

Muscle torque of healthy individuals and individuals with spastic hemiparesis after passive static stretching

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Spasticity is one of the main causes of contracture, muscle weakness and subsequent functional incapacity. The passive static stretching can be included as having the purpose of increasing musculoskeletal flexibility, however, it also can influence the muscle torque. The objective is to verify the immediate effect of passive static stretching in the muscle strength of healthy and those who present spastic hemiparesis. There were assessed 20 subjects, 10 spastic hemiparetic (EG) and 10 healthy individuals (CG), including both sexes, aged between 22 and 78 years. The torque of extensor muscles of the knee was analyzed using isokinetic dynamometer. Results have shown that EG has less muscle torque compared to CG ($p < 0.01$). In addition, EG presented a decrease in significance of muscle torque after stretching ($p < 0.05$), however, it has not shown significant alteration in muscle torque of CG after performing the program that was prescribed. Immediately after the passive stretch, a significant torque decrease can be seen in hypertonic muscle; it is believed that this reduction may be associated with the physiological overlap between actin and myosin filaments and so preventing the muscle to develop a maximum contraction.

Key words: muscle hypertonia, muscle strength, passive stretching

1. Introduction

Cerebrovascular accident (CVA) generally provokes a clinical condition of spastic hemiparesis contralateral to the injured hemisphere; it is characterized by flexion pattern of the upper limb and extension of lower limb [1]–[3].

Spasticity is a consequence of lesion in the pyramidal tract of prefrontal gyrus, which promotes a neural hyperexcitability. Among clinical manifestations due to this dysfunction there are observed Babinski sign, muscle clonus, hyperreflexia and alteration of muscle viscoelastic properties, which may lead to muscle shortening and decrease in muscle fibers recruitment during movement performance [4]–[8].

The greatest challenge for physiotherapists in rehabilitation of patients who present spastic hemiparesis is gaining flexibility and increase muscle strength

in the affected side of the body in order to obtain functional improvements [9].

Muscle shortening is a common result of spasticity that causes series of difficulties in activities of daily living and leads to deformities, joint rigidity, contractures, strains and pain [10]–[12]. The flexibility improvement can be achieved through stretching, which promotes the increase of sarcomeres in series maintaining adequate range of motion. However, in scientific literature, there is evidence showing that this exercise modality may negatively interfere with muscle strength and performance [13], [14].

The muscle strength is related to torque, which is defined as the rotational effect of power produced by a single muscle or muscle group. The peak of torque is the greatest power that can be produced at a specific moment during a repetition [15]. A decrease in strength or paresis is characterized by reduction in ability to produce torque, which may occur due to deficiency in potency or work performed by the muscle [5], [6].

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To assess muscle strength, isokinetic dynamometer has been highly recommended, as it is a precise tool able to standardize speed, angle and power of agonist and antagonist muscles [16]–[19].

Therefore, the objective of this study was to verify the immediate effect of passive static stretching in muscle strength of individuals who present spastic hemiparesis and healthy individuals.

2. Materials and methods

The study was performed at the Laboratory of Biodynamic of Faculty of Health and Science of the University of Vale do Paraiba (UNIVAP), after the approval of the Ethic Committee, CAAE n°: 20482013.5.0000.5503 and after the volunteers have signed the Clarified and Free Acceptance Term.

Patients

As participants there were 20 individuals of both sexes, aged between 22 and 78 years; they were divided into two groups: Experimental Group (EG) involving 10 volunteers 53.9 ± 14.3 with medical diagnosis of cerebrovascular accident, (CVA), presenting spastic hemiparesis, and Control Group (CG) involving 10 volunteers 52 ± 15.3 that did not present any sensory-motor dysfunction.

Table 1. Hypertonia and strength values of the quadriceps of the patients in the experimental group (EG) through Scale Modified Ashworth and Kendall Scale

Subjects EG	Modified Ashworth Scale	Kendall Scale
1	1+	5
2	1	5
3	2	4
4	1+	5
5	1+	4
6	2	4
7	2	4
8	1	5
9	2	4
10	1+	4

Among the inclusion criteria for EG, there were considered: patients who present spastic hypertonia with score 1, 1+ and 2, according to the Modified Ashworth Scale, more than 2 years of lesion history (chronic phase), good cognition, with no orthopedic issue, with or without walking aid. As exclusion criteria, there were considered individuals with severe shortening, joint rigidity, grade of muscle strength of 0, 1 and 2, according to Kendall scale. The quadriceps muscle strength test

was performed by a single physical therapist, with the patient seated and his back against, a resistance was applied in the ankle area and called for knee extension, the Kendall scale was used to grade muscle strength.

The hypertonia and strength values of the quadriceps for the experimental group are shown in Table 1. The control group patients had zero grade muscle tone of the quadriceps through the Modified Ashworth Scale and muscle strength grade 5 through Kendall Scale.

Clinical assessment

Volunteers of EG have undergone a spastic hypertonia assessment according to Modified Ashworth Scale performed by two physiotherapists at double-blind method to actually confirm the score. The volunteers were asked to lay in supine with the affected limb relaxed in order for the therapist to perform a rapid and sudden passive movement to confirm whether the hypertonia grade of extensor knee muscles was according to the inclusion criteria.

After the Modified Ashworth Scale being applied, the assessment of muscle torque of both groups (EG and CG) using the computerized isokinetic dynamometer Biodex System 3[®], was recorded before and after the passive static stretching being performed. The protocol used in the analysis was with isometric mode in the period of 20 seconds.

For the test to be done, volunteers remained seated and stabilized onto the equipment chair, with their knees and hip flexed at 90°. The lever arm was placed 2 cm above the malleolus (medial and lateral) and the dynamometer axis aligned with the femoral tibial joint (Fig. 1). Resisted torque values were recorded by the isokinetic dynamometer software at a frequency of 100 Hz; in other words, every second, 100 torque values were collected and, consequently, the variations of isometric torque present 10 ms of accuracy.



Fig. 1. Isokinetic Dynamometer Assessment for analysis of muscle strength

Physiotherapeutic intervention

After the assessment, the volunteers were subjected to 3 series of 1 minute passive static stretching of quadriceps femoris in the hemiparetic side of EG and dominant side of CG, interval between series of 30 seconds [20]. For the stretching to be performed, the volunteers were positioned in lateral decubitus, with the affected side (EG) or dominant (CG) up. The inferior healthy limb was put into knee semi-flexion while the other limb (affected for EG and dominant for CG) in knee flexion, the same position as used by Almeida et al. [21]. The therapist stabilized their hip and femoral tibial joint. The instep remained placed on therapist abdomen while there was performed a passive extension of the hip.

Data analysis

The program EMGWorks Analyzis processed the data collected by Isokinetic Dynamometer; it quantified the mean torque and standard deviation regarding the isometric contraction of the knee extensors for the period of 20 seconds of all the individuals in the study. The data were exported to electronic spreadsheet, D'Agostino test was used to verify the normality of the data, the data had a normal distribution, so to compare the effect of the stretching intra and inter-group there was applied paired samples Student's *t*-test considering significant values of $p < 0.05$. Bioestat 4.0 program was used to perform these tests.

3. Results

Regarding the CG, results have shown reduction in the muscle torque after the performance of the stretch, however with no significant statistical value ($p > 0.01$), as demonstrated in Fig. 2. Considering the EG, a significant decrease of muscle torque was verified after the performance of the passive stretch with a value of $p < 0.05$, as shown in Fig. 3.

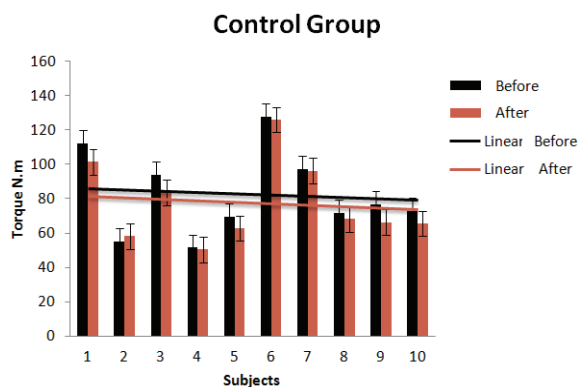


Fig. 2. Torque value before and after passive static stretching of quadriceps femoris of healthy individuals. Linear: trend line

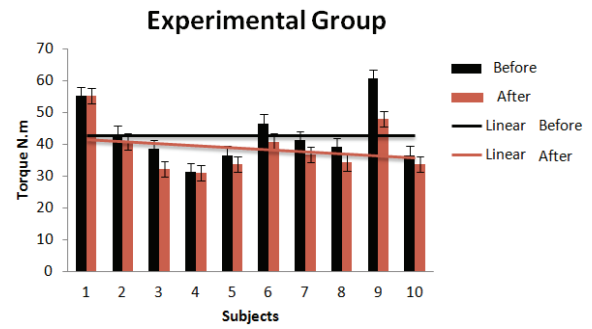


Fig. 3. Torque value before and after passive static stretching of quadriceps femoris of individuals with spastic hemiparesis. Linear: trend line

Comparing with the CG EG before and after passive stretching, as shown in Figs. 4 and 5, respectively, a significant reduction in muscle torque EG ($p < 0.0001$) was found.

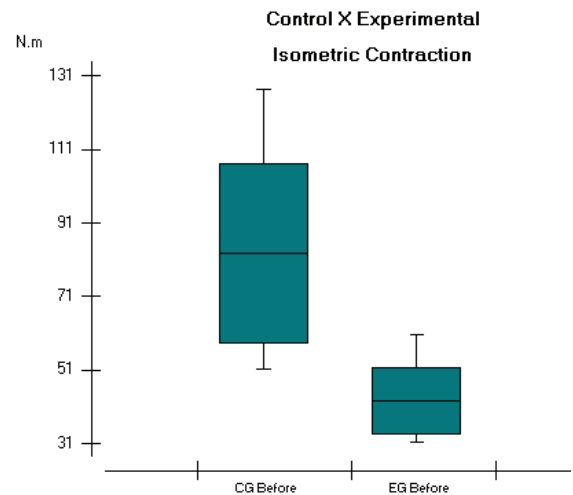


Fig. 4. Comparison of muscle torque between Control Group (CG) and Experimental Group (EG) before passive stretching. CG mean = 82.8 ± 24.4 and EG mean = 42.8 ± 9.0

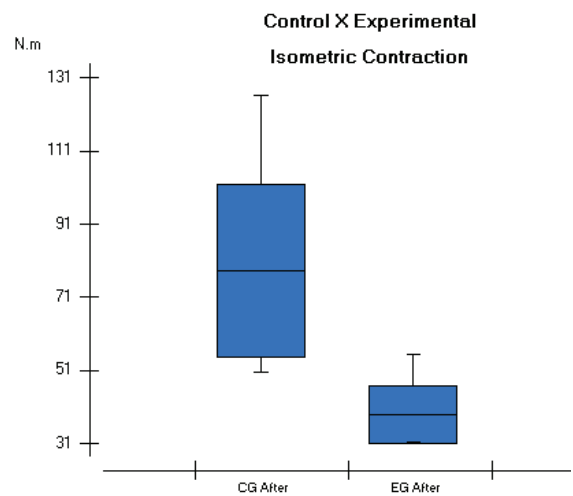


Fig. 5. Comparison of the muscle torque between Control Group (CG) and Experimental Group (EG) after passive stretching. CG mean = 77.8 ± 23.5 and EG mean = 38.6 ± 7.7

4. Discussion

The muscle stretching exercise promotes an improvement in the range of motion by increasing sarcomeres in series. However, there are some controversies regarding the effects of this therapeutic modality in muscle performance [13], [14].

In clinical practice, physiotherapists use passive stretch in order to maintain and/or improve the range of motion and decrease contractures that occur due to the alteration in biomechanical properties of muscles and tendons. This therapeutic resource shows to be efficient as proven before in studies performed in animals and human beings. The positive impact of passive stretching on muscle fascicles has been attributed to a chain of protein-protein interactions leading ultimately to myofibrillogenesis [22]. But there is no consensus in the literature that the passive stretching may or may not change the muscle strength in patients after stroke.

By means of this study, it is possible to observe that the torque of quadriceps femoris on the spastic hemiparetic side is less than a non-injured muscle. Supporting these findings, Bohannon et al. [16] said that there is a reduction in the strength mean of spastic muscles in relation to the antagonist muscle, being $74.0\% \pm 30.3\%$ in flexors of the elbow and $66.4\% \pm 26.3\%$ in medial rotators of the shoulder.

In this study, a significant torque reduction of the spastic muscle was observed in comparison with those without an injured muscle after the performance of passive stretching. It is believed that the torque reduction in quadriceps femoris may be related to the physiological overlap between actin and myosin filaments as it would prevent maximum contraction to happen, interfering, in such a way, in balance control and time/reaction movement [23], [24].

Cramer et al. [25] showed that the peak torque (PT) of healthy women decreased following the static stretching (1 active and 3 passive stretching exercises for knee extensor muscles) in both limbs and at both velocities (60 and $240^\circ \cdot s^{-1}$). The present findings suggested that the stretching-induced decreases in PT may be related to changes in the mechanical properties of the muscle, such as an altered length-tension relationship, or a central nervous system inhibitory mechanism. These findings indicated that static stretching impairs maximal force production.

Damiano et al. [26] verified torque in hamstrings and quadriceps femoris of patients with Cerebral Palsy (CP) in response to passive stretch. Results have shown that there was a reduction in PT of spastic muscles when compared with a non-injured muscle.

Contrary to the above, a study done by Tsai et al. [9] has shown the efficacy of a single session of a sustained muscle stretch of spastic calf, in subjects with hemiplegia, aiming at regulation of the muscle tone. In this study, 3 series of 1 minute of passive stretch in the spastic muscle were performed, and during the test, a reduction of voluntary torque was observed through isokinetic dynamometer.

Similarly, Gao [22] noted that the repeated stretching improved calf muscle force output of triceps surae, which might be associated with decreased muscle fascicle stiffness, increased fascicle length and shortening of the Achilles tendon.

It is important to highlight that the muscle power is related to the integrity of central and peripheral nervous system. Considering that the volunteers, who joined this research, presented a harmed Central Nervous System (CNS) due to Cerebrovascular Accident.

Consequently, this study has shown the reduction of muscle strength immediately after passive stretch, which may interfere in the motor function acquisition once performed before therapeutic interventions and functional activities of spastic hemiparetic patients.

Future studies are needed to identify the underlying mechanisms that influence the time course of stretching-induced decreases in maximal force production in hemiparetic patients after stroke.

5. Conclusion

It is concluded that chronic spastic hemiparetic patients have a reduced muscle torque when compared with individuals who do not present any dysfunction of the musculoskeletal system. Immediately after the passive stretch in 3 sets of 1 minute, significant torque decrease can be seen in hypertonic muscle, it is believed that this reduction may be associated with the physiological overlap between actin and myosin filaments and so preventing the muscle from developing a maximum contraction. Therefore, it is suggested that passive stretching exercise may be performed in chronic hemiparesis patients at the end of the therapy in order not to undermine functional kinesiotherapy.

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