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Effects of Muscle Fatigue on the Kinect Control of Free Throw in the Wheelchair Basketball Sport

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Abstract: Wheelchair basketball is mainly designed for people who are physically challenged with permanent lower body disabilities. Free throw execution is one of the basic skills and could represent the preferred shooting mechanics so as to examine the overall shooting mechanics in basketball players. It requires the body to act as a kinetic chain to summate energy from the wheelchair to the upper extremity for the coordinated movements. Researchers have shown that the kinetic chain of the wheelchair basketball athletes could be affected by the kinematic parameters such as the release velocity and shooting angle [1-3]. The goal of this study was to further explore whether the muscle fatigue affects the control of the upper extremity as well as the whole body of the players during the free throw shooting. Twenty-two experienced healthy male basketball players (aged 20.8±2.4 years) were recruited in this study. Surface wireless EMG (Trigno Wireless System, Delsys Inc., Boston, USA) was used to assess the activations of three muscles of the upper extremity, namely the anterior deltoid, triceps brachii, and wrist flexor. Force plate (Bertec 9090-15, Advanced Mechanical Technology Inc., Columbus, USA) under the wheelchair was applied to assess the postural control in terms of the sway area and sway velocity of the center of pressure. A dedicated camera was also used to record the angles of the shoulder, elbow, and wrist joints. Subjects were instructed to perform thirty consecutive free throw shootings sitting on a standard basketball wheelchair. The subjects were encouraged to make a "swish" defined as the ball went cleanly through the hoop with no contact on the rim. Then the subjects performed another thirty shots under the fatigue condition, i.e. to hold a 5Kg dumbbell for a total of 30 times of fast wrist flexion every 5 shots. The EMG and CoP data were obtained over the shooting course from the upward movement of the shooting arm until the ball leaving the hand. The instant joint angles of the upper extremity were determined by the time just before the ball-leaving. The paired t-test was used for the statistical analysis with the significance level set at $p < 0.05$. There was no significant difference for all the parameters between the swish and missed conditions. As for the EMG data, the triceps activations trended to be increased while the wrist flexor activations were decreased under the missed condition compared with those under the swish condition regardless of the muscle fatigue. The subjects showed significantly decreased joint angles of the whole upper extremity after the muscle fatigue especially under the missed condition. In addition, the sway velocity during the shooting was significantly increased while the sway area was decreased after the muscle fatigue. In conclusion, the muscle fatigue altered the kinetic control not only for the upper extremity but also the whole body which could lead to poor shooting performance. Further study is warranted to include the endurance training of upper extremity aiming to improve the performance of wheelchair basketball athletes.

Keywords: Adaptive sports; free throw; electromyography; posture control

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Table1. The muscle activations (% of maximal voluntary contraction) of the upper extremity before and after the muscle fatigue protocol.

	Before	After	*p* value
Swish			
Anterior deltoid (%)	25.7±6.8	25.9±7.0	0.931
Triceps brachii (%)	18.8±8.8	18.6±8.1	0.924
Wrist flexor (%)	11.0±5.9	11.1±5.4	0.973
Missed			
Anterior deltoid (%)	25.9±7.1	25.2±5.9	0.404
Triceps brachii (%)	19.4±7.6	19.1±8.5	0.721
Wrist flexor (%)	10.5±5.0	11.0±5.5	0.619

Table2. Changes of the center of pressure parameters before and after the muscle fatigue protocol.

	Before	After	*p* value
Swish			
Sway area (mm^2)	1450.4±1444.6	1184.6±1955.3	0.588
Velocity (mm/s)	105.9±54.2	111.2±70.8	< 0.001
Missed			
Sway area (mm^2)	1640.6±1897.0	1104.5±866.2	0.017
Velocity (mm/s)	109.1±56.6	194.5±64.5	< 0.001

Table3. The joint angles of the upper extremity before and after the muscle fatigue protocol.

	Before	After	*p* value
Swish			
Shoulder (º)	37.2±16.7	33.6±15.5	0.695
Elbow (º)	-66.8±14.7	-57.6±34.1	0.949
Wrist (º)	13.0±9.7	12.3±8.5	0.306
Missed			
Shoulder (º)	37.0±17.9	33.2±15.4	< 0.001
Elbow (º)	-65.2±15.0	-56.7±35.6	0.045
Wrist (º)	14.3±8.4	11.7±8.6	< 0.001

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