Implementation Fugl Meyer Assessment of Lower Extremity Method to Develop a Post-stroke Rehabilitation Procedure Using ITS Tricycle

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Abstract. Stroke rehabilitation procedure with tricycle is arranged according to health standard especially stroke patients. The procedure consists of vital sign examination, Six Minute Walking Test (6MWT), and Fugl Meyer Assessment of Lower Extremity (FMA-LE). As the implementation of procedure, five respondents of stroke patients who had passed the critical period and are carrying out physical therapy in RSU Haji Surabaya take therapy by using tricycle. The results showed that the respondents have motor function score improvement from low to very good category. While based on fitness, the respondents have improvement of VO2max capacity from 27.714 mL/(Kg.min) to 29.424 mL/(Kg.min). It can be said that the tricycle has a great meaning for stroke rehabilitation.

1. Introduction

Until now, many stroke physical therapies use static equipment such as a static bike, treadmill, and leg extension (leg curl). Bicycle is one of the means of transportation as well as a safe sport. The rider uses all the muscles in the body limbs to pedalling a bicycle. Therefore, the bicycle becomes a media to do stroke rehabilitation. Since 2015th, students and lecturers in the product design and development laboratory have developed a tricycle. First, the tricycle was designed by tadpole type and static concept. Tadpole type means one wheel at the rear and the other two wheels at the front. Unfortunately, this tricycle was difficult to drive. Second, the tricycle was developed with delta type and dynamic concept. Tricycle type delta means one wheel in front, while the two wheels on back of bike, as showed by figure 1 [1]. This tricycle has a good performance. So it is selected and developed into ‘ITS Tricycle’ for stroke rehabilitation which is aimed to helping the stroke patients take physical therapy, by pedalling a tricycle, either by foot. To take the therapy, paddle therapy procedure has been arranged for pascastroke patients, which was developed from the standard physical therapy procedure in public hospitals in Indonesia [2][3]. The paddle therapy procedure has been developed from a variety of standard physical rehabilitation and used as a guide use of tricycles in the physical rehabilitation of pascastroke patients. It has been already applied on a static bicycle therapy and also tricycle, is a Postural Assessment Scale for Stroke (PASS), muscle strength, and testing of vital sign [2]. However, it turned out that the procedure is still not complete, and haven't been able to evaluate muscle movement. To complete the therapy procedure, a Six Minute Walking Test (6MWT) and vital sign test are added into previous procedure, before and after pedalling bikes [3]. However, the 6MWT
method only indicates the body health in general, i.e. body fitness. Whereas parts of the body most often stricken stroke is leg and hand. However until now, there is no a medical examination of the body at specific points for physical therapy for stroke patients, in particular the measurement of the movement of the motor on the feet.

![Figure 1. ITS’ Tricycle (SERAITS)](image)

Based on the above explanation, a new procedure is developed, i.e. the Fugl Meyer Assessment of Lower Extremity (FMA-LE) method added into existing therapy procedures, so that it becomes comprehensive paddle therapeutic procedure. FMA-LE method aims to find out the condition of the motor and the mobility of joints, in particular the lower body motion [4]. Procedure is implemented to five stroke patients who’s been going through a critical period and is doing physical therapy at the medical rehabilitation RSU Haji Surabaya.

2. Review of the literature

2.1. Examination of Vital Sign
Examination of vital sign aims to know the body systems alteration in the human body. Examination of vital sign consists of examination of respiratory intensity, heart rate, and blood pressure.

2.1.1. Heart rate measurement. There are three ways to find out the number of heart rate, namely the first way is calculating the heart rate by grasping the wrist, exactly on the radial artery. The second way is listening to the heart rate in the chest using a stethoscope, and the third way is measuring the pulse of heart muscle on the surface of the skin with an Electrocardiogram. Normal people usually have an intensity pulse of about 50-80% of the maximum heart rate according to the American Heart Association (AHA) [5]. Standard heart rate intensity are distinguished based on the age of the human, shown in table 1.
Table 1. Standard heart rate based on the age of human [5].

| Age (year) | Maximum Heart Rate (Heart rate/minute) | Heart Rate is needed (Heart rate/minute) |
|------------|----------------------------------------|-----------------------------------------|
| 20         | 200                                    | 100-160                                  |
| 25         | 195                                    | 98-156                                   |
| 30         | 190                                    | 95-152                                   |
| 35         | 185                                    | 93-148                                   |
| 40         | 180                                    | 90-144                                   |
| 45         | 175                                    | 88-140                                   |
| 50         | 170                                    | 85-136                                   |
| 55         | 165                                    | 83-132                                   |
| 60         | 160                                    | 80-128                                   |
| 65         | 155                                    | 78-124                                   |
| 70         | 150                                    | 75-120                                   |
| 75         | 145                                    | 73-116                                   |
| 80         | 140                                    | 70-112                                   |
| 85         | 135                                    | 68-108                                   |
| 90         | 130                                    | 65-104                                   |

2.1.2. Respiratory intensity measurement. Respiratory intensity is influenced by the activities of the body, the factors of age, gender, and sitting position. Table 2 shows the frequency of breathing normally in humans, which is set based on age group.

Table 2. Respiratory frequency based on the age of human[6].

| Age            | Respiratory frequency (per minute) |
|----------------|------------------------------------|
| New born baby  | 35-40                              |
| Baby           | 30-50                              |
| Toddler        | 25-32                              |
| Child          | 20-30                              |
| Teenager       | 16-19                              |
| Adult          | 12-20                              |

2.1.3. Blood pressure measurement. Measurement of blood pressure aims to know the condition of the vascular resistance, the circulation status, cardiac output, and fluid balance. Blood pressure consists of two types, namely: systolic blood pressure and diastolic blood pressure. Normal blood pressure for adults can be classified as shown in table 3.
### Table 3. Blood pressure classification for adults[6].

| Category     | Systolic blood pressure | Diastolic blood pressure |
|--------------|-------------------------|--------------------------|
| Normal       | < 120 mmHg              | (dan) < 80 mmHg          |
| Pre-Hipertensi | 120-139 mmHg           | (atau) 80-89 mmHg       |
| Stadium 1    | 140-159 mmHg            | (atau) 90-99 mmHg        |
| Stadium 2    | ≥ 160 mmHg              | (atau) ≥ 100 mmHg        |

2.2. Six Minute Walking Test Method

This method aims to find out someone's fitness development, by performing measurement of the distance travelled by a person (the stroke patient) for 6 minutes' walking on a certain track. The walking test and mileage measurement was carried out at the early and the end of the program of rehabilitation. Change the mileage in a span of 6 minutes may be showed the healthy improvement stroke patient. Then the someone's fitness can be seen by using the parameters of VO$_2$ Max, obtained after convert the distances into a VO$_2$ Max, by using Equation (1) [7].

\[
VO_{\text{maks}} = 70.161 + (0.023 \times 6\text{MWT}) - (0.276 \times \text{bodyweight}) - (6.79 \times m) - (0.193 \times HR_{\text{rest}}) - (0.191 \times \text{age}) \tag{1}
\]

Where 6MWT is the distance achieved by respondents after walking for 6 minutes. Body weight of respondents are measured when they will start therapy. m is the correction factors for men is 0, and for women is 1. HR$_{\text{rest}}$ is heart rate taken at two minutes after respondents therapy. Then age is age of respondents when they take therapy. The result obtained from Equation (1) is the value of VO$_2$ max. However, the someone's fitness criteria, ranging from bad, less, standard, good, very good and very-very good, known from the magnitude (value range) VO$_2$ Max that is inhaled.

2.3. Fugl Meyer Assessment of Lower Extremity Method

FMA is a method used to measure motor function, balance, and function of joints in passcastroke patients [4]. FMA method is divided into two parts namely Fugl Meyer Assessment Upper Extremity (FMA-UE) and Fugl Meyer Assessment of Lower Extremity (FMA-LE). FMA-LE is a method used to evaluate the performance of motor movement on the lower limbs (hips, knees, feet, and ankles) and predicts recovery function of motion in stroke patients.

FMA-LE method consists of 17 items are organized into several sub-sections, namely reflection part, sinergisitas part, and coordination [8], [9]. Table 4 shows the criteria for assessment of FMA-LE [10].
3. Research Methods
The steps in this study are as the following.

3.1. Determination of respondents (stroke patient)
The respondents in this study was a stroke sufferer who has fulfilled the criteria of inclusion and exclusion and have signed informed consent sheet. Here are the criteria’s that need to fulfilled by the respondents, as following:

a. Inclusion criteria, including the following:
   - Patient is hemoragic or ischemic stroke patients.
   - The gender is male or female.
   - Patient has the muscle power is greater than or equal to 3 from a scale of 5.
   - The systolic blood pressure is 140 mmHg and diastolic is ≤ 90 mmHg.
   - The heart rate is stable.
   - The patient has suffered stroke more than 3 months.
   - The patient is able to sit and walk independently.

| Sub-activity | Assessment | Item (number) | Item (body) | Criteria of assessment |
|--------------|------------|---------------|-------------|------------------------|
| Reflex Activity | 1 Achillies | 0- No reflex activity can be elicited |
| | 2 Patellar | 2- Reflex activity can be elicited |
| Flexor synergy (in supine) | 3 Hip flexion | 0- Cannot be performed at all |
| | 4 Knee flexion | 1- Partial motion |
| | 5 Ankle dorsiflexion | 2- Full motion |
| Extensor synergy (in side lying) | 6 Hip extension | 0- Cannot be performed at all |
| | 7 Hip adduction | 1- Partial motion |
| | 8 Knee extension | 2- Full motion |
| | 9 Ankle plantar flexion | 2- Full motion |
| Movement out of synergy (standing, hip at 0°) | 10 Knee flexion (90°) | 0- No active motion |
| | 11 Ankle dorsiflexion | 1- From slightly extended position, knee can be flexed but no beyond 90° |
| | 12 Knee flexion | 1- Incomplete active flexion |
| | 13 Ankle dorsiflexion | 2- Normal dorsiflexion |
| Normal reflexes (sitting) | 14 Knee flexors | 0- Knee cannot flex without hip flexion |
| | 15 Achilles | 1- Knee begins flexion without hip flexion, but does not reach to 90° or hip flexies during motion |
| | 16 Patellar | 2- Full motion as described |

| Lower Extremity score |
|-----------------------|
| Coordination/ speed sitting; heel to opposite knee (5 repetitions in rapid succession) | 15 Tremor | 0- Marked tremor |
| | 16 Dysmetria | 1- Pronounced or unsystematic dysmetria |
| | 17 Speed | 1- Slight or systematic dysmetria |

| Coordination/ speed score |
|---------------------------|
| Motor Function score | 6 point |

34 point
b. Exclusion criteria, including the following:
   - Patient isn’t willing to participate in research conducted.
   - Patient has abnormalities of the heart.
   - Patient has impaired balance.

   Based on the above criteria, five respondents (stroke patient) is decided to pedalling a tricycle.

3.2. Examination of vital sign
The examination of vital sign is taken with the supervision of a physiotherapist. There are important test, before the respondent doing therapy with tricycle, called a vital sign examination. It means whether respondents were permitted to take therapy with tricycle. The examination of vital sign is also conducted by respondents after therapy. The examination of vital sign consists of the measurement of the respiratory intensity, heart rate, and blood pressure of the patients.

3.3. Examination of body fitness with a Six-Minute Walking Test (6MWT) Method
Examination of body fitness with 6MWT method will be obtained distance travelled for six minutes, which was performed before and after take the therapy. To carry out this examination, it is required some terms, as the following
   a. It needs a trajectory with a flat surface, dense, straight path (not winding), and not on public road. The track length preferably 30 meters (100 feet).
   b. Start and finish time at one point, so that the tagline is marked as a cone or a line to make it more recognizable.
   c. The execution can be stopped if the respondents feel chest pain, shortness of breath, muscle cramps leg, limping, cold sweat, and pale.
   d. This implementation should be undertaken with the supervision of the fisiotherapists to prevent the unwanted occurrence and fisiotherapists can directly provide the recommended handling.

3.4. Examination of motor function with FMA-LE method
This method of FMA-LE is divided into 7 parts of the examination including reflex activity, flexor synergy, extensor synergy, movement combining synergy, movement out of synergy, normal reflex, and coordination/ speed. The examination procedure with the FMA-LE methods are described by the flowchart in figure 2. After the entire examination is done from the first to the sixth examination, then assessment of the motor function is conducted, as shown in figure 3.
To obtain a motor function category, there are four main steps as the following. The first step is calculating the Lower Extremity score using equation 2 [4].

\[
\text{Lower Extremity score} = \text{Reflex Activity score} + \text{Flexor Synergy score} + \text{Extensor Synergy score} + \text{Movement Combining Synergy score} + \text{Movement Out of Synergy score} + \text{Normal Reflex score} \tag{2}
\]

The second step is calculating coordination score using Equation 3 [4].

\[
\text{Coordination score} = \text{tremor score} + \text{dysmetria score} + \text{speed score} \tag{3}
\]

The third step is calculating the Motor Function score by summing the Lower Extremity scores with coordination score using equation 4 [4].

\[
\text{Motor Function score} = \text{Lower Extremity score} + \text{Coordination score} \tag{4}
\]

The final step is determining the value of motor function by dividing the value of the Motor Function Score with a maximum total score of motor function (i.e. 34) as in equation 5 [4].

\[
\text{The value of Motor Function (A)} = \frac{\text{Lower Extremity score} + \text{Coordination score}}{34} \tag{5}
\]

4. Implementation, Results and discussion

4.1. Pacastroke respondent

The respondents were pacastroke patients who have met the criteria of inclusion and exclusion and have signed informed consent sheets. There are five respondents (i.e. respondent A, B, C, D, and E). They are four men and a woman who have mean age 61th years old. The type of stroke is stroke infark. Three of them were stricken right side of the body.
4.2. Paddle test
Five respondents do therapy by using a tricycle. Before they take therapy, their motor functions and fitness is examined by the method of FMA-LE and the 6MWT. Furthermore, their vital sign is also checked to find out the condition of the respondent before pedalling a tricycle. If the vital sign condition is good then the respondents allowed pedaling a bicycle. Respondents do warming up first accompanied by a physiotherapist. Respondents start paddling for the duration set by the researchers that is 5 minutes, 10 minutes, and 15 minutes in 2 sessions of therapy for 9 times. After that, fitness and motor function of respondents are checked by using FMA-LE and the 6MWT method.

4.3. Analysis of Respondent Healthy

4.3.1. After the respondents did paddle test, with FMA-LE method, five respondents show motor function improvement in their bodies. Figure 4 shows the graph of the motor function improvement of the respondents that their motor function improv from 0.4 to 0.906. It means that their motor functions are developed from low category to the category very well.

![Figure 4. FMA-LE graphic of five respondents](image)

After the respondents did paddle test and did 6MWT test, their fitness level increase. Figure 5 shows the graph of the VO₂ Max capacity improvement of five respondents that the VO₂ Max capacity improve from 27.714 mL/(Kg.min) to 29.424 mL/(Kg.min).

![Figure 5. VO₂ Maks graphic of five respondents](image)
5. Conclusion
Based on the research results and discussion, the conclusions are the method of FMA-LE can help stroke patient to take physic rehabilitation by adding to the standard rehabilitation procedures, to be a new comprehensive rehabilitation procedures. The five respondents have improvement in their motor function score, that is from 0.4 to 0.906. It means that they have the motor function improvement from low category to very well category. Their fitness level also increase that is shown by VO₂ Max capacity from 27.714 mL/(Kg.min) to 29.424 mL/(Kg.min). Their developments state that the benefit of tricycle can help stroke patients to take physical therapy.

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