PROLONGED STATIC MUSCLE STRETCH REDUCES SPASTICITY

– BUT FOR HOW LONG SHOULD IT BE HELD?

L A Hale, Msc (Physiotherapy)
V U Fritz, PhD (Med), MBBCh, FCP (South Africa)
M Goodman, PhD (Physiotherapy).

ABSTRACT

The rehabilitation of patients with upper motor neurone lesions often necessitates the reduction of spasticity before normal movement patterns can be taught. One proven technique is that of prolonged stretch to the affected muscle. However, the duration of the stretch has not been defined.

This study aimed to investigate which of the following durations of prolonged muscle stretch – two, ten or thirty minutes – was optimal in reducing spasticity in spastic quadriceps femoris muscles of adult patients following cerebral vascular accidents or head trauma.

The degree of spasticity was measured by the use of four methods, prior to, and after stretching. Twenty-nine spastic muscles were stretched for the three durations on different occasions, and the data analysed using the student's T-test. Results indicated that the most beneficial duration of prolonged muscle stretch in decreasing spasticity was ten minutes.

Key Words: muscle tone, assessment, Cybex II isokinetic dynamometer.

INTRODUCTION

Upper motor neurone (UMN) lesions commonly result in spasticity which may hinder the patient's ability to move normally and thus reduce their functional abilities[1]. Techniques which decrease spasticity are therefore of great interest to the physiotherapist involved in rehabilitation.

There are many techniques available[2,3], one of which is prolonged muscle stretch (PMS)[4]. The spastic muscle is stretched to the end of its available pain-free range and the stretch is maintained until the therapist "feels" the reduction of tone in the stretched muscle. In a similar way, patients are taught how to stretch their muscles on their own.

Several authors have shown clinically that prolonged muscle stretch significantly reduces spasticity[4-7]. These studies have concentrated on demonstrating that the method does indeed work. However, as yet, no work has been done on establishing for how long the stretch should be held.

Most of the studies used stretch times of thirty minutes, although durations of five seconds, and of one and a half minutes have been used. In all cases, no criteria were given regarding the choice of stretch duration, and times appeared to have been arbitrarily chosen.

In order for the physiotherapist to be able to work efficiently, a knowledge of how long to hold a tone-reducing stretch is necessary. If a stretch is held for too short a time, enough reduction in the muscle tone may not be gained. A stretch held for too long will waste time, something which can be ill-afforded in a busy physiotherapy department.

Patients also like to be given a set time in which to stretch at home, and not to be told to stretch until they "feel" looser.

Physiology

The physiology underlying the use of prolonged muscle stretch in the decrease of spasticity is controversial. It appears to affect both the stretch reflex component, and the structure of the muscles and connective tissue.

Three mechanoreceptors within the muscle have been suggested as effecting the neural component: the golgi tendon organs; the group II or flower-spray afferents in the muscle spindle; and the free nerve endings within the muscle spindle, and the free nerve endings within the muscle belly itself. They all respond to stretch and can cause autogenic inhibition[8-11].

Many studies show that spasticity leads to alterations in muscle structure as the muscle is maintained in a shortened position. The main effects being a decrease in the number of sarcomeres and an increase in the sarcomere length. Prolonged muscle stretch may reverse these changes[12-14].

It must be emphasised that PMS is slowly executed until the muscle is fully stretched and then held there for a period.

Aim of study

To investigate which of the following times of PMS – two, ten or thirty minutes – is optimal in reducing spasticity in spastic quadriceps muscles of adult patients following a cerebral lesion.

Spasticity was evaluated primarily with the pendular test[15].

Passive movements of the knee are produced by gravity when the leg to be tested is dropped from the fully extended position, the thigh being supported.

In a relaxed normal subject, the leg swings in a pendular fashion for about six to seven times before coming to rest at approximately 90° of knee flexion. Spasticity usually arrests this movement of the leg a lot sooner so that the angles of swing are smaller and there are fewer swings. Readings are obtained from an electrogoniometer attached to the swinging leg[15-18].

In 1985, Bohannon and Larkin suggested the use of the Cybex II isokinetic dynamometer ("Cybex") as a method of recording the movement of the leg. The machine has a built-in electrogoniometer and recorder, and is available in many physiotherapy departments. A graph of the movement of the swinging leg is obtained from which various objective parameters can be read[15-18] (Figure 1).

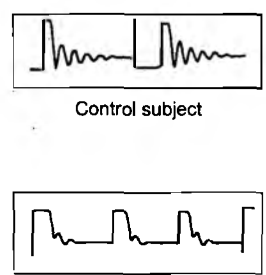

Figure 1. Graphs obtained from a Control and an Experimental (spastic) patient

SUBJECTS

In this study each patient was his/her own control, thus a control group as such was not required. However, in order to establish the baseline parameters of the "Cybex" used in this study, thirty subjects were initially tested on it.

Twenty-six adult subjects who had spasticity of one or both quadriceps muscles as a result of a cerebral lesion, such as a head injury or a cerebral vascular accident (CVA), were tested. They also had to fulfil the following criteria:

- be able to follow commands.
- have full, pain-free passive range of their knee joint
- have had no prior trauma to the knee or quadriceps muscle
- have no active inflammation

Their ages, sex and affected side were not taken into account in this study.

The age of the twenty-six subjects ranged from 22 to 81 years (median 56 years), and comprised five female and twenty-one male patients. The durations of disability ranged from one month to 23 years (median 3.5 years), with 23 patients having had CVAs, two sustained head injuries and one suffering multiple sclerosis.

The first twenty-six patients referred who fulfilled the above criteria were used in the study.

TECHNIQUES AND PROCEDURES

Each experimental group subject attended a test session three times, the interval between sessions was more than twenty-four hours (to prevent any accumulative effect of the stretching).

After obtaining relevant personal data from each experimental subject, their spasticity was evaluated by the following procedures:

Analogue scale

The subject indicated on a scale of 0-10, how spastic they perceived their affected thigh muscles to feel (0 = no spasticity, and 10 = worst they have experienced).

Ashworth clinical test

The tone was assessed clinically, and the amount of resistance to passive movement rated (as described by Ashworth[19]) on a scale of 0–4, where 0 = no spasticity, and 4 = almost no movement available due to strong spasticity.

Performance test

In an attempt to assess the effect spasticity had on the subjects movements, the time taken for each subject to flex and extend his/her leg ten times was measured with a stop-watch.

"Cybex" test

The patient was positioned in supine lying with his/her legs hanging over the edge of the couch of the "Cybex", with the thigh fully supported and strapped to the couch. The leg to be tested was attached to the input shaft of the machine and then fully extended. The "Cybex" was adjusted so that it offered no resistance to the movement of the leg, and the paper speed of the electrogoniometer of the "Cybex" set to run at 5mm/sec. The patient was instructed to relax completely, and the foot was dropped from the horizontal plane. The leg oscillated in a pendular fashion until it came to rest, a graph of this movement was recorded.

The spastic quadriceps muscles of each subject was then stretched for one of the following durations at each session: two, ten, or thirty minutes. The sequencing of the times used for stretching was randomised.

The position of stretch was supine lying with the legs hanging over the edge of the "Cybex" couch, thigh supported. The tested leg was attached to the "Cybex" input shaft and the knee flexed to the limit of the quadriceps pain-free flexibility and clamped into position. The stopwatch was started and the leg remained in this position for the selected duration of the stretch. During this time the subject could either rest or talk quietly to the examiner, according to their wish. The position of stretch chosen ensured that the rectus femoris muscle was also on stretch, and not just the other muscles of the quadriceps femoris group.

The leg not being tested was flexed so that the foot rested on a chair near the foot end of the couch to posteriorly tilt the pelvis into a more comfortable position.

The stretch was immediately followed by the remeasurement of the spasticity by analogue, Ashworth clinical, and "Cybex" methods, and the performance test.

If pain was felt during the stretch, the amount of stretch was lessened slightly until comfortable again. If there was still pain, the stretch would have been discontinued. However, this did not occur in any of the subjects.

The subjects were always comfortably and warmly positioned to prevent any discomfort altering the level of their muscle tone. No subjects had to be removed from the trial because of any knee injuries or inflammations, and none of them had any emotional disturbances that could have affected their level of spasticity greatly.

RESULTS

From each "Cybex" graph obtained, recording of the movement of the leg as it falls, the following data, was calculated in accordance with previous studies[17] (see Figure 2)

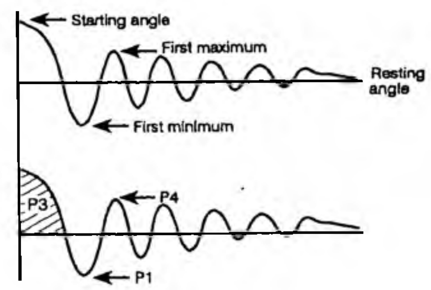

Figure 2. Parameters P1 to P4

P1: Relaxation index – the angle at which the spasticity arrests the natural backward swing. As different patients have differing resting angles, which may also change from day to day, this angle is normalised by the difference in angles between the resting and starting position.
P2: the number of swings the leg performed – calculated by counting the number of maxima on the graph.
P3: the area between the graph and the resting angle prior to the first crossing over of the resting angle.
P4: the first maxima of the graph – this shows how strongly the spasticity pushes back the limb towards the starting angle. In normal subjects, this is usually about 20° to 35°.

The analysed results from the control group established the normal ranges for the parameters P1 to P4 for the "Cybex" machine used in this study. They were as follows:
P1: 1.27 – 1.53 (<1.27 indicates spasticity)
P2: 4.75 – 6.79 swings (<5 swings indicating spasticity)
P3: 9.89 – 22.45mm (>22.45mm indicating spasticity)
P4: 22.69° – 33.77° (<22.69° indicating spasticity)

Statistical analysis of the control group

TABLE I. THE MEDIANS OF THE RESULTS OBTAINED FROM BEFORE – AND AFTER – PMS

CYBEX P1 TEST		ANALOGUE SCALE	
B2	1.05	B2	4.75
A2	1.07	A2	4.25
B10	1.00	B10	4.25
A10	1.05	A10	3.50
B30	1.01	B30	4.75
A30	1.09	A30	4.00
ASHWORTH CLINICAL TEST		**PERFORMANCE TEST**	
B2	2.00	B2	18.5
A2	1.50	A2	18.0
B10	1.75	B10	21.5
A10	1.25	A10	17.0
B30	1.75	B30	20.5
A30	1.25	A30	17.5

B: before stretch. A: after stretch durations data found that the P2, P3, and P4 results had to be read with some caution, as this data was slightly skewed.

Table I shows the medians of all the tests used to measure the before- and after-stretch muscle tone. It can be seen from this table that there was a tendency for spasticity to decrease after stretch.

Proof of a significant difference between the before- and after-stretch values was supplied by the Student's T-test. Tables II and III show only those results that were significant, the differences between the remaining before- and after-stretch results were insignificant.

It can be seen from these tables that the best results were obtained from the ten minute PMS, as three results gave a significant difference ($p<0.001$) between the before- and after-results at the two-tailed significance level, and two results showed a probable significant difference ($p<0.01$).

TABLE II. SUMMARY OF RESULTS AT A TWO-SIDED SIGNIFICANCE LEVEL

TEST TIME OF STRETCH	T-STATISTIC	SIGNIFICANCE LEVEL	
P1			
10 mins	5.22	0.000	***
Analogue scale			
2 mins	2.95	0.000	***
10 mins	8.82	0.000	***
30 mins	2.61	0.015	**
Ashworth Clinical Assessment			
2 mins	6.38	0.000	***
10 mins	6.01	0.000	***
30 mins	6.82	0.000	***
** = p<0.01, *** = p<0.001			

TABLE III. SUMMARY OF RESULTS AT A ONE-SIDED SIGNIFICANCE LEVEL

TEST TIME OF STRETCH	T-STATICTIS	SIGNIFICANCE LEVEL	
P1 2 mins	1.64	0.06	?*
30 mins	1.94	0.04	*
P3 10 mins	1.78	0.04	*
P4 10 mins	1.72	0.05	*
Performance Test			
30 mins	1.85	0.04	*
* = p<0.05, ?* = bordering on p<0.05			

Thirty minutes of PMS was the next best duration as it gave two results of significant difference ($p<0.001$) and two results of probable significant difference ($p<0.01$).

Two minutes of PMS also gave two results of significant difference ($p<0.001$), but only one questionable result at the one-tail significance level ($p<0.06$).

DISCUSSION

It appears that the ten minute stretch is the most effective in decreasing spasticity.

The thirty minute test clinically suggested a dramatic decrease in the tone; however, the "Cybex" test indicated otherwise.

This may have been due to the discomfort the position of the stretch gave a lot of the patients because of the lower lumbar spine being in lordosis for too long in spite of flexing the opposite leg on a chair. The subsequent dropping of the leg during the after-stretch "Cybex" test may have caused an additional strain on the lower lumbar spine resulting in more discomfort and thus increasing their spasticity again.

The two minute test did not appear to decrease spasticity according to the "Cybex" test. However, the clinical and analogue tests favoured it. There may be subtle changes in the level of the spasticity that can be picked up subjectively, but cannot be measured accurately enough objectively.

The results of the analogue scale may be debatable as many of the patients did not really understand what was being asked of them. Some of the patients guessed and therefore did not give a true reflection of their perceived level of spasticity.

The scale may be better applied by using pictorial representations of the varying intensities of spasticity which the patients may understand more easily than the analogue scale.

An impartial assessor of this test would help to prevent subjects from giving information which they think the researcher would like to hear.

The Ashworth clinical assessment of the patients' spasticity showed that stretching was very effective in the reduction of hypertonus. However, patients were tested by only one of the authors, and an element of subjective bias may have been introduced.

The performance test involved the time it took for the patient to flex and extend his/her affected limb ten times. This test proved, both statistically and through observation, to be unreliable. The effort of the patients was variable and there was absolutely no standardisation of the test at all. The results of this test were therefore of dubious use in the analysis of the data.

The Cybex method is objective, giving quantitative results. However, its sensitivity to small changes in muscle tone has not yet been established. Its reliance on the patients ability to relax prior to the dropping of the leg is an additional complication. However, its main disadvantage is that the test has a limited versatility as it can only really test the quadriceps femoris muscle group. The same pendular effect being difficult to obtain from other muscle groups.

The parameter P1 from the "Cybex" test appeared to give reliable results, as has been shown by previous studies[16,20]. However, the reasons for the parameters P2, P3 and P4 for giving variable, insignificant results are not clear.

Of the four tests used to measure spasticity, the "Cybex" (P1 parameter) test appeared to be the most objective. This test showed that there was a definite significant difference between the before- and after-stretch results of the ten minute stretch (p0.001).

CONCLUSION

In order to decrease muscle tone in the affected muscles of patients with spasticity, it is recommended that the muscle be stretched for ten minutes.

It is felt that the "Cybex" test using the P1 parameter, is a good test for measuring spasticity. It not only gives an objective result, but it is quick and easy to do.

Clinical testing remains a good indicator, but has an element of subjective bias, as has been found by other authors[21-23].

In addition to its relaxation effect on the neural component of spasticity, prolonged muscle stretch may also be of benefit in maintaining the flexibility of the muscle and in preventing the effects of spasticity on its structure.

(This research was approved by the Committee for Research on Human Subjects, the University of the Witwatersrand (No. 17/11/91), and was part of a dissertation submitted by Mrs L A Hale to the University of the Witwatersrand in order to complete her Masters degree in Physiotherapy.)

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