stability index (MLSI).

Conclusion: The asymmetry between limbs or weakness of the quadriceps and/or hamstring muscle strength and the resultant change in H:Q ratio should be considered in rehabilitation of older adults.

1. Introduction

Nowadays, population ageing considers as a serious issue for many societies [1]. The number of persons 60 years and over was calculated to be 688 million in 2006 and is estimated to grow to almost 2 billion by 2050 that will be almost 22 percent of the total world's population [1]. Ageing is defined as a natural phenomenon that manifested by some of natural alterations for example loss of muscle mass and strength, impairment in mobility, balance and motor coordination [2]. All these factors are underlying causes for increased risk of falling among the elderly people [3].

Falling is a public health concern and the most common cause of injury [4, 5]. It was reported that almost 30–35% of elderly subjects Living in community experience at least one fall annually [2, 6, 7]. More than 5 to 10% of falls resulted in fractures, hospitalizations or immobilizations [8] , and over 90 percent of hip fractures occur following fall [9]. Injuries

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result from falling such as head injuries and fractures are serious problems that may lead to functional limitation, prolonged or permanent disability, institutionalization or even mortality [10]. Also, falling is a serious economic burden for societies [10, 11].

Many studies have focused on prevention strategies for reducing falling and fall consequences in elderly. Effective strategies for prevention of falling requires sufficient knowledge about risk factors [12]. Some of known risk factors such as muscle weakness and impairment in balance and gait are modifiable [4]. Lower limb strength and balance are important factor for independent activity daily living in older adults. Muscle power and strength asymmetry between knee and ankle muscles has been also considered as falling risk factors [13].

Assessment of agonist and antagonist muscle imbalance is known as an important procedure in rehabilitation and training [14]. Joint stability depends not only on the muscle strength but also on agonist and antagonist muscle balance [15]. Hamstring to quadriceps (H:Q) ratio has been used as an indicator of the balance of knee muscles strength [14]. Normally, its ranges are between 50 to 80% and H:Q ratio of 60% or more is desirable in rehabilitation [16]. It has been shown that the difference in H:Q ratio might predispose leg injuries in athletes [17, 18].

Despite many studies which investigated asymmetry in muscle strength, we didn't find any study that assesses the difference in H:Q ratio between two legs in elderly people. Some of studies have shown the relationship of muscle strength with postural control and dynamic stability [19, 20] and a number of studies investigated the difference of dynamic stability between two lower limbs in young subject [21, 22], but no study investigates this topic for older adults.

The purposes of this study were to determine strength and power asymmetry of hamstring and quadriceps muscles and also the asymmetry of H:Q ratios and their association with dynamic stability between two lower limbs of elderly people.

2. Materials & Methods

This was a correlational study and a total of 19 healthy community doweling elderly people (Mean age: 65.93±3.53 y; Mean weight: 67.03±9.72 kg; and mean height: 159±9 cm) participated in this study. Sampling was performed by simple non-probability method from elderly populations living in several districts of Tehran in 2014. Before the study, a familiarization session was held for each participant. Then, they signed an informed consent form approved by the Human Subjects Committee of University of Social Welfare and Rehabilitation Sciences. The inclusion criteria were 60 years old or more, living independently, able to follow simple instructions. The exclusion criteria consisted of any history of neurological, musculoskeletal, cardiac and metabolic problems [19, 20, 23]

Testing procedures

Isokinetic knee flexion-extension strength and power

After a brief explanation of the testing procedures, isokinetic strength and power of extensor and flexor muscles of knees and H:Q ratios of each side were measured by cybex norm isokinetic dynamometer (Model 770, made in USA). The order of test positions for right and left legs were randomized to minimize the effects of fatigue and learning

Dynamic strength measurement was performed in a seating position while hip flexion angle set in 90 or 100 degrees and the upper leg, the hips and shoulders were stabilized with safety straps [24-26]. The rotational axis of dynamometer was visually aligned with the transverse knee-joint axis (lateral femoral condyle) and distal end of tibia was attached to the length-adjustable dynamometer' lever arm, just above the medial malleolus [25, 26].

The subject performed a series of four repeated isokinetic flexion-extension against the lever arm of dynamometer in 85 to 10 degree of knee flexion at a velocity of 60°/s (full-extension was considered as zero degree) (ICC: 0.95-0.98, CV:0.15–0.18) [27].

Balance assessment

Evaluation of dynamic balance was performed using the biodex balance system (BBS, Biodex, Inc., Shirly, NY). BBS is a multi-axial device with an unstable balance platform which allows more than 20 degree tilt in about the anterior-posterior (AP) and medial-lateral (ML) axes freely and objectively measure and record balance and postural control under dynamic stress [7, 28, 29]. This system provides 8 levels of stability for platform (Level 1 as the most unstable level and level 8 as the most stable level) and three calculations to be achieved including overall stability index (OSI), anterior-posterior stability index (APSI) and medial-lateral stability index (MLSI). We assessed bilateral dynamic stability in a random order while the stability level of platform was set to change gradually from level 8 to level 6, during 20 seconds [28].

Initially, subjects were asked to stand on platform in unipedal stance and then platform has been unlocked so that the subject can find best positioning of foot for keeping their center of pressure in central rings of BBS monitor. The subjects were asked to stand on one leg (according to the order), bare foot, eyes open with their arms hanging at the side of their body and maintain the straight posture without changing foot position and sway their body if necessary. For safety of participants, the handle was available. Balance assessment was consisting of performing two trials (20 seconds) with 10 s rest between trials for any limbs and a mean score of two trials was considered as scale. For familiarization and adaptation with system, all subjects were trained before the test.

Data analysis

Statistical analysis was done using SPSS 19 software. Mean±SD was calculated for all variables. Paired t test and Wilcoxon test was used to compare power, strength, H:Q ratio and balance index of two sides. Significant level was defined at P less than 0.05 for all tests.

3. Results

All values were normalized based on body weight for both legs. There were significant differences in power (P=0.000, P=0.01) and concentric muscle strength (P=0.000, P=0.02) of extensor and flexor muscles between legs, respectively. There was no significant difference in H:Q strength ratio (P=0.057) between the two sides, however there was a mean difference of 14.42% between two limbs (Table 1).

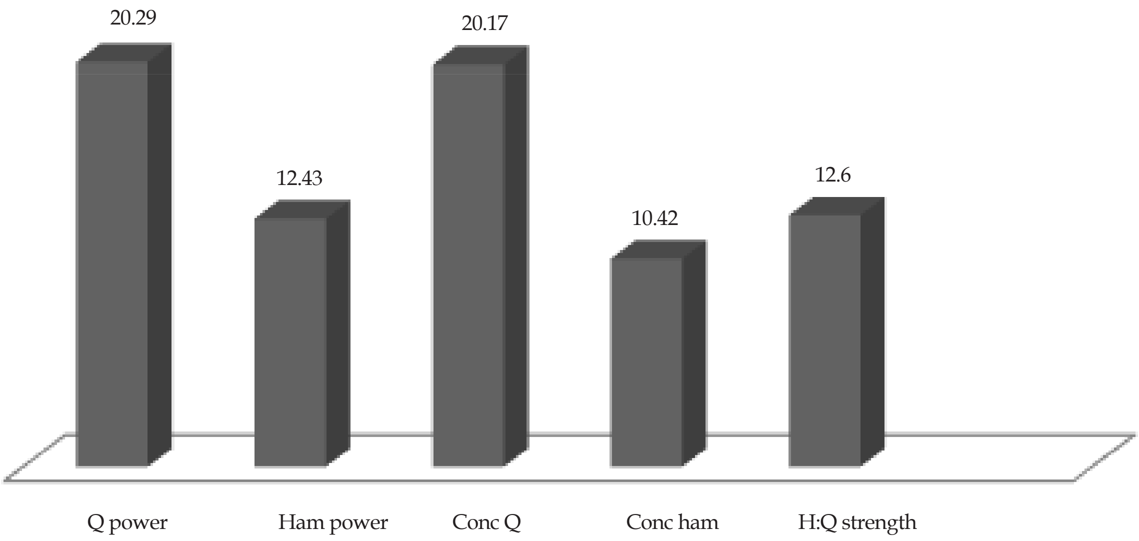

Figure 1. Asymmetry between limbs (weaker leg had significant weakness related to strong leg).
Q:Quadriceps muscle/ Ham: Hamstring muscle/Conc:Concentric muscle strength.
H:Q=Hamstring concentric strength: Quadriceps concentric strength.

PHYSICAL TREATMENTS

Table 1. Concentric power and strength of quadriceps and hamstring muscles and H:Q ratios between two limbs.

Outcome measure	Stronger leg mean±SD	Weaker leg mean±SD	Mean difference±SD	P-value
Q power (W/kg)	51.44±23.26	41±19.66	10.44±8.6	0.000
Ham power (W/kg)	31.29±14.71	28.03±12.87	3.88±7.5	0.013
Conc Q (N/kg)	55.41±24.03	44.22±20.47	11.18±9.5	0.000
Conc ham (N/kg)	31.29±14.71	28.04±12.87	3.26±6.7	0.018
H:Q ratio	57.26±13.32	65.62±21.50	-8.04±23.34	0.057

Q:Quadriceps muscle/ Ham: Hamstring muscle/ Conc: Concentric muscle strength.
H:Q=Hamstring concentric strength: Quadriceps concentric strength.

PHYSICAL TREATMENTS

Table 2. The results of stability index of stronger and weaker legs.

Variable		Mean±SD	P-value
OSI	Stronger leg	2.65±0.96	0.099
	Weaker leg	2.34±0.71	
APSI	Stronger leg	2±0.95	0.030
	Weaker leg	1.38±0.34	
MLSI	Stronger leg	1.77±1	0.938
	Weaker leg	1.78±0.72	

OSI:Overall stability index/ APSI:Antero-posterior index/ MLSI:Medio-lateral stability index.

PHYSICAL TREATMENTS

The mean differences of concentric power and strength of quadriceps and hamstring muscles and H:Q ratios between two limbs have shown in Figure 1.

The result of paired t-test to compare difference in stability index of stronger and weaker legs showed that two limbs had no significant differences in OSI and MLSI, but APSI was significantly different between two legs (P=0.03), Table 2.

4. Discussion

The findings of our study showed that elderly subjects had significant differences between the two limbs regarding dynamic strength and power of knee extensor and flexor muscles. Another finding is that the difference of H:Q ratio between limbs was not significant but H:Q ratio in weaker leg was more than the stronger leg. There was also no significant difference in balance index between the two legs expect for APSI which was significantly different between weaker and stronger legs.

In agreement with our results some previous studies showed the asymmetry in power and strength of knee muscles between limbs in elderly people [13, 23, 30]. Skelton (2002) and Protegijs (2005) reported that older female had significant asymmetry in power and strength of lower limb muscles. Perry (2007) [23] in their study investigated female and male participants and shwed significant asymmetry between limbs similar with our study.

Some studies investigated the H:Q strength ratio in young (16, 31, 32) and adult [33] persons. Lanshamar (2011) [31] and Kong (2010) [16] in young adults assessed the asymmetry in H:Q ratio and didn't find significant difference in H:Q ratio between dominant and non-dominant leg. Lanshamar showed that dominant leg flexor muscles were 8.6% weaker and in non-dominant leg extensor muscles was 5.3% weaker. H:Q ratios were 46% and 53% respectively in dominant and non-dominant legs. In Kong's study the isometric and isokinetic strength ratios asymmetry values were 6.7% and 4.4% respectively.

In agreement with our study, Yoon (1991) [32] and Calmels (1997) [33] did not find any differences between right and left H:Q strength ratios, however they evaluated the subjects in the age of 35 to 70 years old.

Similar to our results, Hoffman (1998) [21] and Alonso (2011) [22] investigated the differences in balance ability between dominant and non-dominant legs in young peoples; They also found no differences between two legs.

According to our results APSI was significantly different between two limbs and weaker leg has lesser stability index (better stability), at the other hand H:Q ratio was greater for weaker leg. We assumed that stronger leg which has stronger quadriceps was better stability but this was not established. It is possible, in weaker leg, stronger hamstring (greater H:Q ratio) compensated weakness of quadriceps and commissioned the stability of weaker leg. This may be reflects the importance of the role of flexor muscles in providing joint stabilization and prevention of injury. For this reason knee joint stability depends not only on the muscle strength but also on agonist and antagonist muscle balance. Although low strength is a falls risk factor, asymmetry between limbs may be more predictive of future falls.

In some cases, musculoskeletal disease, pain and/or dysfunction affect the lower limbs unilaterally, so potentially cause large asymmetry. It looks that, when setting rehabilitation and exercise therapy goals for young and old adults, it may be appropriate to adjust the H:Q ratio and leg strength and power based on considering leg asymmetry.

One of the limitations of present study was small sample size. Also, older adults that participate in this study were physically and mentally active and were independent. Further work including assessments the elderly subject with lower levels of activity and independency and with previous history of falling are required to identify leg asymmetry as falls predictor. In addition to previous studies which focused on comparing power and muscle strength between the two legs, present study evaluates the probable asymmetry in H:Q ratio and balance index between two legs in elderly people. We concluded that:

1. In comparison of the two legs, results indicate that power and muscle strength of both flexor and extensor muscles were different.

2. H:Q ratio values were greater in weaker leg; it means that hamstring muscle could be stronger in weaker leg however, this difference was not significant. Balance was better in anterior-posterior direction in weaker leg (balance in other directions was similar between the two legs).

Acknowledgement

This study was a part of MSc thesis that, supported by the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. The authors thank collaborations of participants and the managers of local health organizations of Zafaranie, Mahmoodie and Evin affiliated to municipality.

Conflict of Interests

This work supported by Iranian Research Center on Ageing, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.

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