CHAPTER V

DISCUSSION

This study investigated the effects of the isometric exercise with and without the neuromuscular electrical stimulation (NMES) on the quadriceps muscle in individuals with spastic diplegia, age ranged between 9 and 21 years. Participants were divided into 2 groups based on age, and all outcome measures as closely as possible. The combined group performed the voluntary isometric exercise with NMES and the control group performed the voluntary isometric exercise alone.

The power analyses of this study were not strong (ranged from 0.2 to 0.4). Therefore, the sample size in this study was very small. Furthermore, the participants in this study were only one type of the cerebral palsy (i.e. spastic diplegia). The results in this study may not be able to generalize to other types of CP or disorders. However, this study may be useful as a preliminary study of the effects of the combined intervention between the NMES and isometric exercise in individual with physical disabilities, especially spastic diplegia.

1. Quadriceps Maximum Voluntary Isometric Contraction (QMVIC)

Strength gains in the individual with CP have been attributed to both neural adaptation and muscle hypertrophy (12, 19-20). In short term training (< 6 weeks), neural adaptation which is related to learning, coordination, and the ability to recruit prime movers play a major role in the strength gain (12). Adaptive alteration in nervous system function that elevate motor neuron output largely account for the rapid and large strength increase early in training and often without an increase in muscle size and cross sectional area (12). In the present study, both groups demonstrated increasing of QMVIC. Although, the present did not aim to investigate the mechanism underlying of QMVIC, it seems that neural adaptation could be responsible for the strength gains in both groups observed in this short term training. The result of this study did not support our hypothesis that the improvement of quadriceps strength will show statistical significant differences between two groups. However, the present study showed the similar results to the single subject on a child with spastic hemiplegia (23). However, this single subject research did not give details of the training protocol i.e. set of exercise and electrical stimulation parameters. So we cannot further compare and discuss. Conversely, other previous studies had found that the ES combined with voluntary exercise could improve muscle strength in healthy adults, athletics, and patients with knee surgery (58-59). Furthermore, the combined group showed the retention effect of the quadriceps strength after 2 weeks at the end of training whereas it was not found in the control group. Therefore, continual stimulation may be exhibited the statistical significant differences between groups. A previous study (58) found that the voluntary exercise combined with NMES reduced and/or reversed more muscle atrophy process than voluntary exercise alone. In additional, the use of maximum intensity ES during an intensive post operative exercise program restored more quadriceps strength (at least 70% recovery) compared with following maximum effort voluntary training (57% recover) (58) after reconstruction of the anterior cruciate ligament. A possible explanation for different results could be the differences in the different protocol of external load applied to the muscle, properties of muscle fiber in participants, characteristic of muscle contraction and posture during training (58-59).

The improvement of quadriceps strength in this study did not show statistically significant differences between two groups. Besides the small sample size, this might be due to the limitation of the protocol for pain tolerance to the ES in order to progress in the current amplitude (starting from 21 to 40 mA, mean±SD = 32.9±7.1 mA) in the combined group might be an important factor. Moreover, it might be due to location of electrode placement. In this study, the researcher did not placed electrodes at the muscle's motor point, that would make it is not possible to stimulate all of the muscle fibers of quadriceps. Another reason, the combined group might not fully voluntarily activated muscle contraction during training as compared to the control group and then might depend on the NMES alone. The NMES assists in gaining muscle fiber recruitment and holding leg during weight training. Therefore, if the participant performed the voluntary isometric contraction in combination with the NMES, the participant could lift and hold his/her leg with weight greater than voluntary exercise alone. However, as mentioned above, the NMES can cause pain during training, therefore, to hold leg with weight. If the participant did not perform the voluntary exercise, it might cause pain and led to not reach the amplitude as maximum as possible.

In addition, muscle fatigability might be another reason for explaining this finding. It has been shown that muscle fatigue is a major component of CP pathology because of the abnormal distribution of the fiber types (62). A previous study reported that the individual with CP exhausted due to local muscle factors rather than cardiopulmonary factors (61). The muscle spasticity may result from metabolic inefficiency and contributes to muscle fatigability (61). The present study found that participants could perform the MVIC for 3-5 seconds but could not hold the 65% of the MVIC for 10 seconds. Therefore, it might be another reason for similarity of strength gains for both groups since the weights training statistically significant difference between groups in this study was not found (56.9% of the MVIC for the combined group and 42.92% of the MVIC for the control group). Consequently, the weight training in the combined group was not greater than the control group as we had expected. This result suggested that determining weight used in the training should set at the same holding time as set in MVIC testing. This result also implied that participants had sufficient muscle strength (could hold for 3-5 seconds) but low muscle endurance (could hold for 3-5 seconds). Therefore, this result suggests that the isometric exercise depends on both muscular strength and endurance. Finally, this study performed exercise for only 7 weeks training (short term training). As mention above, the strength gains might be resulted from only the neural adaptation mechanism for both groups. If the exercise training extended more than 7 weeks, it might be found the difference between groups since the combined training seemed to be superior to the voluntary exercise alone (increase strength 40% in the combined group and 31% in the control group at the end of training).

2. Quadriceps lag (QL)

This study showed that there were no statistically significant differences in quadriceps lags (QL) for all conditions. However, as compared between the pre- and post-training, the combined group decreased the degrees of the QL 12.27% while the control group increased the degrees of the QL 12.06%. Moreover, the QL was decreasing 6.37% after 2-week training as compared to the pre-training in the combined group only. Therefore, the result of the QL seemed to be consistent with QMVIC, this improvement might result from the improvement of the quadriceps strength and reducing spasticity of the quadriceps muscle.

3. QMAS and HMAS

The results of the MAS of quadriceps muscle showed significantly decreased at the end of training in the combined group, this result indicated that the NMES applied directly to the spastic agonist had a potential result to reduce spasticity which was not found in the control group. This result was in agreement with the previous studies (5, 46-47). van der Salm et al (61) and Pawielski et al (23) suggested that the changes in the MAS due to agonist stimulation were primarily caused by mechanical components of the muscle stiffness and the muscle spindles. Because of the muscle contractions, the blood flow will be increased in the stimulated area, agonist, and antagonist, which, in turn, can decrease the muscle stiffness. Although the physiological mechanisms of spasticity modulation are not completely understood, the ES can reduce the interfering spasticity, and the stimulation may act as a sensory cue to encourage recruitment and improve timing of muscle activity (62). Additionally, the stimulation on the spastic agonist may lead to a reduction in activity via recurrent inhibition of its own α motor neuron (63). In addition, this study was found no change in hamstrings spasticity which may be because the MAS of hamstrings muscle was already zero since baseline. Therefore, this result suggested that the NMES protocol can be provided without increasing in muscle spasticity.

4. Angles of hip, knee and ankle joints during standing

Although the quadriceps is the dominant muscle group at the knee, other lower extremity (LE) muscle groups such as hip extensors and ankle plantar-flexors also affected lower extremity function and played an important role to erect posture for supporting the whole body against the gravity (63). Therefore, the target on only one muscle group may be insufficient to improve the standing posture. Moreover, quadriceps strength was assessed in sitting position which was required only one muscle, but standing posture is agonist and is required all muscle groups and joints to act together. Therefore, the difference of position may help explain the non-significant change of joint angle of the LE. The further study may perform strength training exercise in all muscle groups of the LE, and then the standing posture may be improved.

CONCLUSION

The purpose of this study was to evaluate the effects of the isometric exercise with and without the neuromuscular electrical stimulation (NMES) on the quadriceps muscle in individuals with spastic diplegia, age ranged between 9 and 21 years. Participants were matched and randomly assigned into 2 groups. The combined group performed combination between voluntary isometric exercise and NMES and the control group performed voluntary isometric exercise alone. Both groups were scheduled for 30 contractions per trial (a trial had 3 sessions with a 2 minute rest between sessions), 3 trials per week for 7 weeks. The QMVIC, QL, QMAS, HMAS, and angles of hip, knee and ankle joints during standing, were compared between the pre-, post-, and follow up after 2 weeks of training and between treatment groups. The findings in this study suggest that both programs are useful for individuals with spastic diplegia as an alternatively adjunct therapy in rehabilitation program. However, the combination between the voluntary isometric exercise and the NMES seems to be more clinically meaningful than the isometric exercise alone, especially for the retention effects of the muscle strength and the quadriceps lag.

CLINICAL APPLICATION

Both exercises with and without the NMES on the quadriceps muscle have advantages for individual with spastic diplegia. In this study, the combination of the isometric exercise and NMES seemed to show better results than the isometric exercise alone, especially for the retention effects of the muscle strength and the quadriceps lag. Therefore, it is suggested for clinicians to apply the isometric exercise with the NMES for individual with spastic diplegia who can perform the isometric exercise. Moreover, the isometric exercise with the NMES should be a complementary intervention in the early phase of rehabilitation because the NMES may be helpful in choosing the right muscle to contraction since individuals with CP has a problem of muscle selection. The individuals with spastic diplegia should start an exercise in a sitting position, and patients who can better perform may exercise in the transfer to standing position (simply lean against a wall and slide down into a position where the knees are bent slightly and hold this position). In addition, he/she should perform these exercises as often as he/she can and the NMES should be applied not over the quadriceps muscle only, but also other impaired muscles should be applied in order to improve erect posture during standing.

LIMITATION AND FUTURE STUDY

1. The results of this study are based on the small sample size. Therefore, the recommendation is to increase the sample size for each group.
2. Neuromuscular adaptation has been known as one of key considerations for responding after ES or exercise. However, this study did not investigate the neural adaptation and muscle hypertrophy. The strength gains of this study might be from only neural adaptation for both groups. If the exercise training continued than 7 weeks, it might be found the difference between treatment groups since the combined training seemed to be superior to the voluntary exercise alone. Therefore, further study may need more time. (such as 12 weeks).
3. The current amplitude in this study was quite low because the participants might not fully voluntarily activated muscle contraction. The further study should train by performing isometric contraction to the maximum force measure by hand held dynamometer and holding for 10 s instead of ankle weight.
4. The results of this study were not improved upright posture. Therefore, it suggests performing the strength training exercise in all muscle groups of the LE and training in closed kinetic chain.