Effect of adding electrical muscle stimulation to trunk control changes in patients hemiparese post stroke

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Abstract---Hemiparesis post stroke often causes balance disorders due to changes in muscle tone, where these changes cause trunk control disorders that can affect static sitting balance, dynamic and trunk coordination. This study is a quasi-experiment with randomized pretest-posttest control group design, aiming to find out the effect of adding electrical muscle stimulation in weight shifting exercise exercises to changes in trunk control of hemiparese post stroke sufferers, carried out with Poly Physiotherapy RSKD. Dadi South Sulawesi Province with a sample of 24 people who fit the inclusion criteria, which were domesticated into 2 groups, namely the treatment group given electrical muscle stimulation and weight shifting exercise exercises and the control group given weight shifting exercises. Based
on the Wilcoxon test obtained the value of $p = 0.002$ for static and dynamic sitting balance, as well as the value $p = 0.001$ for coordination (treatment), and obtained a value of $p = 0.002$ for static sitting balance and coordination and a value of $p = 0.001$ for dynamic sitting balance (kontrol), which means there is a significant influence on both sample groups on trunk control changes. The Mann-Whitney test result obtained a value of $p = 0.148$ for static sitting balance and a value of $p = 0.187$ for coordination which means no significant difference between the two sample groups, but for dynamic sitting balance obtained a value of $p = 0.017$ which means there is a significant difference between the two sample groups. Combining electrical muscle stimulation and weight shifting exercise is more effective at improving trunk control in dynamic sitting balance than weight shifting exercise alone, but no more effective at improving trunk control in static sitting balance and trunk coordination.

**Keywords**—electrical muscle stimulation, weight shifting exercise, trunk control, hemiparese.

**Introduction**

This brain vascularization disorder gives rise to various clinical manifestations such as weakness of the arms or legs or both on one side of the body, numbness of the face, arms and legs on one side of the body, partial vision loss, loss of ability to speak normally, loss of coordination of the limbs, impaired walking, dizziness and loss of balance (Louis, 2010). Worldwide there are 62 million *stroke survivors*, most people, but there are disorders in one or more functions of movement, sensation, language, memory and emotions. One-third of these people have a long-term and significant disability due to hemiparesis, and 20% need help for daily living activities. In the cohort study, 434 *post-stroke hemiparesis* patients at 6 months *post-stroke*, 54% reported problems with the ability to do homework, meal prep or shopping, 65% reported restrictions in community activities and 53% were unable to perform activities. The proportion of stroke survivors who experience hemiparesis is increasing (Leeanne, 2012).

Based on the 2013 Basic Health Research by the Ministry of Health of the Republic of Indonesia, *stroke* prevalence in Indonesia is 7% and diagnosed by health workers or symptoms is 12.1%. Stroke prevalence based on the diagnosis of health practitioner highest in North Sulawesi (10.8%), followed in Yogyakarta (10.3%), Bangka Belitung and DKI Jakarta each 9.7% per mile. Stroke prevalence based on diagnosed nakes and the highest symptoms are found in South Sulawesi (17.9%), in Yogyakarta (17.9%), Central Sulawesi (16.6%), followed by East Java at 16%.

Based on the results of initial observations at the Dadi Regional Special Hospital of South Sulawesi Province which is a stroke service center in South Sulawesi, it was found that 209 visits of Hemiparesis Post Stroke sufferers from November to December 2018 were found. Based on the observations of researchers, generally people with hemiparesis post stroke are not able to control their balance when
moving or when taking positions. In addition, there is a disturbance in muscle tone in the trunk and pelvic region. This indicates a disturbance in trunk control. Trunk control disorder is a decrease in trunk muscle activity so that the trunk muscle loses the ability to contract normally and maintain an upright posture, to adjust weight transfer and to perform selective trunk movements (Kyoung et al., 2014). Trunk control is needed to change the position of the body, control movement against gravity and move the body so that the limbs can function. In a sitting position, normal trunk control will maintain trunk stability and allow it to move the body and balance and reach something with the arm.

Trunk control refers to the ability of the inner trunk muscles (Bill, et al. 2016) to maintain an upright posture, to adjust weight transfer, and to perform selective trunk movements. All of these functions require proper sensorimotor capabilities on the trunk (Kyoung et al., 2014). In people with hemiparesis post stroke, poor trunk control can result in poor sitting and standing balance, and loss of ability to perform functional activities. This is due to damage to the basal ganglia and brainstem that causes impaired postural control and damage to the flocculonodular node which leads to an inability to stand and maintain balance while walking (Kyoung et al., 2016). There are several intervention methods to increase trunk control activity in hemiparesis post stroke conditions. One of them is the provision of Exercise with Weight Shifting exercise. This technique is designed to improve trunk control especially in M. Lattisimus Dorsi and M. External Oblique. Based on the results of research conducted by Kyoung et, al. 2016, the provision of Weight Shifting Exercise combined with Electrical Muscle Stimulation showed a significant increase in muscle trunk activity rather than just Weight Shifting Exercise. (Kyoung et al., 2016).

The provision of Electrical Muscle Stimulation modalities to M. Lattisimus Dorsi and M. External Oblique before weight shifting exercise aims to increase sensorimotor cortex stimulation through muscle stimulation of the skin which can eventually improve trunk control (Kyoung et al., 2016). Khaslavskaia et al, report that repeated electrical stimulation, is effective in improving trunk motor control in hemiparesis sufferers (Bill et al., 2015). Based on the description of the above problem, the formulation of this research problem is: is there a difference in effectiveness between the combination of Electrical Muscle Stimulation, Weight Shifting Exercise and Weight Shifting Exercise against changes in trunk control in static balance, dynamic, and trunk coordination in hemiparesis post stroke sufferers? Electrical Muscle Stimulation, Weight Shifting Exercise and Weight Shifting Exercise against changes in trunk control in static sitting balance, dynamic, and trunk coordination in people with hemiparesis post stroke.

**Methods**

This type of research is a quasi experimental study with randomized pretest-posttest control group design. This study consisted of 2 sample groups, namely the treatment group given the Intervention Electrical Muscle Stimulation and Weight Shifting Exercise, and the control group given the Weight Shifting Exercise intervention. The population of this study is all post-stroke hemiparesis sufferers who experience trunk control disorders at the Dadi Regional Special Hospital of South Sulawesi Province. The sample in the study was a post-stroke hemiparesis...
sufferer who had trunk control disorder based on inclusion criteria. The sampling technique used is accidental sampling. Based on the results of sample calculations obtained the number of samples as many as 12 people (12.4 rounded to 12) in each sample group. The total sample was 24 people. Data collection is obtained through pre-test and post test data using trunk control measurements. The test procedures are as follows:

- Patient preparation: the patient’s position is in accordance with the trunk impairment scale instrument table where each item is different position.
- Implementation technique: in accordance with the trunk impairment scale instrument table.
- Evaluation:
  - Trunk Impairment Scale score is a minimum of 0 and a maximum of 23.
  - A score of 0 indicates a trunk control disturbance, while a score close to 23 indicates an improvement in trunk control in the normal direction.

**Result**

Based on the results of analysis and statistical tests, it can be described and presented as follows the results of research as follows:

<table>
<thead>
<tr>
<th>Sample tik character</th>
<th>Control Group</th>
<th>Treatment Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re rata</td>
<td>Min-Max</td>
<td>Re rata</td>
</tr>
<tr>
<td>Age (year)</td>
<td>57.25 ± 6.15</td>
<td>46-65</td>
</tr>
<tr>
<td>Sample tik character</td>
<td>Control Group</td>
<td>Treatment Group</td>
</tr>
<tr>
<td>Gender:</td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Man</td>
<td>8 66,7</td>
<td>8 66,7</td>
</tr>
<tr>
<td>Woman</td>
<td>4 33,3</td>
<td>4 33,3</td>
</tr>
</tbody>
</table>

The table above shows the average value and percentage of the sample based on the characteristics of the sample. Judging from the age obtained a value of 57.25 ± 6,151 years for the control group and a value of 55.08 ± 7,763 years for the treatment group. This showed that the average sample belonged to the age of the early elderly and the late elderly in the control group as well as the treatment group. Judging from the minimum and maximum values, the sample age range in the control group was 46-64 years and the treatment group was 42-65 years. Then, judging is from the gender in the control and treatment group, a male sample of 8 people (66.7%) and a female sample of 4 people (33.3%).
Table 2
Average Static sitting balance, dynamic sitting balance and coordination

<table>
<thead>
<tr>
<th>Sample Group</th>
<th>Average Pre test</th>
<th>Average Post test</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Static sitting balance:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>3.83 ± 0.937</td>
<td>5.42 ± 0.793</td>
<td>2.58 ± 0.996</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>3.75 ± 1.138</td>
<td>6.83 ± 0.389</td>
<td>3.08 ± 1.084</td>
</tr>
<tr>
<td></td>
<td>Dynamic sitting balance:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>0.00 ± 0.000</td>
<td>6.67 ± 0.985</td>
<td>6.67 ± 0.985</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>0.00 ± 0.000</td>
<td>8.17 ± 1.586</td>
<td>8.17 ± 1.586</td>
</tr>
<tr>
<td></td>
<td>Coordination:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>0.00 ± 0.000</td>
<td>5.17 ± 1.030</td>
<td>5.17 ± 1.030</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>0.00 ± 0.000</td>
<td>5.67 ± 0.778</td>
<td>5.67 ± 0.778</td>
</tr>
</tbody>
</table>

Based on the table above, the average value of static sitting balance in the control group was obtained, namely pretest of $3.83 \pm 0.937$ and posttest of $5.42 \pm 0.793$ with an average difference of $2.58 \pm 0.996$. In the treatment group, the pre-test average was obtained of $3.75 \pm 1.138$ and posttest of $6.83 \pm 0.389$ with an average difference of $3.08 \pm 1.084$. This indicates a change or improvement in static sitting balance after being given intervention in both the treatment and control groups. For the average dynamic sitting balance value in the control group, namely pre-test of $0.00 \pm 0.000$ and posttest of $6.67 \pm 0.985$ with an average difference of $6.67 \pm 0.985$. In the treatment group, the average pre-test value of $0.00 \pm 0.000$ and posttest of $8.17 \pm 1.586$ was obtained with an average difference of $8.17 \pm 1.586$. This indicates a change or improvement in dynamic sitting balance after being given intervention in both the treatment and control groups. For the average trunk coordination value in the control group, namely pre-test of $0.00 \pm 0.000$ and posttest of $1.030 \pm 1.030$ with an average difference of $5.17 \pm 1.030$. In the treatment group, the pre-test average value of $0.00 \pm 0.000$ and posttest of $5.67 \pm 0.778$ was obtained with an average difference of $5.67 \pm 0.778$. This indicates a change or improvement in coordination after being given intervention in both the treatment and control groups.

Table 3
Test different averages of static and dynamic sitting balance and trunk coordination

<table>
<thead>
<tr>
<th>Data Group</th>
<th>Before</th>
<th>After</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static sitting balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.75</td>
<td>6.83</td>
<td>-</td>
<td>0.002</td>
</tr>
<tr>
<td>Standard</td>
<td>1,138</td>
<td>0,389</td>
<td>3,097</td>
<td></td>
</tr>
</tbody>
</table>

...
The table above shows the results of hypothesis testing using the Wilcoxon test for the treatment group. The results of the analysis obtained a p < 0.05 which means that the intervention of Electrical Muscle Stimulation and Exercise Weight Shifting Exercise can provide significant changes in static and dynamic sitting balance and trunk coordination in post-stroke hemiparesis conditions. This suggests that Electrical Muscle Stimulation exercises and Weight Shifting Exercises can provide significant trunk control changes in post-stroke hemiparesis conditions.

The table above shows the results of hypothesis testing using the Wilcoxon test for the control group. The results of the analysis obtained a p < 0.05 which means that weight shifting exercise exercises can provide changes in static and dynamic sitting balance and significant trunk coordination in post-stroke hemiparesis conditions. This suggests that weight shifting exercises can provide significant trunk control changes in post-stroke hemiparesis conditions.
Table 5
Test of the average of static and dynamic sitting balance and trunk coordination between the control group and the treatment group

<table>
<thead>
<tr>
<th>Data Group</th>
<th>Control Group</th>
<th>Treatment Group</th>
<th>U</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static sitting balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>6.42</td>
<td>6.83</td>
<td>52,000</td>
<td>0.148</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.793</td>
<td>0.389</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic sitting balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>6.67</td>
<td>8.17</td>
<td>34,000</td>
<td>0.017</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.985</td>
<td>1.586</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>5.17</td>
<td>5.67</td>
<td>54,000</td>
<td>0.187</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.030</td>
<td>0.778</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table above shows the results of the mann-whitney test after the intervention, where a p > 0.05 for static sitting balance and trunk coordination meant that there was no significant difference in average after intervention between the treatment group and the control group. As for dynamic sitting balance, a p value < 0.05 is obtained which means that there is a significant difference in average after intervention between the treatment group and the control group.

Discussion

Based on hypothesis testing using the Wilcoxon test obtained a p value of < 0.05 for static, dynamic sitting balance and coordination, which means that Weight Shifting Exercise can significantly improve trunk control in static sitting balance, dynamic and coordination in people with hemiparesis post stroke. Trunk control is needed to change the position of the body, control movements against gravity and shift / move the body so that the limbs can function. In a sitting position, normal trunk control will maintain trunk stability and allow for shifting/moving the body and balance both static sitting balance, dynamic sitting balance and coordination and reaching something with the arm (Kyoung et al., 2016). Loss of trunk control generally occurs in people with hemiparesis post stroke. Trunk control disorders include half-body weakness, loss of stability, stiffness, and loss of proprioception. Experts found impaired trunk muscle activity on the side of hemiparesis, such as the erector spine, latissimus dorsi, rectus abdominals, and external oblique. Bohannon, Cassidy, and Walsh’s research (Glen, 2016) has found a disruption in trunk muscle strength in particular the trunk flexor muscle and lateral trunk flexor muscles, and a significant decrease in trunk muscle strength affects trunk control (Glen, 2016).

Bohannon’s research has evaluated people with post-stroke hemiparesis, where there is a decrease in the lateral strength of trunk flexion and the effect of trunk muscle strength on sitting balance and ambulation. The results showed that the average lateral force flexion on the paresis side was smaller than the average lateral force flexion on the healthy side, where there was significantly a strong correlation between sitting balance and trunk flexor lateral muscle strength (Glen,
Weight Shifting Exercise exercises can increase trunk muscle activity, especially lateral trunk flexors by inducing postural movements to the weak side repeatedly, stimulating proprioceptive and somatosensory (Kyoung et al., 2014). Shifting weight towards the weak side can stimulate proprioceptive in weak muscles while activating the work of the flexor muscle and lateral flexor trunk on the weak side and mechanoreceptor in the weak side weight accumulation joint. This causes sensory feedback so that activation occurs in the brainstem and motor cortex. If this condition is done continuously will cause a postural reaction that stimulates the control of the trunk muscles. The presence of repetition in exercise can result in the body's adaptation to the distribution of weight to the weak side and the appearance of trunk control during certain functional tasks.

Weight shifting exercises also use a biofeedback system designed to provide visual feedback or audioria center of pressure (CoP) and attempt to increase weight distribution towards the weak side, and dynamic stability. Several studies have shown that weight shifting exercise will improve static and dynamic sitting balance control in acute and sub-acute strokes after visual feedback training (Panagiotis, et al., 2015). Panagiotis et al (2015) research shows that weight shifting exercise can improve functional balance scores as measured by berg balance scale. Cabanas-Valde's et al research (Yuji, F, et. Al, 2015) in a systematic review reported moderate evidence that trunk exercise or weight shifting exercise improves trunk performance and dynamic and static sitting balance in people with subacute and chronic stroke.

Based on hypothesis testing using the Wilcoxon test obtained a p value of < 0.05 for static, dynamic sitting balance and coordination, which means that Electrical Muscle Stimulation and Weight Shifting Exercise can significantly improve trunk control in static sitting balance, dynamic and coordination in people with hemiparesis post stroke. The addition of Electrical Muscle Stimulation to the Weight Shifting Exercise intervention can facilitate the improvement of trunk control through stimulation of the muscles. The application of Electrical Muscle Stimulation to the latissimus dorsi muscle and external oblique can improve the work of these muscles because both muscles have a large role in adjusting posture. The researchers noted emg activity in the erector spine and latissimus dorsi bilaterally during activities involving arm flexion as well as EMG activity in rectus abdominis and external obliqus during activities involving hip flexion (Glen, 2016).

Functionally, the dorsi latissimus muscle plays a role in the unilateral movement of the lateral trunk flexion, while the external oblique plays a role in bilateral trunk flexion movement and trunk rotation, so that both muscles play a role in posture adjustment and trunk control (Glen, 2016). In addition, the addition of sensory input with electrical muscle stimulation can strengthen motor recovery. A study reported that a sample group that received electrical muscle stimulation combined with certain exercises had a statistically more significant increase in muscle strength. Chan et al (Kyoung et al., 2014) assessed the effects of trunk exercise by applying EMS on lattissimus dorsi and external oblique, showing a greater increase in average TIS scores than the placebo group. (Kyoung et al., 2014). Previous research has shown that electrical muscle stimulation can stimulate Aα,β fibers (which are large), until they reach motor fibers because
increased sensory input can facilitate cortical synaptic reorganization and motor output so as to activate sensory and motor performance (Shamay & Christina, 2017). Based on the results of research conducted by Kyoung, et al (2014) giving weight shifting exercises combined with electrical muscle stimulation showed a significant increase in muscle trunk activity.

Recent research has shown that 10-15 hours of trunk exercise combined with EMS significantly improves trunk motor control such as static, dynamic sitting balance and coordination as measured by TIS (Bill, et al., 2015). Based on hypothesis testing using the mann-whitney test after the intervention, a p > 0.05 was obtained for static sitting balance and coordination, and obtained a p value of < 0.05 for dynamic sitting balance. This shows that there is no difference in effectiveness between Electrical Muscle Stimulation + Weight Shifting Exercise and Weight Shifting Exercise against changes in trunk control in static sitting balance and trunk coordination in people with hemiparesis post stroke, but there is a difference in effectiveness between Electrical Muscle Stimulation + Weight Shifting Exercise and Weight Shifting Exercise against changes in trunk control in dynamic sitting balance.

The addition of Electrical Muscle Stimulation by stimulating the latissimus dorsi and external obliquus muscles leads to the recovery of the work of the two muscles that undergo paresis. Both muscles play more of a role in trunk control accompanied by arm and hip movement activities so that the two muscles play more role in dynamic balance. As for achieving trunk control in static and dynamic sitting balance, it is needed the strength and stability of core muscles in addition to the strength of the latissimus dorsi muscle and external obliquus (Glen, 2016). Then, the Weight Shifting Exercise intervention is an active exercise method that produces isotonic contractions in the trunk muscles instead of isometric contractions, by stimulating the work of the muscles isotonically in the trunk extensor muscle and lateral trunk flexor. This influenced the results of this study, where the combination of Electrical Muscle Stimulation and Weight Shifting Exercise was more effective than Weight Shift. The results of the Panagiotes et al study are consistent with the findings of Hamman et al (Panagiotis, et al., 2015) which stated that weight shifting exercises can increase dynamic balance sizes but have no effect on static balance measures. Rhythmic visual feedback in weight shifting exercises significantly improves dynamic balance function for hemiplegia stroke patients (Panagiotis, et al., 2015)

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Conflict of Interest
There is no conflict of interest in this study

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