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Reliability and objectivity of motor coordination assessments for wheelchair users
Fiabilidad y objetividad de una batería de evaluación de la coordinación motora para usuarios de sillas de ruedas

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Abstract. Motor coordination is the ability to perform motor activities, including fundamental movement patterns and fine motor skills necessary to manage daily tasks. Its development allows mastering the environment, such as handling objects. The wheelchair user needs good coordination to perform movements efficiently, directly impacting their quality of life. The objective of the present study is to establish the scientific authenticity, in terms of reliability and objectivity, of an already validated battery of motor coordination assessments for wheelchair users (BACMoC). The reliability and objectivity of the instrument were measured with the same sample of 32 wheelchair users ($\bar{X}$ = 32.66 ± 11.41 years), consisting of members of the Pará Physically Disabled Association (PPDA), called evaluation group (EG). Initially, at this stage, a single professional applied the BACMoC twice in the SEG to assess the reliability (intra-evaluator error). Then, with the EG, a second evaluator applied the battery above to evaluate objectivity (inter-evaluator error). It was possible to observe a significantly high degree in the stages of verification of reliability and objectivity, with results presented: reliability ($r=0.95$ with $p<0.01$) and objectivity ($r=0.95$ with $p<0.001$). Therefore, the evaluated battery can be indicated as a valid option for evaluating the motor coordination of wheelchair users.
Keywords: ataxia, wheelchairs, motor skills, parathletes; disabled persons.

Resumen. La coordinación motora se puede definir como la capacidad de realizar actividades motoras, incluidos los patrones de movimiento fundamentales y las habilidades motoras finas que son necesarias para realizar las tareas diarias. Su desarrollo permite dominar el entorno, facilitando el manejo de objetos. El usuario de silla de ruedas necesita una buena coordinación para realizar movimientos de manera eficiente, impactando directamente en su calidad de vida. El objetivo del presente estudio es establecer la autenticidad científica, en términos de confiabilidad y objetividad, de una batería ya validada de evaluaciones de coordinación motora para usuarios de sillas de ruedas (BACMoC). La confiabilidad y objetividad del instrumento fueron medidas con la misma muestra de 32 usuarios de silla de ruedas ($\bar{X}$= 32,66 ± 11,41 años), compuesta por miembros de la Asociación de Discapacitados Físicos de Pará (PPDA), denominada grupo de evaluación (GE). Inicialmente, en esta fase, un solo profesional aplicó el BACMoC dos veces en el GE para evaluar la confiabilidad (error intraevaluador). Luego, aún con la GE, un segundo evaluador aplicó la batería antes mencionada para evaluar la objetividad (error interevaluador). Fue posible verificar un grado significativamente alto en las etapas de Determinación de Confiabilidad y Objetividad, presentándose como resultados: Confiabilidad ($r=0,95$ con $p<0,01$) y Objetividad ($r=0,95$ con $p<0,01$). Por lo tanto, la batería evaluada puede indicarse como una opción válida para la evaluación de la coordinación motora de usuarios de silla de ruedas.
Palabras-clave: ataxia, silla de ruedas, destreza motora, paratletas, personas con discapacidad.

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Introduction

In Brazil, according to data from the national health survey carried out by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE), in 2019, approximately 17.3 million people have at least one type of disability, either auditory, motor, visual or mental/intellectual (IBGE, 2021). Persons with disabilities have long-term physical, mental, intellectual, or sensory impairments which, in interaction with one or more barriers, may hamper their full and effective participation in society on an equal basis with others (Brazil, 2015).

There are several types of disabilities, each with different behavioral specifics and social factors. Motor impairment, as an example, can limit the individual's autonomy in daily activities, such as walking and climbing stairs (Roldán, et al., 2021; Vieira, et al., 2021). In this context, the use of wheelchairs stands out as a necessary tool for about 75 million people worldwide, according to estimates by the World Health Organization (WHO, 2019). This device is crucial because it increases the mobility of people with disabilities and is essential as it allows them to move independently (Abdulghani, et al., 2020; Larraga-García, et al., 2019).

Sports practice for people with disabilities provides health and personal well-being benefits, having an extraordinary value in the context of inclusion and social integration. In this sense, embracing individuals with some physical impairment in sports is fundamental for physical and mental health (Santana, et al., 2022; Solera, et al., 2021). This practice was initially intended to be a recreational and therapeutic activity. However, it became one of the credible alternatives for competitive participation for people with disabilities. For instance, as a high-performance sport whose primary means of disseminating achievements, the Paralympic Games is configured as the main venue of support for people with disabilities (D'elia, et al., 2021; Pullen & Silk, 2019).

Adapted activities and paralympic sports are not restricted to the Games (the largest high-performance sports competition for athletes with disabilities). They are repre-

sented in the various events organized by the International Paralympic Committee, confederations, and federations linked to it, as well as covering athletes with various deficiencies in the mixed levels of rendition such as school, leisure, or high performance (Cardoso, et al., 2020; Marques, 2016).

In sportive practice, one of the most critical components (whether at a competitive level or in leisure) is motor coordination, which is also indispensable in daily functional/intentional tasks, and physical/leisure activities. (Lima, et al., 2019; Palencia, et al., 2022). It is presented as the ability to use skeletal muscles more efficiently, resulting in a more practical and economic global action, and can be defined as the ability to perform motor activities, including fundamental movement patterns and fine motor skills that are necessary for managing daily tasks (Ma, et al., 2021; Santana, et al., 2019).

In general, motor coordination is subdivided into four categories: general motor coordination, which is responsible for the individual to be able to master his own body and control all movements; specific motor coordination, which materialized by controlling specific movements to perform a specific type of activity, such as kicking a ball or participating in a basketball game; gross motor coordination, which mainly involves large muscle groups, and can be developed from the practice of physical activities. Lastly, fine motor coordination is related to tasks requiring higher precision, involving mastering the control of smaller muscle groups (Logan, et al., 2018).

Wheelchair athletes participate in adapted sporting events and constitute the majority of paralympic competitors in sports modified according to the abilities of athletes with lower limb and trunk disabilities (Sasadai, et al., 2020). These skills are essential in the practice of physical activity or sport, and the higher the level of physical activity a person has, the better his motor coordination will probably be (De Gregorio, et al., 2019; Guillamón, et al., 2020; Mejia & Pérez, 2021;). For instance, Li et al. (2020) showed a strong relationship between motor coordination and physical activity. Thus, the need to correctly assess motor coordination is essential since there is a limitation in studies on wheelchair users regarding motor coordination.

In the assessment of motor coordination in wheelchair users, an instrument above is necessary to provide reliable, valid, and objective data is needed (Thomas, et al., 2012).

Reliability is an integral part of validity and refers to the consistency or responsiveness of a measure. It is related to objectivity, which demonstrates that the results of its application are reproducible; a test cannot be considered valid if it is unreliable. Therefore, reliability is necessary to ensure any form of valid assessment (Bolela, et al., 2018; Sa, et al., 2019).

Objectivity, in turn, demonstrates the degree to which different evaluators can achieve identical scores in the same subjects. Known as reliability between raters, ensuring objectivity is also necessary to guarantee any form of valid assessment (Sa, et al., 2019).

Multicomponent exercise programs such as muscular endurance, balance and strength are interventions that have improved a person's functional capacity. In the motor assessment, it is necessary to apply reliable instruments (Mollinedo Cardalda, et al., 2022).

The Motor Coordination Assessment Battery for Wheelchair Users – BACMoC (acronym derived from the Portuguese name of the battery - *BATERIA DE AVALIAÇÃO DA COORDENAÇÃO MOTORA PARA CADEIRANTES – BACMoC*) is an instrument validated in 2021 that assesses the motor coordination of wheelchair users, whether paralyzed or not. BACMoC consists of five tests designed to assess four existing types of coordination: fine motor coordination; specific motor coordination; gross and general motor coordination, and gross motor coordination (Júnior, et al., 2023).

Therefore, the study's objective is to establish the scientific authenticity, in terms of reliability and objectivity, of an already validated battery of motor coordination assessments for wheelchair users.

Methods

Study participants were selected from Pará Physically Disabled Association (PPDA) members, located in the city of Belem, in the Pará state, Brazil. Preliminarily, people with disabilities were selected who were purified by the inclusion and exclusion criteria presented below: In the study on screen, people with disabilities were included - wheelchair parathletes with motor impairment in the lower limbs, of both sexes with the age group of adults, from 18 to 59 years old (Fox, et al., 2021).

Individuals who were unable to practice physical activity were excluded; had health problems (anal fistula and phlebitis); did not carry out the proposed activities; if they were absent on the day of data collection, or did not present documents with legal signatures to participate in the research; in addition to non-wheelchair parathletes.

The sample consisted of the total number of members who met the inclusion criteria and did not fall within the exclusion criteria. The sample size calculation was estimated using the G*Power 3.1 software (Faul, et al., 2007). The following information was introduced: Student's t-statistical test, Cohen's effect size (d) = 0.4; error $\alpha = 0.05$; test power = 0.80 for three groups with one measure.

The sample size from the indicated process was calculated in 27 participants for each collection (Beck, 2013). In order to prevent sample death and the existence of outliers, an increase of 10% was carried out, reaching a sample size of 32 individuals.

The Reliability and Objectivity of the Instrument were measured at two collection times, both carried out in November 2021, with the evaluation group (EG). Initially, to assess Reliability (intra-evaluator error), a single evaluator applied the BACMoC in EG twice in a row, with an

interval of two days. Then, on the last day of the collection week, the EG was evaluated by a second evaluator in order to determine Objectivity (inter-evaluator error). The evaluators are physical education professionals, one master and the other a doctor. Both have experience with sports practice and motor coordination in adults.

The present work meets the standards for researching human beings, according to the guidelines established by the Declaration of Helsinki (2008) and by Resolution 466 of December 2012 of the National Health Council (CNS), Brazil, and the Ethics Committee approved the present study of the University of the State of Pará - UEPA under the number of CAAE 51930821.2.0000.5174, through decision No. 5.012.266, of October 1st of 2021.

Results

As mentioned above, BACMoC's Reliability and Objectivity Assurance stage was carried out in November 2021 with members of the Pará Physically Disabled Association (PPDA), residing in Belém, state of Pará, Brazil. The final sample consisted of 32 participants ($\bar{X} = 32.66 \pm 11.41$ years). The general characterization of the sample (absolute and relative values and comparison of prevalence using the chi-square test) can be seen in table 1.

Tabela 1.
Sample Characterization

Variable	Condition	Description		Prevalence	
		N	%	x^2	p
Etnicity	White	6	15.6	17.50	<0.01*
	Brown	17	53.1		
	Black	9	28.1		
Civil state	Solteiro	17	53.1	11.31	<0.01*
	Casado	13	40.6		
	Outra	2	6.3		
Disability motive	Birth	12	37.5	35.00	<0.01*
	Accident	10	31.3		
	Disease	4	12.5		
	Other	6	18.7		
Scholarship degree	Ellementary (incomplete)	2	6.3	19.38	<0.01*
	Ellementary (complete)	1	3.1		
	Highschool (incomplete)	4	12.5		
	Highschool (complete)	12	37.5		
	College (incomplete)	10	31.3		
	College (complete)	3	9.4		
Labor activity	Study, take care of family and work	5	15.6	1.75	0.78
	Take care of family	7	21.9		
	Study	9	28.1		
	Study, take care of family	5	15.6		
	Study and work	6	18.8		
Current occupation	Athlete	6	27.3	14.00	0.17
	Retired	4	18.2		
	Autonomous	3	13.6		
	Entrepreneur	2	9.1		
	Other	7	30.8		
Family income	Less than 2 minimum wages	19	61.3	11.10	<0.01*
	Between 2 a 4 minimum wages	7	22.6		
	More than 4 minimum wages	5	16.1		
Family history	Arterial hypertension	6	20.7	15.48	0.01*
	Obesity	2	6.9		
	Diabetes mellitus	7	24.1		
	Heart attack	1	3.4		
	Other cardiac disease	2	6.9		
	Multiple	11	37.9		

Source: Research data

Table 1 shows a significant sample prevalence of brown and single people with disabilities from birth or by accident, with complete high school or incomplete higher education, with a family income of up to 2 minimum wages, and multiple pathologies of family history.

Figure 1 shows the general characterization of the sample in absolute and relative values and a comparison of the prevalence through the chi-square test for the motor coordination variables.

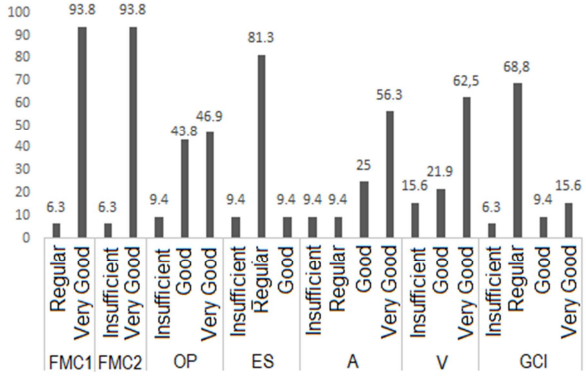

Figure 1. Results of motor coordination tests (%). Legend: FMC1: Fine Motor Coordination 1; FMC2: Fine Motor Coordination 2; OP: Oculo-manual Precision; ES: Explosive Strength; A: Agility; S: Speed; GCI: General Coordination Index
Source: Research data

Figure 1 shows a significant sample prevalence of individuals with: acceptable motor coordination level 1 (outline the line), Very Good; fine motor skills 2 (cut out the circle), Very Good; eye-hand precision, Very Good or Good; explosive strength, Regular; agility, Very Good; speed, Very Good; and, as for the general index of motor coordination, Regular.

Table 2 shows the sample characteristics of the general index of motor coordination (minimum, maximum, arithmetic mean ± standard deviation).

Table 2.
Sample General Coordination Index (GCI)

Variable	Minimum	Maximum	Arithmetic Average	Standard Deviation
General Coordination Index	13.90	35.50	23.29	5.54

Source: Research data

It is observed that the investigated sample proved to be heterogeneous for the general index of motor coordination, which was verified given the high standard deviation verified in the sample.

A significantly high degree of reliability and objectivity was found for the evaluation of objectivity and reliability, as seen in tables 3 and 4.

In table 3, regarding the degree of reliability, there is a significantly high degree of reliability, observed through the r=0.95 with $p<0.01$ for the general index of motor coordination between the two measures of the same evaluator. When analyzed separately, it was also noticed in the other variables, with r varying between 0.75 and 1.00.

Tabela 3.
Intra-evaluator Pearson's correlation (reliability)

Variable	r	*p*
Fine Motor Coordination	0.86	<0.01*
Oculo-manual Coordination	0.90	<0.01*
Agility	1.00	<0.01*
Speed	0.75	<0.01*
Explosive Strength	0.94	<0.01*
General Coordination Index	0.95	<0.01*

Source: Research data

In table 4, concerning the degree of validity, it is possible to observe a significantly high degree observed through r=0.95 with $p<0.01$ for the general index of motor coordination between the two measures of the different evaluators. When analyzed separately, it was also verified in the other variables, with r varying between 0.81 and 0.98.

Table 4
Pearson Correlation Inter-evaluator (validity)

Variable	r	p
Fine Motor Coordination	0.86	<0.01*
Oculo-manual Coordination	0.81	<0.01*
Agility	0.96	<0.01*
Speed	0.98	<0.01*
Explosive Strength	0.84	<0.01*
General Coordination Index	0.95	<0.01*

Source: Research data

The inter-rater 95% ICC (day 1 x day 2) ranged from -1.12 to 1.12. The inter-rater 95% ICC (day 1 x day 3) ranged from -1.90 to 0.41.

Discussion

When evaluating the motor coordination of wheelchair users, a battery of tests that are adequate and efficient is necessary. The BaCMoc is an instrument that proves to be consistent and reliable for use in wheelchair users. It is possible to observe a significantly high degree in the stages of ascertaining reliability and objectivity, reliability (r=0.95 with $p<0.01$) and objectivity (r=0.95 with $p<0.01$). According to Leão et al. (2019), the observation of intra and inter-evaluator relationships is necessary to identify the quality of the evaluation, as this allows for minimizing possible errors that may arise during the research.

The importance above shows solid scientific evidence regarding using correlation to identify intra and inter-evaluator data. Lopes et al. (2019), Aburachid et al. (2019), Pinto et al. (2019), and Barroso et al. (2019) also conducted the correlation in order to ensure the quality of the reliability and objectivity of the study they performed. In the study by Anciães et al. (2020), whose aim was to determine the intra-rater and inter-rater reliability of their device, excellent levels of reliability were observed. The one by Lopes et al. (2019) presented a 95% confidence interval for intra- and inter-rater reliability, providing evidence for their study's conclusion.

Melo Filho et al. (2020), used intra and inter-rater reliability to translate and adapt the test to Portuguese, showing excellent reliability in the results. The reliability results of the study by Aburachid et al. (2019), Pinto et al. (2019), and Barroso et al. (2019) pointed out excellent intra and inter-evaluator indices, ensuring reliability and objectivity. In the study by Carvalhosa et al. (2019), there was good inter and intra-evaluator consistency for the instrument's applicability.

The studies by Moreira et al. (2022), Mcallister et al. (2020), Ribeiro et al. (2020), Roch et al. (2020), Dos Santos et al. (2020), and Chan et al. (2017) showed high consistency in inter and intra-evaluator reliability, proving to be a reliable and viable tool for use in the public studied by the authors. Shahri et al. (2020) also observed the instrument's reliability through intra- and inter-rater error for the validation of an instrument. It is essential to mention that the current literature presents reliability and objectivity as necessary tools in validating instruments, as suggested by Thomas, Nelson, and Silverman (2012).

Conclusion

It is worth remembering that the study aimed to establish the scientific authenticity, in terms of reliability and objectivity, of an already validated motor coordination assessment battery for wheelchair users.

Regarding the degree of reliability, a significantly high degree was obtained (r=0.95 with $p<0.01$) for the general index of motor coordination between the two measures of the same evaluator, as was also verified in the other variables, when analyzed separately, with r varying between 0.75 and 1.00.

Concerning the degree of objectivity, there was a high degree (r=0.95 with $p<0.01$) for the GCI between both measures between different evaluators, as observed in other variables when analyzed separately, with r varying between 0.81 and 0.98.

Therefore, the battery test can be a valid option in evaluating the motor coordination of wheelchair users, regardless of whether they were parathletes.

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