# CHAPTER IV

# RESULTS

## 1. Demographic data of the participants

Eighteen participants with spastic diplegia were recruited to the study. The demographic characteristics of the two groups (control group and NMES group) are presented in Table 5.

**Table 5** The demographic characteristics of the participants (N = 18)

|  | Groups | |
|---|---|---|
|  | Control (N=9) | NMES (N=9) |
| **Demography** | | |
| Age mean (±SD), yr. | 11.22 ± 4.44 | 13.11 ± 4.05 |
| Body weight mean (±SD), kg. | 34.28 ± 9.97 | 33.39 ± 11.72 |
| Male: Female, No. | 9 : 0 | 3 : 6 |
| **CP classification, No.** | | |
| GMFCS level II | 2 | 2 |
| GMFCS level III | 7 | 7 |
| **Assistive devices** | | |
| Anterior walker | 4 | 3 |
| Posterior walker | 1 | 0 |
| Crutches | 0 | 1 |
| Wheelchair | 2 | 3 |
| None | 2 | 2 |

Both groups were consisted of nine participants with spastic diplegia (N=9). The average age of the control group and NMES group were $11.22 \pm 4.44$ years and $13.11 \pm 4.05$ years, respectively. The average weight of the control group and NMES group were $34.28 \pm 9.97$ kg and $33.39 \pm 11.72$ kg, respectively. Both groups were consisted of seven participants who classified into GMFCS level III and two participants who classified into GMFCS level II.

In the present study, all participants completed the study and no adverse effect was reported. All outcome measures were assessed in both legs of all participants, therefore, the outcome measures of eighteen legs (n = 18) in each group were used for statistical analysis and the results are shown below.

**2. Comparisons of the normalized QMVIC, quadriceps lag, angles of hip, knee and ankle joints during standing, QMAS and HMAS between control group and NMES group for pre-training**

The average normalized QMVIC at pre-training in the control group and NMES group were $9.91 \pm 3.62\%$ and $9.58 \pm 4.15\%$, respectively. The average quadriceps lag at pre-training in the control group and NMES group were $18.74 \pm 6.04$ degrees and $18.59 \pm 5.97$ degrees, respectively. The average hip angle during standing at pre-training of the control group and NMES group were $156.97 \pm 4.86$ degrees and $153.91 \pm 5.55$ degrees, respectively. The average knee angle during standing at pre-training of the control group and NMES group were $147.86 \pm 8.73$ degrees and $143.75 \pm 8.81$ degrees, respectively. The average ankle angle during standing at pre-training of the control group and NMES group were $89.43 \pm 4.66$ degrees and $91.93 \pm 6.85$ degrees, respectively. The median score of QMAS and HMAS at pre-training of

the control group and NMES group were two and zero, respectively. The results demonstrated that there were no significant differences in all outcome measures between control group and NMES group at pre-training as shown in Table 6.

**Table 6** Comparisons of the normalized QMVIC, quadriceps lag, angles of hip, knee and ankle joints during standing, QMAS and HMAS between control group and NMES group for pre-training (values presented as mean ± SD)

| | Groups | | |
| --- | --- | --- | --- |
| Outcome measures | Control (n=18) Mean ± SD | NMES (n=18) Mean ± SD | *p*-values |
| Normalized QMVIC (%) | 9.91 ± 3.62 | 9.58 ± 4.15 | 0.80 |
| Quadriceps lag (°) | 18.74 ± 6.04 | 18.59 ± 5.97 | 0.94 |
| Hip angle during standing (°) | 156.97 ± 4.86 | 153.91 ± 5.55 | 0.12 |
| Knee angle during standing (°) | 147.86 ± 8.73 | 143.75 ± 8.81 | 0.18 |
| Ankle angle during standing (°) | 89.43 ± 4.66 | 91.93 ± 6.85 | 0.39 |
| QMAS median (min-max) | 2 (0 - 3) | 2 (0 - 3) | 0.81 |
| HMAS median (min-max) | 0 (0 - 1) | 0 (0 - 1) | 1.00 |

**3. Comparisons of the normalized QMVIC, quadriceps lag, angles of hip, knee and ankle joints during standing, QMAS and HMAS between groups for each test time and between test times for each group**

According to mixed repeated measures ANOVA (group [2] x time [3]), the results demonstrated that there were statistically significant for the interaction between time x group effect on normalized QMVIC ($F_{2,34} = 13.34$, $p < 0.001$) and quadriceps lag ($F_{2,34} = 34.86$, $p < 0.001$) as shown in Figure 15 and 16 respectively. In addition, there were statistically significant for only the main effect of test time on

the normalized QMVIC ($F_{2,34} = 9.03$, $p < 0.001$) and quadriceps lag ($F_{2,34} = 14.93$, $p < 0.001$).
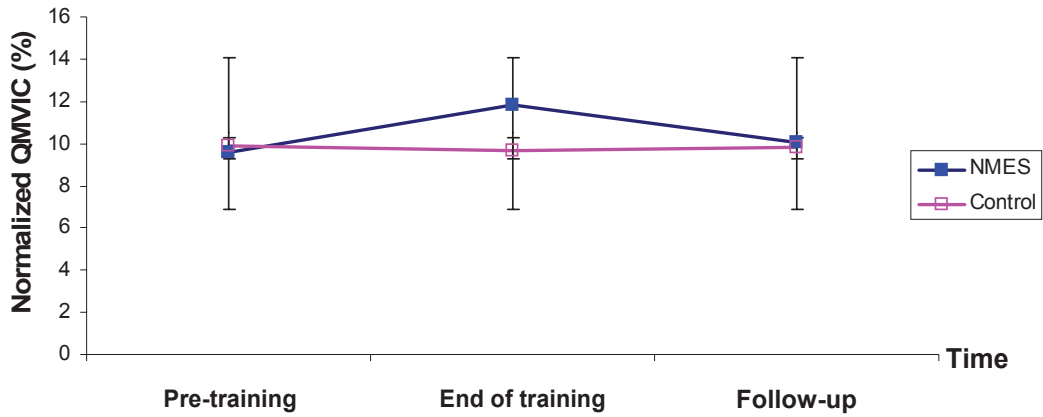


**Figure 15** Profile plot for interaction effect between time x group of normalized QMVIC.
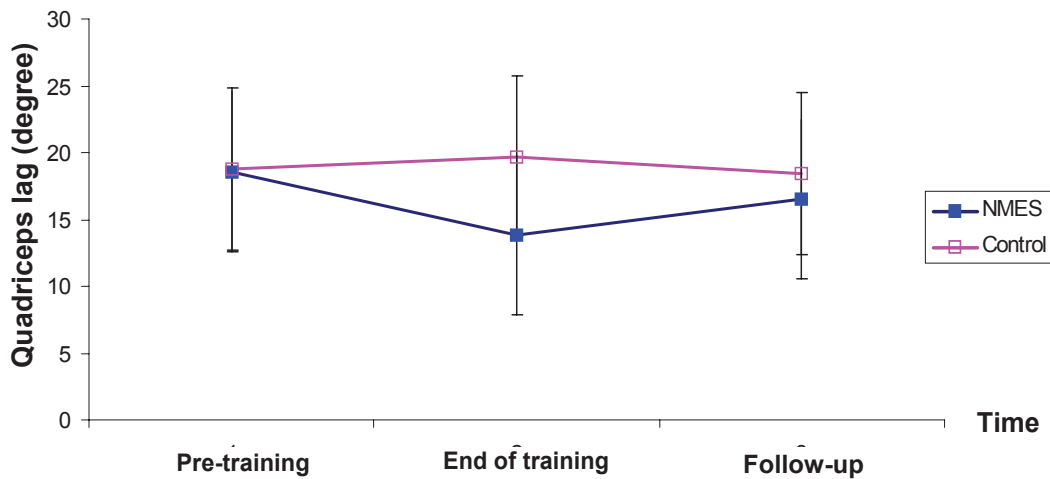


**Figure 16** Profile plot for interaction effect between time x group of quadriceps lag.

Mean and standard deviation values of the normalized QMVIC, quadriceps lag, angles of hip, knee and ankle joints during standing, QMAS and HMAS for all test times for each group are presented in Table 7. The results indicated that there were statistically significant differences between groups for the quadriceps lag ($p < 0.016$) and QMAS at the end of training ($p < 0.05$) whereas there were no significant differences between groups for the normalized QMVIC, angles of hip, knee and ankle joints during standing and HMAS at the end of training. In addition, the results also demonstrated that there were no significant differences between groups in all variables as mentioned above at the follow up. Only the NMES group showed significantly increase of 1.25% ($p < 0.008$) of the normalized QMVIC, decrease of 4.7º of the quadriceps lag ($p < 0.008$) and decrease of the QMAS from 2 to 1 ($p < 0.05$) at the end of training as compare to the pre-training. In addition, the quadriceps lag also showed significantly decrease of 2.6º ($p < 0.008$) at the follow up as compare to the pre-training. However, there were no significant differences in the angles of hip, knee and ankle joints during standing and HMAS between test times in the NMES group. For the control group, the results indicated that there were no significant differences in all variables as mentions above between test times.

**Table 7** Comparisons of normalized QMVIC, quadriceps lag, angles of hip, knee and ankle joints during standing, QMAS and HMAS between groups and between test times for each group

| Variables | Groups | |
|---|---|---|
| | Control (n=18) MEAN ± SD | NMES (n=18) MEAN ± SD |
| **Normalized QMVIC (%)** | | |
| Pre-training | 9.90 ± 3.62 | 9.58 ± 4.15 |
| End of training | 9.66 ± 3.71 | 11.83 ± 4.81 * |
| Follow-up | 9.78 ± 2.82 | 10.04 ± 3.93 * |
| **Quadriceps lag (°)** | | |
| Pre-training | 18.74 ± 6.04 ** | 18.59 ± 5.97 |
| End of training | 19.71 ± 6.41 | 13.82 ± 6.36 * |
| Follow-up | 18.42 ± 6.91 | 16.53 ± 5.95 * |
| **Hip angle during standing (°)** | | |
| Pre-training | 156.97 ± 4.86 | 153.91 ± 5.55 |
| End of training | 158.48 ± 6.86 | 155.19 ± 5.85 |
| Follow-up | 155.75 ± 5.28 | 154.75 ± 5.50 |
| **Knee angle during standing (°)** | | |
| Pre training | 147.86 ± 8.73 | 143.75 ± 8.82 |
| End of training | 145.36 ± 9.61 | 146.12 ± 10.0 |
| Follow-up | 148.46 ± 7.99 | 144.70 ± 7.56 |
| **Ankle angle during standing (°)** | | |
| Pre-training | 89.43 ± 4.66 | 91.93 ± 6.85 |
| End of training | 90.53 ± 4.76 | 91.20 ± 7.97 |
| Follow-up | 91.01 ± 6.39 | 92.04 ± 6.13 |
| **QMAS** | **mode(min-max)** | **mode(min-max)** |
| Pre-training | 2(0 - 3) †† | 2(0 - 3) |
| End of training | 2(1 - 3) | 1(0 - 2) † |
| Follow-up | 2(1 - 3) | 2(0 - 2) † |
| **HMAS** | **mode(min-max)** | **mode(min-max)** |
| Pre-training | 0(0 - 1) | 0(0 - 1) |
| End of training | 0(0 - 1) | 0(0 - 1) |
| Follow-up | 0(0 - 1) | 0(0 - 1) |

** significant differences were found at $p < 0.016$ using independent t-test

* significant differences were found at $p < 0.008$ using dependent t-test

†† significant difference was found at $p < 0.05$ using Mann Whitney-U test

† significant differences were found at $p < 0.05$ using Wilcoxon signed rank test

**4. Comparisons of the percent changes in the QMVIC between groups for each test time and between test times for each group**

The results demonstrated that there were statistically significant for the interaction between time x group effect on the percent changes in the QMVIC ($F_{2,34} = 22.55$, $p < 0.000$) as shown in Figure 17. In addition, there were statistically significant for only the main effect of test time on the percent changes in the QMVIC ($F_{2,34} = 10.34$, $p < 0.05$).
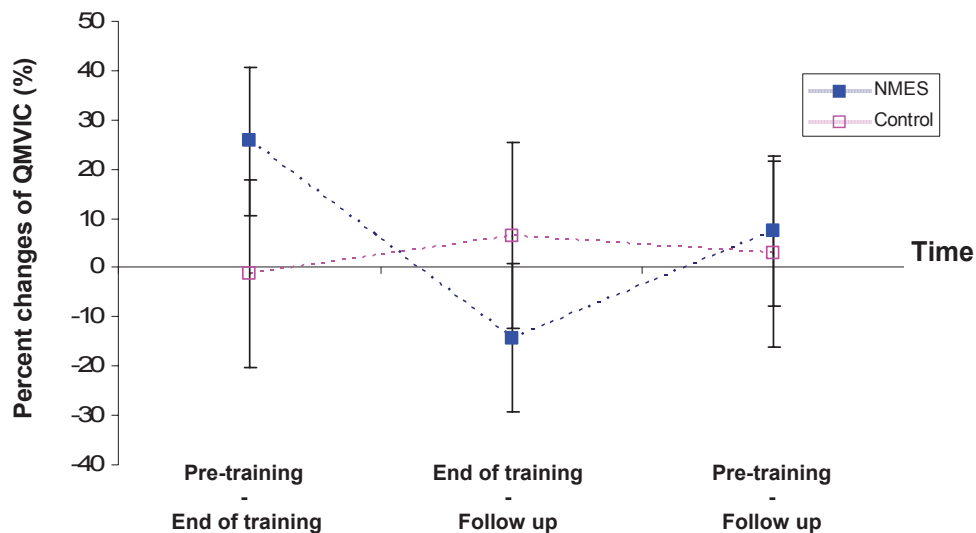


**Figure 17** Profile plot for interaction effect between time x group of the percent changes in the QMVIC. Values presented as mean difference ± SD value between pre-training - end of training, end of training - follow up and pre-training - follow up respectively.

Mean difference and standard deviation values of the percent changes in the QMVIC between test times for each group are presented in Table 8. The results demonstrated that there were statistically significant differences between groups for the percent changes in the QMVIC between pre-training - end of training ($p < 0.016$) and between the end of training - follow up ($p < 0.016$). However, there were no significant differences between groups for the percent changes in the QMVIC between pre-training - follow up.

**Table 8** Comparisons of the percent changes in the QMVIC between groups for each test time and between test times for each group

| Variables | Groups | |
|---|---|---|
| | **Control (n=18)**<br>**Mean difference ± SD**<br>**(min - max)** | **NMES (n=18)**<br>**Mean difference ± SD**<br>**(min - max)** |
| **Percent changes of QMVIC (%)** | ** | |
| ▪ Pre training - End of training | -1.20 ± 17.73 | 25.65 ± 15.13 |
| | (-34.71 to 24.69) ** | (8.52 to 72.09) * |
| ▪ End of training - Follow up | 6.51 ± 22.69 | -14.27 ± 7.23 |
| | (-20.86 to 76.19) | (-30.47 to -4.11) * |
| ▪ Pre training - Follow up | 2.84 ± 15.90 | 7.44 ± 13.46 |
| | (-25.32 to 23.81) | (-7.44 to 41.86) |

** significant differences were found at $p < 0.016$ using independent t-test

* significant differences were found at $p < 0.008$ using dependent t-test