A NEUROMOTOR CONTROL MODEL FOR SPASTICITY : AN EXPERIMENTAL VERIFICATION

by

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CERTIFICATE

This is to certify that the thesis entitled "A Neuromotor Control Model for Spasticity : An Experimental Verification" being submitted by Mr. Dinesh Kant is a record of original bonafide research carried out under my supervision. The results contained in this thesis have not been submitted in part or in full to any other university or institute for the award of any degree.

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ABSTRACT

Spasticity is a neuromotor disorder in which the stretch reflex of the affected muscles is exaggerated. However there is no general agreement regarding mechanism of this disorder.

This thesis reports the results of the study undertaken to investigate the neuromotor control mechanism of spastic and normal human beings. The control mechanism was studied theoretically by mathematical modelling of the system in which the gamma efferent activity was considered to be linked to the alpha motoneurone activity. Experimental study involved the study of the stretch reflex of the digitas superficialis muscle of the spastic and normal subjects with the muscle under preload and no load conditions.

The results of the experiments and the modelling show that :

1. There is a link of the gamma efferent activity to the alpha activity.
2. The gain control disorder of reduced inhibition to the gamma neuron results in spasticity.
3. In spastic patients, when the muscle is contracting, the fusimotor activity is hyper.
4. The alpha motoneurones of the spastic patient are unaffected and behave normally.

LIST OF SYMBOLS

Symbols using English Alphabets

S.No.	Symbol	Description
1.	C	Central Nervous System activity.
2.	CE	Excitation signal from the Central Nervous System to the neurons.
3.	CI	Inhibitory signal from the Central Nervous System to the neurons.
4.	F_{aa}	Force generated as a result of the contraction of the antagonostic muscle.
5.	F_{ap}	Passive component of force of resistance offered by the antagonostic muscle.
6.	F_{ba}	Force generated (active) as a result of the contraction of the bicep (agnostic) muscle.
7.	F_{bp}	Passive component of force of resistance offered by the agnostic muscle.
8.	g	Acceleration due to gravity.
9.	G_a	Gamma afferent activity.
10.	G_{ad}	Gamma afferent activity from the dynamic spindle receptors.
11.	G_{as}	Gamma afferent activity from the static spindle receptors.

12.	G_{an}	Gamma afferent activity from the spindle receptors of the antagonostic.
13.	G_{ed}	Gamma efferent activity to the dynamic spindle receptor intrafusal fibers.
14.	G_{es}	Gamma efferent activity to the static spindle receptor intrafusal fibres.
15.	K_{a}	Sensitivity of the dynamic spindle receptors to the speed of stretch.
16.	K_{b}	Sensitivity of the static spindle receptors to the stretch.
17.	K_{bl}	Sensitivity of the intrafusal fibres to the efferent activity.
18.	K_{ma}	Constant defining the muscle force generated to the input excitory signal for type S muscle fibres.
19.	K_{mb}	Constant defining the muscle force generated to the input excitory signal for type F muscle fibres.
20.	LEN	Length of the forearm.
21.	L_{m}	Input load.
22.	ΔL	Change in length of the muscle.
23.	M	Mass of the forearm.
24.	OA	Distance between the fulcrum point and the point of insertion of the agnostic muscle.

25.	OA'	Distance between the fulcrum point and the point of insertion of the antagonostic muscle.
26.	t	Time.
27.	T_a	Torque at the fulcrum point due to the contraction of the antagonostic muscle.
28.	T_b	Torque at the fulcrum point due to the contraction of the agnostic muscle.
29.	T_f	Time to build up of maximum strength of contraction of the type F fibres.
30.	T_h	Lower threshold of the motoneurone when it begins to fire.
31.	T_i	Torque on the forearm due to the load.
32.	T_s	Time to build up of maximum strength of contraction of type S fibres.
33.	TVR	Tonic Vibrational Reflex.
34.	T_1	Delay in transmission of the neural signal for the alpha nerve fibres.
35.	T_2	Delay in transmission of the neural signal for the gamma nerve fibres.
36.	Z4	Neural activity (alpha) to the muscle.

Greek Symbols

1.	α	Neural activity to the muscle.
2.	γ_a	Neural activity from the spindle receptors to the spinal cord (gamma afferent).
3.	γ_e	Neural efferent activity to the intrafusal fibres of the spindle receptors.
4.	θ	Angle of the forearm with the x-axis.
5.	ϕ_o	Angle of the biceps with the forearm at the point of insertion.
6.	ϕ_i	Angle of the triceps with the forearm at the point of insertion.
7.	ω	Angular acceleration of the forearm.

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