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Measurement of the Angle of Plantar Flexion An Objective Way of Assessing Muscle Relaxation in Children with Spastic Cerebral Palsy

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Abstract

Infants and young children with spastic cerebral palsy (CP) do well with a single daily dose of diazepam given at bedtime, as the muscle relaxation decreases the spasticity and faciltates both passive and voluntary movements. This double blind randomized control trial showed that reducing the hypertonia enhanced the child's mobility and quality of life without causing daytime drowsiness. The traditional method of assessing the muscle tone is by using the Ashworth's scale. However this is a subjective measurement and inter-rater variability is invariably present. The angle of plantar flexion at the ankle was measured in this study using a goniometer and compared with the Ashworth scores to study if it is a valid and reliable indicator of muscle relaxation. Measuring the angle of plantar flexion is easy to perform and is an effective and objective tool to monitor the dose of diazepam required for optimum muscle relaxation.

Key Words : **Diazepam, plantar flexion angle, spastic cerebral palsy, goniometer, hypertonia,**

Introduction

One of the key clinical features of spastic cerebral palsy (CP) is that hypertonia leads to paucity of movements. The voluntary movements and range of passive movements are limited in children with CP. As the motoric responses are reduced the motor milestones are delayed. The muscle tone is increased and the deep tendon reflexes are brisk and sustained ankle clonus may be present. Some infants with marked spasticity may show extensor hypertonus affecting trunk and neck muscles. The positive symptoms, such as exaggerated reflexes and flexor spasms play a significant part in the performance deficits (negative symptoms) like weakness of limbs and decreased motor activity[1]. Children with hypertonia are frequently in distress because of muscle spasm and pain on movement of the limbs. For the same reason they shun movement and are often reluctant to allow passive movement of the limb.

Over the years many drugs have been used to treat spasticity and diazepam has proved particularly effective[2]. The clinical response of improved mobility following muscle relaxation brought about by diazepam and the consequent decrease in painful muscle spasms, improvement in motor activity and decrease in sleep disturbances suggest that diazepam has a role in encouraging movement in children with spasticity caused by spastic CP[3]. When the spasticity that hinders

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movement is reduced, it is possible to initiate motor activity and play based learning and consequently there is progress in the motor developmental sequences. A single bedtime dose of diazepam causes adequate muscle relaxation to promote motor activity without making the child drowsy during the day[4].

Hypertonia and spasticity of the muscles cause the ankle to be fixed in plantar flexion[5]. Reduction of spasticity will reduce the abnormal posture and physical therapy will help the joint to return to the optimum position[6]. When the muscle is relaxed, the angle of plantar flexion (APF) at the ankle is around ninety degrees, the calf muscles touch the couch in the supine position and in the upright position the child is able to place the feet plantigrade on the ground and experience weight-bearing[7].

The monitoring of muscle relaxation is difficult and often dependent upon subjective evaluation. The lack of such effective measurement techniques has been a limitation in the ability to judge the efficacy of pharmacological or physical therapies[8]. This restricts the quantification of muscle relaxation and therefore the assessment of hypertonia has been based primarily on observer dependent measurements. Although clinical scales offer only qualitative information they have been widely used in the study of spasticity and are the present yardsticks against which newer and more exact methods must be compared[9].

The traditional method of assessing the muscle tone is by using the Ashworth's scale (AS), which is a five point gross clinical scale to grade muscle tone from 0 (normal) to 4 (severe). This rating scale was first proposed by Ashworth[10] and grades the severity of hypertonia to passive limb movement with reasonable inter-rater reliability[11].

As the AS is a subjective test, based on the assessment of the tone by moving the limb and gauging the resistance, we looked for a more objective tool to monitor the muscle relaxation achieved with diazepam. Quantitative measurements of joints have been used as a basis for assessing effectiveness of therapeutic intervention[12]. We measured the angle of plantar flexion (APF) to test its efficacy as a tool to measure muscle relaxation.

In this placebo-controlled, double blind randomised trial, to study the efficacy of diazepam as a muscle relaxant in spastic cerebral palsy, we compared the AS score to the APF score in monitoring muscle relaxation. The APF at the ankle is an index of the spasticity of the gastrocnemeus and soleus[13] and is an objective tool for monitoring the muscle relaxation at the ankle. The goniometric measurement of the APF of the affected ankle with the child in the_supine position and the knee kept in full extension[14] is shown in Image 1.

The aim of this study was to establish if the change in the APF after using diazepam as a muscle relaxant is a specific and sensitive index for titrating the optimum dose of diazepam required for adequate muscle relaxation. As the APF indicates the status of the gastrocnemeus-soleus, the scores for the change in APF will reflect muscle relaxation while the child is receiving diazepam. The correlation between the APF and the AS scores achieved with a bedtime dose of diazepam, will provide the evidence that the APF is a reliable and valid tool to measure muscle relaxation.

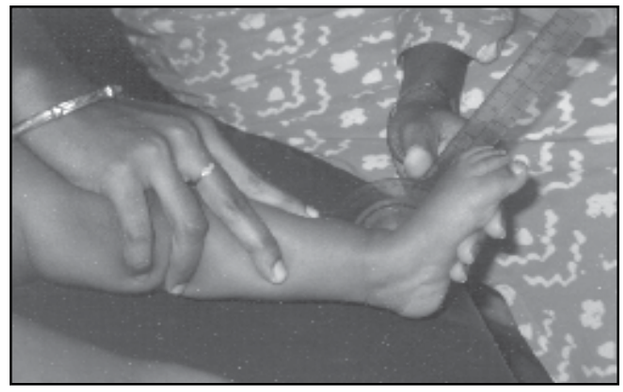

Fig. 1 Measuring the angle of plantar flexion with the help of the goniometer, baby in supine position.

Material and Methods

One hundred and eighty children diagnosed to have spastic cerebral palsy were recruited serially to study the efficacy of diazepam to reduce hypertonia and facilitate movement. All children recruited to the study were first weighed and allocated to **Category A** if they weighed less than 8.5 Kg and to **Category B** if they weighed 8.6 Kg to 15 Kg. Of the 90 children recruited to Category A (< 8.5 Kg), 37 were girls and 53 were boys and of the 90 children recruited into Category B (8.6-15 Kg), 32 were girls and 58 were boys. All children in Category A were below the age of 5 years while in Category B, 17 children were over five years of age.

The children received one of the two doses of diazepam or placebo (lactose & starch) at bedtime. The double-blinded regimen was selected by random allocation using the method of equal allocation by Clinstat Computer randomisation. Children from Category A randomly received 1 mg of diazepam or 0.5 mg of diazepam or placebo and children from Category B received 2 mg or 1 mg of diazepam or placebo, with 30 children in each arm of each category. The muscle tone was graded using the AS and the muscle relaxation by measuring the APF with the help of a goniometer (Fig 1). The data were analysed using the Statistical Package for Social Sciences (SPSS) using the one-way analysis of variance (ANOVA). The primary outcome and details of this study have been published elsewhere.[3, 4.]

Table 1. ASHWORTH SCALE FOR CLINICAL ASSESSMENT OF TONE

Score 0	No increase in tone (0-normal)
Score 1	Slight increase in tone, giving a catch when limb is moved in flexion or extension (1-catch)
Score 2	More marked increase in tone but limb can still be easily flexed (2-tight flexion/ extension)
Score 3	Considerable increase in tone; passive movement difficult (3-passive movement difficult)
Score 4	Limb rigid in flexion or extension (4-rigid)
	Ashworth (1964)

Observations

Assessing Muscle Relaxation

The muscle relaxation was assessed using the AS and quantified by measuring the APF. The decrease in muscle tone was found to be comparable.

A. Assessing the muscle tone using AS

The muscle tone was assessed using the specified criteria and graded using the AS (1964) for clinical assessment of tone as given in table 1.

B. Monitoring the muscle tone using the APF

The APF at the ankle was measured at rest with the knee in full extension with the help of a goniometer (Image 1) at the first visit and again after three weeks of starting the drug regimen. The APF was measured at each ankle and the more affected side was taken into account. This procedure was repeated after 3 weeks of administration of the drug and the difference in the APF was carefully noted and the mean values for each group obtained to study if there was a dose dependent change in the APF with diazepam.

Results

There was a significant difference in the scores for muscle tone after administering diazepam indicating that both the doses of diazepam produced significant muscle relaxation compared to placebo (Table 1 & Fig 2). This was evident in the lowered AS scores and the reduced APF at the ankle.

The AS score change for the 173 children who completed the study was as follows:

- 0.5 (SD 10.5) in the 55 children who received placebo
- 8.5 (SD 7.4) in the 60 children who received 0.5/ 1mg diazepam and
- 13.3 (SD 6.2) in the 58 children who received 1mg/ 2mg diazepam.

Table 2. Mean Score Change in the Ashworth Scale (AS) and in the Angle of Plantar Flexion (APF) in the Three Study Groups

	Mean Score Change(SD)			
	Placebo	0.5/1 mg diazepam	1 / 2 mg diazepam	P value*
Change in Ashworth Score (AS)	0.53 (SD 10.5)	8.53 (SD 7.4)	13.32 (SD 6.2)	< .001
Change in Angle of Plantar Flexion (APF) at Ankle	0.44 (SD 7.8)	7.35 (SD 8.5)	13.41 (SD 7.7)	< .001

* P value calculated by Analysis of Variance (ANOVA)

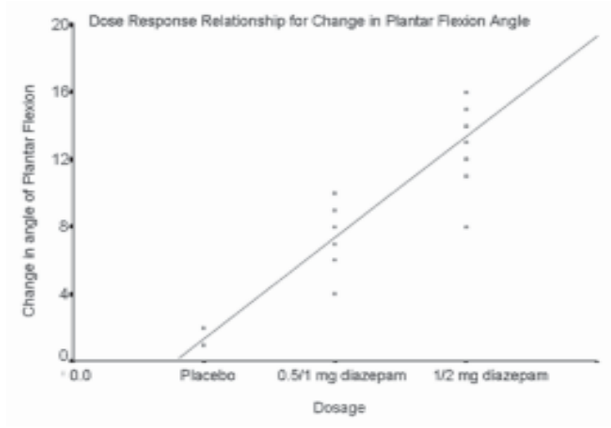

Fig. 2 Dose response relationhip for change in plantar flexion angle

The mean change in the APF for the 173 children who completed the study was as follows:

- 0.4 (SD 7.8) in the 55 children who received placebo
- 7.4 (SD 8.5) in the 60 children who received 0.5/ 1mg diazepam and
- 13.4 (SD 7.7) in the 58 children who received 1mg/ 2mg diazepam.

The mean APF before treatment was 120.0 with a standard deviation of 7.6. After treatment the mean APF in the children who received diazepam (all doses n = 118) was 109.5 with a standard deviation of 10.4. The mean APF at the ankle in the children who received 1mg/ 2mg diazepam decreased from 119.7 before treatment to 106.3 after treatment, while in the children who received 0.5/1mg diazepam, the mean APF reduced from 119.9 at first visit to 112.5 after treatment. In the placebo group the APF was initially 120.4 and after treatment the mean APF was 120.0.

Discussion

Measuring the APF is a simple procedure that can be done in the outpatient setting using a hand held goniometer. The change in APF with the higher dose of diazepam (1/2 mg) is almost two fold that of the change with the lower dose (0.5/1 mg), which was significantly greater (p value < .001) than the change with placebo. The study also showed that there was a significant improvement in both the range of movement (ROM) and the voluntary movement[3]. Thus the APF at the ankle can be used as a tool to monitor the dose of diazepam required to produce adequate muscle relaxation.

The change in the APF is the response compared to the dose of diazepam illustrated in the dose-response graph in Figure 2. The change in the APF after giving the regimen is plotted on the y axis and the predictor variable (the dose) on the X axis.

The variable y = a (constant) + bx (slope x dose).

Therefore the change in the angle of flexion(y) = 5.64 + (6.382 x dose).

The coefficient of determination for the change in the APF = 0.961.

It is seen that the muscle relaxation caused by increasing doses of diazepam is reflected linearly in the change in APF. This graph shows that 96.1% of the variation in APF can be explained by the dose of diazepam which is highly significant as the p value is < 0.001.

Conclusion

The measurement of the APF with the help of a goniometer is a simple and practical way of assessing muscle relaxation in the outpatient setting both to monitor the dose of diazepam required for adequate muscle relaxation and as an objective parameter in planning a programme of physical therapy.

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