The Effect of Music Rhythm on the Electromyography Activity of Lower Extremity and Trunk Muscles in Patients with Cerebral Palsy and Healthy People While Walking

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Abstract--- The aim of this study was to evaluate the electromyography activity of lower extremity and trunk muscles in patients with cerebral palsy and healthy individuals during natural walking and rhythmic walking. Ten patients with spastic cerebral palsy participated in this study voluntarily and subjects walked normally and with a rhythm of 6/8. Using wireless EMG and Bounce Metronome software to give rhytmic task, the intensity of activity in RF, ES, GM and TFL was recording with normal walking and walking with 6/8 rhythms. Data were analyzed by paired t-test and repeated measures analysis of variance. The results showed that Cerebral palsy group during walking without rhythm with normal speed had greater EMG activity in RF, TFL and GM muscles of the left leg ($p = 0.001$) and ES muscle in trunk ($p=0.035$) and RF and TFL muscles in the right leg ($p=0.001$. $p = 0.025$) and ES muscle in trunk ($p=0.045$) than normal subject. The effect of Allegro 6/8 rhythm on healthy individuals on both sides of the body was almost the same ($p = 0.001$). The allegro 6/8 rhythm pattern increased the activity of the lower extremity and trunk muscles on the left side ($p = 0.001$).

Keywords--- Gait Analysis, Muscles Activity, Stimulation.

I. Introduction

Cerebral palsy is a group of disorders of the nervous system in infancy or early childhood that has a permanent effect on body movements and muscle coordination and is one of the most common diseases in children (1, 2). The frequency of cerebral palsy was calculated as 1.2-2.5/1000. In a study conducted in Turkey (3), the prevalence of CP was found to be 4.4 per 1000 live births. One-third of children with cerebral palsy have unilateral movement disorders (hemiplegia) or partial paralysis (4). Semi-paralysis is a form of spastic cerebral palsy in which the upper and lower limbs are often involved on the right or left side of the body. This is the most common syndrome among children with cerebral palsy at birth. Children with spastic cerebral palsy have many problems with movement and balance. Consecutive falls due to weakness in postural fluctuations and dynamic balance of these people are very common (5). According to the findings of Rose, Wolff (5) decreased dynamic balance in children with spastic cerebral palsy is a major factor in gait disorders in these patients. Other gait disorders in people with hemiplegic cerebral palsy include decreased speed, decreased stride length, greater stride width, increased power production from the ankle to the thigh, and poor gait stability (6-8).

Also, more than 65% of CP people have visual-spatial, functional, concentration, attention and learning disabilities (9). The use of rhythm and melody during the activities of people with disabilities causes more involvement of their sensory-deep receptors (7, 10, 11). According to research, music plays an important role in physical activity, and the most important reasons for using music can be mentioned as follows: It can distract a person from feeling tired; As a stimulant, it changes a person's arousal and can also be considered as a reliever to alleviate anxiety; Due to the similarities between rhythm and body movements, it can increase people's efficiency; And the rhythmic nature of music mimics patterns of physical skills, thus increasing the acquisition of motor skills (12, 13). In addition to the role of music in physical activity, due to its cost-effectiveness, non-invasiveness, ease of use and attractiveness, along with common treatments its use as a complementary method to recommended for people with movement disorders and neurological defects (14, 15). Evidence shows that music can be effective in the production and regeneration of nerve cells and plasticity, and by changing the level of steroids in the auditory circuits, emotional circuits and emotional system can also affect spatial perception and cognitive functions (16). Studies also show that listening to music causes physical changes in the brain in the form of harmonization and synchronization of neural patterns (7, 17). Studies in patients with neurological disorders such as Parkinson's, cerebral palsy, and traumatic brain injury have shown that music therapy improves the gait parameters of these patients.

The mechanism and manner of muscle activity during listening to particular rhythm of music an activity such as walking in patients with cerebral palsy has not yet been determined. Knowing how to engage in muscle activity while listening to the rhythm of music while walking can be a good guide in evaluating and designing appropriate methods for exercise program and improving the quality of life in people with cerebral palsy. Therefore, the aim of this study was to investigate the effect of rhythm on the electromyographic activity of lower extremity in patients with cerebral palsy and healthy individuals while walking. The hypotheses of the study were: a) There is a difference between the intensity of electrical activity of muscles in patients with cerebral palsy and healthy individuals and b) The effect of rhythm on the intensity of electrical activity in patients with cerebral palsy is more than healthy persons.

II. Methods

The present study was a comparative study and the present research method was quasi-experimental through control and experimental groups. The statistical population of this study included all patients with hemiplegic cerebral palsy in the left side of Tabriz. Among these people, 10 people were selected by available sampling and participated in this study voluntarily as a statistical sample. This descriptive study was performed in Movafaghian Rehabilitation Clinic in Tehran. According to G-Power (G Power, Franz Faul University of Kiel, Germany) software, 16 samples were sufficient for the two groups for a significance level of 0.05, power of test 0.95 and effect size of 0.50 for two groups, for this study 20 sample were selected. Before the study, the research protocol was explained to the subjects and their parents and they were given informed written consent to participate in the research voluntarily and the subjects could leave the research if they did not want to continue their cooperation at any stage of the research.

The inclusion criteria for subjects with left-sided unilateral cerebral palsy were the ability to understand and follow verbal instructions, the ability to walk independently, the ability to maintain balance, the ability to carry a box, and the absence of significant cognitive impairments. Exclusion criteria were lack of balance control, inability to walk independently, lack of cooperation between parents and children, cognitive impairment, mental retardation, vision and hearing problems. The subjects in the control group were healthy individuals without a history of surgery who did not have any neuromuscular, visual, auditory or motor problems.

Also, 10 healthy subjects from Tehran were all selected as the control group. Table 1 shows the height, age, weight and BMI characteristics of the subjects in both groups. Inclusion criteria for people with cerebral palsy in this study included, left-sided type, ability to understand and follow verbal instructions, ability to walk independently, ability to maintain balance, ability to carry a box and no significant cognitive impairment. Exclusion criteria were lack of balance control, inability to walk independently, lack of cooperation between parents and children, cognitive impairment, mental retardation, vision and hearing problems. The subjects in the control group were healthy individuals without a history of surgery who did not have any neuromuscular, visual, auditory or motor problems.

Procedures

Both disabled and non-disabled people were walked on the platform of the gate analysis and ten three-dimensional motion analysis cameras devices (model made in England), electromyographic activity of the Rectus Femoris (RM), Semitendinosus muscle (S) and Gastrocnemius (G) by wireless electromyography system (16 channels, construction England) was recorded in last 10 gait cycles. Before the test, all participants walked on the analysis gate platform several times to adapt with environment and warm up. Disposable silver-chloride surface electrodes (INTCO model) were used in the electrode replacement. Following this information, the largest electrode size in the direction of the muscle fibers is equal to 9 mm. The distance from the center to the center of the electrodes was approximately 2.5 cm. Initially, to reduce the resistance of the skin surface impedance and to increase the texture of muscle signals from the skin surface, the skin was shaved using a razor and cleaned with sandpaper and 70% alcohol. The electrodes were also glued to the muscle fibers on both legs according to the SENIAM protocol (Surface Electromyography for the Non- Invasive Assessment of Muscles). The electrodes were attached longways over the central of the muscle stomach (18, 19). In order to record EMG information, we were followed all the principles of the SENIAM (20). Also in this study, we were used BEOUNCE METRONOME software to play the 6/8 Allegro rhythm (7).

Before the main study, it was necessary to calculate the maximum voluntary isometric contraction (MVIC) test by using a 16 channels surface electromyography device (MYON, made in the United Kingdom) as a standard source to compare the change in electromyographic activity between different samples and muscles (20, 21). Standard manual muscle test was used to measure the maximum voluntary isometric contraction of the Rectus Femoris, Semitendinosus and Gastrocnemius muscles (22). For each muscle, two MVICs test were performed for 5 seconds, with a one-minute rest between each repetition to reduce the effect of fatigue, and the mean was considered as MVIC (23, 24).

Gluteus Medius muscle were assessed by this position, first the person is placed in a side-to-side position and examiner leg were placed on top and lower leg were placed at the bottom while the thigh is in a 45-degree flexion position and the knee is in a 90-degree flexion position to increase stability. In this position, the examiner exerts a force through the ankle to bring the thigh closer through the ankle while the test foot is in 50% of the abduction, neutralization and hip were in extension position (25, 26). To evaluate the MVIC of the tensor-fascialata muscle, the person was placed on his back while the test leg is in flexion and slightly thigh inner rotates with a straight knee. In this position, the examiner exerts a force through the ankle to open the thigh (25-27). The MVIC test of the spine erector muscles was performed in Sorensen position, in which the person lay on his back on the bed with the upper torso out of the pelvis and the person's legs on the bed, then using the bar, pelvis, thighs, and legs were tied to the bed, and the person tried to exert maximum force in the zero-degree extension position while resisting (28). Finally, the Rectus Femoris muscle MVIC test was performed in such a way that the person was sitting on the bed and his leg was tied to the bed and he tried to open her leg in a 90-degree flexion position despite the resistance (29, 30).

Statistical Analysis

Descriptive and inferential statistics were used to evaluate the statistical analysis of raw data obtained from the research. Mean and standard deviation were used to describe the demographic characteristics of the subjects and Shapiro-Wilk test was used to evaluate the normality of data distribution. Due to the normality of data distribution after analysis, normalization and filtering of data obtained from recording electromyographic activity of the studied muscles and lower limb kinematics using Matlab 7.1 version, also SPSS software version 22 was used to analysis statistic data and paired t-test was used to compare the results within the group and independent t-test was used. for Comparison of the results obtained between groups.

Figure 1: The Subject is Walking in Rhythmic and Non-rhythmic Situations

Table 1: Mean and Standard Deviation of Anthropometric Characteristics of Subjects

Groups	Age	Weight	Height	BMI
CP	13±3.5	45±8.9	155±5.4	18.7±6.2
Healthy	13±1.5	48±3.1	158±3.2	19.2±4.1

III. Results

Table 2 shows the results of related to the intensity of RF, ES, GM, TFL muscles matching activity of subjects with cerebral palsy and the group of healthy people when walking normally (without rhythm). According to the information in Table 2, the intensity of muscle activity on the left side of CP people is significantly higher than healthy people (p=0.045) and the intensity of electrical activity of RF, ES, GM, and TFL muscles on the left side of CP subjects were significantly respectively 2.46, 1.26, 2.15 and 2.4 times higher than the control group (p=0.003, p=0.035, p=0.001, p=0.001).

Table 2: Intensity of Muscles Matching Activity During Normal Walking (Without Rhythm) in Subjects

			Right side			**Left side**
Muscles	Healthy	CP	P	Healthy	CP	P
RF	14.88	28.40	0.001*	13.50	33.43	0.001*
ES	11.96	19.43	0.045*	14.31	18.10	0.035*
GM	20.04	22.18	0.841	22.89	33.01	0.001*
TFL	8.73	13.13	0.025*	10.32	22.23	0.001*

In Table 3 summarized the results of the intensity assimilated activity of rectus Femoris, Erector Spine, Gluteus Maximus and TFL muscles while walking 6/8 Allegro rhythm. The results showed that walking with Allegro rhythm of 6/8, the intensity of muscles activity, RF, ES, GM and TFL muscles on the right side of cerebral palsy subjects respectively were 1.93, 1.71, 1.45 and 1.82 times were greater than healthy people. Also, the CP group subjects left side muscle activity when walking with 6/8 rhythm, RF, ES, GM and TFL muscles were 2.20, 1.56, 1.97 and 2.62 times higher than healthy people, respectively (p=0.001). Generally, regardless of the effect of other factors, the intensity of electrical activity of the studied muscles during walking with a rhythm of 6/8 Allegro was higher than normal walking (p=0.001). Playing Rhythm while walking increases the intensity of muscle activity. In this study, we showed that the use of rhythm on the electrical activity of both groups was increasing, but the increase of muscle activity in CP group was more than the control group, which indicates the interaction between the motor function factor and the group factor. These results showed in Figure 1.

Table 3: Intensity of Muscles Matching Activity during Walking with a Rhythm of 6/8 in People with Cerebral Palsy and Control Group

	Right side			**Left side**		
Muscles	Healthy	CP	P	Healthy	CP	P
RF	18.71	36.26	0.001*	20.90	46.10	0.001*
ES	15.18	25.93	0.002*	20.03	31.41	0.002*
GM	23.65	34.34	0.005*	28.69	56.54	0.001*
TFL	10.82	19.73	0.024*	12.60	33.03	0.001*

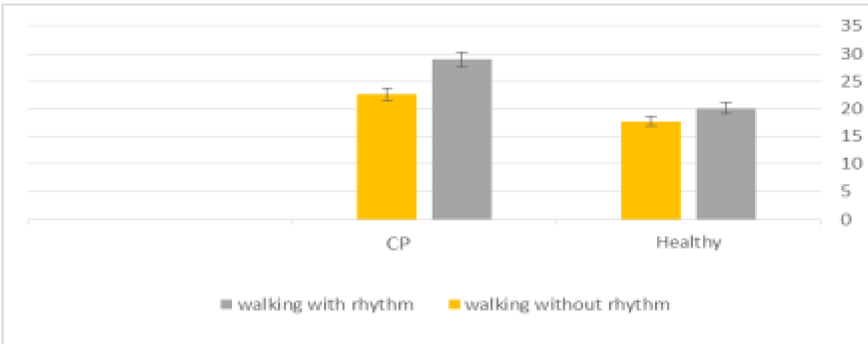

Figure 2: Pattern of Muscle Activity Intensity in Normal Gait and Rhythmic Gait

The results also showed that the assimilated electrical activity of RF, ES, GM and TFL muscles changes while walking without rhythm and normally (p=0.001), so that the effect of rhythm on GM and RF muscles activity were greater than other muscles.

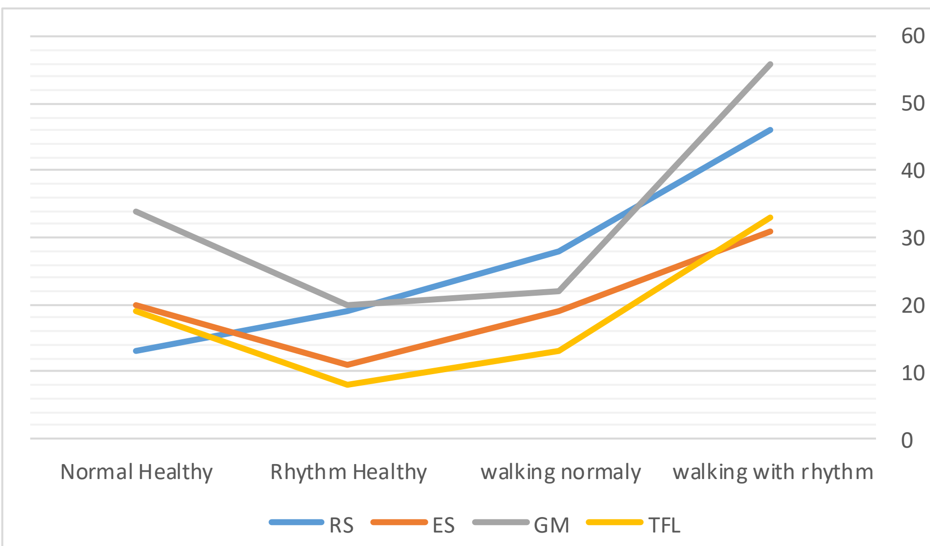

Figure 3: RF, ES, GM and TFL Muscles Activity Intensity Pattern in Normal Gait and Rhythmic Gait

The pattern of changes in the intensity of electrical activity in RF, ES, GM and TFL muscles during normal walking and walking with 6/8 rhythm were different in both of healthy and CP groups and between the three factors of group, muscle and movement task were a mutual significant effect (p=0.001). Regardless of the group factor, the pattern of change in muscle activity intensity during normal walking and rhythmic walking on the right and left sides of the body was similar and no interaction was observed between the three factors of body side, muscle and motor function (p=0.149). But this pattern was not different in the two groups of healthy and cerebral palsy and had a significant effect between the four factors of the group, muscle, body position and motor function (p=0.001).

IV. Discussion and Conclusions

The results of the present study showed that while walking normally and walking with Allegro 6/8 rhythm, the intensity of RF, ES, GM and TFL muscle activity on both sides of body in CP patients was significantly higher than healthy individuals and the effect of Allegro 6/8 rhythm on the intensity of activity in cerebral palsy patients was more than healthy individuals. Findings on Yazdani and Elhami (24), Zwaan, Becher (31), Bojanic, Petrovacki-Balj (32), Prosser, Lee (33) and Farina, Merletti (34) is consistent with the findings of the present study (24, 31-34). Previous studies have shown that CP patients have difficulty in controlling their balance and have more postural fluctuations, weaker postural control, and a different movement control strategy than healthy individuals (3, 35). These people also have gait defects, their speed and stride length decreased, step width increased, thigh range of motion decreased and their double support time increased and they do not have good stability during walking (7, 36, 37). Therefore, in order to maintain their posture in static and dynamic conditions, these people during walking may need more muscle activity than healthy people and activate their muscles more to maintain their balance while walking. The results of previous studies also indicate muscle weakness in patients with cerebral palsy (38). To compensate for muscle weakness in people with cerebral palsy, these people have to use more muscle fibers during daily activities, which is characterized by an increase in muscle EMG in their body. Therefore, the increase in electrical activity of muscles in these patients during normal walking can be attributed to the great effort to control static and dynamic balance and also to compensate for muscle weakness in them. Contrary to the findings of the present study, Di Nardo, Strazza (39) reported less muscle activity on the spastic side of hemiplegic individuals than on the healthy side during walking. The reason for the inconsistency of the results of the study with the present study can be attributed to the studied muscle, the extracted EMG variable and the method of data normalization. In their study, the frequency of activity of the tibialis anterior muscle was normalized to the time of the one gait cycle and was compared between healthy and spastic side of people with cerebral palsy (39).

A more detailed discussion of increasing the intensity of electrical activity studied muscles in this study is also expressed separately in below.

The results of this study showed, the people with cerebral palsy have more activity in the left RF muscle, which may be due to the collapse of the knee joint. Collapse causes the knee joint to flex (crouch gait), and CP persons use their quadratus muscles especially the RF, to prevent the knee bending too much and falling during walking (40). In this study, we also concluded that ES muscle activity was higher in people with cerebral palsy than in healthy people. The increase in the activity of the erector spine muscle at the level of the third lumbar vertebra can be due to the rotation of the pelvis and the maintenance of the forward posture gate in these people. These people have more pelvic rotation and trunk flexion than healthy people during walking, so this extra movement also affects the kinematics of the spine. In order to maintain the stability of the spine these people should show more intensity of activity in the ES muscle. while walking (41, 42).

In this study, left GM muscle activity in cerebral palsy patients was higher than healthy individuals. The gluteus Maximus muscle, with its eccentric and concentric contractions, plays an important role in controlling flexion and extension of the thigh when walking, respectively. It is worth mentioning the collapse of the hip joint is also seen in people with cerebral palsy, so to prevent the collapse of the hip joint, the activity of this muscle increases (43). In addition, the hip joint of these people is in a bended position, so to perform hip extension, these people should do more activity, which is associated with increased electrical activity of the extensor thigh muscles, such as the Gluteus Maximus muscle. Also, due to the presence of spasms in the affected limbs, muscle tone and EMG activity of extensor muscles increase (40).

Generally, the intensity of electrical activity of the studied muscles was higher during walking with an Allegro 6/8 rhythm than normal walking. This result is consistent with the findings of Gerek and Moghaddami (7), Ghai, Ghai (11), Zarandi, Seyfeddini (44) and Baram and Miller (10), who showed the effect of rhythm on a variety of neuromuscular patients. Increased intensity of muscle activity and changing the parameters of gate during walking with different rhythms can be interpreted in this way (7, 10, 11, 44).

Considering that in some CP rehabilitation methods, occupation therapist focuses on increasing the strength and endurance of muscles instead of reduce reducing spasms in the muscles, using rhythm while walking can also increase the strength and endurance of the muscles. The cerebral palsy patients especially those who have more spasms in the left half of body have more attention and perception problems and rhythm training can also improve the order in the frequency of gait.

Walking faster than normal and with a continuous rhythm in front of the body causes flexural torque in the trunk. Therefore, the muscles of the trunk extensor should be more active to maintain the balance of the trunk when walking at a special speed and rhythm. For this purpose, first, to overcome the gravity and maintain the balance of the trunk while walking, a greater number of movement units are called, Also, when walking with a fast rhythm, in addition to slow-twitch fibers, also called fast-twitch fibers, which will record more EMG activity by calling fast-twitch fibers (45, 46). The results also showed that the effect of 6/8 rhythm task on the intensity of various muscle activity was different in the both of groups (healthy and cerebral palsy). It seems that in the 6/8 rhythm task walking, both tasks compete for the resources of the mind, and walking at a faster gait than normal gait reduces attention and interferes with the specific rhythm walking task. On the other hand, people with cerebral palsy have problems in actions such as continuous and distributed attention and giving a rhythm task for walking can help them to have a coherent and rhythmic gait through their attention. Therefore, performing a specific rhythmic walking task may have a greater effect on the attention and concentration of people with cerebral palsy and make a conscious concentration during walking (10, 47), for this reason CP patients increase their muscle activity to have a more normal kinematics along the walking.

According to the results, the pattern of change in muscle activity intensity during normal walking and rhythm 6/8 on the right and left sides of the body was similar, but this pattern was different in the both groups of healthy and cerebral palsy on both sides of the body and Patients with cerebral palsy were more active on the left side. Syczewska and Święcicka (48) and Gross, Leboeuf (49) showed in their study on the symmetry of muscle activity in the right and left legs of hemiplegic and diplegic cerebral palsies and they studied the influence of gait speed on co-activation in unilateral spastic cerebral palsy children, and they showed that hemiplegic cerebral palsy had less muscular symmetry than diplegic cerebral palsy (48, 49). Due to the fact that these patients had left hemiplegic cerebral palsy, the muscle tone on their left side was higher, which causes more activity in the muscles on the affected side, and in the meantime, music can give the necessary order to coordinate this increase in muscle tone (7, 11, 50, 51).

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