BJMB
Brazilian Journal of Motor Behavior

Research Article

Agonist/Antagonist Ratio for ankle joint is similar between active and inactive older adults compared to hip and knee joints

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https://doi.org/10.20338/bjmb.v14i01.158

HIGHLIGHTS

- Older people present greater agonist/antagonist ratio in ankle joint compared to young adults.
- The agonist/antagonist ratio for lower limbs joints of active and inactive older adults is similar.
- The agonist/antagonist ratio is higher in 60°/s than 120°/s velocity for hip abduction/adduction. For knee flexion/extension the agonist/antagonist ratio is higher in 120°/s than 60°/s.

ABBREVIATIONS

AAR	agonist/antagonist ratio
ATV	Active group
EGS	Exercise Guidance Service
ITV	Inactive group
LAFEC	Strength and Conditioning Laboratory
MMSE	Mini-Mental State Examination
PT	peak torque
YA	Young adult group

PUBLICATION DATA
Received 05 12 2019
Accepted 21 03 2020
Published 01 04 2020

BACKGROUND: Previous studies performed analyses of the agonist/antagonist ratio (AAR) largely in athlete population. However, no study has observed the effects of physical activity on the AAR in different movement velocities for older people.
AIM: This study aims to: i) investigate the influence of aging on the agonist/antagonist ratio of lower limbs joints in different angular velocities; ii) compare the agonist/antagonist ratio of lower limb joint between older participants of Exercise Guidance Service (EGS) and inactive older adults.
METHOD: 86 individuals were distributed into three groups: young adults (n=25); inactive older group (n=30); active older group (n=31). In order to evaluate agonist/antagonist ratio (AAR), an isokinetic dynamometer was used, and the tests consisted of maximal concentric contractions of hip flexor/extensor and abductor/adductor muscles, knee flexor/extensor muscles and ankle dorsiflexor/plantarflexor muscles.
RESULTS: AAR was higher at 60°/s than 120°/s for hip joint (abductor/adductor) for young adults and older adults (active and inactive). In addition, AAR was higher in 120°/s than 60°/s for knee joint (flexor/extensor) for young adults and older adults (active and inactive). Finally, AAR was higher in older groups (active and inactive) than young adults for ankle dorsiflexor/plantarflexor.
CONCLUSION: The Exercise Guidance Service does not contribute to aspects related to the production of torque and power in lower limbs muscles, consequently, not influencing AAR of hip, knee and ankle between active and inactive groups. Moreover, it seems like aging can influence the AAR in ankle joint.

KEYWORDS: Angular velocity | Isokinetic dynamometer | Torque | Muscle balance

INTRODUCTION

Torque can be defined as the rotational effect caused by a force on a joint[1]. Thus, it is possible to understand that a muscle, by contracting and moving the bony part in which it is inserted, will produce a certain value of joint torque. Throughout the range of motion, there is a higher value generated for torque, known as peak torque (PT), used to calculate the balance ratio between the agonist and antagonist muscles of each joint[2]. This agonist/antagonist ratio (AAR) provides information about possible muscle imbalances regarding power and torque production capacity and is widely used in injury rehabilitation strategies and high-performance sports[3]. Another way to analyze the AAR is through muscle co-contraction, understood as a simultaneous contraction of agonist and antagonist muscles that cross a joint[4]. Several activities depend on agonist and antagonist muscles coordination during a voluntary contraction[5]. Iwamoto, Takahashi and Shinkoda (2017)[4] compared the ankle joint muscles co-contraction in the older and young adults in a stability test at different velocities. These authors found that muscle co-contraction was greater for older adults than young adults. Furthermore, only for young group, the muscle co-contraction values were greater for faster than preferred speed. In addition, it was observed that co-contraction was higher in the deceleration phase than in the acceleration phase for both groups. Thus, it was possible to conclude that the velocity of ankle joint-related muscle contraction is different for young and older adults. In this context, older people use greater muscle activation compared to young adults, in order to maintain stability during movement. However, this may be a risky strategy in relation to cost-benefit ratio of energy demand.

Therefore, the aging process can be understood as a natural and inherent process in humans, leading to a deterioration of body systems, including the musculoskeletal and sensory, which is closely linked to a decline in mobility[6]. Furthermore, the decline in lower limbs neuromuscular function (e.g., decline in muscle peak torque) caused by aging may be a risk factor for falls for older adults[7]. Lanza et al. (2009)[8] compared torque, velocity and power of the knee and ankle joint muscle groups between young and older adults at different angular velocities. The authors verified that the older group compared to young adults presented lower concentric torque and muscle power, for knee extensors (32%) and ankle dorsiflexors (26%) in different velocities (e.g., 60°/s, 120°/s). These authors evidenced the decline in strength and muscle power in older people and showed that the deterioration of muscle function in older adults occurs in different proportions and different muscle groups of lower limb. Moreover, peak torque and muscle power may influence older people's ability to perform daily tasks[9].

In this context, physical activity is an important tool for positively impacting physical, cognitive and social aspects[10]. Moreover, physical exercises are linked to the protection of functional capacity at different ages, with capacity for the development of muscle strength and power[11]. Among the types of physical activities, programs that aim to simultaneously develop strength, balance and flexibility, known as multicomponent programs, seem to be linked to improvements in the functionality in older adults[12]. Thus, it seems to be important to develop oriented physical activity to promote health. With this aim, the Exercise Guidance Service (EGS), created by the Municipal Secretariat of Vitória/ES in 1985, develops activities to improve muscle balance (i.e., agonist/antagonist ratio), such as stretching and functional circuit[13] for people of various age groups[14].

Despite being a solid program, there is little evidence on the health benefits of EGS in population (e.g., improvement of physical aptitude), more specifically on the effects of EGS on the age-related decline on the musculoskeletal system. Moreover, multicomponent exercises, such as offered by EGS, has been usually recommended for health[15]. Thus, it is important to understand the influence of the practice of these types of exercises (i.e., multicomponent exercises) on agonist/antagonist ratio (AAR) performance of older adults. Furthermore, most studies on AAR involved young adults and focused high-performance sports (e.g., soccer, running)[16], however, it is not totally clear the effect of aging on this ratio. Movement velocity also influences torque output, since slower velocities such as 60°/s are used to evaluate higher total muscle work (torque) and higher velocities such as 120°/s are better associated with the assessment of muscle power[17]. This study aims to: i) investigate the influence of aging on the agonist/antagonist ratio of lower limbs joints in different angular velocities; ii) compare the agonist/antagonist ratio of lower limb joint between older participants of Exercise Guidance Service (EGS) and inactive older adults.

The hypotheses of this study are: i) older adults (participants of EGS and inactive) will present lower AAR for hip, knee and ankle joints compared to young adults; ii) 60°/s velocity presents higher AAR than 120°/s due to the higher peak torque (PT) than the lower velocity. Inactive group will perform lower AAR for hip, knee and ankle joints than active group of EGS.

METHODS

Participants

Eighty-six individuals participated in this study and were distributed into three groups: 1) Young adult group (YA– 25 participants, 23,08 ±4,4 years | 67,4 ±14,1 kg | 1,69 ± 0,09 m) used as control group; 2) Inactive group (ITV – 30 participants, 66,7 ±4,5 years | 68,2 ±10,5 kg | 1,60 ± 0,05 m), constituted of older people who didn't practice physical activity for three months[15]; 3) Active group (ATV – 31 participants, 65,2 ±4,2 years | 66,5 ±9,6 kg | 1,60 ± 0,06 m) used as experimental group, which was composed of older adults who regularly practice more than three months of multicomponent exercises offered by Exercise Guidance Service (EGS) twice a week in sessions with 60 minutes of duration. Participants were included in this study if they were free from neurological and musculoskeletal disorders that prevented from performing motor tasks and cognitive impairment. All participants provided consent prior to data collection. The study was approved by the Research Committee of the Federal University of Espírito Santo (2.061.608).

Experimental Procedures

Data collection was performed in two days. The first day, anamnesis and anthropometric evaluations were performed in EGS units (Vitória/ES). The physical activity level was assessed through modified Baecke Questionnaire for older adults[18], this questionnaire investigates about the daily sports and leisure activities. Mini-Mental State Examination – MMSE[19] was used to assess the cognitive function of older adults (active and inactive). On the second day, in the Strength and Conditioning Laboratory (LAFEC), located in Physical Education and Sports Center of the Federal University of Espírito Santo (CEFD/UFES), the muscle function was evaluated. Participants performed a 5-minute warm-up on the cycle ergometer and were positioned on the isokinetic dynamometer (Byodex System 4 Pro, Biodex Medical System, Shirley, NY, USA) according to the manufacturer's recommendations. The movements evaluated were: hip flexion and extension; hip abduction and adduction; knee flexion and extension; dorsiflexion and plantar ankle flexion. Concentric mode was used in velocities of 60°/s (5 repetitions) and 120°/s (10 repetitions) for all movements analyzed and participants were encouraged to develop maximum strength during the tests, with a rest interval of 60 seconds between different velocities evaluated. Measurements were collected only on the dominant limb (characterized as that used to kick a ball). The calibration and gravity correction procedures were performed according to the manufacturer's recommendations.

Dependent variables

The dependent variable used to assess muscle balance was the agonist/antagonist ratio (AAR), measured by calculating the peak of torque at angular velocities of 60°/s and 120°/s. To evaluate muscle balance, the following variables were analyzed: AAR on hip joint during flexion and extension movement; AAR on hip joint during abduction and adduction movement; AAR on knee joint during flexion and extension movement; AAR on ankle joint during plantar flexion/dorsiflexion movement.

Statistical analysis

Independent sample *t* Tests were performed to compare clinical characteristics (MMSE and Baecke Questionnaire). Analysis were performed using the SPSS software and the level of significance was kept at $p < 0.05$. For the agonist/antagonist ratio (AAR) variables, we conducted two-way ANOVAs (group [YA, ITV, ATV] x angular velocity [60°/s and 120°/s]) with repeated measures in the last factor for each dependent variable. When necessary, Tukey HSD post-hoc comparisons were performed as well.

RESULTS

In relation to the level of physical activity, the Baecke Questionnaire was used, showing that the older participants of the EGS presented a higher level of physical activity compared to the inactive older adults (ATV: 13.9 ± 4.3 points | ITV: 3.8 ± 4.3 points, $p < 0.05$). The young adults were physically active (8.9 points). In relation to Mini-Mental score, the statistical analysis revealed no differences between older active group and older inactive group (ATV: 27.87 ± 1.67 points | ITV: 27.80 ± 1.40 points, $p > 0.05$).

The ANOVA for AAR on hip joint during abduction/adduction movement revealed no mean effect of group ($F_{2,83}$=2.280, p=0.109), but revealed mean effect of angular velocity ($F_{1,83}$=8.773, p=0.004), and no interaction between group and angular velocity ($F_{2,83}$=1.350, p=0.265). The AAR was higher in 60°/s (96.7%) than in 120°/s (84.9%) (Figure 1A). The ANOVA for AAR on hip joint flexion/extension movement revealed no mean effect of group ($F_{2,83}$=2.450, p=0.093), no mean effect of angular velocity ($F_{1,83}$=0.051, p=0.821) and no interaction between group and angular velocity ($F_{2,83}$=2.028, p=0.138). The ANOVA for AAR on knee joint during flexion/extension movement revealed no mean effect of group ($F_{2,83}$=0.080, p=0.923), but revealed mean effect of angular velocity ($F_{1,83}$=6.022, p=0.016), and no interaction between group and angular velocity ($F_{2,83}$=0.712, p=0.494). The AAR was higher in 120°/s (51.9%) than in 60°/s (48.8%) (Figure 1B). Finally, the ANOVA for AAR on ankle joint during plantar flexion/dorsiflexion movement revealed mean effect of group ($F_{2,83}$=5.766, p=0.005), but no mean effect of angular velocity ($F_{1,83}$=1.844, p=0.178), and no interaction between group and angular velocity ($F_{2,83}$=1.821, p=0.168). The AAR was higher for both older groups (ATV – 87.2%; ITV – 74.2%) than young adults (56.9%) (Figure 2).

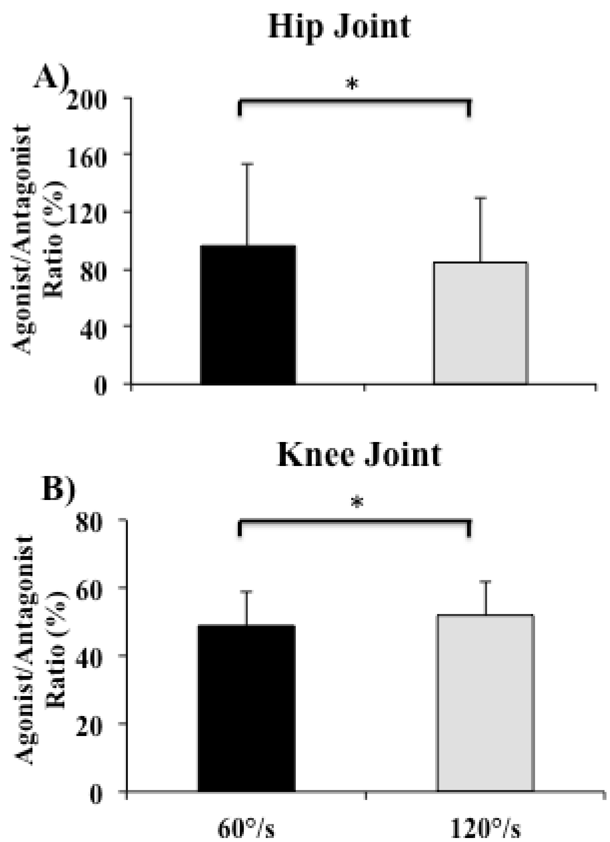

Figure 1. Mean and standard deviation of hip (A) and knee (B) joint agonist/antagonist ratio for velocities of 60°/s and 120°/s. Note: symbol (*) indicate statistically significant difference between velocities.

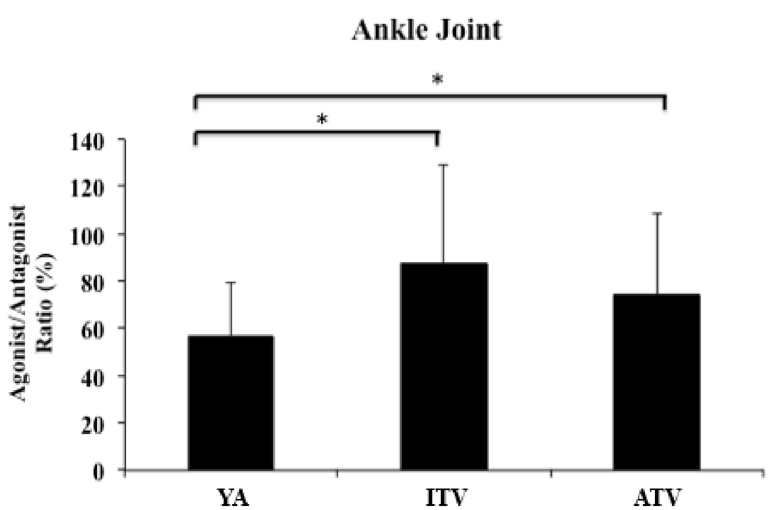

Figure 2. Mean and standard deviation of ankle joint agonist/antagonist ratio for young adults (YA), inactive (ITV) and active (ATV) groups. Note: symbol (*) indicate statistically significant difference between groups.

DISCUSSION

The aims of this study were to verify the influence of aging on the agonist/antagonist ratio, analyze the effect of different angular velocities on agonist/antagonist ratio (AAR) of the lower limbs of older participants of Exercise Guidance Service activities (EGS) and compare them with inactive older adults. The main findings were: for hip and knee joints, there was only difference in AAR for 60°/s and 120°/s velocities for both groups. In the hip joint, for abduction/adduction movements, the three groups presented higher AAR for 60°/s than 120°/s velocity and in the knee joint, for flexion/extension movements, a higher AAR for 120°/s than 60°/s velocity. For ankle joint, in plantar flexion/dorsiflexion movements, there was a difference between groups; older adults (ATV and ITV) presented a higher AAR than young adults. These results partially confirm the hypotheses previously presented.

The results revealed that older groups (active and inactive) presented higher values of agonist/antagonist ratio (AAR) for ankle joint than young adults. This difference can be explained by a possible greater activation of the ankle muscles of older adults compared to young adults in order to maintain stability during the movement. Recently, Chandran et al. (2019)[20] compared the co-contraction of the knee muscles (vastus lateralis and biceps femoris muscles) and ankle muscles (tibialis anterior and gastrocnemius muscles) between the older adults and young adults during walking and up and down stairs. These authors suggest that older adults showed greater co-contraction only in the knee joint muscles, which supports the premise that activation of agonist and antagonist muscles in older adults differ to young adults. It seems that cortical inhibitory circuits are less active on older when compared with younger adults, which can result in higher muscle activation of antagonistic muscles, consequently, higher co-contraction[21]. In addition, the aging process is associated with impaired neuromuscular function, loss of muscle mass and consequently greater difficulty in performing daily tasks. The results found by Chandran et al. (2019) were different of the present study, which can be explained by different characteristics of the experimental tasks. For example, Chandran et al. (2019) analyzed muscle active in walking and stairs activities and the present study analyzed lower limbs movements in dynamometer isokinetic. Felício et al. (2015)[22] analyzed the performance of the knee joint muscles in groups of older women in the community and compared between the ages of 65 to 74 years and 75 years or older; the results showed that muscle aging impacted the PT of these two groups, in which the younger group obtained a higher value in relation to the older one for 60 and 180°/s velocities. Thus, the authors identified that there was no difference in AAR for both velocities, pointing out that values below 40% indicate the predominance of extensor muscles or flexor muscles deficit, which may represent a knee joint imbalance.

In relation to the 60 and 120°/s velocities, the results revealed difference in AAR between hip and knee joints for young adults and older adults (active and inactive). This may indicate that perform abduction/adduction of the hip in lower velocity (60°/s) required a relatively higher contraction of antagonist to control the velocity of the movement, and relatively lower activation of agonist to generate the movement compared with higher velocity (120°/s), resulting in a higher AAR during 60°/s vs. 120°/s. On the other hand, during rapid knee flexion/extension movement, the antagonist needs to be highly active to generate eccentric force to break the movement and/or stabilize the knee joint, a situation that is less necessary during less demanding knee flexion/extension isokinetic contraction. Oliveira (2006)[23] compared the strength between the agonist and antagonist muscles for hip joint of older adults and young people. These authors found that AAR was not different between groups for the 60°/s velocity, corroborating the results found in the present study. On the other hand, Borges et al. (2015)[24] demonstrate higher peak torque values for hip and knee joints at 60, 120 and 180°/s angular velocities for adults compared to older adults that supports the idea of the effects of aging on torque production and movement velocity. Although the importance of resistance exercices for older adults is well elucidated in the literature, there is a divergence regarding the issue of execution of training to improve the maximum force (peak torque) and those that aim to improve the muscular power. In a protocol proposed by Englund et al. (2017)[25], changes in muscle function in the older adults were analyzed during 6 weeks of isokinetic training at high velocity (240°/s) or at low velocity (75°/s). The results showed that older group that was involved in high velocity improved muscle power and mobility.

The activities proposed by Exercise Guidance Service (EGS) are general (multicomponent exercises) and may not to contribute to aspects related to the AAR level of population. Although the older group who participated in the activities offered by the EGS did not show significant difference from the inactive group, which may be related to a lower co-contraction of the antagonist muscles involved or a higher peak torque due to physical activity, multicomponent programs, such as those offered by EGS, have been indicated for improving muscle function for older adults. However, Vieira (2019)[17] separated two groups of older adults, one that followed the activities proposed by the EGS and the other group composed of inactive older adults, submitting them to a protocol on the isokinetic dynamometer in order to evaluate muscle function (strength and muscle power) of the muscle groups of each lower limb joint (hip, knee, ankle) at velocities of 60 and 120°/s. The results showed that there was no significant difference for muscle strength between active and inactive older adults, but there was for the average power, which was related to the pratice of activities offered by the EGS. Similarly, the present study found no difference in AAR between active and inactive.

The present study presents some limitations. First, we did not carry out a pre- and post-training investigation of the modalities offered by EGS to elucidate possible changes caused by each of the practices. Second, EGS is a program that aimed to improve social aspects (e.g., leisure and socialization), thus, it becomes difficult to control training parameters (e.g., overload and intensity) that can provide more accurate data on changes and adaptations promoted to the participants. Finally, a robust longitudinal study would provide more information about the possible changes that EGS activities promote in AAR on older population. Further research should be conducted to clarify the benefits of the activities offered by the Exercise Guidance Service.

CONCLUSION

The agonist/antagonist ratio (AAR) of the lower limbs was not different between the active and inactive older adults for both analyzed velocities (60 and 120°/s), which may indicate that the activities performed in the program do not contribute to aspects related to the production of torque and power. Moreover, older adults (activie and inactive) presented higher AAR than young adults in plantar flexion/dorsiflexion for ankle joint, indicating an aging process influence on muscle balance.

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Citation: Garcia GR, Vieira LA, Seibel VV, Razuk M, Rinaldi NM. Agonist/Antagonist Ratio for ankle joint is similar between active and inactive older adults compared to hip and knee joints. BJMB. 2020: 14(1): 4-13.
Editors: Dr Fabio Augusto Barbieri - São Paulo State University (UNESP), Bauru, SP, Brazil; Dr José Angelo Barela - São Paulo State University (UNESP), Rio Claro, SP, Brazil.

Funding: There was no funding for this study.
Competing interests: The authors have declared that no competing interests exist.
DOI: https://doi.org/10.20338/bjmb.v14i01.158