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Design of a hydrotherapy device to accelerate recovery from muscle fatigue after physical exercise

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ABSTRACT

This study aimed to create a hydrotherapy device to accelerate recovery after physical exercise. To achieve this goal, the researchers employed a Research and Development (R&D) approach. The study involved two experts with competence in media and material fields. In the initial stage, validation tests were conducted to assess the strengths and weaknesses of the designed device. The experts evaluated the device based on product feasibility, clarity of language, and device design. Following the validation tests, the product's feasibility was further assessed through two stages of trials: small-scale and large-scale. A total of 16 male students aged 21–25 participated in the small-scale trial, while 36 male students in the same age range took part in the large-scale trial. These participants were selected using purposive sampling. The results indicated that expert validity averaged 87%, categorizing it as very feasible. The validity for the small-scale trial was 80%, and for the large-scale trial, it was 84%, both considered very good. In summary, the hydrotherapy device is feasible for accelerating recovery after physical exercise and has the potential to enhance athletic performance. We recommend conducting further investigations to fully evaluate the device’s effectiveness in speeding up recovery.

KEYWORDS

Hydrotherapy; Recovery; Muscle Fatigue; Physical Exercise

1. INTRODUCTION

High-intensity physical exercise can trigger several problems, such as muscle fatigue (Ishii & Nishida, 2013; Ayubi et al., 2022). Muscle fatigue becomes an obstacle during exercise because it leads to dysfunction. (Wan et al., 2017). For health, muscle fatigue is a decrease in the ability of muscles to produce strength and interferes with performance (Taylor et al., 2016).

The muscle fatigue mechanism is considered a complex interaction phenomenon between central and peripheral factors (Constantin-Teodosiu & Constantin, 2021). Theoretically, the central nervous system (CNS) process that reduces nerve impulses to muscles causes decreased muscle strength, known as central fatigue (Taylor et al., 2016). However, peripheral fatigue is mainly triggered by an increase in blood lactate levels (Ishii & Nishida, 2013). Currently, blood lactate is frequently used as an indicator to predict muscle fatigue and performance after physical exercise (Brooks, 2018; Khan et al., 2019). One study reported that an increase in lactate also contributes to ischemic pain by acting on sensory neurons that innervate muscles so that it will have an impact on performance during physical exercise (Immke & McCleskey, 2001).

This research is focused on finding solutions to overcome muscle fatigue. Moreover, advances in science and technology have helped humans in various fields, including sports science (Packard, 2018). One of the popular tools in the medical field is hydrotherapy.

Hydrotherapy is well known as an alternative treatment to reduce pain that involves using water. Hydrotherapy modulates body temperature by sending cold or heat to the body. Previous studies have reported that hydrotherapy could reduce lower back pain (Mirmoezzi et al., 2021). In addition, a study reported that a combination of hydrotherapy and massage could increase Nerve Growth Factor (NGF) (Shourabi et al., 2020). Currently, hydrotherapy is generally carried out in pools. However, these can be very expensive and difficult to find.

Thus, in this study, we aim to develop a feasible hydrotherapy device for accelerating muscle fatigue recovery after physical exercise.

2. METHODS

We used a Research and Development (R&D) approach to produce a hydrotherapy device (Figure 1) and test its effectiveness. This research involved two experts who are competent in media and material fields. At the initial stage, validation tests were carried out to determine the designed product’s weaknesses and strengths. The criteria used by the experts in determining the validity of the product included product feasibility, language, and device design. After the validation test, the resulting product was tested. The trial was carried out in two stages: large-scale and small-scale trials. A total of 16 male students aged 21–25 agreed to participate in the small-scale trial, while 36 male students aged 21–25 participated in the large-scale trial. These students were recruited via the purposive sampling technique.

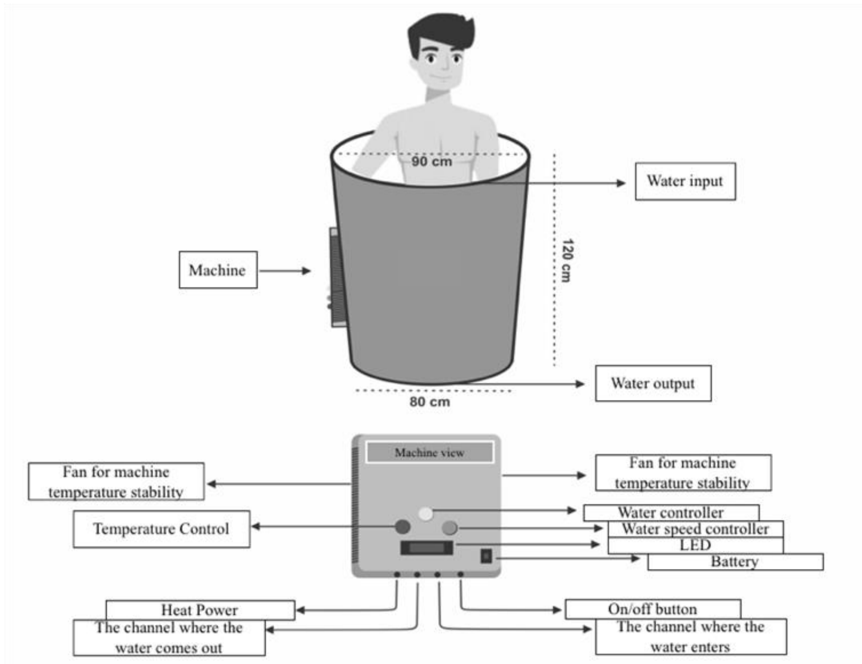

Figure 1. Hydrotherapy device design

3. RESULTS

Figure 2 shows photographs of the hydrotherapy device, providing a detailed view of its design and components.

Figure 2. Photographs of the hydrotherapy device

Figure 3 illustrates the device in use during a trial, highlighting its application and functionality in a real-world setting.

Figure 3. Device trial

Table 1 summarizes the expert recommendations for revising the hydrotherapy device. Key suggestions include using standardized language for clearer instructions, emphasizing the device's effectiveness, ensuring practicality and portability, and enhancing efficiency while maintaining environmental considerations. Additionally, experts emphasized user-friendliness in operation.

Table 1. Parts of the revised hydrotherapy device based on expert advice

Number	Suggestions from experts on parts that should be revised in the device
1	The material "development of a hydrotherapy device" is used for therapy to improve muscle fatigue recovery.
2	The instructions should use a standard language to help users understand the hydrotherapy device easily.
3	The language used is easy for users to understand, so the device is easy to use.
4	The designed device clearly aims to emphasize tool effectiveness compared to existing or conventional designs. Still, the results need to be proven empirically.
5	The designed device is practical and portable.
6	The design must be made as efficient as possible and environmentally friendly.
7	This hydrotherapy device should be easy to operate.

Table 2 presents the experts' assessment of the tool's feasibility, with high scores across all components: Appropriateness (86%), Language (88%), and Presentation (87%), all rated as "Very

Worthy." The average percentage of 87% indicates strong overall feasibility for developing the hydrotherapy device to reduce blood lactate and enhance recovery.

Table 2. The percentage and level of tool feasibility as assessed by experts

Number	Component	Percentage	Criteria
1	Appropriateness	86%	Very Worthy
2	Language	88%	Very Worthy
3	Presentation (Device Design)	87%	Very Worthy
	Average Percentage (%)	87%	Very Worthy

Table 3 details the outcomes of small- and large-scale trials for the hydrotherapy design. The small-scale test, involving 16 participants, achieved an 80% success rate, while the large-scale test with 36 participants reached an 84% success rate, both rated as "Very Good." These results support the feasibility of the hydrotherapy design for effectively reducing blood lactate and enhancing recovery.

Table 3. The results from the small- and large-scale trials

Number	Trials	n	Percentage	Criteria
1	Small-Scale Test	16	80%	Very good
2	Large-Scale Test	36	84%	Very good

4. DISCUSSION

The study results indicated that the expert's validity test met the requirements. Thus, the results were categorized as very feasible. Validity in research is something that shows the truth and accuracy (Komaini et al., 2022; Rifki et al., 2022). In the validity test, the eligibility criteria are stated based on the criteria set for each component (Komaini et al., 2022). For example, the eligibility criteria in this study were assessment items that should fulfill physical aspects, including product size, plate thickness, support leg diameter, net weight, power load, and heat power. Meanwhile, the linguistic criteria consist of suitable writing, effective and communicative language, and an easy-to-understand language. Finally, the criteria for the presentation (the designed device) covered clear objectives, the use of the tool components to help clarify the function of the items, and the clear sequence of instructions. In addition, these criteria include the design flexibility when used by field instructors and were developed according to the material. In short, the designed device should meet several rules, such as effectiveness in use, cost-saving, and helping athletes accelerate recovery.

Furthermore, the results of small-scale and large-scale trials revealed that the hydrotherapy device was feasible for accelerating muscle fatigue recovery properly. This confirmed that all the components used in the hydrotherapy device use a standard language that is easy to understand. In addition, the device is easy to operate. The results also indicated that all existing components worked well. Panels, valves, and knobs functioned well, as shown in the manual, allowing the students to easily use it. The conditions for the hydrotherapy device also showed that the LED panel (light-emitting diode) with temperature in degrees (°C) and the speed in liters/second were accurate.

Several studies have reported that hydrotherapy benefits the body. For instance, de Andrade et al. (2008) reported that water therapy at a temperature of 28–33 °C was effective for accelerating recovery, reducing pain intensity, and improving sleep quality. This finding was reinforced by a study of López-Rodríguez et al. (2013) that claimed that water therapy at a temperature of 29 °C after physical exercise significantly reduced pain intensity, improved sleep quality, and reduced depression/anxiety. Meanwhile, another study (Hamlin, 2007) reported a positive result for athletes who had performed sprint training and were then given hydrotherapy treatment with cold temperatures (8–10 °C) for 3 min. This treatment was found to reduce blood lactate levels and lower heart rate.

The main result of this study is the development of a feasible hydrotherapy device to accelerate recovery after physical exercise. Until now, local athletes often used design products to speed up recovery after physical exercise. In further studies, we strongly recommend testing the effectiveness of the devices that have been developed.

5. CONCLUSIONS

The hydrotherapy device was successfully developed and implemented for therapeutic recovery following physical exercise. This device aims to accelerate recovery and enhance overall athletic performance by effectively reducing muscle fatigue and promoting quicker healing. Its successful application underscores its potential to support athletes in achieving improved performance and faster recovery times.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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