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# DEVELOPMENT OF AN ERGOMETRIC PROTOTYPE TO ASSIST IN PHYSICAL ACTIVITIES OF PEOPLE WITH PARAPLEGIA IN ORDER TO COMBAT OBESITY AND CARDIORESPIRATORY DISEASES

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**Abstract.** Obesity is a problem for many Brazilians, and the percentage of disabled people who are overweight is twice or three times higher than obese people with normal mobility, according to the research of the Brazilian Institute of Geography and Statistics (IBGE) disclosed in 2010. In public areas of São Luís-MA, in Brazil, there is equipment suitable for physical exercises, for example, Bom Menino Park and Litorânea Avenue, although, the equipment allows to exercise only people without disabilities, they are not adapted for a wheelchair user. In an attempt to contribute with paraplegic people on overcoming their difficulties, self-esteem improvement and health so was elaborated and developed an ergometric prototype which allows the execution of physical activities of wheelchair users' upper limbs. The ergometric prototype was designed regarding the improvements on the physical condition of the wheelchair user, with the purpose to narrow the relation between wheelchair users and physical activities. This equipment will provide to the user an physical exercise similar to vertical bench press. The equipment presented, during its construction, a satisfactory result, however, the efficiency related to physical rehabilitation of the user will be verified with the help of monitoring equipment, such as heart rate and blood pressure meter, which the wheelchair will use while they practice the physical test exercises on the equipment, accompanied by a physiotherapist, who will evaluate the user performance and a workplace safety professional.

**Keywords:** Biomechanics, ergometric prototype, obesity, paraplegia, physical activities

## 1. INTRODUCTION

According to Health Ministry research (2000), 51% of the Brazilian population are overweight, being 17% considered obese, the majority of this group are wheelchair users. Obesity is a common problem among them, because of the mobility limitations the wheelchair allows. Furthermore, patients with spinal cord lesion and/ or others important bones structures can develop metabolic and hormonal problems, circulatory, digestive, reproductive and excretory systems deficiency.

There are public areas in São Luís-MA, Brazil, in which contains equipment appropriate to the practice of physical exercises only for people without disabilities, such as, Bom Menino Park, Litorânea Avenue, Lagoa da Jansen, squares,

and others. However, there are not in the city installed equipment for physical activities which are destined for wheelchair users.

For these reasons, this work studied the construction of an ergometric apparatus, which allows wheelchair users to realize physical activities. The elaboration of this mechanism will allow paraplegic people to practice physical exercises, which seek enable the person to do diary activities, defining the upper musculature, increasing, the user's coordination, strength, and posture, permitting physical re-education. The equipment utilization can stimulate autonomy, as well as improving physical health, the self-esteem of people with motor disabilities.

## 2. METHODOLOGY

The ergometric prototype was designed based on studies of wheelchair user ergonomics, considering the improvements of physical conditions it might result, in order to narrow the relation between wheelchair users and physical activities. The prototype will focus on upper muscles, such as Pectoralis major muscles, clavicular pectoralis major, among others muscles, according to Fig 1.

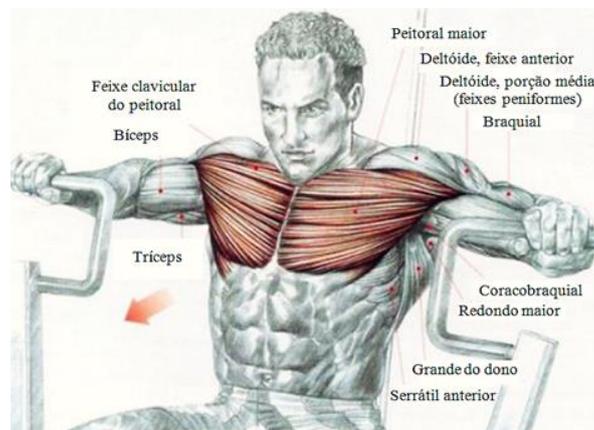


Figure 1. Muscles exercised with the use of the ergometric apparatus similar to the vertical bench press

The apparatus was designed considering the ergonomics and autonomy limitations of a wheelchair provides to the paraplegic user, as consulted in NBR 9050, which is the Standard of Edifications, Furniture, Urban Areas and Equipments, in order to the wheelchair users do the physical exercises in the correct way and do not suffer any type of injury, according to Amaral (2015). The prototype is similar to the vertical bench press, illustrated in Fig 2, it has a cross-shaped base, allowing the wheelchair user to approximate towards the apparatus until their position is adequate to practice. After setting the wheelchair position, the user should adjust the height of the grab device until the hand position is correct for the safe usage.

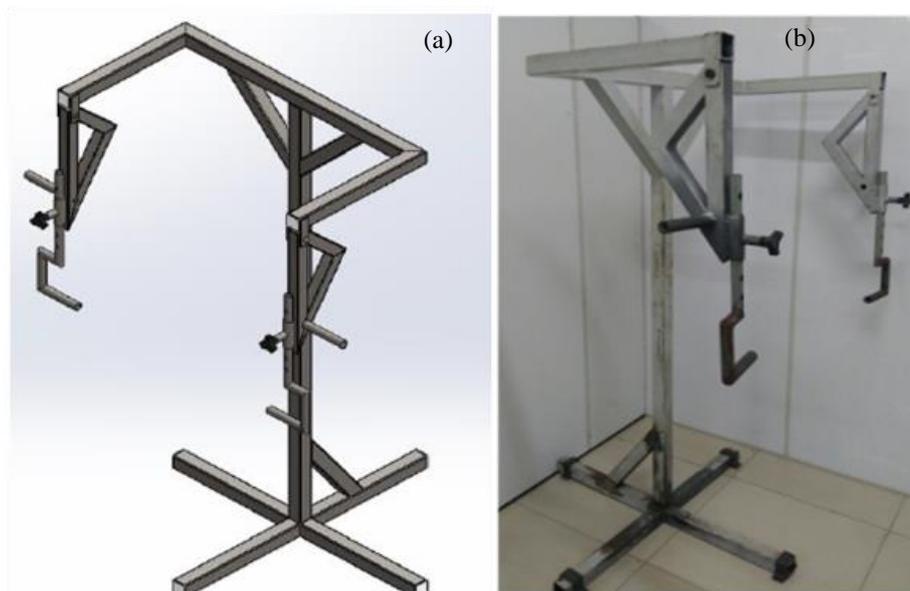


Figure 2. Ergometric apparatus similar to vertical bench press. (a) Apparatus designed on software; (b) Vertical structure, base and upper part of the prototype in finishing state

### 3. RESULTS AND DISCUSSION

Before the manufacturing process, the ergometric prototype was simulated by computational analysis on software ANSYS, considering the load of 25kg on each support device where the weights are placed, to determine the mechanical loads. The result was satisfactory, the structure deformation was disregarded, so the apparatus construction was feasible. Fig 3 shows the simulation result, in which the red colored parts is related to the maximum structural deformation.

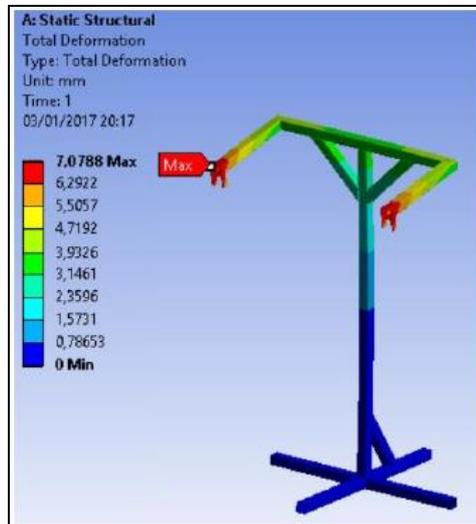


Figure 3. Result of ergometric prototype simulation obtained by ANSYS

The ergometric prototype is built and available for verification tests of performance and efficiency. The apparatus provides the users to perform physical exercises similar to vertical bench press, allowing to work the upper musculature with the ergometric prototype, preventing muscular atrophy and with the assistance of a doctor, nutritionist, psychologist and physical educator, resulting in health improvement.

Another important parameter studied was the value of Von Misses Maximum Tension in which the structure was submitted when it is used a load of 50 kg as the Fig 4 shows.

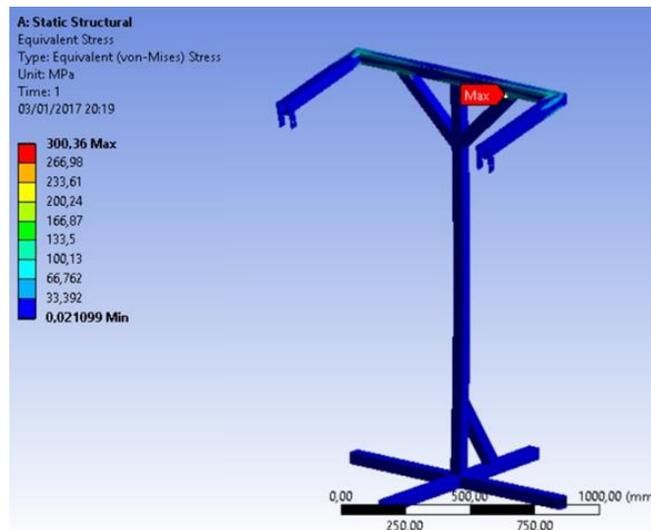


Figure 4. Simulation of maximum tension which the structure was submitted

Using as fundamental the Maximum Tension of Von Misses to determine the security factor, we applied the Eq (1).

$$FOS = \frac{\sigma_{esc}}{\sigma_{VonMisses}} \quad (1)$$

Calculating using the yield point of the 1025 steel, the material used in the structure, it is equal to 370 MPa:

$$FOS = \frac{370}{300,36} = 1,24 \quad (2)$$

For this structural prototype, the obtained value of security factor is acceptable. Therefore, the ergometric prototype was built and it is available to be tested to verify its performance and future efficiency validation, as the Fig 5 shows.



Figure 5. Main structure

Considering the analysis of the structure with the help of a physiotherapist, it was seen it was necessary a structural modification of the movable arms to exercise more muscles. The movement extension of the modified component is larger than the previous one, as shown in Fig 6.



Figure 6. Necessary modification of the movable arms

The apparatus enables the users to accomplish similar movements of the vertical bench press, so it is possible to focus on upper body muscles, aiding in the prevention of muscle atrophy and, with the help of a doctor, nutritionist, psychologist and physical educator, we can achieve improvements in the patient's health.

#### 4. CONCLUSIONS

This work studied that exercising the upper members and upper body musculature can improve the life of wheelchair users. Physical exercises and conventional fitness equipment should be adequate to the person biotype, life and health conditions, limitations and disabilities. Furthermore, the adaptations performed on the ergometric prototype allow wheelchair users to practice exercises providing improvements in their quality of life.

## 5. ACKNOWLEDGMENTS

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