

Development of Gymnastics Models to Lower the Risk of Diabetic Ulcers in Diabetics

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Abstract Diabetes mellitus (DM) is a condition characterized by increased glucose levels in the blood. DM patients are at risk of diabetic foot ulcers. To lower the risk, DM patients need to exercise to train aerobics, balance, endurance, and legs. For this reason, this study aims to produce a gymnastics model that combines aerobics, balance training, resistance training, and leg training. Research using the Research and Development method refers to the Borg &Gall development model, which aims to produce products. Instrument development involves six stages: needs analysis, initial product development, expert assessment, initial product revision, trial, and final product. The results showed that the percentage of the results of expert assessments and trials was more significant than 80%, so this model is said to be very feasible. So it can be concluded that the gymnastics model which combines aerobics, balance exercises, resistance training, and leg training is feasible and applied to diabetic patients. The gymnastics help prevent or lower the risk of diabetic foot ulcers in people with DM.

Keyword Gymnastics Models, Diabetic Ulcers, Diabetes Mellitus

1. Introduction

Diabetes mellitus (DM) is a metabolic disease characterized by the onset of hyperglycemia. Diabetes

mellitus can be caused by impaired insulin secretion and resistance, resulting in high glucose levels [1]. The presence of an increase in blood sugar levels can cause various disorders in various organs in the body. Diabetes causes complications that affect several organs, including the heart, kidneys, eyes, and brain [2]. Diabetes is also associated with increased cardiovascular risk [3]. Hyperglycemia produces non-enzymatic collagen bands converting delicate tissue into non-elastic, causing joints to stiffen, Achilles tendons to become tight, and front foot pressure to worsen, resulting in motor dysfunction [4].

People with diabetes may occur sensory neuropathy and ischemia. Diabetic peripheral neuropathy (DPN) is a common complication of type-2 diabetes mellitus (T2DM) that can result in an increased risk of falling in the elderly [5]. Sensory neuropathy is the primary and most important causative factor. It can experience a loss of protective sensation, making it prone to physical and thermal trauma, thus increasing the risk of foot ulcers [6]. DPN can result in impaired function in the feet and ankles (strength and flexibility), affecting the patient's daily physical activity and quality of life [7]. Diabetic patients with diabetic peripheral neuropathy (DPN) are vital risk factors that can cause leg ulcerations and amputations [8].

People with diabetes are at risk of diabetic foot ulcers. Diabetic foot is a common symptom in people who experience peripheral neuropathy, especially in the early stages [9]. Diabetic foot ulcers (DFUs) are severe complications of long-healing diabetes mellitus (DM), resulting in repeated hospitalizations, requiring intense and

expensive treatment, and reducing the quality of life [10]. The healing process is slow, one of which is influenced by the body's position, which results in the lack of smooth blood circulation to the legs [11]. Diabetic foot ulcers (DFUs) can result in a high risk of infection that can cause amputation [12]. The occurrence of diabetic foot ulcers, infections, gangrene, and amputations is associated with a higher risk of death and has a poor prognosis [13].

It is essential for people with diabetes to do physical activity/exercise [14]. Physical activity is any body movement produced by skeletal muscles using more energy [15]. Many factors need to be considered in determining exercise and during the implementation of exercise for diabetic peripheral neuropathy (DPN) patients, including the state of the joints, the frequency of exercise to avoid fatigue, and other patient conditions [16]. For people with diabetes, pain is generally a barrier to physical activity [17]. In addition to pain, other factors that can interfere with physical activity are numbness, reduced nerve conduction speed, and fear of falling [9]. Exercise can increase the ability of people with diabetes to actively carry out physical activities in daily life [18]. Physical activity can correct motor dysfunction to reduce unwanted impacts [9].

The risk of diabetic foot ulcers can be prevented by doing physical activity/exercise. DPN patients can experience neuro-musculoskeletal changes, but doing exercises such as strengthening, stretching, balancing, and gait training can prevent the occurrence of foot ulcers and amputations, reduce the risk of falling, and increase the daily physical activity and quality of life [7]. People with diabetes engaged in regular physical activity, such as walking, resistance exercises, or flexibility exercises, can improve cognitive abilities and gait in the elderly [19].

However, comprehensive and structured exercises to improve foot biomechanics in type 2 diabetes mellitus are still lacking, so special exercises are needed to control and prevent musculoskeletal changes and complications in the legs [20]. Gymnastics performed by people with diabetes to lower the risk of diabetic foot ulcers is still focused on the foot area only. Diabetic foot exercises can be a program to help reduce the symptoms of neuropathy because they can improve blood glucose control and insulin sensitivity [21].

There is a combination of DM gymnastics and foot gymnastics that shows better results than foot exercises alone. The combination of gymnastics combines aerobics, balance, resistance, and leg training. Exercises that combine ROM and stretching exercises are proven to increase lateral pressure of the front legs [4]. However, the type of gymnastics that exists today is not suitable for DM sufferers who are generally elderly, so it feels heavy and difficult to do. The movements in gymnastics are varied, and the rhythm is fast, requiring much energy so that it makes people tired quickly. Then a gymnastics exercise model is needed for DM sufferers that suit the needs and

conditions of the sufferer. People with DM can have motor neuropathy damage, which results in motor nerves changing the body's ability to coordinate movements and deformities in the feet, Charcot feet, hammerhead toes, and claws. Motor neuropathy triggers atrophy of the leg muscles, which results in changes in the anatomy of the legs so that there is a risk of osteomyelitis, mechanical changes, and redistribution of pressure on the legs that can lead to ulcers [22]. For this reason, this research is essential to do which aims to develop a gymnastics model that combines aerobics, balance exercises, resistance training, and leg training.

2. Materials and Methods

2.1. Research Design

Research uses research and development methods. Research-development procedures help clarify and improve instrument items and designs. In developing the instrument, the researcher refers to the development model of Borg and Gall (1983), which aims to produce products. Six steps have been adapted to various aspects, including (1) Needs analysis, (2) Developing an initial product, and (3) Expert assessment. (4) Revision of the initial product; (5) Trials; and (6) Final products.

2.2. Participants

Participants in this study consisted of two groups. The expert group consists of 6 experts in the field of health and experts in the field of sports to provide expert assessments related to the gymnastics model made. Meanwhile, the DM patient group was 40, consisting of 10 DM patients in the initial test and 30 in the final test.

2.3. Data Collection

Data collection in this study used instruments to evaluate this model, namely questionnaires. Questionnaires were used to assess the feasibility of "MULDA" gymnastics by experts using PIECES (Performance, Information, Economic, Control, Efficiency, Services) criteria. Meanwhile, the assessment by the group uses five criteria, namely Performance, Information, Economics, Control, and Efficiency.

2.4. Data Analysis

Data analysis in this study uses quantitative analysis by calculating the percentage of each indicator. Calculation results are then used to determine the feasibility of the media or products produced using the category range in table 1.

2.5. Ethical Approval

This research is registered in the health research ethics committee at Sebelas Maret University (UNS) No. 075/UN27.06.6.1/KEPK/EC/2020. The implementation of this study refers to the applicable provisions. Before data collection began, respondents in the study had been explained that their participation was voluntary and that they also had the right to withdraw from the study at any time without any sanctions.

Table 1. Eligibility Categories

Score	Interval
81% - 100%	Very Eligible
61% - 80%	Eligible
41% - 60%	Fairly feasible
21% - 40%	Not Eligible
0% - 20%	Very Unfeasible

3. Results

3.1. Needs Analysis

The needs analysis is carried out by analyzing the existing gymnastics. The results of discussions with experts obtained the following conclusions: 1) The type of gymnastics that aims to prevent existing diabetic foot ulcers is foot gymnastics. 2) The limitations of gymnastics that were previously only focused on the legs did not involve the entire limb, so it was necessary to develop gymnastics that involved the whole limb and combined several exercises, namely aerobics, balance exercises, resistance training, and leg training.

3.2. Initial Product Development

The developed gymnastics model is structured in the form of modification and creativity by combining four exercises; aerobics, balance exercises, resistance training, and leg training. Incorporating all four exercises in one gymnastics model is expected to be more effective in lowering the risk of diabetic foot ulcers. In addition, it is more efficient and effective in terms of the time of its implementation. This model of gymnastics was given the name gymnastics "MULDA". The "MULDA" gymnastics was designed for 40 minutes with a total of 51 movements, consisting of warming up ten movements for five minutes, the core there were 31 movements for 30 minutes, and cooling there were ten movements for 5 minutes. All designed movements are performed by standing.

3.3. Expert Assessment

Based on the results of expert validation, it can be stated that the gymnastics "MULDA" should pay more attention to patient safety. From health experts, they provide input on safety and comfort in gymnastics. During leg training, it should be done to minimize the risk of falling during gymnastics. Based on these inputs, it is necessary to revise some movements, especially for leg training. However, in general, the assessment results of the six components scored more than 80%, so this "MULDA" gymnastics was declared very feasible. The results of expert validation can be illustrated in the following figure 1:

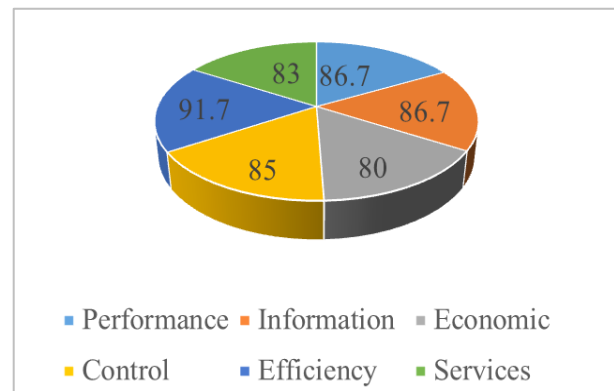


Figure 1. Expert Validation

3.4. Preliminary Product Revision

Based on the expert evaluation, some parts need to improve in the gymnastics model. The part that was revised was in the cooling movement. In the cooling section, all the movements initially done by standing in the revision became done by sitting. This is because, in this cooling part, movements are focused on training the legs. So leg exercises done by sitting reduce the risk of falling in people with diabetes.

3.5. Group Trial

The "MULDA" gymnastics trial was conducted twice in a small group of 10 diabetic patients, followed by testing in a large group of 30 diabetic patients. The results of the first trial, of the five components each, scored more than 80%, likewise, in the results of the second trial. So from the trial results, the gymnastics "MULDA" is said to be very feasible and can be applied to diabetics. The results of the trial on a group of DM sufferers can be illustrated in the following figure 2:

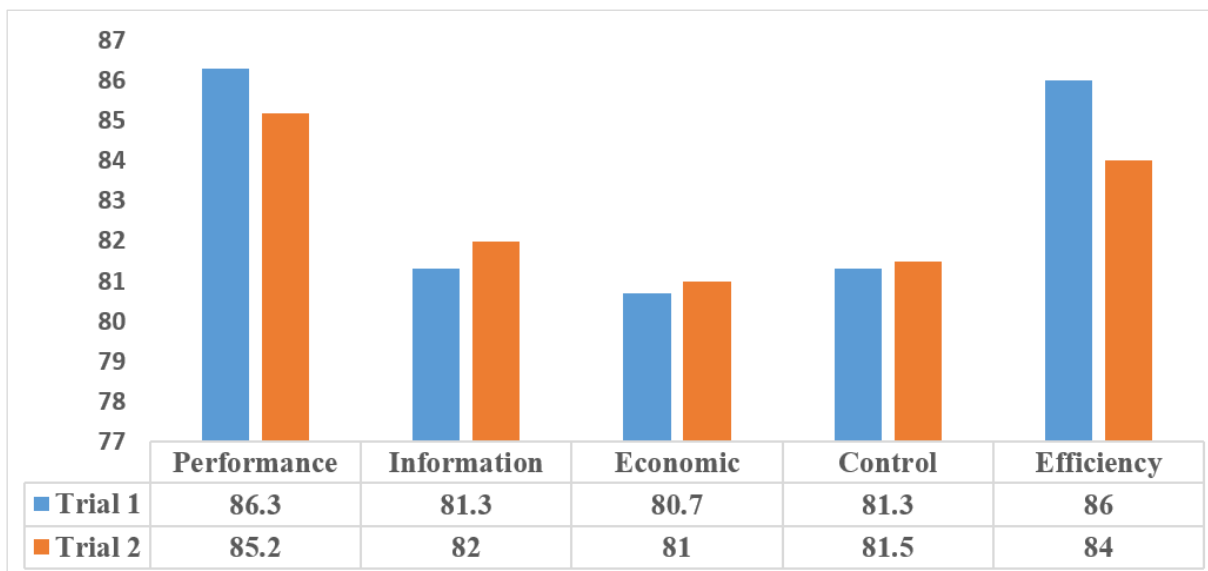


Figure 2. Test Group Validation

3.6. Final Product

This stage is the final stage in the development of the gymnastics model. After the gymnastics model was tested on a group of diabetics and the results stated that this gymnastics model was feasible, then the next step was the refinement of the gymnastics model. The movement on the heating and core is by the initial planning, while for the movement in cooling, there is a change; that is, the movement is done by sitting. Cooling movements are more focused on leg exercises.

3.7. Effectiveness Test of Experiment Group

To prove the effectiveness of "MULDA" gymnastics in reducing the risk of diabetic foot ulcers, tests were carried out on 30 people with diabetes. The intervention was carried out for 12 weeks with 24 meetings. Before and after the intervention, people with diabetes are examined for blood sugar and ankle-brachial index (ABI) to detect the risk of diabetic foot ulcers.

Table 2 explains that the test value for the effectiveness of blood sugar test results has a pre-test median of 282.5 and a post-test median of 188.5. From the analysis, it can be concluded that there are differences in blood sugar before and after the "MULDA" gymnastics.

Table 3 explains the effectiveness test scores of the ABI test results with an average pre-test value of 1.1 and an average post-test of 1.15. From the analysis, it can be concluded that there are differences in ABI before and after the "MULDA" gymnastics.

Based on tables 2 and 3, it can be concluded that the treatment model can significantly lower the risk of diabetic foot ulcers.



Figure 3. "MULDA" Gymnastics Video Show

Table 2. Wilcoxon's analysis results on blood sugar

	n	Median (minimum-maximum)	p value
Pre test	30	282.5 (108 – 496)	<0.001
Post test	30	188.5 (69 – 472)	

Table 3. Paired t test analysis results of Ankle-Brachial Index (ABI)

	n	Mean ± Standard Deviation	p value
Pre test	30	1,1 ± 0.12	0.037
Post test	30	1.15 ± 0.12	

4. Discussion

Gymnastics is part of the sport that aims to prevent the occurrence of diabetic foot ulcers. Exercise is defined as body movements produced due to the contraction of skeletal muscles that requires energy to increase energy expenditure from within the body [23]. Exercise can improve energy metabolism, reduce insulin resistance, and control glucose homeostasis. Exercise is one of the effective ways to reduce glucose levels and symptoms of diabetes [2].

In developing gymnastics for people with DM, one of the factors that must be considered is safety. This is because, in people with DM, there is a decrease in the function of body organs. DM sufferers can also cause various complications, including macro-vascular, micro-vascular, neuropathy, retinopathy, nephropathy, cardiovascular and cerebrovascular complications, peripheral vascular disease, and diabetic foot ulcers [24-26]. The condition can increase the risk of falling in people with DM.

The developing gymnastics is a gymnastics that combines four exercises, namely aerobics, balance training, resistance training, and leg training. With combined exercises, there will be an increase in postural balance and gait, an increase in the level of activity, and a reduced risk of complications of diabetes, especially in the lower extremities. Balance exercises that are part of the exercise are essential in lowering the risk of falling [27]. Combination exercises can also improve physical function, reduce weakness, and lose weight [28].

The novelty of this incorporation product, namely; 1) "MULDA" gymnastics combines four types of exercises, including aerobics, balance, resistance, and leg training. Therefore, the gymnastics is perfect for people with diabetes. 2) The music used to accompany the gymnastics "MULDA" is music that consisting of Indonesian national songs.

5. Conclusions

Based on the results, the gymnastics "MULDA," which combines aerobics, balance exercises, resistance training, and leg training, is considered excellent and worth using. For this reason, the gymnastics can be implemented in diabetics to prevent the occurrence of diabetic foot ulcers. The gymnastics is also easy and can be done independently since there are already available videos that can be used as a guide in gymnastics.

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