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Background:

Neuromuscular electrical stimulation is the application of electrical current transcutaneously to innervated, superficial muscles to stimulate muscle fibers. It is usually applied as an adjunct to physical therapy in the management of children with neuromuscular impairment to reeducate muscle, strengthen muscle and improve gait.[1-4] It is recommended that electrical stimulation be used while the child is engaged in task-specific, goal-directed activities so that the child can take an active role in the process of motor learning.[5] This approach is consistent with the principle of conductive education. Conductive education adopts an educational model instead of a medical model in the habilitation of children with neurological impairments. It believes that active learning trough a holistic approach and a facilitative learning environment are the keys to success in the habilitation of children with disabilities. A description of the use of electrical stimulation under the principle of conductive education is illustrated in the following case example.

Clinical Application:

HY was a five-year-old girl diagnosed with cerebral palsy, spastic diplegia. She had normal intelligence. She ambulated with two quadripods independently indoors and outdoors. Due to spasticity in the calf muscles, she walked with a toe-walking gait which was partially corrected by a pair of AFO. She was a boarder and went back home in weekends.The physical training that HY previously received in the Conductive Learning Centre was delivered in the form of group motor programmes and daily functional routine training. The motor programmes and daily routine training focused on education on postural awareness as well as body and movement concepts; control and coordination of ankle, knee and hip movement; standing balance; gait training; and motor planning. Electrical stimulation was added to HY's physical training when she was five years old. Electrical stimulation was implemented in a strengthening and endurance programme.Before electrical stimulation was administered, an introductory session was given to the staff, explaining the use of electrical stimulation and how it was implemented in the daily schedule of the child. A familiarization session was given for the child to know the function of electrical stimulation and be familiar with the sensation of electrical stimulation. Electrical stimulation was used an average of three times a week. Each session took about 40minutes in the morning free play time when the boarders finished breakfast. Electrical stimulation was not given within the group motor programmes since the former focused more on strength and endurance while the latter focused more on coordination and balance. Electrical stimulation was applied to bilateral calf muscles while the child was engaged in gait and pre-gait activities including rising on heels, stepping up and down a low stool, exercising on the stepper, walking on the treadmill and walking on the ground. Besides actively involved in the core physical training, the child was also given responsibility to help prepare the material and apply the electrode pads on the muscles, set the time for training, solve the problem of getting in and out of the treadmill or stepper, clean up the legs after treatment finished, and give feedback during and after treatment. The child received electrical stimulation within the conductive education setting for a period of eight

months.Response Select (Empi, Inc., USA) was used for electric stimulation. The protocol of electrical stimulation was based on the guidelines recommended by Carmick.[5] Typically electrical stimulation is used where the amplitude of the stimulation is sufficient to elicit muscle contraction within the child's tolerance. However, HY could only tolerate the stimulation on a sensory level, that is, at amplitude lower than that resulting in a muscle contraction.Progress on gait wad recorded by video camera and analyzed by Photoshop software. Progress on gross motor abilities was assessed by Gross Motor Function Measure(GMFM) which is a standardized assessment to test gross motor functional changes in children with cerebral palsy. Since the operation of electrical stimulation involved getting the child out of her peer group during the morning free play session, a survey was distributed to staff to help observe the influence of electrical stimulation on the psycho-social behaviour and learning routine of the child.

Result:

Physical Aspect Before electrical stimulation was used, the child has been receiving physical training from conductive education programmes. Continuous improvement was made the one-year conductive education programme. The child progressed from using a posterior walker to using two quadripods to walk, indicating an improvement in postural stability and balance. Also the child has attained the ability to walk without support for a few steps and the ability to climb up and down stairs holding onto rail. Moreover, gait was improved in terms of increased step length. However, there was no change in foot contact area during gait and walking speed. When electrical stimulation implemented in strengthening and endurance programme was added, further improvement was made in gait and motor abilities. The mean step length of the left foot increased from 35 cm to 40 cm, and the right foot from 28 cm to 36 cm. Gait also demonstrated improvement in increased area of foot contact. In the initial contact phase of the left foot, the frequency of landing on toes or forefoot was reduced; instead, there were more occasions on landing on flat foot while landing on heels was occasionally observed. In the mid-stance phase of both feet, forefoot contact was on longer observed; instead, there were more occasions of nearly full foot contact. Walking speed was slightly increased from 0.11 m/s to 0.14 m/s. Besides, GMFM showed a further gain in motor abilities. HY could maintain free standing for more than 30 seconds, as compared to a previous record of 5 seconds; she could also attain standing from sitting on a chair without using arms, as compared to the previous need of using arms. There was only minimal change in the range of movement in the ankle joint and tone of the calf muscles.

Psycho-social Aspect The staff working with HY commented that while administration of electrical stimulation during the morning free-play time did take up some of the child's time to play and interact with other children, there was no adverse effect showen in the psycho-social behaviour of the child. As well, although sometimes the child was slightly later for the first lesson, the influence on learning was minimal. When the psycho-social and cognitive learning goals of the child set for this year were reviewed at the end of the training period, nearly all the goals were fulfilled, indicating that the training didn't bring alone any adverse effect on the child's learning.

Discussion:

Effectiveness of Electrical Stimulation It was shown in this case example that electrical stimulation together with strengthening and endurance training refined gait and motor performance in children with spastic diplegia, built on the substantial physical improvement gained from conductive education programmes. Especially, electrical stimulation helped to increase foot contact area during gait. This result is consistent with the results of other studies which demonstrated positive effect of electrical stimulation on gait and motor abilities in children with cerebral palsy.[1-4,6] However, the improvement shown in this case example could not be attributed solely to the effect of electrical stimulation since both electrical stimulation and strengthening and endurance training were delivered to the child at the same stage. Strength

training programmes are known to be able to increase strength and motor activities in children with cerebral palsy without adverse effects.[7] In this case example, only the sensory level of the electrical stimulation was used. In fact, during the process of selecting appropriate candidates for electrical stimulation, one of our children even demonstrated an adverse response of tensing up the muscles of the whole body when the sensory level of electrical stimulation was given. Previous studies on electrical stimulation used the motor level electrical stimulation to demonstrate the effect of electrical stimulation on children with physical impairment. The age of the children in these studies were as young as twenty months of age.[1,3,4] However, there has been no report on the use of electrical stimulation on children who cannot tolerate the motor level electrical stimulation. Recently, a number of studies investigated the use of low amplitude sensory stimulation as a treatment alternative. Investigators are especially interested in the effect of therapeutic electrical stimulation (TES), a night-time delivery of low amplitude electrical stimulation, which claims to able to improve motor abilities in children with cerebral palsy through improved muscle bulk.[6,8] However the effect of TES is controversial.9 Apart from being used as the TES protocol, the sensory level electrical stimulation can be used as a facilitative tool through its sensory input to enhance sensory awareness. A few children reported to us that the tickling or tapping sensation allowed them to 'feel' the muscle in sue. For those children with poor perception of movement and without adverse responses toward the sensation of electrical stimulation, the sensory input is likely to facilitate motor learning. This case example indicates that electrical stimulation implemented in strengthening and endurance programme is beneficial to children with spastic diplegia, specifically in the improvement of area of foot contact during gait. Even though electrical stimulation may not be used at the motor level in some children, its sensory input may serve to facilitate sensory perception of movement in these children, provided that these children demonstrate no adverse response toward the sensation of electrical stimulation.

Implementation of Electrical Stimulation in a Conductive Education Setting Besides that the electrical stimulation with strengthening program itself brought about therapeutic effect on gait and motor ability, this case example also illustrates that the way the program introduced to the child and her learning environment could enhance the management of the child in a wider scope. When the electrical stimulation with strength training programme was introduced in the Conductive Learning Centre, it was not regarded solely as a physiotherapy programme that only the physiotherapist involved could play an active role. Instead, it was introduced in a holistic manner, paying respect to the transdisciplinary team approach. First, the introduction of the modality to the staff working with the child helps to enhance transdiscuplinary understanding on the management of the child and facilitates team cooperation in administrating the programme. Second, the child was requested to be actively involved in an all-round manner in the training session, based on what she has learned in the conductive education environment, including a sense of self-responsibility, knowledge on body concept and movement concept and motor planning. As such, the child had all-round benefits, besides the motor benefit, under the educational principle. Third, the training sessions were carefully scheduled so that it would not interfere or interrupt the child's core learning time. The child in this case example had satisfactory psycho-social development and her major learning goal was on the physical aspect. As such, her psycho-social development was not affected by the reduction in free play time with peers. Besides, since HY had a higher functioning ability then her peers, it is necessary to provide her with more specific and more challenging motor tasks apart from the group motor programmes. However, for children whose learning goals involve social interaction as well, in order not to interfere the core learning time including free play session, their motor group programmes and daily routine have to be re-structured so that the training with electrical stimulation and strengthening could be implemented in the programmes.This case example illustrates that, first, conductive education and electrical stimulation with strengthening programme could be compatible and complement each other as

long as the educational principle and holistic view of management are well taken. Second, in order to obtain optimal results from the electrical stimulation programme, appropriate candidates should be selected; mainly are those who do not have adverse response toward electrical stimulation and whose major learning goal is on the motor aspect.

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