

Evaluation the influence of core stability exercise on standing stability of hemiplegic cerebral palsy

mohammad Karimi (✉ mohammad.karimi.bioengineering@gmail.com)

Research article

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Abstract

Background: Cerebral palsy (CP) is one of the most common neurological disorders influences the abilities of the subjects to stand and walk. Various kinds of exercise are recommended to improve the stability of CP subjects during quiet standing. However, there is no evidence regarding the effects of core stability exercise on stability of CP subjects. Therefore, the aim of this research was to determine the efficiency of this exercise on stability of CP subjects.

Method: Two group of normal and CP children were recruited in this study (10 subjects). The stability of the subjects was determined by use of a Kistler forceplate. The stability of the subjects was measured by Approximate entropy (ApEn) based on COP sways. The dynamic stability was evaluated by Berge balance scale. Ashworth scale was used to determine the spasticity of lower limb muscles groups.

Results: The mean value of ApEn of CP patients in the anteroposterior and mediolateral directions were 0.465 ± 0.11 and 0.426 ± 0.099 , respectively compared to 1.02 ± 0.11 and 0.426 ± 0.099 for normal subjects. There was a significant increase in ApEn of CP subjects before and after exercise ($p\text{-value}<0.05$). The mean value of Berge scale was 46.2 ± 5.77 and 51.87 ± 3.9 before and after exercise, respectively.

Conclusion: As lower value of ApEn associated with decrease in complexity, higher rigidity and instability, it can be concluded that CP subjects were unstable than normal subjects. Use of core stability exercise improves complexity of the system and improves the stability of the subjects due to its effect on muscular spasm.

Background

Cerebral palsy is one of the most common neurological disorders caused by non-progressive brain lesion influences the abilities of the children to stand and walk (1, 2). It occurs before, during or shortly after birth with incidence of 2 to 2.5 per 1000 live birth (1-3). It should be emphasized that cerebral palsy results in posture and movement impairment which is permanent but not unchanging (2). This disorder, which is characterized as a cause of upper motor neuron syndrome, is characterized by spasticity, hyper-reflexia and cocontraction, sensory deficient and poor balance and motion controls (4). Spastic hemiplegia is one of the most common type of cerebral palsy in which the subject can walk independently (4). However, they have abnormal gait pattern, asymmetry in the loads applied on the limb and have problems to control balance during standing and walking (5, 6). Based on the results of various research studies, hemiplegic cerebral palsy subjects have worse static balance in various sensory environments and also impairment in dynamic balance than non-disabled children (7, 8).

Postural control during quiet standing is defined as the abilities of subject to keep the body close to vertical to keep the Central of Mass (COM) within the base of support and to reduce asymmetry between left and right weight bearing legs (9).

It has been claimed that the mean values of anteroposterior and mediolateral displacements of Center Of pressure (COP), measured by force plate in children with hemiplegic CP represents poor stability. However, Rose et al showed that there was no difference between stability of CP and normal subject (10). Although standing stability is controlled by ankle, hip and trunk strategies, it has been defined that poor control at the ankle joint is main reason to use compensatory postural control strategy in children with CP (11-13). Other research showed that there was no significant difference in contribution of hip, body transverse rotation and ankle strategy (14).

Balance training is one of the treatment approaches used for rehabilitation of CP patients to enhance and improve the performance of CP patients during quiet standing. However, in most of the studies the stability was evaluated by berg balance scale (15). In the recent research the effect of balance training by Biodex on stability of CP was evaluated (16, 17). It has been shown that Biodex training is a useful tool to improve stability in this group of subjects (18, 19). Weight bearing distribution between legs during quiet standing is also a parameter to represent stability (20). Based on this parameter CP patients have an asymmetry in weight distribution. Moreover, postural training exercise influence the symmetry of forces applied on both legs. The results of the research done by Ledebt showed that balance training with visual feedback influence stability of CP subjects during quiet standing (21).

Core stability exercise has also been used to control the position and movement of central position of the body (22). It has been shown that core stability exercise helps to control the movement of the limbs to be more coordinated. Therefore, it prevents risk of falling from bad posture. There are a few studies regarding the effects of this exercise on stability of CP patients (22, 23). However the stability during quiet standing was measured based on berg balance scale test (22, 24).

Unfortunately most of research on stability of CP patients is controversial and has been done by use of berg scale test (22, 24) .there was only one study on training of core muscle in spastic cerebral palsy by monitoring the motion of COP sways (23). Moreover in a few studies done by use of force plate the stability was evaluated by linear approach which shows only the quantity of stability (15). However, nonlinear approach (approximate entropy) represents the quality of standing stability.

There was a lack of evidence regarding the influence of Core stability exercise training on stability of CP patients by use of a standard method (force plate) (22, 24). Therefore, it was aimed to find the difference between stability of CP patients with that of normal subjects. Moreover, it was aimed to find the influence of training on standing stability of hemiplegic CP patient. The main hypothesis associated with this standing were that stability of hemiplegic CP patients differs from that of normal subjects and also core stability exercise improves the stability of CP patients.

Method

Two groups of normal children and those with spastic hemiplegic cerebral palsy were recruited in this study. The inclusion criteria of CP patients were:

1. a) Level I rating on the Gross Motor Function Classification System for children with cerebral palsy (This corresponds to ability to walk independently).
2. b) No vision or hearing impairment
3. c) Able to understand the comments
4. d) No surgical intervention.

The normal subject was matched with CP patients based on age and height. An ethical approach was obtained from Isfahan University on Medical Sciences Ethical Committee. Moreover, a consent form was signed by the parents of the participants before data collection. Table 1 shows the characteristics of the subjects participated in this study.

Some parameters such as approximate entropy was calculated based on CoP data obtained from force plate before and after exercise. In order to evaluate dynamic stability of the subjects before and after exercise Berg Balance Scale test was used, which is valid instrument for evaluation of effectiveness of various interventions (18, 25). The spasticity of the muscles surrounding hip, knee, and ankle joints were determined Based on modified Ashworth Scaled (scaled from 0 to 4). The stability of subjects was evaluated by use of a Kistler Force plate. The subjects were asked to stand on the force plate for one minute in comfortable position. They were asked to look straight forward with their hand at their sides. The data were recorded with 120 hrz. They were filtered with Butterworth low pass filter with a cut off frequency of 10 hrz(26, 27). In order to remove the effect of sudden standing on force plate and to remove the effects of fatigue, the first and last fifteen seconds of data were removed and only 30 seconds of the data were chosen for final analysis. The stability of the subjects was evaluated based on nonlinear analysis by use of approximate entropy (ApEn) parameter. The mathematical method used to calculate ApEn was the one used by Pincus and Kafman (28). Here the ApEn was defined as $ApEn(m, r, N)$, which m is the length of compared runs, r is a tolerance and N is input data points. It was calculated by use of the following equations:

See formula in the supplementary files.

Core stability exercises have been used 3 times per week over a 8 week period. This exercise consisted of 12 sessions, 3 times per week over an 8 week period with each exercise lasting for approximately 15 minutes. The main reason to use core stability training is to target the muscles of abdomen connect to spine, pelvic and shoulder to assist in maintaining of good posture and provide the foundation for all arm and leg movements. The normal distribution of the parameter was evaluated by use of Shapiro-Wilk test. Since the parameter had a normal distribution a parametric test (paired t test) was used for final analysis.

Results

The mean value of ApEn of the normal and CP are shown in table 2. The mean value of ApEn of normal in the mediolateral and anteroposterior directions were 0.9482 ± 0.182 and 1.02 ± 0.11 compared to 0.4652 ± 0.11 and 0.4263 ± 0.099 for CP patients (p-value of difference = 0.0). Table 2 shows the mean values of

stability parameters of normal and CP participants. Figure 1 shows the COP sway pattern of CP subjects before and after exercise and also normal subjects.

The mean value ApEn in the mediolateral direction before exercise was 0.4652 ± 0.11 compared to (0.6506 ± 0.161) after exercise ($p\text{-value} \leq 0.05$). There was different between ApEn in the anteroposterior direction before and after exercise (it was 0.4263 ± 0.099 before and $(0.8707 \pm 0.203$ after exercise), Table 3. Berg Balance Scale test was also used in this research study. There was a significant increase in this scale follow a period of core stability exercise ($p\text{-value} = 0.003$), Table 3.

The results of spasticity analysis based on Ashworth Scale are shown in table 4. The spasticity of hip joint flexor before and after exercise were 1.18 ± 0.842 and 0.75 ± 0.886 , respectively ($p\text{-value of difference} = 0.085$). There was a significant difference between spasticity of hip joint adductor follow the exercise ($p\text{-value} = 0.04$). The spasticity of knee joint flexor decreased significantly before and after exercise (Table 4).

Discussion

Cerebral palsy is one of the most common neurological disorders caused by non-progressive brain lesion influences the abilities of the children to stand and walk (4, 5). The ability of children with CP to stand and keep their COM within the base of support decreases compared to normal subjects (7, 20). One of the exercises used to improve the stability of CP patients is core stability test. There is no evidence regarding the effects of this exercise on stability of subjects with CP. Therefore, the aim of this study was to evaluate the influence of this exercise on stability of CP patients.

The results of this research study showed that the mean value of ApEn of the patients was significantly less that of normal subjects. Based on the results of various research studies lower value of approximate entropy associated with decrease in complexity. This represents that the system is too rigid and too unstable. Therefore, it can be concluded that higher value of approximate entropy in CP patients compared to normal subjects represents instability of CP children. It means that their neuromuscular system had a lower adaptability and is too rigid. The main reason related to spasms of lower extremity musculature.

Although in most of research studies on stability of CP patients, the stability was measured by use of berg balance scale or by use of force plate based on linear approach, however most of them confirm that the CP subjects are more unstable than normal subjects. The impairment in gait and stability of CP subjects may be due to changes in mechanical properties of muscle tendon system, impairment muscles activation, loss of selectivity in neuromuscular output and abnormal velocity dependent of muscles activity(8, 29, 30). It should be emphasized that in this research, nonlinear analysis approach was used which specifically represent the quality of stability.

As can be seen from table 3, the mean values of ApEn of CP patients increased follow core stability exercise. The main reason to use this exercise is to improve the function of abdominal muscles, pelvic

and shoulder to assist in maintaining of posture (15, 31). Increase in ApEn interpreted as increase automaticity of postural control and also efficiency of postural control. Therefore, it can be concluded that the stability of CP patients improved in both planes follow a period of core stability exercise. The interesting points were that the spasm of hip joint flexor, adductor, knee flexor and ankle plantar flexor decreased follow the use of this exercise. It can be emphasized that stability of CP patients improves by use of this exercise due to its influence on lower extremity musculature spasm.

Berg Balance Scale was also used in this study. Actually this is a 14 items scale designed to measure balance of elderly and handicapped subjects in a clinical setting (25). A high record of this scale (Maximum 56) indicates less impairment in balance function. As can be seen from table 3, the records of Berg Balance Scale test of CP patients improved significantly follow use of core stability exercise. Therefore, it can be concluded that not only static stability of CP subjects improved (determined by use of ApEn), but also the dynamic stability of the subjects improved as well.

There is no study on use of core stability exercise on stability of CP subjects. However, the results of the research done by Kim et al on hemiplegic subjects (46-75 years old) shown that core stability exercise is effective to improve static and dynamic stability (15). Balance training exercise with and without visual feedback was also studies in some researches (11, 21). It has been shown that balance training exercise improves standing stability and increases the amplitude of voluntary weight shift. Some benefits of balance training exercise include: faster activation of the muscles, faster stability recovering, and emerge of a distal proximal muscle sequence (11).

The results of this study represented that stability of CP subjects, static and dynamic, improved significantly follow a period of exercise, however, there were some limitation which should be acknowledged. The main limitation associated with this study was the number of subjects. Furthermore, dynamic stability did not measure during walking. Therefore, it is recommended to do the same study on big number of subjects and also it is recommended to evaluate stability during walking.

Conclusion

The results of this study showed that stability of cerebral palsy subjects improved follow a period of core stability exercise. The reason for improvement of stability related to effects of exercise on spasticity of the lower limb musculatures. It is recommended that the same study will be done on big number of subjects and also measure dynamic stability during walking.

What Does This Article Add?

Core stability exercise influences static and dynamic stability of the subjects with cerebral palsy. It is recommended that this exercise should be used for this group of the subjects.

- Ethics approval and consent to participate: both got from the committee and the parents of the patients

- Consent for publication: Done
- Competing interests: None
- Funding: None
- Authors' contributions: the same contribution

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Tables

Participants	Age (year)	Mass (kg)	Height (m)
Normal	11.68±4.9	38.6±13.69	1.42±0.21
Cerebral palsy	12.88±5.86	39.56±15.44	1.42±0.26

Table 1: The characteristics of the subjects participated in this study

participants	ApEn in anteroposterior	ApEn in mediolateral	Berg balance scale
Normal	0.9482±0.182	1.02± 0.11	53±2.6
Cerebral palsy	0.4652±0.11	0.4263 ± 0.099	46.25 ± 5.77
p- value	0	0	0

Table 2: The mean value of stability parameters of normal and CP subjects

Parameters	ApEn in anteroposterior	ApEn in mediolateral	Berg balance scale
Before exercise	0.4652±0.11	0.4263 ± 0.099	46.25 ± 5.77
After exercise	0.6506 ± 0.161	0.8707 ± 0.0203	51.87 ± 3.9
p- value	0.003	0.00	0.003

Table 3: The mean values of stability parameter before and after exercise in hemiplegic group

Parameters	Hip flexor	Hip adductor	Knee flexor	Ankle plantar flexor
Before exercise	1.18 ± 0.542	1.5 ± 0.755	1.81 ± 0.842	3.25 ± 0.462
After exercise	0.75 ± 0.886	1.125 ± 1.126	1 ± 1.06	2.625 ± 0.916
p- value	0.085	0.04	0.015	0.025

Table 4: The mean values of spasticity analysis of lower limb muscles groups before and after exercise in hemiplegic group

Figures

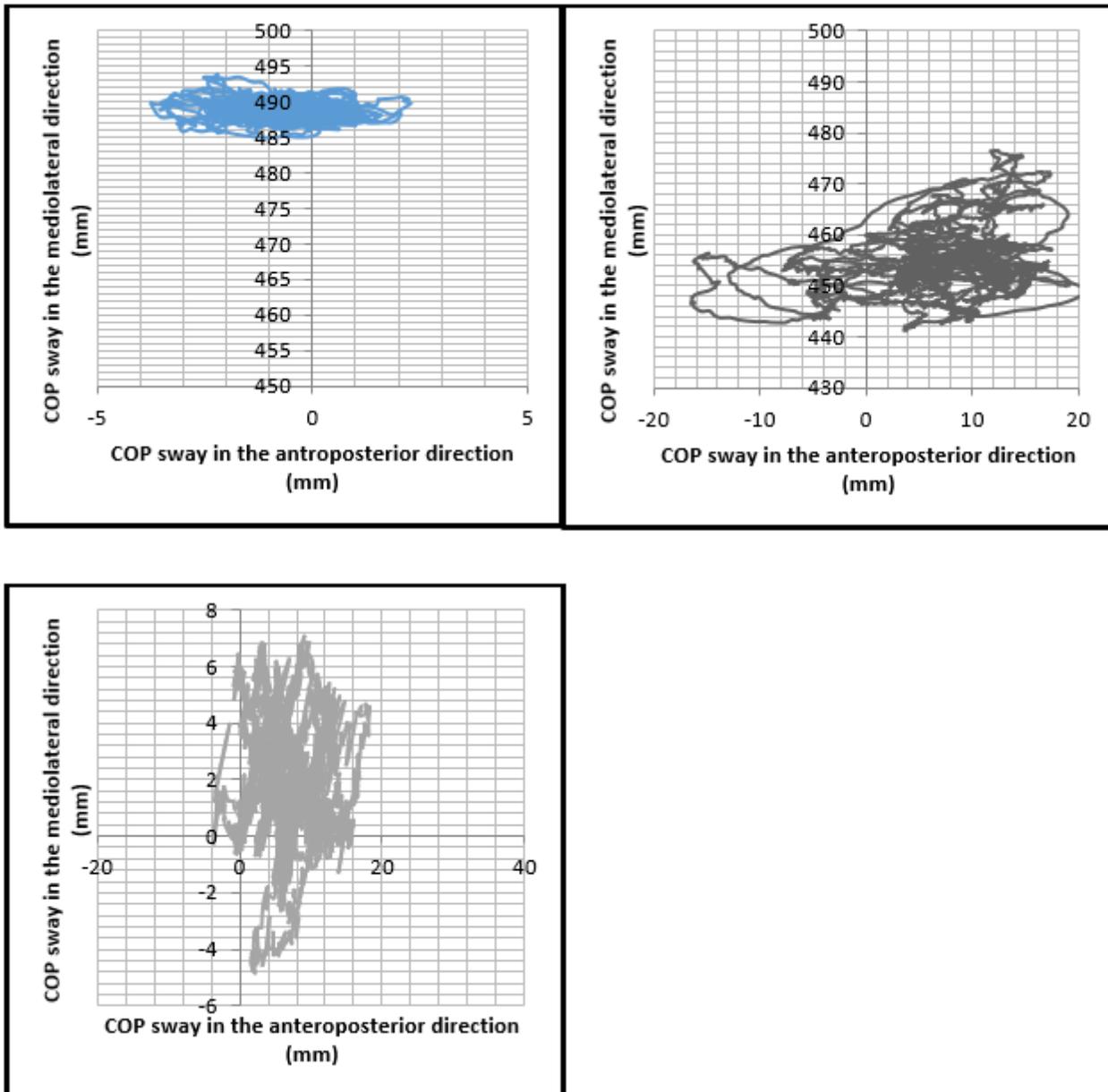


Figure 1

The COP sway of a CP subjects before and after exercise (left and right, respectively) and a normal subject (down)

Supplementary Files

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- [formula.PNG](#)