Pakistan Journal of Engineering and Technology, PakJET
Multidisciplinary | Peer Reviewed | Open Access
Volume: SI, Number: 01, Pages: 111- 115, Year: 2020

Effect of Occupational Therapy on Multi-Scale Entropy of sEMG in Cerebral palsy Children

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Abstract- **Cerebral paralysis (CP) is the most widely recognized motor disability in adolescence. Populace based investigations from around the globe report CP going from 2 to 2.5 per 1000 live births. It occurs when there is some damage to the part of the brain that controls motor function. CP is classified according to the degree of motor disability. Types of CP include monoplegia, diplegia, triplegia, hemiplegia and quadriplegia. There is no cure for this disease; however, management of symptoms is possible by using different interventions like physical or occupational therapy. Surface EMG detected at various muscles simultaneously can be used as a tool for the analysis of gait in CP children. Gait analysis is the most crucial method for treatment of the cerebral palsy patient, providing the most vital information about the abnormality of the gait of the cerebral palsy patient. Surface EMG allows assessing the activity of different muscles during walking to show coordination. Multi-scale entropy helps to extend expected single scale entropy into multi time scale by using the coarse grained technique, has demonstrated the analytical ability to examine the sEMG changes on multiple time scale during the functioning of the muscle. The objective of this study was to investigate the effects of occupational therapy on the multi-scale entropy of surface electromyography (sEMG) in children with CP. The selected group of CP subjects were given OT for consecutive six sessions, and improvement in their lower limb muscles was quantified in terms of MSE. The designed study revealed that OT was sufficient for the rehabilitation of CP patient with a significant difference ($p<0.05$) observed in gastrocnemius muscle. Therefore one can conclude that occupational therapy helps the children who have spastic cerebral palsy to improve in muscles and help children to perform their daily activity in which walking independently is the most important one.**

Index Terms-- **Cerebral paralysis (CP), surface electromyography (sEMG), multi-scale entropy (MSE)**

I. INTRODUCTION

Cerebral palsy is a group non-progressive, non-contagious, characterized by inefficient muscle coordination, caused by brain damage before birth or during infancy [1, 2]. Cerebral palsy that effect movement muscle tone posture [3]. Cerebral palsy occurs when cerebral cortex of the brain fully developed or damage before birth signs and symptoms appear before school years or during infancy [4]. Cerebral palsy causes loss of muscle movement, the rigidity of limbs, trunk, abnormal body position and walk is not steady [5]. Cerebral palsy also affects swallowing eye muscles person is not able to focus on the same object. Sign and symptoms of cerebral palsy vary among people. Some people can walk normally; another person need help [6]. Some cerebral palsy patients have average intelligence others have abnormality, epilepsy, blindness, or deafness may also present [7].

Surface EMG can measure electric potentials when muscle performs the function by placing electrode over the muscle skin in a non-invasive manner [8]. Surface EMG detected at various muscles simultaneously has become an essential method for analyzing the gait of children with cerebral palsy. Gait analysis is the most important method for treatment of the cerebral palsy patient, providing the most crucial information about the abnormality of the gait of the cerebral palsy patient [9,10]. Surface EMG allows assessing the activity of different muscles during walking to show coordination. Now a day surface EMG becomes a treatment for children with cerebral palsy. Entropy, described in the nonlinear dynamic system as the rate of knowledge production, was created to quantitatively calculate the intensity of a time series pulse or the system producing the signal. Multi-scale entropy help to extend expected single scale entropy into multi time scale by using coarse-grained technique has demonstrated the analytical ability to analyze the surface EMG changes over multi time scale during muscle contraction [11].

Occupational therapy helps the children who have spastic cerebral palsy to improve in muscles EMG and joint movement and coordination issue without which life become difficult [12]. Occupational therapy is a crucial part of the overall treatment program of the cerebral palsy patient. The motto of occupational is to help children to perform their daily activity like eating, getting dressed, walking and using the bathroom. Occupational therapy also helps in processing sensory information. Occupational treatment also improves the physical movement of a cerebral palsy patient [13-14].

This study aimed to find the effect of occupational therapy through multi-scale entropy on sEMG before and after intervention of occupational therapy sessions and conclude if OT truly aids in the rehabilitation of CP patients.

II. METHODOLOGY

This section highlights the methods used to acquire appropriate and accurate EMG signals from the subjects, as shown in Fig. 1.

A. Subjects

Electromyographic signals of 32 patients who have cerebral palsy, diplegic age mean of 7.83 (S.D=±3.2) were acquired. Inclusion criteria include that none of the selected CP patients could walk independently or without any support. None of them had a previous history of surgery and drugs (botulinum toxin or baclofen). For reference comparison, data from a control group of normal healthy children were also acquired. This study was approved by the ethics committee of Riphah International University Islamabad (RIPHAH/MERC/BME-18-02).

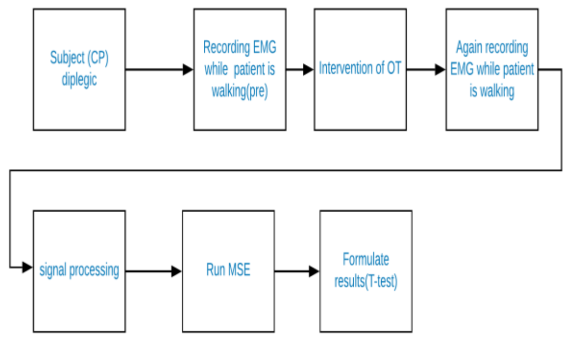

FIGURE 1: Block diagram of steps followed in this study.

B. Data Acquisition

The data was collected from the subjects using the BIOPAC® Systems Inc. (USA) MP36 windows acquisition unit. To provide anti-aliasing for the digital IIR filers and to reduce high-frequency noise it employs an approximately 20KHz Low Pass Filter. Furthermore to accommodate the DC offsets associated with a range of bio-potentials and transducer signals, it operates a switchable bank of single pole high pass filters whose options are DC (HP filter off), 0.05 Hz, 0.5 Hz and 5 Hz. It also has a D/A resolution of 16 bits. sEMG signals were acquired from the lower limb muscles namely *Tibialis anterior, gastrocnemius and soleus* which are responsible for dorsiflexion and planter-flexion movements of foot while walking. Bipolar non-invasive Ag/AgCl surface electrodes with an inter-electrode gap of 2 cm were placed over each of the examined muscles following the SENIAM guidelines. The sEMG activity of a soleus muscle was measured by pairs of non-invasive surface Ag/AgCl electrodes positioned in a longitudinal direction above the belly of muscle and reference electrode was placed on ankle, for gastrocnemius muscle the pairs of an electrode placed at 1/3 of the line between the head of fibula and heel as shown in Fig. 2 . On tibialis anterior, the pair of an electrode placed between the tip of the fibula and medial malleolus.

All subjects after signing consent form volunteered for data acquisition. This study analyses data collected from 32 test subjects, 20 male and 12 female. All subjects were registered at Armed Forces Institute of Regenerative Medicine (AFIRM). For both the control and CP patients, group protocol was similar except for CP patients OT intervention was used. Subjects were asked to walk barefooted at their own pace on lane of 15m while data was recorded.

FIGURE 2: Electrode placement sites for soleus muscle and gastrocnemius muscles.

C. Intervention

Occupational therapy was given to the patients by the occupational therapist at AFIRM for three months, thrice a week. This therapeutic intervention was designed and monitored by the AFIRM, which was not accessible to us. Riphah international university signed a MOU to help in quantifying the effect of their technique by using computational time series algorithms. The procedure allows the patients to achieve the maximum level of function. Few things are taken into account before qualifying the patient for therapy these include, cognitive function, patient's ability to adapt, emotional state, willingness to improve, and supportive home environment.

FIGURE 3: Some of the equipment used for OT at AFIRM.

The exercises that a therapist might include may be different for every patient depending on the need. For example, if a patient is a spastic diplegic, then OT would revolve around strengthening the lower limb muscles the exercise could include walking on the treadmill, walking up and down the stairs as shown in Fig. 3. The main goal is divided into smaller doable steps for the patient, so the constant progress is ensured. The outcome of this therapy is that the patient can perform everyday tasks which we tested using MSE score.

D. Data Analysis

sEMG data was acquired and then filtered to remove the artefact from the signal [4]. The sEMG signals from all three-target muscle were then processed offline using Matlab where after artefact removal and segmentation MSE was applied.

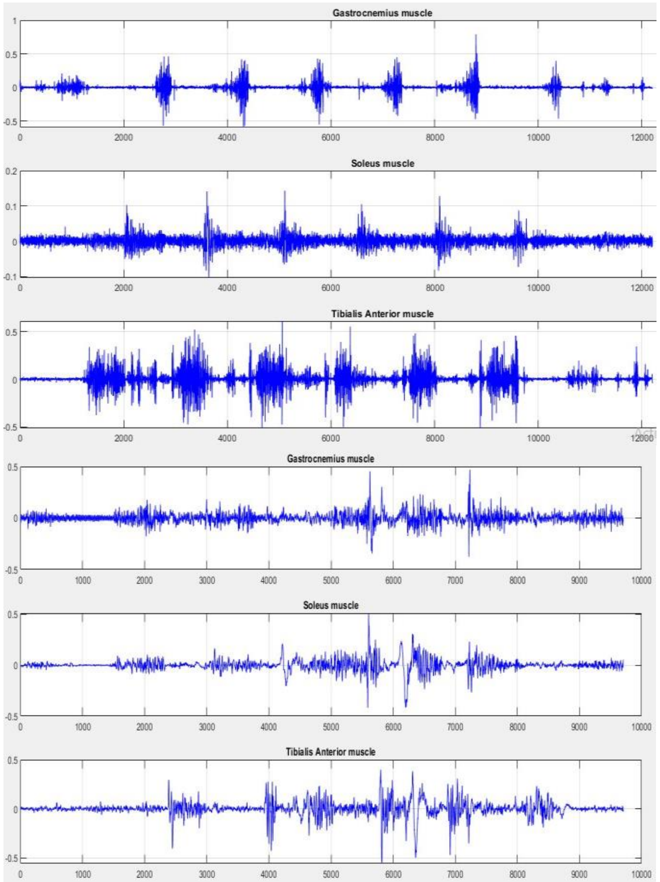

FIGURE 4: Raw normalized unfiltered sEMG data of CP patient and filtered signal.

III. RESULTS

Signals from both the groups were acquired and processed for the evaluation of OT effect on MSE. Figure 5 shows the mean MSE score for the CP patients (baseline, i.e. with no intervention at the start of the study), then the mean for each month segregated into three sessions namely session one, session two and session three.

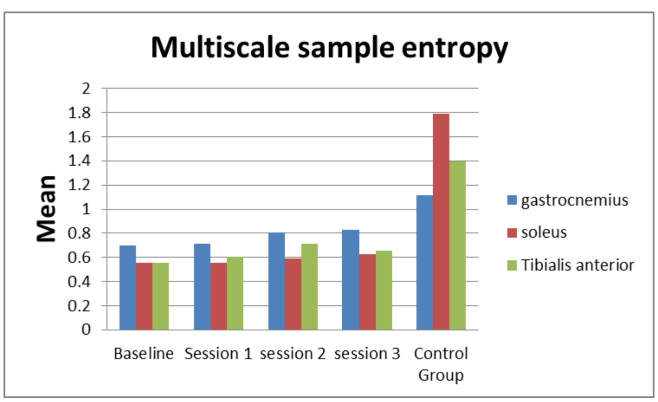

Figure 5. MSE mean results both the groups.

The above data indicates that there has been improvement in patients after undergoing OT. However, the degree of improvement seen is of the essence. Indeed, the improvement is not much so that the patient would gain complete functioning of the lower limb. It is enough for the patient to perform daily activities with ease.

Figure 5 also shows a comparison of MSE results of normal subjects and CP patients. The apparent difference in complexity values can be seen. The trend of the graph shows that after every session there is an improvement. ***Gastrocnemius muscle shows the most improvement.***

There was no significant improvement within the month, so it is not reported. Overall the results indicate gradual improvements after every session, about 0.3%.

The following table shows the T-test results. The mean comparison is between before and after the intervention of OT.

Table 1. T-test results of the mean of data.

Muscle	T-test between initial and session 1	T-test between initial and session 2	T-test between initial and session 3
Gastrocnemius	0.000440129	0.008757387	0.0018010247
Soleus	0.149871867	0.146709276	0.056903965
Tibialis anterior	0.016242129	0.0150469419	0.389338823

IV. CONCLUSION

This present study aims to verify OT as a useful therapeutic means in CP children. This research aimed to find out whether OT has any significant effect on CP patients or not. This was quantified by using multi-scale entropy, which gives us information about the complexity of a signal. Before giving OT to the patient's initial data was obtained, which gave us a starting point in regards to the complexity of the signal. After the intervention for three months, sEMG signals were analyzed, and the results show the signs of improvement. The complexity of the EMG signal increased in terms of numerical values. Apart from these mathematical results, the patients reported improving mood and decrees in the amount of pain and spasticity. Which also adds in favour of OT as a go-to therapeutic intervention.

Furthermore, T-test analysis also shows a significant difference between data sets of different sessions. Spastic diplegic patients showed low motor functions. OT was used as an intervention to improve motor function, which had a significant improvement in ***Gastrocnemius muscle.***

OT can be used as a verified therapeutic intervention. Due to the limited amount of time we had and the current situation of the country due to pandemic it was not possible to extend the OT intervention longer than three months, but this study could be further extended to see the OT effect and to investigate the extent there is a significant difference in motor function. We consider this study as open-ended research on which further work can be done, and more compelling results can be achieved.

ACKNOWLEDGEMENT

The authors would like to thank the therapists and volunteers of the Armed Force Institute of Rehabilitation Medicine, Rawalpindi for their time and assistance in this research. Also, the authors would like to thanks admiration of Riphah International University, Islamabad for their support throughout the research period.

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