Effect of Resisted Exercise on Muscular Strength, Spasticity and Functionality in Chronic Hemiparetic Subjects: A Systematic Review

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ABSTRACT

The purpose of this study was to verify, by a systematic literature review, the effect of resisted exercise applied to the inferior limbs spastic muscles in relationship to muscular force, spasticity and functionality of hemiparetic subjects. A literature review of the Medline, Lilacs, Scielo, PEDro, PubMed and Ebsco databases was performed. The following terms were used (MeSH key words): stroke, physical therapy modalities, muscle spasticity, muscle strength, muscle stretching exercises, rehabilitation, and its correspondents in the Portuguese language. A total of 961 references were located. Fourteen studies followed the inclusion criteria. Of these, 78.6% had been evaluated for muscle strength, and 91% of this group had increased significantly; 42.9% had been evaluated for spasticity level and none from this category had observed changes in muscular tonus; 85.7% of the studies had evaluated functionality by means of fourteen different instruments. Among these forms of evaluation, eight had been used in more than one study, in which two showed 100%

significant improvement, three showed 50% improvement, one presented 66.7% improvement, and another study presented 25% improvement. Resisted exercise can be an important tool in physical therapy treatment since the primary aim is to improve functionality of chronic hemiparetic subjects.

INTRODUCTION

Cerebral vascular accident (stroke) is an event characterized by a blood flow interruption in the brain. The two forms of stroke are ischemic and hemorrhagic[1]. Each year, 15 million people suffer a stroke. Of this number of people, 5.5 million die (10% of the deaths in the world are caused by strokes), and another five million people become invalids. In Brazil, in 2002, 129.172 cases of death occurred due to a stroke[2].

Stroke causes the death of brain neurons, and is capable of unlocking clinical disturbances related to superior motor neuron syndrome (SMNS), such as spasticity[3].

Spasticity is characterized by hypertonia that involves decurrent velocity-dependence with hypersensitivity of the stretching reflex, and possessing selectivity of anti-gravitational muscles (predominant in flexors of superior limbs and extensors of inferior limbs)[4]. These muscles perform parafunctional positions that restrict the range of movement and the contraction of soft tissues[5]. The abundance of muscular activity and spastic hypertonia are described as positive aspects; muscular weakness, fatigue, deficit of coordination, and the reduction of movement speed are called negative aspects[3], and they are the main limitations of functional ability.

Muscle weakness, described as muscular incapacity to produce force and to generate movement[6], is directly related to ability and functionality. They are determinative for the maintenance of independent lifestyle and prevention of falls[7]. Therefore, the rehabilitation of muscular force becomes necessary in these patients.

In the past, the strengthening viability of spastic muscle was argued to be that resistance exercises of these muscles would increase spasticity, and thereby reinforce parafunctional patterns[8]. However some studies have demonstrated in clinical trials[9,10,11] and literature reviews[12,13] that muscular strengthening does not promote increase of spasticity in trained muscles.

Therapeutic strengthening exercises aim to correct or to prevent musculoskeletal deficiencies and to improve the function, health, and daily life activities through neuromuscular adaptations[14,15].

However, the strengthening of spastic muscles still demonstrates controversial results in literature. This occurs because distinct methodologies and different types of strengthening are used. Some utilize strengthening by functional postures, functional electrical stimulation (FES), muscle re-education, and other techniques that may or may not be associated to resisted exercise.

Although the benefits of resisted exercise are widely known to benefit the health of its subjects[14], the authors of this study have not acknowledged a systematic review that would analyze research papers that utilized resisted exercise as a strengthening method, associated or not associated to other tasks.

In view of the fact that muscular weakness as it relates to strokes, is closely connected to inability and dependence, the purpose of resisted exercise is as a therapeutic exercise. Due to the existence of controversies about the strengthening of spastic muscles, the purpose of this study was to verify, by a literature review, the effect of resisted exercise on spastic muscles in relation to muscular force, spasticity and the functionality in inferior limbs. The purpose was to identify the different methodologies regarding the degree of muscular force, spasticity, and functionality in inferior members.

METHODS

Identification of the studies

A literature review in the Medline, Lilacs, Scielo, Physiotherapy Evidence Database

(PEDro), PubMed and Ebsco databases from 1997 to 2008 was performed, using the following terms (MeSH key words): stroke, physical therapy modalities, correspondent terms in the Portuguese language. The title and summary of the researched studies were previously analyzed according to inclusion and exclusion of proposed criteria.

Clinical trials (controlled or not controlled, randomized, blind or double-blind) were included in this study in which subjects were evaluated with a medical diagnosis of stroke with a time of injury superior to six months. A resisted program had been developed with overload (associated or not to other guided activities, and is considered any activity associated with resisted exercise), to inferior limbs (associated or not to trunk and/or superior limbs); published in Portuguese or English and available within Brazil. This study excluded case reports, literature reviews, descriptive research, studies that had used FES as strengthening tool and/or to help in the voluntary movements of inferior limbs, and studies that performed secondary analysis without methodology descriptions.

In papers in which the summary of the study did not clarify all the inclusion and exclusion criteria, a full text was acquired for prior analysis.

All of the studies obtained through this research were analyzed separately and discussed among the authors in relation to their inclusion or exclusion.

Description of the evaluated data

The potential studies were selected in accordance with the inclusion and exclusion criteria and acquired in full text for specific analysis of the relevant variables of the proposed issue.

The aspects of the research evaluated were: (1) total result of the research; (2) total result of studies found in more than one database; (3) distribution of the total result by database; (4) distribution in relation to the language; (5) number of papers previously selected; (6) number of papers excluded after specific analysis, and (7) total papers selected and included in the study.

The studies selected were evaluated in relation to: (1) quality of the studies, and they were evaluated according to Jadad Quality Scale, as described by Jadad et al. (1996)[16], and the evaluation was made independently by two evaluators (CASB and KCC), in

***Table 1** – References distributed in accordance with the cross-referencing performed in the databases*

Databases	A	B	C	D	E	F	G	H	I	Total per data-bases
EBSCO	190	57	93	31	-	-	-	-	44	327
MEDLINE	138	38	8	26	-	-	-	-	23	187
PEDRO	66	7	1	12	-	-	-	-	16	70
PUBMED	221	107	61	32	-	-	-	-	51	370
LILACS	-	-	-	-	0	3	2	4	3	6
SCIELO	-	-	-	-	0	1	0	0	0	1
Total										961

A=Stroke and Strength and training; B=Muscle and Spasticity and Stroke and Muscle and Strength; C=Muscle and Spasticity and Stroke and Physical and Therapy; D=Muscle and strengthening and Stroke; E=Acidente cerebral vascular and exercício resistido; F=Espasticidade muscular and Acidente cerebral vascular and força muscular; G=Espasticidade muscular and Acidente cerebral vascular and fisioterapia; H=Fortalecimento muscular and acidente cerebral vascular; I= studies founded in more than one database.

which agreement of study value was obtained; (2) subjects included; (3) described and implemented programs evaluated in relation to: warm up application, number of series and repetitions, the applied load, the equipment used, rest time between the series, the fortified muscular groups, and type of exercise, the association of other guided activities, the use of cooling down, and the time or frequency of training; (4) the methods of evaluation and evaluated parameters; and (5) the final results.

RESULTS

The research

Nine hundred sixty-one references were found and distributed in accordance with the cross-referencing performed in the databases (Table 1). Of these references, 954 (99.27%) were written in English and seven

Table 2 *– Scores obtained based on the Jadad Quality Scale*

	1. Randomization		2. Double blinding		3. Withdrawals and dropouts	Results
	1A. Was the study described as randomized?	1B. Was the method described and it was appropriate?	2A. Was the study described as double-blind?	2B. Was the method described and it was appropriate?	Was there a description of withdrawals and drop outs?	
FLANSBJER et al., 2008	Yes (+1)	No (-1)	No (0)	No (0)	Yes (+1)	1
KIM et al., 2001	Yes (+1)	No (-1)	Yes (+1)	Yes (+1)	Yes (+1)	3
OUELLETTE et al., 2004	Yes (+1)	No (-1)	No (0)	No (0)	Yes (+1)	1
SHARP; BROUWER, 1997	No (0)	No (0)	No (0)	No (0)	Yes (+1)	1
AUGUSTO et al., 2003	No (0)	No (0)	No (0)	No (0)	No (0)	0
TEIXEIRA-SALMELA et al., 2003	No (0)	No (0)	No (0)	No (0)	No (0)	0
AKBARI; KARIMI, 2006	Yes (+1)	No (-1)	Yes (+1)	Yes (+1)	No (0)	2
GUIMARÃES et al., 2007	No (0)	No (0)	No (0)	No (0)	No (0)	0
CARR; JONES, 2004	No (0)	No (0)	No (0)	No (0)	No (0)	0
TEIXEIRA-SALMELA et al., 1999	Yes (+1)	No (-1)	No (0)	No (0)	Yes (+1)	1
ENG et al., 2003	No (0)	No (0)	No (0)	No (0)	Yes (+1)	1
TEIXEIRA-SALMELA et al., 2001	No (0)	No (0)	No (0)	No (0)	Yes (+1)	1
CRAMP et al., 2006	No (0)	No (0)	No (0)	No (0)	Yes (+1)	1
WEISS et al., 2000	No (0)	No (0)	No (0)	No (0)	Yes (+1)	1

(0.73%) in Portuguese. Among these references, 550 studies were found in more than one database. The remaining 411 studies were found in a single database.

After analysis of the titles and summaries, 28 studies were selected in accordance with the inclusion and exclusion criteria proposed in these abstracts. These had been acquired as complete text, and an additional 14 studies were excluded after specific analysis. Fourteen studies were selected and included in this review.

The studies

Quality of the studies

Of the 14 selected studies, four obtained a value of zero (28.57%), eight obtained a value of one (57.14%), one study received a value of two (7.14%), and one study obtained a value of three (7.14%) based on the Jadad Quality Scale (Table 2).

Included subjects

A total of 318 subjects were evaluated, however, two of the included studies in this review were secondary analysis. The total in both studies was 43 subjects[17, 18]. Therefore, 275 represents the real number of subjects evaluated, and the average number of subjects per study was 23. It was observed that the age of these subjects varied between 30 and 82 years old. In relation to the time of injury, 42.85% of the studies had selected patients at least six months after injury, while 35.72% had selected patients with more than one year after injury, and 21.43% with at least nine months after injury.

Described and utilized programs

The utilized programs were analyzed in relation to: warm up, number and series and repetitions, applied load, equipment used, time of rest between series, exercised muscle groups and the type of exercise, the association of other guided activities, the use of cooling down, and the time and frequency of the trainings (Table 3).

A total of 78.58% of the included studies reported warm up period along with passive stretching, calisthenics and range of motion exercises, ergometric bike exercise, free active exercises, and resisted active exercises in association or not.

The number of series and repetitions applied in 61,54% of the studies was three sets of 10. With respect to the imposed load, 71.42% of the studies had used the protocol of 1 maximum repetition (MR). Of these, 30% used 70% of 1 MR, 20% used 80% of 1 MR, 20% used 100% of 1 MR, while 20% worked out between 50% and 80% of 1 MR and 10% used between 20% and 50% of 1 MR.

Of the 14 selected studies, 35.71% used free weights, 35.71% used bodybuilding devices, and 28.58% used isokinetic equipment in association or not.

The rest time between series was not reported in 57,14% of the 14 included studies in this review.

Among the included studies in this review, it was observed that inferior limbs within eight muscular groups became stronger. Of these studies, 71.42% had increased knee extensor strength in association to other groups. Three studies performed trunk and superior limbs strengthening along with inferior limbs strengthening. Only one study aimed specifically at strengthening muscular groups.

In relation to the type of exercise, 57.14% of the studies performed concentric exercises in association or not to eccentric and/or isometric exercise.

In this review, 42.85% of the included studies did not perform any activity in association to strengthening. Among the 57.14% that performed associations, 37.5% had associated resisted exercises only to aerobic exercises, 25% performed the resistance training associated with home exercises, and 12.5% performed the resistance trainings in concert with aerobic and function training.

Among the 14 studies, it was observed that 71.42% of these related to cooling down by manual, passive stretching.

The time of the training varied between four and 24 weeks. Thirty-five point seventy-one percent of the studies performed

Table 3 – Description of utilized programs

STUDIES	WARM-UP	STRENGTH TRAINING							COOLING DOWN	ASSOCIATION OF OTHER GUIDED ACTIVITIES	TIME AND FREQUENCY
		Series / repetitions	*Applied load*	*Equipment used*	*Time of rest*	*Exercised Muscle groups*	*Type of exercise*	*CG*			
FLANSBJER et al., 2008[28]	5' EB; 5 reps FAE + 5 reps 25% 1MR	2 x 6-8	80% 1MR	Bodybuilding devices	2'	FL and EX of K	Not reported	Yes	PS	Not done	10 wks, 2 x wk, (90')
KIM et al., 2001[29]	5' FAE + PS	3 x10	100%1MR	Isokinetic equipments	Free	FL and EX of H, K, and AN	CO	Yes	PS	Not done	6 wks, 3 x wk, (45')
OUELLETTE et al.,2004[30]	4 reps 25% 1MR	3 x 8-10	70% 1MR	Bodybuilding devices	Not reported	EX of K, DF and PF	Not reported	Yes	Not done	Not done	12 wks, 3 x wk
SHARP; BROUWER,1997 [31]	5' EB + PS	3 x 6-8	100% 1MR	Isokinetic equipments	Not reported	FL and EX of K	CO	No	PS	Not done	6 wks, 3 x wk, (40')
AUGUSTO et al., 2003[32]	5'-10' PS + ROM + calisthenic	3 x10	Without protocol	Bodybuilding devices and free weights	> 30"	SL, trunk and IF (ABD, ADD, FL and EX of H, FL and EX of K, DF and PF)	CO, EC and IS	No	PS and RL	Aerobic exercise	10 wks, 3x wk, (90' a 150')
TEIXEIRA-SALMELA et al., 2003[17]	5'-10' PS + ROM + calisthenic	3 x10	Without protocol	Bodybuilding devices and free weights	1' -2'	SL, trunk and IL (Not reported which muscles)	CO, EC and IS	No	PS and RL	Aerobic exercise	10 wks, 3x wk, (90' a 120')
AKBARI; KARIMI, 2006 [33]	Not done	1 x 10	70% 1MR	Not reported	Not reported	ABD, FL and EX of H, FL and EX of K, DF and PF	CO	Yes	Not done	Aerobic exercise and functional exercise	4 wks, 3x wk, (3h)
GUIMARÃES et al., 2007[34]	PS	4 x 10	80% 1MR	Free weights	Not reported	Triceps surae	CO, EC and IS	No	PS and RL	Not done	8 wks, 3 x wk (30')
CARR; JONES, 2004[35]	Not done	2 x 10	Without protocol	Isokinetic equipments and free weights	Not reported	SL and IF (Not reported which muscles)	Not reported	Yes	PS	Aerobic exercise	16 wks, 3x wk
TEIXEIRA-SALMELA et al., 1999[36]	5'-10' calisthenic + PS + ROM	3 x 10	50% - 80% 1MR	Body weight, free weights and elastic bands	1'- 2'	ABD, FL and EX of H, FL and EX of K, DF and PF	CO, EC and IS	Yes	PS and RL	Aerobic exercise and home exercises	10 wks, 3x wk (60'- 90')
ENG et al., 2003[37]	FAE of SL+ PS	Not reported	Borg (11-13)	Free weights	Not reported	Not reported	Not reported	No	PS	Functional exercise	8 wks, 3 x wk (1h)
TEIXEIRA-SALMELA et al., 2001[18]	5'-10' calisthenic + PS + ROM	3 x 10	50% - 80% 1MR	Body weight, free weights and elastic bands	1'- 2'	ABD, FL and EX of H, FL and EX of K, DF and PF	CO, EC and IS	No	PS and RL	Aerobic exercise and home exercises	10 wks 3x wk (60'- 90')
CRAMP et al., 2006[38]	3'- 5' EB + PS of IL	3 x 10	20% -50% 1MR	Body weight, elastic bands and Bodybuilding devices	Not reported	EX and ABD of H, EX of K	Not reported	No	Not reported	Functional exercise	6 months, (among 16 and 24 wks), 2 x wk
WEISS et al., 2000[39]	Not done	3 x 8-10	70% 1MR	Bodybuilding devices	Not reported	FL, EX and ABD of H, EX of K	Not reported	No	Not done	Not done	12 wks, 2 x wk

Abbreviations : ABD: abductor; ADD: Adductor; An: ankle; CG: Control group; CO: concentric; DF: dorsiflexors; EB: ergometric bike; EC: eccentric; EX: extensors; FAE: free active exercise; FL: flexors; H: hip; IL: inferior limbs; IS: isometric; K: knee; 1MR: one maximum repetition; PF: plantarflexors; PS: passive stretching; reps: repetitions; RL: muscular relaxations; ROM: range of motion exercises; SL: superior limbs; wks: week.

strengthening for ten weeks. In relation to frequency, 78.57% of the studies completed three sessions per week, with a frequency variation of two and three times per week.

Evaluation methods and analyzed parameters

The parameters evaluated that were considered excellent for this review were: spasticity, muscle force, and functionality.

The spasticity was evaluated in 42,86% of the included studies. The Modified Ashworth Scale (MAS) was used in 66.66%, and the pendulum test for 33,33%. In relation to power, 78.57% had evaluated power, and 54.54% of these had used the isokinetic dynamometer, 1 MR, and manual dynamometer.

The functionality was evaluated in 85.71% of the studies by 14 different instruments. Of these studies, 57.14% of these instruments had been used in more than one study. Between the most common instruments, it was shown that 50% of the studies had used the gait speed measurement with a chronometer as the evaluation method, and 25% had used the six minute walk test (6MWT). The gait evaluation in a motion analysis laboratory was used as the method of evaluation in 16.66% of the studies. The following methods were found in the same proportion: Balance Mater System, Human Activity Profile (HAP), Berg Balance Scale (BBS) and Time get up and go (TUG).

Obtained Results

In view that several variable are directly associated to the parameters evaluated for each study, the authors of this review preferred to quantify the results in accordance with statistical significance in: "total increase and/or improve" (75% of the parameters obtained significant increase and/or improve), "partial increase and/or improve" (50% to 75% of the parameters obtained significant increase and/or improve) or "no increase and/or improve" (less than 50% of the parameters obtained no significant increase and/or improve). The percentile points of the results did not take into consideration this classification. Of the studies that had evaluated spasticity, none demonstrated changes in muscular tonus in final evaluations.

Among the studies that had used 1 MR or manual dynamometer as measurement, all presented increase in power. In the studies that used isokinetic dynamometer as a form of measurement, 83.33% had demonstrated increase in power.

In relation to the functionality, the results were separated in accordance with the applied instruments (Figure 3). Of the studies that used the gait speed measurement with a chronometer as the evaluation tool, 50% of these had demonstrated significant improvement. Only 25% of the studies that applied time measurement of functional activities had shown significant improvement. Around 66.66% of the studies that had used 6MWT as a tool had demonstrated significant improvement. In the studies that used a gait laboratory, only one showed improvement among the analyzed parameters. All the studies that used BBS and HAP methods, had presented improvement. In the evaluation by Balance Master System, one study of two that had used it presented significant improvement. None of the studies that performed TUG as the evaluation tool presented improvement.

DISCUSSION

The variability of the results regarding muscle strengthening applied to spastic subjects is related to the variety of evaluated parameters and methodological differences of the analyzed studies. Only 14 studies followed all the inclusion criteria considered by the authors of this study. For quality evaluation of the studies a Jadad Quality Scale was used. In their study, Silva Filho et al. (2005)[19] compared the scales Jadad, Maastricht, Delphi and Cochrane Collaboration, showing moderate correlation results between them, suggesting that all are applicable in the quality evaluation of clinical studies. Furthermore, the great familiarity the authors had of this review of their methodologies was determinative of their choices.

According to the Jadad Quality Scale,

only one clinical trial can be considered randomized or double-blind. Because the purpose of randomized clinical trials has the intention to minimize results bias[20], it was observed that in the included studies, only one presented great scientific relevance.

The number of subjects varied in the studies between 7 and 42, resulting in an average of 23 subjects for study. Also, there was great age variation among the subjects (30 to 82 years old). It is well-known that functional declination starts around 30 years old and becomes serious around 65-70 years old[21]. However, there is a great functional discrepancy between subjects 30 and 82 years old. The pathological factors related to strokes must also be considered because it can to accentuate the physiological deficits generated by aging. A young subject has greater physical recovery than an older subject because age influences the neural plasticity process.

In relationship to the time after injury, the authors of this review chose studies that had selected chronic subjects. It is known that early intervention after encephalic injury is essential for attainment of satisfactory results. However, immediately after encephalic injury, the shock period confers hypotonia and muscular weakness to the subject known as flaccid paralysis[8], and voluntary motion can return in a few months. That phase shows the actual remaining disorders. Therefore, the effect of therapeutic intervention during the stationary phase of the encephalic injury becomes evident and measurable, and is reproducible in homogeneous groups. For this reason, all the selected studies had adopted inclusion criteria for the minimum period after injury of six months to one year.

The main purpose of this review was to evaluate the effect of resisted exercise on spasticity, power and functionality, and the second purpose was to verify the methodology of the described programs.

It was observed that few studies in this review aimed to evaluate the effect of resisted exercise on spasticity since there are a great amount of studies concerning this topic[[10,11,12] showing that resisted exercise did not promote increase of tonus.

None of the studies that evaluated spasticity by MAS or pendulum test related to increased tonus after intervention. These findings agree with previous studies in, confirming that resisted exercise does not generate increase of tonus.

Power was evaluated in more than 78% of the included studies. It can reveal the acceptance in the literature of the use of power on spastic muscle as an important therapeutic application. Of the studies that had utilized power evaluation, only one did not present significant differences between the groups. It is known that the resisted exercise variable (number of series and repetitions, applied load, time of rest between series, i.e.) influences neural and morphologic muscle adaptations. However, because the methodological variety of this type of study, there is no consensus about how this variable can influence muscular patterns[22].
For subjects with a stroke, Gordon et al. (2004)[23] consider that the resisted exercise must be performed 2-3 times per week, with 1 to 3 series of 10-15 repetitions. It was done by circuit training, bodybuilding devices, weight lifting, and isometric exercises. Of the included studies, the great majority used circuit training, bodybuilding devices, weights, and isometric exercises. Of the included studies, the great majority used these parameters and indicated the number of series, repetitions, and frequency.

The load application to perform the muscle strengthening is an extremely important variable for intervening directly and acquiring the intended outcome. This happens because muscular power and resistance are based on the principle of gradual resistance[24]. It has been indicated that strengthening should be performed with, at least, 40% to 50% of 1 MR to provide considerable increase of power in sedentary subjects. For progression, it is indicated that 1 MR should be re-evaluated every two consecutive sessions with 2% to 10% of 1 MR[23]. Among the studies that applied the protocol of 1 MR for load superimposition, only three performed progressive load. After having learned the importance of load progression[23] from studies with power evaluation, only one did not present significant differences, suggesting that the imposition of 70% of 1 MR is less effective perhaps than its progression. However, it must be emphasized that the effect of the load depends on the imposition time, in which satisfactory results were found in relationship to power in 8-12 weeks of intervention. Only two studies performed protocols with intervention time less than eight weeks, showing that the minimum intervention demonstrates good results.

In relation to rest time, the ideal rest time must be around 1-2 minutes to provide the necessary recovery in order to accomplish the next series[22,24]. Therefore, this parameter must be taken into consideration because it interferes with muscular performance.

All the studies that related to this type of exercise, had performed concentric exercise. This is because concentric exercise performed with bodybuilding devices allows targeting exercise to provide the facilitation and learning of this activity[23], and performance improvement during the exercise. Also, the great requirement of concentric exercise limits it to the last type of contraction exercise used in a strengthening program[23]. These two factors can justify the greater application of concentric exercise among bodybuilding devices.

Although the warming up and cooling down are very useful in clinical practice, knowledge of real benefits related to the muscular performance still remains limited. It is expected that a warming up period can improve the muscular pattern of exercise and decrease the probability of injury[25]. In the same way, a cooling down period seems necessary for the return of vital signs to normal and the reduction of risk of syncope after exercise[22,25]. According to McArdle; Katch; Katch (2002)[22], the lack of clear evidence of contraindications concerning the warming up period suggests that its practice can be maintained.

It was observed that none of the parameters was determinative in the obtained results and its integration was responsible for the findings presented in this review.

More than 85% of the studies had evaluated functionality, which indicates that the effect of resisted exercise on functionality is still not clear. It seems that these effects are not clear yet due to a great number of studies that associate resisted exercise with other guided activities, or properly performed strengthening by functional exercises. The association of other functional activities such as strengthening method, or functional training can influence motor learning. This happens because the training for motor learning has the potential to direct the brain to reorganize and to optimize functional performance[11]. More than 57% of the studies had used at least one guided activity in association to resisted, including aerobic exercise and functional training, and supervised or unsupervised exercise. This makes it difficult to understand the results, therefore, certainty is not known if there must be strengthening, or the association of guided activities. Also there were a number of instruments used for functional evaluation (14 instruments). Therefore the results were separated in accordance with the instruments utilized.

The gait was evaluated in most of the studies with or without validated instruments. It was observed that only one study that targeted gait evaluation did not strengthen the knee extensor muscles. This demonstrates the importance of this muscular group in relationship to gait performance. Because knee extensor muscles are the dominant muscle group of the knee joint, and they act as a limb motion stabilizer[26]. Also it was observed that only one study was specifically aimed toward the strengthening of one muscular Group. However, according to Perry (2004) [26], the human motor complex is composed of 11 joints of the inferior limbs and pelvis that are under the control of 57 muscles which act selectively. That is, the improvement of performance during gait can be related to extensive strengthening of large muscle groups of the inferior limbs and trunk. The same can be observed in other functional activities, in view of the fact that the strengthening of only one muscle group is perhaps, not enough to impose changes in the evaluated parameters[27]. It is important to comment that the performance of any functional activity depends on strengthening and previous training.

It must be affirmed that functional capacity depends on several factors. In a general way, the subjects that suffered a stroke usually present functional inability connected to the decrease of muscular power, learning deficit, and a decrease in aerobic capacity. The development of muscular resistance and cardiovascular conditioning for aerobic training allows the subject to perform more activities before the onset of muscular fatigue[11]. Furthermore, the training and learning of an activity uses less energy and improves functional performance, which in turn, directly changes the quality of life. Therefore, not only the functional training directly changes functional ability, but also improves aerobic capacity.

From the obtained results, it was observed that the analyzed studies agree that muscular strengthening can act in a beneficial way to increase power and reduce fatigue in the paretic inferior limbs without generating tonus increase. There is also agreement that guided activities applied with resisted exercise can improve functionality. Nevertheless, it is not possible to attribute these improvements of guided activities, to the resisted exercise, or both. This is because of the great methodological diversity found, difficulty in quantifying the interference of resisted training, or the performance of guided activities on functional improvement. In several studies, the association of these kinds of exercises was observed in conjunction with activities that could not only influence the power, but motor learning and physical conditioning of each subjects as well, thus modifying the final results of functional improvement.

CONCLUSION

After the analysis of research studies, it was possible to verify that resisted exercise did not promote tonus increase in the trained subjects, yet presented beneficial effects in relation to the power of spastic muscles. In addition, this can be an important tool in physical therapy treatment when a subject's functionality is emphasized. However, it was observed that there is still a significant methodological diversity in the way that protocol elaboration is used for parameters evaluation. Therefore the necessity of controlled, randomized and rigorous methodology trials is evident. This approach utilizing resisted exercise without the association of guided tasks is very important if it takes into consideration not only injury time, but also age and the pathological process of each subject observed. In this way, it can evaluate not only an increase in power, but also the obtained functionality increase, resulting in great scientific relevance.

REFERENCES

1 World Health Organization [Internet]. Switzerland: World Health Organization (WHO); [access in 2008 Aug 30]. Stroke, cerebrovascular accident; [one page]. Available at: http://www.who.int/topics/cerebrovascular_accident/en/.

2 World Health Organization [Internet]. Switzerland: World Health Organization (WHO); [access in 2007 Sept 20]. The atlas of heart disease and stroke; [one page]. Available at: http://www.who.int/topics/cardiovascular_diseases/en/.

3 C.B. Ivanhoe and T.A. Reistetter, Spasticity: the misunderstood part of the upper motor neuron syndrome, *Am J Phys Med Rehabil* October 83(10) (2004), S3-S9.

4 B.B. Bhakta, Management of spasticity in stroke, *Br Med Bull* 56(2) (2000), 476-85.

5 T. Akbayrak, K. Armutlu, M.K. Gunel and G. Nurlu, Assessment of the short-term effect of antispastic positioning on spasticity, *Pediatr Int* 47(4) (2005), 440-45.

6 F.P. Kendall, E.K. Mccreary and P.G. Provance. Músculos: provas e funções. 4nd ed. Barueri (SP): Manole; 1995.

7 L.F. Teixeira-Salmela, E.S.G. Oliveira, E.G.S. Santana and G.P. Resende, Fortalecimento muscular e condicionamento físico em hemiplégicos, Acta Fisiátrica 7(3) (2000), 108-18.

8 B. Bobath. Hemiplegia no adulto: avaliação e tratamento. São Paulo (SP): Manole; 1978.

9 E.G. Fowler, T.W. Ho, A.I. Nwigwe and F.J. Dorey,

The effect of quadriceps femoris muscle strengthening exercises on spasticity in children with cerebral palsy, *Phys Ther* 81(6) (2001), 1215-223.

10 R.T. Junqueira, A.M. Ribeiro and A.A. Scianni, Efeitos do fortalecimento muscular e sua relação com a atividade funcional e a espasticidade em indivíduos hemiparéticos, Rev Bras Fisioter 8(3) (2004), 247-52.

11 Y. Yang, R. Wang, K. Lin, M. Chu and R. Chan, Task-oriented progressive resistence strength training improves muscle strength and functional performance in individuals with stroke, *Clin Rehabil* 20 (2006), 860-70.

12 L. Ada, S. Doch and C.G. Canning, Strengthening interventions increase strength and improve activity after stroke: a systematic review, *Aust J Physiother* 52 (2006), 241-48.

13 E.G. Fowler, T.H. Kolobe, D.L. Damiano, D.E. Thorpe, D.W. Morgan and J.E.Brunstrom, et al, Promotion of physical fitness and prevention of secondary conditions for children with cerebral palsy: section on pediatrics research summit proceedings, *Phys Ther* 87(11) (2007), 1495-510.

14 J.P. Folland and A.G. Williams, The adaptations to strength training: morphological and neurological contributions to increased strength, *Sports Med* 37(2) (2007), 145-68.

15 C.M. Hall and L.T. Brody. Exercícios terapêuticos: na busca da função. 2nd ed. Rio de Janeiro (RJ): Guanabara Koogan; 2007.

16 A.R. Jadad, R.A. Moore, D. Carroll, C. Jenkinson, D.J.M. Reynolds and D.J. Gavaghan, et al, Assessing the Quality of Reports of Randomized Clinical Trials: Is Blinding Necessary?, *Clin Trials* 17 (1996), 1-12.

17 L.F. Teixeira-Salmela, P.C.Silva, R.C.M. Lima, A.C.C. Augusto, A.C. Souza, and F. Goulart, Musculação e condicionamento aeróbio na performance funcional de hemiplégicos crônicos, *Acta Fisiátric*a 10(2) (2003), 54-60.

18 L.F. Teixeira-Salmela, S. Nadeal, I. Mcbride and S. Olney, Effects of muscle strengthening and physical conditioning training on temporal, kinematic and kinetic variables during gait chronic stroke survivors, *J Rehab Med* 33 (2001), 53-60.

19 C.R. Silva Filho, H. Saconato, L.O. Conterno, I. Marques and N.A. Atallah, Avaliação da qualidade de estudos clínicos e seu impacto nas metanálises, *Rev Saude Publica* 39(6) (2005), 865-73.

20 M.R.C. Nobre, W.M. Bernardo and F.B. Jatene, A prática clínica baseada em evidências parte III: avaliação crítica das informações de pesquisas clínicas, *Rev Assoc Med Bras* 50 (2004), 221-28.

21 J.R. Rebelatto, J.I. Calvo, J.R. Orejuela and J.C. Portillo, Influência de um programa de atividade física de longa duração sobre a força muscular manual e a flexibilidade de mulheres idosas, *Rev Bras Fisioter* 10(1) (2006), 127-32.

22 W.D. Mcardle, F.I. Katch and V.L. Katch. Fundamentos de fisiologia do exercício. 2nd ed. Rio de Janeiro (RJ): Guanabara Koogan; 2002.

23 N.F. Gordon, M. Gulanick, F. Costa, G. Fletcher, B.A. Franklin, E.J. Roth and T. Shephard, Physical activity and exercise recommendations for stroke survivors: an American Heart Association Scientific statement from the council on clinical cardiology, subcommittee on exercise, cardiac rehabilitation, and prevention; the council on cardiovascular nursing; the council on nutrition, physical activity, and metabolism; and the stroke council, Circulation 109 (2004), 2031-41.

24 American College of Sports Medicine, ACSM position stand on progression models in resistance training for healthy adults, *Med Sci Sports Exerc* 34(2) (2002), 364-80.

25 S.K. Powers and E.T. Howley. Fisiologia do exercício: teoria e aplicação ao condicionamento e ao desempenho. 5nd ed. Barueri (SP): Manole; 2005.

26 J. Perry. Análise da marcha: marcha normal. Barueri (SP): Manole; 2004: Vol. 1.

27 U.B. Flansbjer, M. Miller, D. Downham and J. Lexell, Progressive resistance training after stroke: effects on muscle strength, muscle tone, gait performance and perceived participation, *J Rehabil Med* 40 (2008), 42-48.

28 C.M. Kim, J.J. Eng, D.L. MacIntyre and A.S. Dawson, Effects of isokinetic strength training on walking in persons with stroke: a double-blind controlled pilot study, Journal of Stroke and Cerebrovascular Diseases 10(6) (2001), 265-73.

29 M.M. Ouellette, N.K. LeBrasseur, J.F. Bean, E. Phillips, J. Stein and W.R. Frontera, et al, High-Intensity resistance Training improves muscle strength, self-reported function, and disability in long-term stroke survivors, Stroke 35 (2004) 1404-09.

30 S.A. Sharp and B.J. Brouwer, Isokinetic strength training of the hemiparetic knee: effects on function and spasticity, *Arch Phys Med Rehabil* 78(11) (1997), 1231-36.

31 A.C.C. Augusto, L.R. Teixeira-Salmela, P.C. Silva, R.C.M. Lima and F. Goulart, Musculação e condicionamento aeróbio em hemiplégicos: impacto no desempenho motor, *Rev Bras Fisioter* 7(3) (2003), 209-15.

32 A. Akbari and H. Karimi, The effect of strengthening exercises on exaggerated muscle tonicity in chronic hemiparesis following stroke, *Am J Med* Sci 6(3) (2006), 382-88.

33 R.M. Guimarães, J.S. Pereira and L.A. Batista, Fortalecimento do músculo solear: impacto na cinemática da marcha de indivíduos hemiparéticos, Fisioterapia em Movimento 20(3) (2007), 11-16.

34 M. Carr and J. Jones, Physiological effects of exercise on stroke survivors, *Top Stroke Rehabil* 9(4) (2003) 57-64.

35 L.F. Teixeira- Salmela, S.J. Olney, S. Nadeau and B. Brouwer, Muscle strengthening and physical conditioning to reduce impairment and disability in chronic stroke survivors, *Arch Phys Med Rehabil* 80 (1999),1211-18.

36 J.J. Eng, K.S. Chu, C.M. Kim, A.S. Dawson, A. Carswell and K.E. Hepburn, A community-based group exercise program for persons with chronic stroke, *Med Sci Sports Exerc* 35(8) (2003),1271-78.

37 M.C. Cramp, R.J. Greenwood, M. Gill, J.C. Roth-

well and O.M. Scott, Low intesity strength training for ambulatory stroke patients, *Disability and Reabilitation* 28(13-14) (2006), 883-89.

38 A. Weiss, T. Suzuki, J. Bean and R.A. Fielding, High intensity strength training improves strength and functional performance after stroke, *Am J Phys Med Rehabil* 79(4) (2000), 369-76.