

Elaboration of a Low-Cost Aquatic Ergometric Bicycle

Elaboração de uma Bicicleta Ergométrica Aquática de Baixo Custo

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Abstract

After a visit to a hydrotherapy laboratory, limited resources for use in lower limbs were noted. For this reason, the goal is to design a water bike from low-cost material. The process took place in three phases: (1) project carried out, (2) prototype construction and (3) bicycle construction. The confection was divided into six parts; the materials used were polyvinyl chloride (PVC) tubes for the construction of sewer system. In addition to PVC materials, other products were used: two plastic pedals; a gel saddle, a seat post, two cranksets, a pipe clamp, a central shaft, two industrial bearings, three 40-millimeter aluminum cylinders and four suction cups. The final product was measured 69 centimeters (cm) in width, 59.05 cm in length; as the seat can be adjusted, the height varies. The prototype ranges from 73 to 102 cm in height and supports up to 85 kilograms (kg). It is concluded that although there is a limitation as to the design of the final product due to the limited formats of the PVC connections and as to the adaptations that must be made so that the final product can support a considerable weight, it is feasible to make a low-cost water exercise bike using PVC as the main material that can be used in the pool. It is noteworthy, however, that this product will still be tested to ascertain functionality as for equipment for clinical practice.

Keywords: Hydrotherapy. Low-Cost Technology. PVC Pipes.

Resumo

Após a visita em um laboratório de hidroterapia denotou-se a limitação de recursos para membros inferiores. Devido a isso, o objetivo é elaborar uma bicicleta aquática de material de baixo custo. O processo se deu em três fases: (1) design realizado, (2) produção do protótipo e a (3) construção da bicicleta. A confecção foi dividida em seis partes; os materiais utilizados foram tubos de Policloreto de vinila (PVC) para esgoto predial. Além de materiais de PVC foram utilizados outros produtos: dois pedais de plástico; um selim de gel, um canote, dois pedivelas, uma braçadeira de tubo, um eixo central, dois rolamentos industriais, três cilindros de alumínio 40 milímetros e quatro ventosas. O produto final teve como medida 69 centímetros (cm) de largura, 59,05 cm de comprimento; como o banco pode ser regulado, a altura varia. o protótipo varia entre 73 a 102 cm de altura e suporta até 85 quilogramas. Conclui-se então que embora haja limitação quanto ao design do produto final por conta dos limitados formatos das conexões de PVC e quanto à adaptações que devem ser feitas para que o produto final consiga suportar um peso considerável, é viável a confecção de uma bicicleta ergométrica aquática de baixo custo utilizando o PVC como material principal e que pode ser utilizada na piscina. Destaca-se, entretanto, que este produto ainda será testado para averiguar a funcionalidade quanto equipamento para a prática clínica.

Palavras-chave: Hidroterapia. Tecnologia de Baixo Custo. Tubulações de PVC.

1 Introduction

Water has been used for healing since Greek civilization around 500 B.C. Hippocrates used hydrotherapy and immersion techniques to treat neurological and rheumatic diseases; the Romans also manipulated water for preventive purposes, however, in athletes. Over the centuries, the therapeutic use of water grew and gained space; various methods were developed using this medium, such as Bad Ragaz and Halliwick. In Brazil, in mid-1922, Santa Casa do Rio de Janeiro started hydrotherapy by bathing in fresh and salty water¹.

Hydrotherapy, in turn, is part of the numerous physiotherapeutic resources and uses heated pools for the

treatment of several functions². Among the physical effects are the hydrostatic pressure and fluctuation that provide relaxation, decrease in pain, increase in range of motion and strengthening³. Through its physical properties, hydrotherapy acts as a facilitator or resistance during therapeutic exercises⁴.

The devices used in hydrotherapy have as a support function for fluctuation or resistance in some exercises, always making use of the benefits of the effects that heating and water resistance provides to patients, constantly acting as allies to achieve the proposed therapeutic objectives¹. Hydrotherapy has several instruments to be used, among them bicycles and cycle ergometers can be highlighted.

The use of aquatic bicycles has similarities when compared to the cycle ergometer, besides having the above factors,

the aquatic environment itself is used as resistance during exercise⁵. In addition, the use of the resource in healthy people can improve the respiratory capacity of these individuals⁶.

The cycloergometer has several effects, the main ones being applied to the musculoskeletal system by means of peripheral muscle strength⁶ and to the cardiorespiratory system by means of respiratory frequency⁷. Studies with three patients from the rehabilitation program after training with a cycle ergometer showed improvements in forced vital capacity, forced expiratory volume in one second and increased inspiratory pressure⁸.

However, the implementation of the use of ergometric bicycles for training in the aquatic environment finds some barriers, especially the high cost of bicycles in the market, as well as the small amount of swimming pools adequate to the normative parameters and the high cost of bicycles in the market⁹. It is necessary, then, to develop new proposals for adaptation of aquatic ergometric bicycles; it was opted for the use of low-cost raw material, such as polyvinyl chloride (PVC), for the manufacture and expansion of access to these, increasing the arsenal of therapeutic resources¹⁰. As a result, new proposals are needed to adapt this product with low production costs. Thinking about this, polyvinyl chloride (PVC) is a low-cost raw material, which becomes a viable option to increase the therapeutic resources arsenal¹⁰.

In considering the possibility of expanding resources to be used in the aquatic environment, estimating health promotion and disease prevention, the objective of this study is to develop an aquatic bicycle of low-cost material.

2 Material and Methods

The research consists of a product development study, with the character of technological innovation, with the purpose of elaborating and preparing an aquatic ergometric bicycle using low-cost materials. This project was carried out in the thematic axis of Integrated Activity III by the students from the 5th semester in 2019 of the Physiotherapy Course of the University of the State of Pará (UEPA), being carried out through *Project-based-Learning* (PjBL), which, according to Bender (2015), is a learning model created at the beginning of the 20th century that consists of allowing students to identify

problems themselves, determine how to address them and find solutions to them.

A visit was made to the hydrotherapy Laboratory of the University of the State of Pará and there was a limitation of resources to be used for lower limbs. Then the idea of making a low-cost product that would solve this problem arose.

The project was divided into three phases: in the first phase, the planning was carried out, involving research of similar papers, choice of materials and survey of ergonomic and normative data; the second consisted of the elaboration of illustrations, technical drawings and product specifications, material purchase; and the last was the acquisition and separation of materials, and the product construction.

Table 1 – Materials used for the manufacture of the product

Quantity	PVC sewage materials, manufactured on 12/29/2018	OTO brand
01	Tube size 40mm diameter and 6 meters in length	
01	Single connection 40mm	
09	T 40mm	
01	Connection 45 mm	
01	Connections 90° 40mm	
04	Plugs 40mm	
	Other materials	
02	Plastic pedals	
01	Gel saddle	
01	Seat post	
02	Crankset	
01	Seat post clamp	
01	Center axle	
02	Industrial bearings	
03	40mm aluminum cylinders and four suction pads	
04	Suction pads	

Source: Research data.

3 Results and Discussion

The project has a design of the product (Figure 1), the making of an initial prototype (Figure 2) and the final product (Figure 3, 4, 5 and 6). The bicycle assembly process was divided into six parts, respectively: products fragmentation, frame for the seat, connecting shaft, support base, suction pads frame and pedal axis.

Figure 1 - Product Design



Source: The authors.

Figure 2 - First bicycle prototype



Source: The authors.

After tests of the prototype performed with the authors themselves, some failures were pointed out. The first was the deformation and structural failure of the support base on the seat axis due to the weight of one of the individuals on the same; it was necessary to install more cranksets close to the shaft in order to ensure greater resistance to the base, avoiding deformation. The second was the recurrent rupture of the axis containing the pedals due to the force on it during the pedaling, being resolved by inserting an aluminum tube internally into the PVC tube. These two amendments not only solved the above problems, but also allowed the bicycle to bear a higher body weight.

The low-cost exercise bike was initially designed for use in the hydrotherapy Laboratory, which features a 5-meter long, 4,95-meter wide and 1.45-meter-deep pool with non-slip floors and side bars. To use the bike, the user must sit on the saddle, adjust the height, if necessary, rest his or her hands on the side rails and position his or her feet on the pedals to start pedaling.

As a final result, the prototype was 69 centimeters (cm) wide, 59.05 cm long. Because the seat can be adjusted, varying in height, the prototype varies from 73 to 102 cm in height and supports up to 85 kilograms (kg). Compared to AB-DO-02 AQUABIKE®, brand DIOOIST, which is 58 cm wide, 106 cm long, and 155 cm high, the material is stainless steel 316, weighing 19 kg¹¹, at a low cost, which after manufactured costs about 13 times less.

Figure 3 - Side view



Source: The authors.

Figure 4 – Front View



Source: The authors.

Figure 5 – Rear View



Source: The authors.

Figure 6 – Top View



Source: The authors.

The initiative to manufacture a product using low-cost materials is an alternative to the models currently found in the market, where much of it has a high cost of production and sometimes, due to being considered an obstacle in the administration of health managers when there is the objective of health promotion and diseases prevention¹⁰.

The study cited above confirms the reality found in the teaching unit, where, in the absence of the resource elaborated and prepared in this work, limited therapies are available. With the availability of the low-cost bicycle, the benefits to the population served in the Laboratory could be numerous.

Naveca et al.¹² corroborates saying that most of the articles that deal with the manufacture of products justify the search based on the lack of certain equipment or technology for evaluation or intervention, in addition to what would be the possible repercussion in the services to the users.

The choice of the approach in the aquatic environment increases the work relevance, since the use of the cycloergometer, in most studies, is as used in soil, that is, outside the water, there is a scarcity of literature⁵.

The fact that building something that is low-priced would encourage the students and other researchers to make equipment more accessible, not only for those who would use as an object of work, but also for all the population, benefited by having new forms of therapeutic conducts. A study shows that the proposal to elaborate a device that requires few financial resources can be considered as a gain in the academic environment, because in addition to the proposal itself, it consists of technological innovation and alternative means. The low cost of materials, associated with practicality and versatility, is an assertive for the implementation of new therapeutic purpose¹³.

Dellegrave et al.¹⁴ emphasize that PVC is a widely used product in the manufacture of low-cost technologies. Although it is a petroleum derivative, this product has an easy hygiene, it has ease in remodeling and reuse, besides ensuring mechanical resistance and standardization of parts.

In addition, polyvinyl chloride has excellent water resistance, making it one of the first choices of raw material in the manufacture of products to be submerged. However, there is a deficit of the material mechanical resistance when submitted to a certain amount of load. To compensate for fragility, it is necessary to use other materials, which are more resistant to give the necessary support and the implementation of a base that supports the axis with higher overload support⁵.

The use of PVC as a raw material is efficient for the manufacture of low-cost products by lay persons because it has standardized connections and eliminates specific finishing or machinery¹⁴. Nevertheless, standardized connections restrict product making, especially in the absence of such a connection or if the preliminary idealized form of the item is not compatible with the PVC connective standards.

In the study by Dellegrave et al.¹⁴, where a low-cost Home Treatment Unit (UTD) was made using PVC as raw material, a 25% reduction in the product final cost was concluded in relation to the same commercialized material.

As in addition to PVC, other materials were needed that are not possible to be replaced by low-cost ones, the final value was reduced by about 12% than the one found on the market. However, since PVC is sold in large quantities, its surplus would be enough to make two more units of the product, thus reducing future expenses and allowing a larger manufacture scale.

4 Conclusion

The product resulting from the study, after several tests and modifications, using PVC as the main material, presented a technological innovation character, because it showed a significant improvement compared to the similar ones present in the market, mainly in relation to the cost of production and its feasibility of application in public health services.

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