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CHEST WALL KINEMATICS OF ATHLETES WITH TETRAPLEGIA

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The purpose of this study was to analyze the 3D dimensional kinematics of the chest wall to describe the respiratory movement of tetraplegic athletes. Wheelchair rugby players were filmed during respiratory maneuvers. Markers were affixed to the trunk of the volunteers. From the 3D coordinates of markers, four compartmental volumes of the trunk were calculated. We analyzed the coefficient of variation of volumes in different compartments of the trunk for each subject, and the results were compared among the compartments. It was possible to verify the contribution of each compartment during respiration. The lower abdomen compartment had the highest average coefficient of variation. The methodology was able to identify the volume variations of chest wall and can be efficient to evaluate the effects of sports on ventilatory mechanics of tetrapelgic.

KEY WORDS: kinematical analysis, quadriplegics, quad rugby.

INTRODUCTION: Respiratory dysfunction is a common complication for people with high spinal cord injuries and there are many consequences arising from the changes in respiratory function of these individuals (Mueller et al, 2006). The regular practice of sports can be used to assist the improvement of the respiratory system in quadriplegics. (Dallmeijer, et al 2001).There are several ways to analyze the respiratory function, but there are few methodologies that enable the identification of patterns of thoracoabdominal motion during breathing. Considering that respiratory function may be a relevant indication to physical performance, it is of great importance to evaluate the changes of respiration through sport. The three-dimensional kinematic analysis of the chest wall allows analyzing the respiratory behavior, being possible to verify the involvement of the trunk compartments according to their volumetric changes, the contributions of different compartments and the interactions among them. This study aims to present the use of the kinematical analysis to describe the respiratory motion of four compartments of the trunk (superior thorax ,inferior thorax ,superior abdomen, and inferior abdomen) of tetraplegic athletes.

METHODS: A group of 8 male athletes with spinal cord injury level C4 to C7 was studied. The criteria of inclusion were time of lesion higher than 12 months, stable clinic condition, no smoking, absence of respiratory diseases or acute complication, training wheelchair rugby regularly. The volunteers remained sat on an adapted chair with shoulders abduction of 70º , forearms supported, 90º of knee and hip flexion and feet on the ground. Thirty spherical retroreflective markers (Ø 5mm) were fixed to the trunk of the subjects according to a model presented by Sarro et al (2008). The three-dimensional coordinates of the markers were obtained with kinematical analysis system DVideo (Figueroa et al., 2003), with 6 digital gen-locked Basler cameras arranged around the subjects. They performed five breathing with maximum inspiration and expiration. The trunk was split in four compartments: superior thorax (ST), inferior thorax (IT),superior abdomen (SA), and inferior abdomen (IA). Each compartment was geometrically defined as the sum of two irregular dodecahedron with 8 vertices, defined by markers. From 3D marker coordinates, the partial volumes were calculated in function of time for each compartment. The coefficient of variation of the volume curve was used to represent the relative change in percentage of volume in each compartment over time. The coefficient of variation of the trunk volume was analyzed in different compartments for each subject and this value was compared among the four compartments. Considering that percentage does not show normal distribution, the coefficient of variation was normalized by arcsine transformation. To verify the difference among the compartments the ANOVA one way ($p < 0.05$) was used.

RESULTS AND DISCUSSION: Table 1 shows the mean values of total volume and volumes of each compartment, the coefficient of variation of each compartment, group mean and standard deviation..

Table 1
Mean volume of each compartment in liters (l), percentage of coefficient of variation of each compartment, and mean group and standard deviation in trunk compartments: superior thorax (ST), inferior thorax (IT),superior abdomen (SA),and inferior abdomen (IA) of tetraplegic athletes, n = 8

Athletes	Total trunk Volume (l)	ST(l)	%ST *	IT(l)	%IT	SA(l)	%SA	IA(l)	%IA*
1	14.77	5.48	**1.73**	2.97	**2.40**	4.46	**3.57**	1.86	**5.98**
2	19.83	7.37	**0.71**	4.30	**0.98**	5.69	**1.70**	2.47	**2.79**
3	18.15	6.99	**1.54**	3.46	**2.06**	4.90	**2.63**	2.79	**1.40**
4	15.47	5.50	**0.83**	3.43	**1.11**	4.04	**1.86**	2.51	**4.98**
5	18.14	6.91	**3.51**	3.72	**4.25**	4.78	**5.48**	2.72	**3.79**
6	17.93	6.96	**2.33**	3.05	**2.78**	5.07	**4.86**	2.86	**5.54**
7	15.27	4.97	**0.51**	3.19	**0.87**	4.57	**0.32**	2.54	**4.44**
8	20.11	7.89	**0.55**	3.69	**0.47**	4.75	**1.20**	3.78	**1.63**
	17.45±2.6	6.50±1.4	1.46±1.5	3.47±0.3	1.86±1.6	4.78±0.8	2.70±1.0	2.69±0.3	3.81±1.3

* $p < 0.05$

The highest average coefficient of variation was found in the inferior abdomen and the smallest in superior thorax. The results of one-way ANOVA showed a significant difference ($p < 0.05$) between these 2 compartments. No significant differences were found when the other compartments were compared.
The results showed an increased motion of the compartments controlled by the diaphragm and a decreased motion of the compartment controlled by intercostals muscles. Considering that tetraplegics have a lack of action of intercostals and abdominal muscles and an intact diaphragm (Bodin et al., 2003), the highest abdominal motion observed could be caused by the descent action of the diaphragm against non active abdominal and intercostals muscles. Morgan et al. (1985) found an increase in abdominal motion in some tetraplegic patients after a period of recovery from the injury and suggest that this increment can be due to stiffening of the rib cage through joint stiffness, intercostal spasticity, and atrophy of the abdominal wall allowing the diaphragm to move more effectively.

CONCLUSION: The results showed that the methodology was able to identify variations of the partial volumes in different chest wall compartments in tetraplegic athletes. In the evaluated group there was a higher variation in the abdomen region and inferior thorax compared to the superior region of the thorax.

REFERENCES:

Bodin,P. Kreuter, M,Bake, B., & Fagenik, O.M.(2003) Breathing patters during breathing exercises in person with tetraplegia. *Spinal cord,* 41, 290-295.

Dallmeijer, A. & Woud, V. (2001) Health related functional status in men with spinal cord injury: relationship with lesion level and endurance capacity. *Spinal Cord*, 39, 577- 583.

Figueroa,P.J,Leite,N.J & Barros, R.M.L.(2003) A flexible software for tracking of markers used in human motion analysis.*Computes Methods amd Programs in Biology*, 72, 155-165.

Morgan, M.D.L.,Gourlay, A.R.,Silver, J.R.Willians,S.J., & Denison,D.M. (1985) Contribution of the rib cage to breathing in tetraplegia.*Thorax*, 40, 613-617.

Mueller G, Perret,C, & Spengler,C. M. (2006) Optimal intensity for respiratory muscle endurance training in patients with spinal cord injury. *J Rehabil Med* ,38,381-386.

Sarro, K.J. Silvatti,A. P & Barros,R.M.L.(2008) Coordination between ribs motion and thoracoabdominal volume in swimmers during respiratory manoeuvres. *Journal of sports science and medicine*, 7,195-200.

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