ORIGINAL ARTICLE

Comparison between the isokinetics parameters of shoulder joint and independence functional level in manual wheelchair users

Comparação entre parâmetros isocinéticos da articulação do ombro com nível de independência funcional em usuários de cadeira de rodas manual

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ABSTRACT

Shoulder pain is a common complaint in the wheelchair user's population. This condition brings loss of independence and quality of life. **Objective:** The aim of this paper is to correlate shoulder joint isokinetic parameters and independence level of manual wheelchair users with or without pain. We hypothesize that users more independent are exposed to overuse injury of shoulder joints. **Method:** This is an explorative cross-sectional study with a quantitative approach. Community patients attended at a Rehabilitation Center. Manual wheelchair users. Twenty-four patients participated, we used the Functional Independence Measurement (FIM) to investigate the independent level of wheeled patients and isokinetic parameters of internal/external rotators and flexion/extension muscles of shoulder joint was collected using Biodex System 4 Pro. Statistical analyses were made by Fisher Test, Spiro-Wilk Test, Pearson Correlation test, Spearman test and the Coefficient of correlation's value was squared to estimate the percentage of variation in dependent variable, explained by independent variable. **Results:** Total FIM variation was between 79 and 117 and median ipsilateral strength ratio of rotator muscles were 0.94 on 75°/s and 0.95 on 150°/s for the right limb and respectively 0.96 and 0.93 for the left limb. **Conclusion:** Wheelchair users present internal/external rotators shoulder muscles imbalance and the covariations samples of time of injury and peak torque ratio external/internal shoulder rotators have a significant predictive value on total MIF. These results suggest that there is correlation between the studied patients and shoulder impairment.

Keywords: Shoulder Pain, Wheelchairs, Disabled Persons, Quality of Life

RESUMO

Dor no ombro é uma queixa comum na população de usuários de cadeira de rodas. Esta condição acarreta perda de independência e de qualidade de vida. **Objetivo:** Correlacionar parâmetros isocinéticos da articulação do ombro com níveis de independência de usuários de cadeira de rodas manual com e sem dores. Nossa hipótese é que usuários mais independentes estão mais expostos à lesões em ombros por sobrecarga. **Método:** Trata-se de um estudo exploratório transversal com abordagem quantitativa. Foram avaliados pacientes oriundos da comunidade, usuários de cadeira de rodas manual atendidos em um centro de reabilitação. Participaram do estudo vinte e quatro indivíduos e foram utilizados os instrumentos: Medida de Independência Funcional (MIF); parâmetros isocinéticos de rotadores interno/externo e flexor/extensor da articulação de ombro coletados usando Biodex System 4 Pro. Análises estatísticas foram feitas através dos Testes de Fisher, Spiro-Wilk, Correlação de Pearson, Spearman e os coeficientes da correlação foram utilizados para estimar a variação de variáveis dependentes, explicadas por variáveis independentes. **Resultados:** A variação do MIF total foi entre 79 e 110 e a relação entre a média da força ipsilateral dos músculos rotadores foi 0,94 em 75°/s e 0,95 em 150°/s para o lado direito e respectivamente 0,96 e 0,93 para o membro esquerdo. Usuários de cadeira de rodas apresentam desequilíbrio entre rotadores e as covariáveis de tempo de lesão e relação de pico de torque dos rotadores de ombro apresentam valor preditivo significativo no MIF total. **Conclusão:** Estes resultados sugerem uma correlação entre os pacientes estudados e comprometimento da articulação do ombro.

Palavras-chaves: Dor de Ombro, Cadeiras de Rodas, Pessoas com Deficiência, Qualidade de Vida

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INTRODUCTION

The manual wheelchair is a device greatly used to promote mobility and postural support to subjects with walk deficiency.[1] The World Health Organization estimates that 650 million people in the world live with some kind of deficiency and 10% of these depend on the wheelchair as a mobility device.[1] Although the manual wheelchair is an important instrument to patients with lower limbs' impairment, this is still considered low efficiency equipment because only 20% of the force applied on the pushrim will effectively move the subject forward, which complicates the outdoor environments use.[1-4]

The shoulder is a complex system that promotes extensive mobility, characterized by a great instability and the largest range of movement of the whole human body.[5] Under that perspective, the muscles of this joint hardly work in the stabilization process with the objective of not allowing regular dislocations.[6-8] Helm et al.[9] report in a quasi-static study of propulsion in wheelchairs that the contact force in the glenohumeral joint reaches values above 2000N, a result that suggests that a great part of the joint moment is directed to stabilize the shoulder.

The manual wheelchair users are required to transfer basic and instrumental activities of daily life to the superior limbs.[7,10,11] The low efficiency of the shoulder joint can predispose this group to overload injuries.[4] There are three biomechanical factors to which the manual wheelchair users are exposed that favor the development of pathologies to the upper limbs that are: higher demands of force, repetitive strain and extreme joint posture.[12] Statistically, shoulder pain complains varies over 30% to 70% in individuals with paraplegia, and new cases of this symptom in spinal cord injury patients increases 3-9 times compared to non-disabled population, condition that increases expressively the lost of functionality and bring on a higher health cost to those subjects due to the complication of secondary comorbidities.[13-15]

The measurement under the clinical aspect of dynamic muscle performance through isokinetic dynamometry is currently considered gold standard.[16,17] The isokinetic evaluation is characterized by an exercise realized with an adjustable resistance, on a constant and pre-established velocity.[16,17]

Considering the new global perspective in better health for persons with disability, efforts have been converging towards greater care to the quality of life in this population. As we can see in the Convention on the Rights of Persons with Disabilities and in the Brazilian Inclusion Law, the elaboration of scientific projects that allow a better visualization of the pathological affections that can occur in these individuals is extremely important to achieve some of the main points of these papers, like improve functionality and independence.

The purpose of the current study was to provide some relevant data that can assist healthcare to make decision about wheelchair for individuals with reduced mobility, by correlating shoulder joint isokinetic parameters and independence level of manual wheelchair users with or without pain. Taking into account the regulation of the Unified Health System from Brazil (SUS) for the provision of assistive technology, the results presented may additionally update the conditions of prescriptions for wheelchairs. It is also worth mentioning that the project is original in the proposed evaluation parameters and can contribute immensely to wheelchair users.

OBJECTIVE

The aim of this paper is to correlate shoulder joint isokinetic parameters and independence level of manual wheelchair users with or without pain.

METHODS

This is an explorative cross-sectional study with a quantitative approach. The research and the Informed Consent Term were approved by the Ethic Committee of Faculdade de Medicina de Marília with the register number: 2.318.820 e CAAE: 72677317.6.00005413. All participants received details about the study and signed the Term. And the collection period was between October 2017 and april 2019.

Sampling size was non-probabilistic, for convenience. The subjects were selected by physiatrist from active research on electronic medical records or from clinical examination in medical appointment, being included gender male and female; aged 10 or more; with mobility impairment that were manual wheelchair users. Eligibility criteria were: (a) patients with spinal cord injury with functional diagnosis of paraplegia or tetraplegia (sensitive level T4) or lower limb amputee; (b) have been in use of manual wheelchair as a mobility device for 6 months or more; (c) use the wheelchair for at least 1 hour/day. Ineligibility criterions were: (a) previous shoulder injuries; (b) moderate or severe cognitive impairment; (c) inability to drive the wheelchair without assistance.

Measurement of the daily time use of the wheelchair was based on a Wheelchair Clinic Protocol used at Lucy Montoro Rehabilitation Center (Marília, São Paulo – Brazil), in the section Interview, when the subject was questioned about how many hours per day, he/she uses the wheelchair. The answer was classified in five groups: 1) Less than 1 hour; 2) Between 1 and 3 hours; 3) Between 3 and 5 hours; 4) Between 5 and 8hours; 5) More than 8 hours.

Quantification of shoulder pain was based on subject evaluation using the Visual Analogue Scale. The subject was questioned if he/she had shoulder pain. If the answer was affirmative, they were encouraged to use the Scale. If the subject's answer was negative for the question, the Visual Analogue Scale scored 0.

Functional Independence Measure (FIM), a validated instrument in Brazilian portuguese,[18] was used to quantify the level of wheelchair user independence. This tool scores between 1 and 7 some of daily life's activities, considering score 1 for total assistence and score 7 for complete independence. The maximum possible score is 126 and minimum possible score is 18. Tasks are divided into two complementary sections: motor score (13 activities related with self care, sphincter control, transfers and locomotion) and cognitive score (5 activities related to communication and social cognition). All questions were performenced by the same interviewer using the "Use and Classification Procedures Manual for FIM from the Lucy Montoro Rehabilitation Institute HC FMUSP".

Subjects were seen at a 30 minutes medical appointment and the Interviews were individual, after acceptance and signature of Informed Consent Term. The applications were made for the same interviewer, respecting systematization.

Isokinetic parameters of peak torque and total work on sagittal and transverse planes were gauged through the maximums exercise test using the dynamometer Biodex System 4 Pro. The calibration was made based on provider instructions and belts were used for body stabilization (trunk and lower limb) to avoid compensatory movements. Concentric strength at 75°/second and 150°/second angular velocity was measured from shoulder joint following the sequence: 1) Flexion and Extension of dominant limb; 2) Flexion and Extension of non dominant limb; 3) External and Internal rotation of dominant limb; 4) External and Internal rotation of non dominant limb. The dynamometer axis was positioned using the references: flexion/extension at glenohumeral joint and external/internal rotation at elbow joint. Before each test, it was established the range of joint motion of flexion/extension between 0° and 180° and external/internal rotation between -45° and 55°.

These references were considered because shown to be a comfort movement for all age and gender groups of this study. The limb's weight was gauged in both planes. The familiarization protocol consisted of 3 repetitions for each velocity and for each limb, with an interval of 1 min between them. The 75°/second's angular velocity test was with 5 repetitions and the 150°/second's angular velocity test used 10 repetitions. The voluntary effort was maximum and the patient was encouraged with verbal command. All tests were performed with visual and verbal feedback.[17,19]

Qualitative variables were described by Absolute Frequency Distribution (f) and Relative Frequency Distribution (%). Quantitative variables were described by mean standard deviation (SD). The association between qualitative variables was analyzed using Fisher Test. Normality distribution of quantitative variables was analyzed by the Spiro-Wilk Test. The relationship between quantitative variables was assessed from Pearson Correlation test and Spearman test were used for variables that exceeded the assumption of normality. The Coefficient of correlation's value was squared to estimate the percentage of variation in dependent variable, explained by independent variable. The significant level adopted was 5% (p<= 0.05). Data were analyzed by SPSS, version 19.0.

RESULTS

Twenty-four patients were evaluated. The median age was 38,9, the median time of lesion was 9 years and 75% were male (18 patients). About the diagnosis, 20 were spinal cord injuries, 2 with myelomeningocele and 2 were amputees. The majority (75%) of patients use the manual wheelchair for more than 5 hours per day and 70.8% didn't refer to shoulder pain on interview (Table 1).

Quantitative parameters of isokinetic evaluation, independent functional measurement (FIM) and shoulder pain quantification (Visual Analogical scale – VAS) were described on Table 2. The total FIM variation was between 79 and 117 and the median VAS scored 1.46. From the results, median ipsilateral strength ratio of rotator muscles were 0.94 on 75°/s and 0.95 on 150°/s for the right limb and respectively 0.96 and 0.93 for the left limb (Table 2). For the flexor / extensor muscles, the mean values were 0.85 and 0.83 for the right side and 0.89 and 0.81 for the left side at 75°/s and 150°/s respectively (Table 2).

Table 1. Mean/Standard Deviation for age and time of injury and distribution of absolute frequency (N) and relative frequency (%) of the characteristics of the sample

	Média	SD	Min.	Máx.
Age (years)	38.9	15.3	14	70
Injury time (years)	9.6	9.4	0.8	34
		N	%	p-value
Time Using Wheelchair (hs)	1-5	6	25	0.014*
	>5	18	75	
Pain	Negative	17	70.8	0,041*
	Positive	7	29.2	
Gender	Mal	18	75	0,014*
	Fem	6	25	

*SD standard deviation; Min. Minimum value; Max. Maximum value, * (p-value ≤0.05) significant difference in the distribution of proportion by the chi-square test*

Table 2. Mean and standard deviation total FIM, VAS and Isokinetic Parameters

	Média	SD	Min.	Max.
FIM	104.88	10.95	79	117
VAS	1.46	2.36	0	6
R_re/ri_PT75	0.94	0.19	0.69	1.37
L_re/ri_PT75	0.96	0.21	0.7	1.52
R_re/ri_W75	1.02	0.23	0.59	1.43
L_re/ri_W75	1.13	0.33	0.76	2.43
R_re/ri_PT150	0.95	0.18	0.66	1.35
L_re/ri_PT150	0.93	0.18	0.69	1.4
R_re/ri_W150	1.03	0.22	0.7	1.7
L_re/ri_W150	1.04	0.25	0.51	1.72
R_fl/ex_PT75	0.85	0.15	0.57	1.15
L_ fl/ex _PT75	0.89	0.19	0.63	1.24
R_ fl/ex _W75	0.92	0.15	0.67	1.26
L_ fl/ex _W75	1.02	0.36	0.52	2.26
R_ fl/ex _PT150	0.83	0.13	0.61	1.05
L_ fl/ex _PT150	0.81	0.1	0.64	0.99
R_ fl/ex _W150	0.85	0.14	0.56	1.08
L_ fl/ex _W150	0.93	0.26	0.62	1.85

SD standard deviation; Min. Minimum value; Max. Maximum value; FIM Functional Independence Measure; VAS Visual Analogic Scale; R right side; L left side; re/ri external rotation and internal rotation ratio; fl/ex flexion extension ratio; PT Peak T

Analyzing correlation between the values of peak torque and total work ratios of the external / internal rotator and flexors / extensors at speeds 75°/s and 150°/s with complaints of shoulder pain and values of total MIF, no significant correlations were evidenced (Table 3). The same was also not found in the comparison of the mean and standard deviation of FIM between patients with and without pain symptoms. P-value calculated by Student's t test for independent samples (p= 0.110).

Table 3. Analysis of the correlation between FIM and VAS with isokinetic evaluation

	VAS			FIM		
	r	R2	p-valor^s	r^p	R2	p-valor^p
R_re/ri_PT75	0.09	0.01	0.659	0.06	0.00	0.780
L_re/ri_PT75	0.01	0.00	0.964	-0.02	0.00	0.943
R_re/ri_W75	0.20	0.04	0.354	0.19	0.04	0.379
L_re/ri_W75	0.00	0.00	0.998	-0.07	0.00	0.750
R_re/ri_PT150	-0.09	0.01	0.692	-0.07	0.01	0.737
L_re/ri_PT150	0.10	0.01	0.626	0.13	0.02	0.555
R_re/ri_W150	0.05	0.00	0.805	-0.05	0.00	0.809
L_re/ri_W150	0.27	0.07	0.205	0.24	0.06	0.251
R_fl/ex_PT75	-0.09	0.01	0.689	-0.11	0.01	0.625
L_ fl/ex _PT75	-0.08	0.01	0.702	0.00	0.00	0.985
R_ fl/ex _W75	0.04	0.00	0.848	0.03	0.00	0.887
L_ fl/ex _W75	0.04	0.00	0.844	-0.06	0.00	0.798
R_ fl/ex _PT150	-0.17	0.03	0.426	-0.13	0.02	0.554
L_ fl/ex _PT150	-0.22	0.05	0.312	-0.12	0.02	0.565
R_ fl/ex _W150	-0.04	0.00	0.848	0.05	0.00	0.834
L_ fl/ex _W150	0.05	0.00	0.815	-0.02	0.00	0.913

p-value by the Pearson correlation test for MIF and Spearmans correlation test for VAS; r correlation coefficient; R2 percentage of variation

Considering the values of normality on the peak torque ratio of the external / internal rotators between 0.67 and 0.85,[19] it is possible to observe a significant difference between values above this interval with the age of the individual studied for the right limb and with the total MIF on the left limb. These data suggest that values above the normal interval were significantly higher in older individuals when considered the right side (p= 0.033) and with the lower MIF when considered the left side (p= 0.006) (Table 4).

Having the MIF as a dependent variable due to its importance for the proposed work, a regression analysis was performed for covariate effect on the variation of this, as explained in Table 5. In this context, it was possible to observe that the injury time in years and the torque peak to external / internal rotator ratios of the two sides evaluated presented significant values to predict FIM (p= 0.009 and p= 0.049).

Table 4. Comparison of the mean standard deviation (SD) between patients with the peak torque ratio of external / internal rotators on the right and left sides normal or above the normal range

	PT re/ri Right					PT re/ri Left				
	Normal (n= 12)		Above (n= 12)			Normal (n= 10)		Above (n= 14)		
	Média	DP	Média	DP	p-valor	Média	DP	Média	DP	p-valor
FIM	109	8.9	100.8	11.6	0.063	111.8	7	99.9	10.7	0.006*
VAS	1.17	2.17	1.75	2.6	0.63	1	2.16	1.79	2.52	0.546
Age (year)	32.3	11.3	45.4	16.4	0.033*	34.1	12.5	42.3	16.7	0.204
Injury time (year)	11.7	9.8	7.5	8.9	0.198	12.7	10.6	7.4	8.2	0.259

** p-value ≤0.05 for significant difference between groups by Student's t-test for independent sample, except for VAS and injury time that p-value was calculated by the non-parametric Mann-Whitney test*

Table 5. Regression analysis for covariate effect on MIF variation

Variable		Regression Coefficients				Model	
Dependent	*Independent*	*B*	*IC 95%*		*p-value*	*R*	*p-value*
			LI	*LS*			
FIM	(Constant)	120.07	100.03	140.10	<0.001	0.412	0.067
(model 1)	VAS (0 a 10)	-0.90	-2.77	0.96	0.322		
	Age (years)	0.08	-0.21	0.38	0.558		
	Time of lesion (years)	0.20	-0.31	0.70	0.423		
	Gender (1= mal; 2= fem)	-1.72	-11.33	7.89	0.712		
	PT EXT/INT L (1= normal; 2= above)	-10.67	-19.85	-1.49	0.025*		
FIM	(Constant)	118.12	102.89	133.35	<0.001	0.364	0.009†
(model 2)	Time of lesion (years)	0.31	-0.13	0.75	0.156		
	PT EXT/INT L (1= normal; 2= above)	-10.24	-18.44	-2.04	0.016*		
FIM	(Constant)	113.11	93.12	133.10	<0.001	0.304	0.218
(model 3)	VAS (0 a 10)	-1.01	-3.04	1.02	0.309		
	Age (years)	0.09	-0.26	0.44	0.593		
	Time of lesion (years)	0.25	-0.29	0.80	0.343		
	Gender (1= mal; 2= fem)	-1.08	-11.59	9.42	0.831		
	PT EXT/INT R (1= normal; 2= above)	-7.57	-18.16	3.01	0.150		
FIM	(Constant)	111.16	95.86	126.46	0.000	0.250	0.049†
(model 4)	Time of lesion (years)	0.38	-0.09	0.85	0.107		
	PT EXT/INT R (1= normal; 2= above)	-6.62	-15.28	2.04	0.127		

*B regression coefficient; IC 95% confidence interval for B. LI lower limit for 95% IC; LS upper limit for 95% IC; * p-value ≤0.05 significant effect of the variable by the Wald statistic; † p-value ≤0.05 indicates that the model is significant*

DISCUSSION

The purpose of the current study was to identify correlations between the isokinetic parameters of the shoulder with functional independence level associated with or not complaining of shoulder pain. The initial hypothesis was that those more functional patients would be more likely to develop muscle imbalances in the shoulder joints due to overload. This idea approaches the one proposed by van Drongelen et al.[20] since it expresses the possibility that more independent individuals are more prone to upper limb joint pain with increased lesion time. With the presented results it was not possible to establish a relation with the explored variables.

The FIM is a questionnaire comprising 18 items divided into two groups, motor and cognitive, with each item scored between 1 representing total dependence and 7 representing complete independence.[21,22] Although this scale has been assessed separately by groups in some studies, Maritz et al.[22] demonstrated the internal validity of the total FIM based on the 18 items together for both neurological disorders and musculoskeletal disorders, which are addressed in the present study, which support its use in clinical practice. This maxim can be observed based on the theory that in the activities of daily life, motor activities reflect in cognitive aspects and vice versa.[22]

Kinematically, the wheelchair propulsion occurs by flexion, internal rotation and adduction of the shoulder, being the muscles involved in these movements more exposure to injuries by overload.[7,8] The joint motion plans selected for the isokinetic evaluation of the shoulder in this study represented by flexion and internal rotation are involved in the generation of the tangential force vector responsible for the anterior displacement of the wheelchair.[3,4] An extensively widespread concept puts muscle imbalance between the ipsilateral agonist

and antagonist of a joint movement as a risk factor for injury.[23] The function of the rotator muscles of the shoulder are crucial for joint stabilization, as described by the Haubert et al.[24]

In the regression analysis of the present study, it was possible to identify that the covariates of injury time and peak torque ratio in external / internal rotators of the shoulder at 75°/s on both sides have significant predictive values for the Total MIF dependent variable. These data can be compared with studies by Eriks-Hoogland et al.[23] that demonstrated the significant predictive value of MIF for changes in joint range of motion in wheelchair users. In addition, the means described in the results of this work show that the external / internal rotator ratios at speeds 75°/s and 150°/s on the right and left sides are above the range of normality described in the literature ranging from 0.67 to 0.85.[19] These results may suggest an impairment of the internal rotator muscles in the studied population, and approaches of Berckmans et al.[25] studies that propose this muscular group as more prone to overload injuries.

When we consider each factor separately, the information about shoulder pain by the manual wheelchair user from the present paper approaches literature data that estimates a prevalence of 30% to 75% of this complaint in this population.[13-15,26] It's extensively known that the requirement of upper limbs on propulsion techniques and daily life activities increase the chances of development of shoulder joint injuries because this joint is characterized by a complex functional anatomy that demands a major muscle strength to perform multiaxial movements.[7,10]

van Drongelen et al.[20] evidence in their studies that during the process of rehabilitation the wheeled patient could present shoulder pain that break off after finishing it, what suggest that training new skills could cause muscle stress and pain, making us to believe that shoulder pain isn't always related to repetitive movement of the wheelchair propulsion. On the other hand, Jayaraman et al.[27] evaluated shoulder pain complaint and wheelchair propulsion variability based on tenets of the loss of complexity hypothesis of aging applied to musculoskeletal system of wheelchair user and concluded that those who have shoulder pain were prone to adaptively modified the recovery phase of propulsion, suggesting the chronic process of injury development in this joint.

Furthermore, even when the wheeled patient doesn't complain about shoulder pain, it has been related to degenerative impairment, and in these cases the shoulder injury is subclinical.[27] Possibly, our results (29.2% of patients with pain) could be induced by the phase of rehabilitation or by the time of lesion.

Analyzing separately agonist/antagonist shoulder rotators from both sides (right and left), the results showed a significant relation between the imbalance strength ratio of right side and older patients and between the imbalance strength ratio of left side and less independent level. The first one corroborates the idea of joint degenerative process associated with aging like was described previously.[27] The other results manifest an opposite idea of the initial hypotheses of this paper that was based on the belief that the more independent the patient is, the more he/she is prone to develop overuse injury. This opposition could be explained by the fact that people with disability commonly go in a vicious circle of initial increased functionality that causes joint pain, kinesiophobia and loss of functionality.[28,29]

CONCLUSION

In conclusion, although this paper couldn't establish correlation between the isokinetic parameters of the shoulder with functional independence level and others variables, we could observe that 1) time of injury and peak torque ratio of agonist/antagonist shoulder rotator have a high predictive value for MIF and 2)wheeled patients of this study presented with possible imbalance impairment of shoulder joint rotators muscles that could suggest that this sample is more prone to develop shoulder pathology. This finding can be used to understand the susceptibility of the wheelchair user to musculoskeletal impairment. We need to consider whether that sample size wasn't enough to bring the ideal correlation.

The findings of the present study were inconclusive from the perspective of the initial hypothesis that more functional manual wheelchair users would also be more prone to shoulder injuries, requiring further studies with the participation of more individuals to increase the significance of the results found in this epidemiological study. It is also worth emphasizing the importance of expanding the literature on isokinetic shoulder studies to consolidate references in future studies.

The importance of preventing shoulder pain in the wheelchair population should be worked by health professionals aiming to prevent loss of independence and consequently loss of quality of life.

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