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WHEELCHAIR DYNAMOMETER: A NEW CONCEPT TO EVALUATION OF THE PROPULSIVE POWER

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INTRODUCTION

The ability of propulsion in wheelchairs is a multifactorial phenomenon that has many characteristics of order kinematic, kinetic and anthropometric (3). The propulsive power (PO) is the variable that is present in the analysis of movement of wheelchair users, being related to physical performance in daily activities or sports. In contrast, most of the equipment available so far disregards the interaction between the subject and his own chair, has oversized (4) and using assumptions based on criteria analysis ergometric and not focusing on dynamometry (1) (2). Therefore, the objectives of this research were: a) develop a compact dynamometer for evaluation of propulsive power in wheelchairs, and b) validate the equipment from known physical parameters to the method of kinematry.

METHODS

Development of prototype: the prototype was developed in the Laboratory of Human Performance Assessment (LAPH) in partnership with researchers at the Center for Distance Education (NEAD), especially during device programming. All procedures of this investigation have been duly authorized by the Ethics Committee on Human Research of the University of Pernambuco.

Portion Mechanical: The mechanical part of the prototype is divided into two sets of parallel cylinders (Easy Scroll, Brazil), fixed by screws per side stems anti-vibration. A screw secures both kits drums as a form of fitness equipment to various sizes and types of wheelchairs. Between both starter is placed a central rod with double sheaves for computing the moment of inertia (MI) of both sets of cylinders. Information on the calculation of experimental MI are in the appendix. By counting the number of rotations and the predetermined values of MI, the power can be calculated using the relationship between force and displacement (equation 1).

$$PO\ (W) = \frac{MI\ \cdot 0{,}24\ \cdot\ RPM}{1} \qquad [1]$$

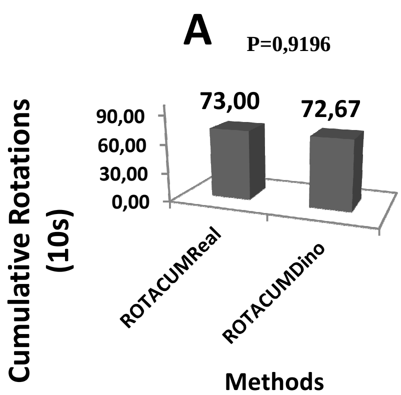
Electronical portion: The electronics consists of two sensors inductive type (SensorBrás, Brazil) placed perpendicular to the cylinders for detecting metal rings attached to each side in their rotation. After detection of metals signals (electrical impulses) are sent to an analog-digital board Arduino Mega (Arduino, Italy), programmed to detect signs every 0.1 millisecond. The data are interpreted by an algorithm and plotted in real time on an Excel spreadsheet (Office 2007, USA), via the PLX-DAQ software (Parallax, United States).

Validation protocol: A sample of healthy subjects was selected to participate in a sprint protocol for 20 seconds, preceded by heating 1 minute. A high speed camera (Samsung WB200, 240Hz, Japan) was placed behind the prototype, perpendicular to the two cylinders. Reflective markers were placed at the same height of inductive sensors for concurrency information. The data obtained by the two methods (prototype and videography) in the early 10s rotation, according to the protocol described by Faupin (2008), were compared.

Statistical analysis: After checking the normality of the data, the data and power rotation between both methods were compared using the t test for independent samples.

RESULTS AND DISCUSSION

The final prototype is summarized in Figure 2. Participants were 21 healthy subjects (age: 20.9 ± 2.4 years, weight: 68.9 ± 7.9 kg, height: 174.0 ± 7.1 m, BMI: 22.7 ± 2.5 kg • m2), not users of wheelchairs. After data collection and application of inferential statistics was found that no statistically significant differences between the rotations and power acquired by the prototype system and by reference to the number of rotations (P = 0.9196) and the propulsive power (P = 0.9496), Figure 1.



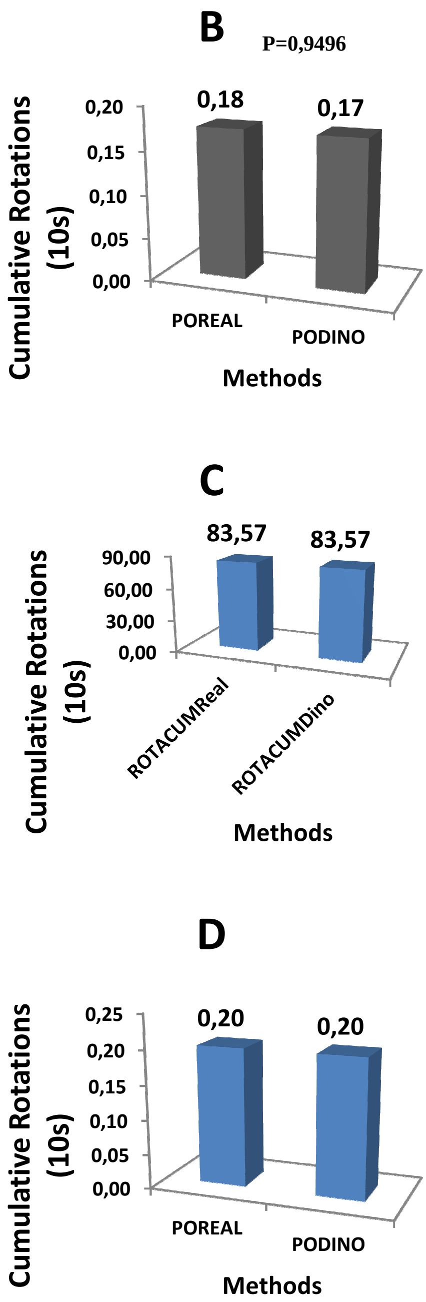


Figure 1: Data of Propulsion Power and Rotation for both methods of analysis. (A) accumulated rotations to the right, (B) accumulated power to the right; (C) accumulated rotations to the left side; (D) accumulated rotations to the left side.

CONCLUSIONS

We conclude that the new device produces reliable results, having concurrent validity when compared to a reference method in the real world.

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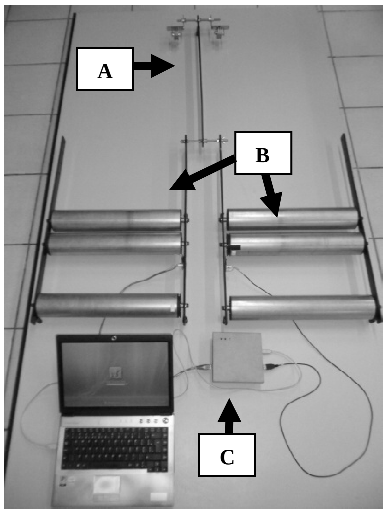

(A) calibration system for determining. Moment of inertia instrumentation of cylinders
(B) System parallel cylinders, for positioning and supporting weight;
(C) System electromechanical counting, calculation and storage of information of speed and power;

Figure 2: Prototype compact dynamometer. Top view

Apendix

Pupo e cols (2011), showed a standardized procedure for checking the moment of inertia experimental. An object of known mass is suspended by a calibration rod located in the central region of the prototype at a height of 0.45 m. After its release, the mass remains constant speed until it reaches its lowest point (ground). This object is connected by a nylon wire of 0.1 mm (Mazzaferro, Brazil) to the cylinder instrumentation, transmitting its velocity and kinetic energy. Therefore, considering the rate equations and kinetic energy we have:

$$MI = \frac{2m}{w^2}\left(gh - \frac{v^2}{2}\right) \qquad [2]$$

As h is the height, velocity v and w is the angular velocity of the cylinder instrumentation. Whereas:

$$h = \left(\frac{1}{2}\right)at^2 \qquad [3]$$

$$v = at \qquad [4]$$

$$w = \frac{v}{R} \qquad [5]$$

Substituting the values in the original equation, we can consider that the moment of inertia for the system calibration of the prototype would be organized:

$$MI = \frac{2m}{\left(w = \frac{v}{R}\right)^2}\left(g\left\{\left[\frac{1}{2}\right]at^2\right\} - \frac{[at]^2}{2}\right) \qquad [6]$$

Simplifying equation 6 values by means of mathematical procedures we obtain the following mathematical model for determining the moment of inertia:

$$MI = mR^2\left(\frac{g-a}{a}\right) \qquad [7]$$

Where m and R^2 are the mass and radius of the cylinder instrumentation, respectively, g the acceleration of gravity (determined in $10 m/s^2$) and a acceleration cylinder instrumentation in the time interval until the object touches the ground.