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Isokinetic Peak of Torque and Fatigue Index in Simulated Wheelchair Propulsion in Elite Wheelchair Rugby Players

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ABSTRACT

Background: In sports such as wheelchair rugby, the correct assessment and quantification of an athletes' peak of torque and fatigue index in sport-specific actions are essential in monitoring an athletes' training performance. The increase in the number of people practicing Paralympic sports has been growing exponentially, contributing to an increase of competition level and of athletes' performance. **Objective:** Thus, physical training for Paralympic sport must aim to maximize athletes' fitness potential by investigating and evaluating what variables are most important in determining ideal sporting performance. **Methods:** Six high-level wheelchair rugby athletes had their wheelchair propulsion peak of torque and fatigue index evaluated by isokinetic dynamometry in three different angular velocity and repetition schemes. **Results:** The athletes presented no significant statistical difference in peak of torque and fatigue index for both arms at different number of repetitions and angular velocity. **Conclusions:** This shows that independent of dexterity parameters or duration of stimuli, these high-level athletes display this motor skill in constant levels of performance. These results will allow coaches to set up normative parameters to test and evaluate their players' performances.

Key Words: Wheelchair Rugby, Paralympic Sports, Peak of Torque, Fatigue Index

INTRODUCTION

The increase in the number of people practicing Paralympic sports has been growing exponentially according to data from the International Paralympic Committee[1]. This directly contributes to an increase of competition level and of athletes' performance. Since the main objective of physical training in Paralympic sport is to maximize athletes' fitness potential[2,3], the need arises to investigate and evaluate what variables are most important in determining ideal sporting performance for these modalities[4,5].

It is known that muscle strength is a factor of great influence on athletic performance. Explosive strength, for example, is a crucial component in sprint performance[6]. Dowson et al.[7] supported the idea that the magnitude of force generated during dynamic muscle contraction is related to the amount of velocity an athlete can produce during a sprint. The ability to sprint intermittently is critical to many sports, and in Wheelchair Rugby this is no different[8] . Thus, the athlete who can maintain peak power for a longer time will be able to perform constant stimuli (rapid movement over and over again) without the early onset of fatigue[9]. Sprinting requires high power output associated with high speed of muscular contractions[10]. Although research has shown that in able bodied athletes leg force production capacity may be the key component of sprinting[8,11], there is a lack of data observing this relation in wheelchair-specific movements and its relation to force.

In sports such as wheelchair rugby, the correct assessment and quantification of an athletes' peak torque and fatigue index in sport-specific actions are essential in monitoring an athletes' training performance[12-14]. Thus, this research aimed at contributing to this field of study by investigating these variables in actions related to wheelchair sprinting.

METHODOLOGY

Subjects

Six high level athletes comprised the subjects of this study. They presented a mean age of 30.35 ± 6.62 years, sport practice time of 38.33 ± 17.77 months, and 7.22 ± 2.43 years since the original onset of their spinal cord injury. All athletes are formerly classified by the International Wheelchair Rugby Federation as quadriplegic[15,16]. This study was approved by the Committee of Ethics in Research with Human Beings of the Faculty of Medical Sciences of University of Campinas, under

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protocol No. 405/2009. It followed guidelines and norms that regulate research with human beings according to Brazilian Law 196/96. All subjects signed consent forms authorizing the publication of the data found in this study

Evaluation Protocol

Isokinetic evaluation has been used in the last three decades as a preferred method in determining the functional pattern of muscle strength and balance[17]. With this methodology, it is possible to quantify torque and work values of muscle groups, as well as the agonist/antagonist performance ratio of such groups[18]. To better evaluate peak torque and fatigue index in actions related to wheelchair rugby, an isokinetic evaluation was applied using a protocol adapted for upper limbs, using a Biodex System 4 dynamometer (Biodex Medical Systems, New York, USA) in two speeds: 210º/sec. and 300°/sec as described below.

The positioning of the subject and the alignment of the joints were performed according to their positioning on their competition wheelchairs[19]. The seat was maintained at 0° of rotation and 85° of inclination and the dynamometer at 0° of rotation and 15° of inclination, as to simulate the camber angle of a wheelchair's wheel. After the subjects were comfortably seated, fixations bands were placed at trunk, hip, and thigh levels in order to stabilize these body segments and restrict as much accessory movements[20]. The dynamometer's rotation axis was aligned with the head of the subject's femur, and a wheel input adaptor was used to simulate a wheelchair's wheel. Then, the following protocol followed:

- A warm up series of five repetitions at 210°/sec. of concentric movements simulating the propulsion movement of a wheelchair for each arm, as shown in figures 1 and 2.
- One minute of rest,
- A series of five repetitions at 210º/sec for each arm
- Three minutes rest
- A series of 15 repetitions at 300º/sec for each arm
- Three minutes rest
- A series of 30 repetitions at 300º / sec for each arm

To our knowledge and research, no studies have been published with information on how many propulsions a wheelchair rugby player performs in different game actions[21]. Thus, we chose the number of repetitions for our study based on personal experience and many years of coaching the modality, in an attempt to closely approach the reality of the game itself.

Statistics Analysis

R-plus® 2.14 Software was used for graphical analysis of the results (quarters, symmetry and curtosis) and ANOVA testing between different means. A significance level of 5% ($p = <0.05$) was adopted.

RESULTS

In this study, were involved as subjects high-level athletes with spinal cord injuries. Although some published research exists with this specific population, no reference values for the variables studied exists in the scientific literature. For this reason, we will present our data in its totality (Table 1 and Figures 3-6), without assessing qualitative judgement on the athletes' performance. In addition, despite the references values present in the Biodex Isokinetic machine

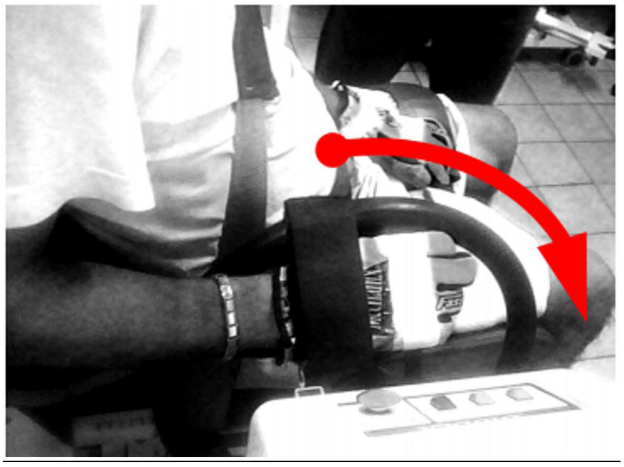

Figure 1 - Initial phase of simulated propulsion movement. Source: Authors' Personal Archive

Figure 2 - Final phase of simulated propulsion movement. Source: Authors' Personal Archive

Table 1 - Peak torque and fatigue index mean values for the right and left arms

Series	PTRA (N/m)	PTLA (N/m)	FIRA (%)	FILA (%)
5 repetitions @ 210º/sec	45.53 ± 19.21	39.85 ± 18.74	10.23 ± 19.99	31.56 ± 5.78
15 repetitions @ 300º/sec	44.15 ± 18.08	35.83 ± 15.71	17.43 ± 11.54	27.66 ± 14.63
30 repetitoins @ 300º/sec	43.68 ± 17.74	34.2 ± 15.87	31.26 ± 8.71	29.28 ± 4.54

Note: PTRA = Peak of Torque of the Right Arm, PTLA = Peak of Torque of the Left Arm, FIRA = Fatigue Index of the Right Arm, FILA = Fatigue Index of the Left Arm; N/m= Newton por metro.

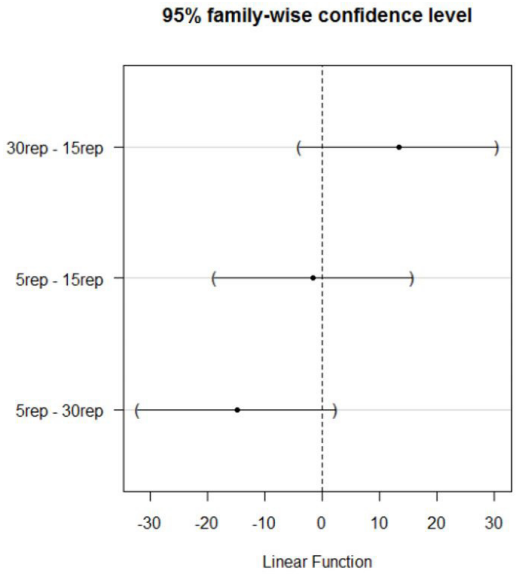

Figure 3 - Comparison between groups for the fatigue index of the right arm variable

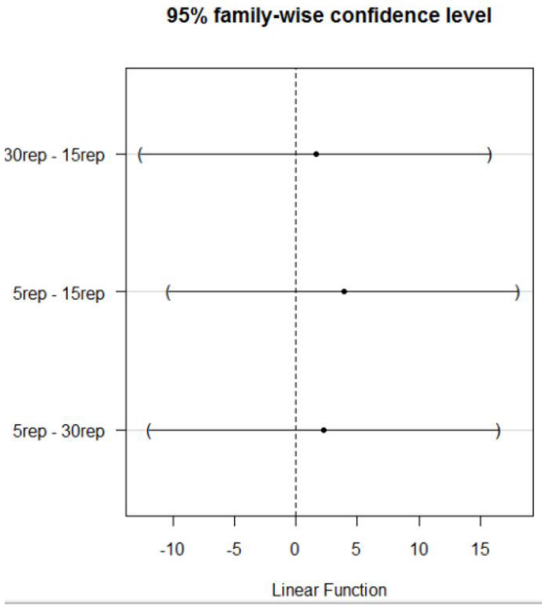

Figure 4 - Comparison between groups for the fatigue index of the left arm variable

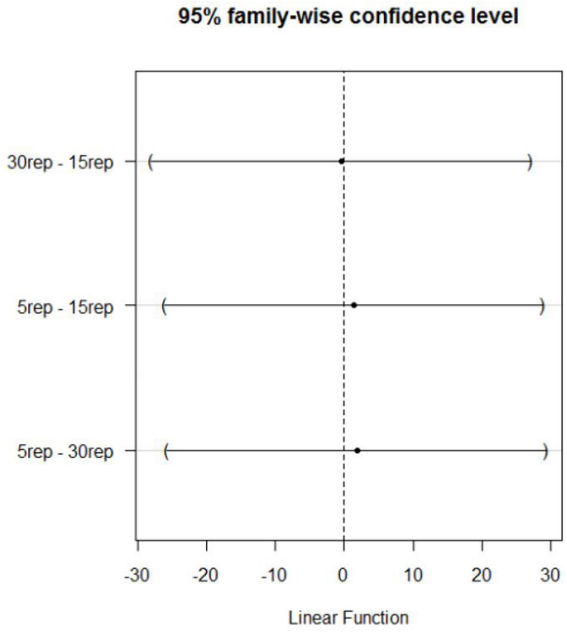

Figure 5 - Comparison between groups for the peak of torque for the right arm variable

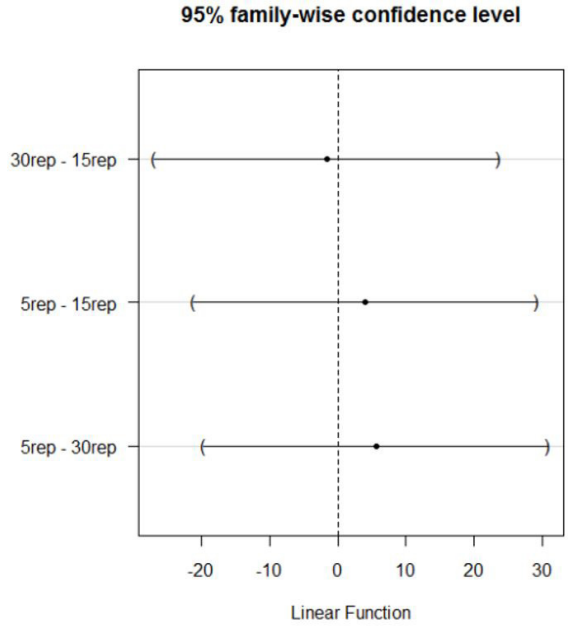

Figure 6 - Comparison between groups for the peak of torque for the left arm variable

(Biodex Medical Systems, New York, USA) Manual for high and low peak of torque and fatigue index, they were not taken into account as they were standardized for a different public.

DISCUSSION AND FINAL CONSIDERATIONS

As can be seen in the data above, results show that the athletes presented no significant statistical difference in peak of torque and fatigue index for both arms at different

number of repetitions and angular velocity. This shows that independent of dexterity parameters or duration of stimuli, these high-level athletes display this motor skill in constant levels of performance. We expected these results for the fatigue index parameter, as wheelchair propulsion is a concentric-only action similar to bike pedaling, thus naturally allowing the athlete to perform less muscular work. However, the results for the peak of torque were surprising, as the protocol varied greatly between the stimuli (5-30), which ranged from purely anaerobic to aerobic actions. This may be a testament of these athletes' adaptation and conditioning level. A practical application of this finding is that wheelchair rugby coaches can monitor these parameters in their players in order to monitor performance and the onset of fatigue, which in turn will allow them to organize better training plans for their athletes, as well as prevent injuries[22,23]. With this, we hope that our findings further captivate the interest of Paralympic sports researchers, which in turn will increase the amount and quality of scientific information on Paralympic sports available to the academic and general public.

AUTHOR'S CONTRIBUTION

FM and JIG drafted the original research design; FM carried out the acquisition of data; FM, RFC, ANR, and SRSN analysied the data; FM, RFC, ANR, SRSN drafted and revised the original draft; JIG and IBV supervised all steps of the research; All authors approved of the version to be published.

CONFLICTS OF INTEREST

Nothing to declare.

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