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Original Paper

Electromyographic Activities in the Trunk Muscles of Stroke Induced Hemiplegic Patients during Symmetric Movements

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Abstract

The purpose of this study was to compare the electromyographic (EMG) activities of affected and unaffected trunk muscles in hemiplegic patients during symmetric trunk movements. The subjects were seven hemiplegic patients (five men and two women, 66.9 ± 13.9 years old). EMG activities from both sides of the rectus abdominis and lumbar erector supinae muscles were recorded and analyzed during maximum voluntary contractions and trunk flexion-extension movements in the sitting position. Data analysis was based on the timing and amount of muscular activities of bilateral corresponding muscles. High synchronous activities occurred in both sides of the trunk muscle of hemiplegic patients. However, there were great variations in the amount of IEMG (integrated EMG). These results indicated that the bilateral corresponding axial trunk muscles co-contract during symmetric trunk movements, but the amount of activitiy was influenced by excessive contraction of the affected side or compensatory contraction of the unaffected side.

Introduction

The stability of proximal parts of the body and trunk is very important for smooth movements of the peripheral parts of the extremities in stroke induced hemiplegic patients as well as healthy people. Recently, improving the stability of the proximal parts and the trunk has been emphasized as one of the main aims for the recovery of affected extremities in the clinical physical rehabilitation setting. Devis emphasized strengthening the abdominal muscles to stabilize trunk function, since the muscle tone of the affected side is often low [1]. However, hemiplegia due to stroke is known to effect the distal more than the proximal musculature [2][3]. This phenomenon may be explained by the fact that motor neurons innervating axial and proximal extremity muscles receive both ipsilateral and contralateral descending inputs, whereas the peripheral muscles are supplied by motorneurons, of which the supraspinal is mainly conrtralateral. In addition, objective evidence of contralateral dysfunction of the axial and proximal muscles, such as the trunk muscle, in hemiplegic patients after stroke is sparse. Using CT (computerized tomography scan), Kotake found no laterality of cross-sectional areas of either the abdominal or erector supinae muscles in the trunks of hemiplegic patients [4]. Dickstein et al. reported that bilateral corresponding axial trunk muscles in hemiplegic patients co-contracted during symmetric trunk movements, and synchronous activity

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was at its highest level during voluntary tasks and was greater in the rectus abdominal muscles than in the erector supinae muscles [5]. The purpose of this study was to investigate and to confirm the activities of trunk muscles by comparing the EMG activities of the affected and unaffected sides in hemiplegic patients during symmetric trunk flexion-extension movements.

Subjects and Methods

The subjects were seven hemiplegic patients (five men and two women, 66.9 ± 13.7, ranging in age from 42 to 78 years old). The condition of their lower extremities ranged from Brunnstrome' stage II to VI (II- two patients, III-two patients, IV- two patients, VI- one patient). Five patients required an ankle-foot orthosis and a cane to walk, and two were able to walk without any aids. Informed consent was obtained from all subjects prior to their participation. Bipolar surface electrodes were attached to both sides of the rectus abdominis and lumbar erector supinae muscles after skin preparation. The subjects were tested while seated in a chair (46 cm height). Testing was conducted during maximum voluntary contractions (MVC) of the trunk muscles (the rectus abdominis and erector supinae muscles), and the following two movements, each of which was performed three times: (1) Trunk flexion; bringing the trunk forward to 90 °of hip flexion from a reclined sitting position (45 ° hip flexion). (2) Trunk extension; bringing the trunk to an upright sitting position from a forward bending position (135 ° hip flexion). EMG data (20-500 Hz width, 1000 Hz sampling frequency) were collected during a resting period of 10 seconds as well as during performance of three 5 second long repetitions of each movement. The intervals between repetitions were also 5 seconds long. The data were rectified and integrated, and then the integrated EMG was normalized using the values obtained during MVC (% IEMG). The timing and amount of activitiy of both sides of the trunk muscles were compared.

Results

1) Timing of muscular activity (Fig. 1)

In all subjects, high synchronous activitiy was obtained from both sides of the rectus abdominis and erector supinae muscles, when the muscles acted as prime movers. A slight activity was observed before the preparation for the movement.

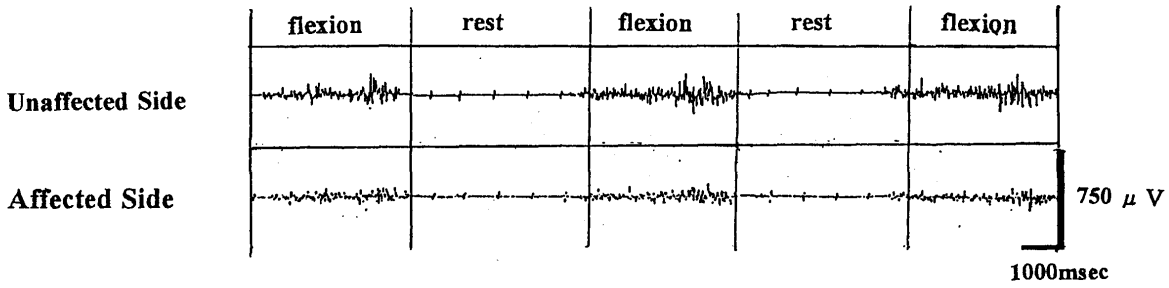
2) Amount of muscular activity (Table 1)

During the flexion movement, the rectus abdominis muscle of the affected side was more active than the unaffected one in four hemiplegic patients and less active in three patients. In the erector supinae muscle during the extension movement, the affected side was more active than the un affected one in three patients and less active in four patients.

Discussion

In the present study, the timing of muscular activation was highly synchronous for both sides of the abdominal and the erector supinae muscles when these muscles acted as prime movers. Kuypers reported that, in primates, the motor neurons innervating trunk muscles receive both ipsilateral and contralateral descending pathways from the cerebral cortex anatomically [2]. Carr et al. studied evidence of bilateral innervation of certain homologous motorneuron pools in man [3]. They observed that following magnetic stimulation of the dominant motor cortex, responses were recorded from both the right and left diaphragm, rectus abdominis and masseter muscles, whereas when they were recorded from homologous upper limb

A. Trunk flexion: the rectus abdominis muscle



B. Trunk extension: the erector supinae muscle

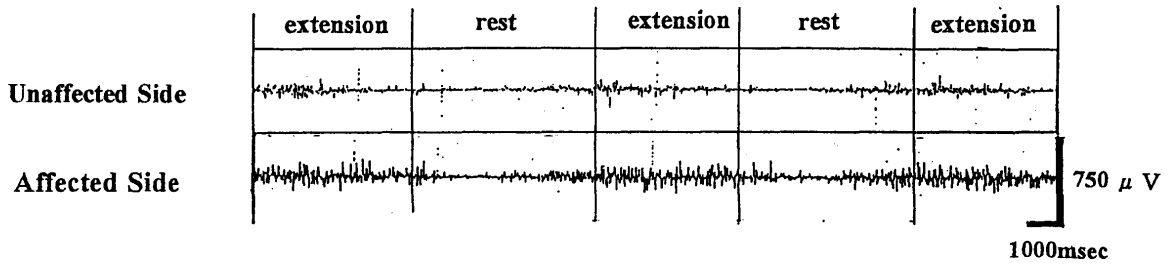


Fig. 1 Timing of muscular activity: EMG activity profile of the unaffected and affected sides of the rectus abdominis muscles (A) and erector supinae muscles (B). During the trunk movement, the synchronous activity was observed in both sides.

Table 1 Amount of muscular activity (%IEMG) in affected and unaffected sides of the rectus abdominis muscles during trunk flexion and the erector supinae muscles during trunk extension.

	Flexion		Extension	
	Rectus abdominis		Erector supinae	
Case	Affected	Unaffected	Affected	Unaffected
A	5.5	4.0	29.9	24.5
B	26.2	4.4	24.0	33.7
C	20.9	16.2	6.2	6.1
D	26.4	31.0	15.9	21.3
E	45.6	52.2	79.5	113.8
F	11.2	25.0	13.9	14.8
G	36.6	24.7	27.3	13.8

muscles, a response was only seen contralateral to the side of stimulation. The authors also considered that synchronization between the EMG recordings of bilateral axial muscles during trunk movements in hemiplegic patients could indicate a common drive simultaneously subserving bilateral motor neuron pools. Irregular laterality has been found in the amount of EMG activitiy in the trunk muscles of hemiplegic patients. Kotake reported that no laterality of cross-sectional areas of either the abdominal muscles or the erector supinae muscles was found in the trunks of hemiplegic patients using CT. He concluded that no significant atrophy between the affected and the unaffected sides of the trunk muscles was found because the trunk muscles receive both ipsilateral and contralateral descending inputs from the cerebral cortex

[4]. Dickstein et al. reported that no laterality was found in the amount of EMG activity of the rectus abdominis during flexion movement in hemiplegic patients. However, with regard to the erector spinae muscle, laterality differences in EMG activities were found in hemiplegic patients. They explained that in the bilateral function of the muscle, the claim of an existing malfunction of the rectus abdominis in the hemiplegic patients could not be confirmed, but a likely explanation might be related to a higher recruitment rate of motor neurons as an a priori compensation for weakness [5]. Such weakness, if it exists, would probably have been more apparent with more strenuous or long lasting movement. Worth noting here is the report by Gandevia and McCloskey, who found that hemiplegic patients consistently overestimated the magnitude of force generated on the affected side [6]. The authors considered that the results of the present study indicated that the laterality of activity in both the abdominal muscles and the erector supinae muscles was brought about by compensatory and excessive activitiy in the affected side during the forced symmetric trunk movement. Dysfunction of trunk movement in hemiplegic patients has been reported and is characterized by asymmetry. Trunk control should be considered an important predictor of stroke rehabilitation outcome and correlated with established functional and motor assessments. However, the correlation between dysfunctions in performance of trunk movements and activities of the trunk muscles has not been established. Our results showed no definite correlation. Further study regarding the role and nature of the trunk muscles in hemiplegic patients is required for efficient poststroke rehabilitation.

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