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POSTURE VIDEO ANALYSIS OF ATHLETES WITH LOCOMOTOR DISABILITIES, IN TENNIS GAME

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Abstract: *The game of tennis is one sport approached by people with disabilities in order to maintain tonicity of unaffected muscular system. A significant number of them fail notable sports performance and therefore can participate in their dedicated Olympics. In this research we have developed a methodology for video analysis of various types of specific movements (service, backhand and forehand) in order to determine the posture comfortable during play tennis. In the first part of the paper are presented aspects of wheelchair for athletes that are immobilized locomotor and also mentioned several options for recording and video processing. In the second part of paper is presented registration methodology that includes the experimental structure, sequence of procedures and manner of storage and data processing of video sequences. The final part of the paper presents the results of video analysis on two cases of athletes with locomotor disabilities in the game of tennis.*

Key words: *video, tennis, locomotor disabilities, sportive, posture.*

1. Introduction

Sports, performance or amateur among disabled people is an opportunity and a chance to integrate them into the community and to maintain tonicity for muscle groups unaffected by disabilities. Especially for people immobilized into a wheelchair, sports in various forms cause an increase in life expectancy, better psychosomatic evolution and not least, a better adaptability.

Wheelchair types for Paralympic athletes who practice the sport of tennis are customized as needed. They are equipped with various types of undertakings or knots in the legs, where there is a risk of unbalancing due to translational motion from the moment of the service or trips between the main moments of the game of tennis.

Fig. 1. *Variants of connections in wheelchair [1]*

Position in a wheelchair, but also the connections between the locomotor system and trunk in this chair has two aspects that contribute to the possibility of performing movement tennis convenience, comfort

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and performance. These forms of knots on the seat, general or personalized are presented in Fig.2-5.[1]

Fig.2. *Fitting variant with profiled covers [1]*

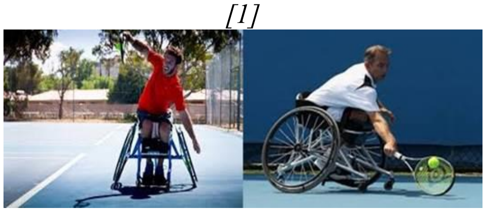

Fig.3.*Variant of positioning and fitting bar [1]*

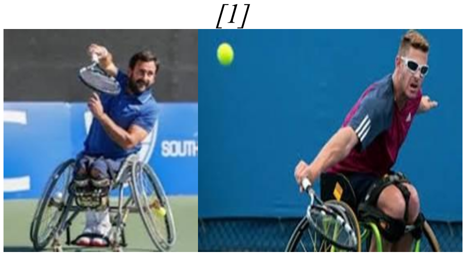

Fig.4.*Grip variant with strap and separator [1]*

Fig.5. *Wheelchair grip personalized version [2]*

Movements of the tennis game are very fast, they takes place on large spaces and requires a highly sensitive tracking system. Therefore their analysis is performed using high speed video systems and software which can be obtained data on speed, acceleration, displacement and even on levels of energy consumption. From the many high speed and high accuracy video systems we can enumerate systems like: Vicon, SimiMotion, Contemplas, Ariel, CineLab and in terms of software packages that can process data recorded may include: software dedicated Vicon and SimiMotion, then Kinovea, Tracker, CvMob, Templo, APAS and more others. In addition, to create generalized models can be used simulation-modeling software packages like: LifeMOD, Anybody or OpenSim.

2. Theoretical aspects

Athlete position in a wheelchair represents, for the performance of its tennis game, the most important aspect for the necessary comfort. Therefore, determining the limits of motion (space, angles, distances, forces and moments) that athlete can accomplish in the game of tennis represents the most important step in establishing the procedure for the game improvements. Stability of the ensemble player-wheelchair athlete must determine ability to succeed passage of the ball over the net more than 2 times in exchange of the ball in the game's courts. This ensemble is defined by structure (shape and material) of the wheelchair, and the form of locomotor disability of the athlete.

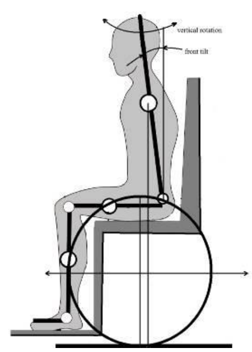

Fig.6. *Human body position in wheelchair*

Movements executed by the athlete, who

was in a wheelchair, from the front surface of the seat, in the game of tennis can be classified as follows: rotational vertically movements of the trunk (on the three-axis); translational motion, perpendicular on direction of the wheel axle, respectively, compared to the soil surface; rotating moving of integral ensemble, player-chair, around vertical axis. For each type of shot in tennis these moves can be combined, resulting in a complex movement of the athlete. At this increased complexity of movements performed by sports will add additional energy consumption.

In order to posture analysis of locomotor disability athlete sitting in wheelchair were established the propulsion points on the chair and have represented the forces that act on the contact between the hand and wheelchair.

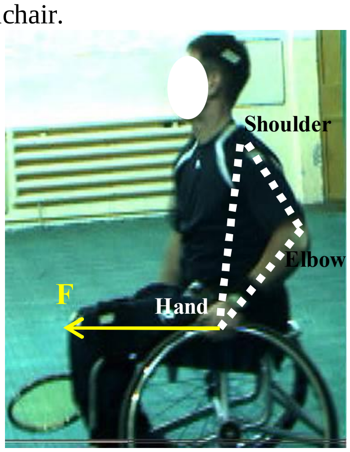

Fig.7. *Initial player position in wheelchair*

The athlete is in the initial point of the movement and controls the position of the entire system through the left arm and especially through the shoulder and elbow joints. Left hand is in constant contact with wheelchair wheel and the left arm aligned with the shoulder.

As mentioned in the paper [9] can be defined the effect of propulsive like power that they act with his left hand on the wheelchair, as follows:

$$E = \left(\vec{r}_{ah} \times \vec{F}\right)\omega \tag{1}$$

where $\vec{r}_{ah}$ it is the vector between hand and wheel center, $\vec{F}$ is the push force and ω is angular speed of the wheel.

$$C = V_S \frac{\left|\left(\vec{r}_{sh} \times \vec{F}\right) + M_{0s}\right|}{M_{\max S}} + V_e \frac{\left|\left(\vec{r}_{eh} \times \vec{F}\right) + M_{0e}\right|}{M_{\max e}} + C_0 \tag{2}$$

where V_s and V_e are muscle masses involved in shoulder and elbow joints;

M_{0s} and M_{0e} are moments (shoulder and elbow) that counter-acts gravity and inertia system;

$M_{max\ s}$ and $M_{max\ e}$ are maximum amplitudes of joints moments involved in action, moments that depend on the angular position and speed;

C_0 it is a parameter that contains the initial data. [9]

In tests conducted by the author of paper [9] was obtained biomechanical maximum yield of 80% which allowed determining the direction of thrust for a certain amount of effort required. In this way one can determine construction (shape and dimensions) using a wheelchair software modeling / simulation. In the same way, the subject anthropometric measurements are required to define the limits of movement of the assembly wheelchair player, the limits positioning and action of the assembly arm-joints. Video acquisition and processing system is in this case the solution which can highlight and calculate these kinematic and dynamic parameters for knowing the player's posture and increasing its performance in the sports activity.[7]

3. Experimental Setup

In order to carry the experiments was chosen system of video recording based on radiation in the visible range and a software package consists of several routines in order to determine the kinematic parameters of the movement that carries the tennis player with locomotor disabilities, found in the wheelchair.

It was also analysed the playing surface (dimensions 23.77 m x 10.97 m) in order to determine the position of three cameras, in places and directions needed to obtain digital images of different sequences of movements in the game of tennis.

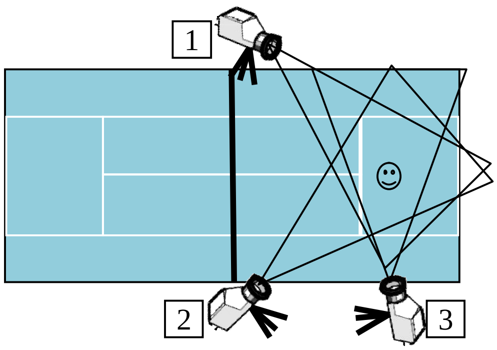

Fig.8. *Initial position of player and experimental system*

The experiments were recorded on an indoor tennis court, an area specific to this type of sport, making recordings on two subjects with locomotor disability but being performance tennis players.[5]

The first step of methodology consisted in positioning, calibration and adjustment of cameras set so that it can capture the subject's posture and movement. This posture was captured from two directions placed on both sides of the net (video cameras 1 and 2) and by a third videocam placed perpendicular to the length of the field (videocam 3) according to Fig. 8. Also were noted environmental data to correct certain data values if these exceed the state of comfort. The second part of the methodology consisted in making the subject to perform a series of specific movements and also in joint marking action of the subject. [7] The third step in developing the methodology followed to capture synchronized sequences of player images using video tri-axial system and software package Templo. Video cameras have captured synchronized images at the speed of 125 frames / sec and these images were stored in the folder of each variant of movement. There have been movements of forehand, backhand and service in order to analyse their parameters. Special attention was paid to the tennis racket with that the athlete executed movements, because differences in performance every movement is not achieved only through technique that addresses the player but also from the effect achieved by the impact of the ball with the opponent racket. [5]

In the fourth stage sequences were selected with images the most information possible to process and routines were introduced in processing (CvMob, Protrack and Kinovea).

4. Results and Discussions

The results of these records are divided into two areas for the two tennis players. First of all, at the athlete No.1 (left hand player) were determined angles between hand and rocket, between trunk and wheelchair when service action.[7]

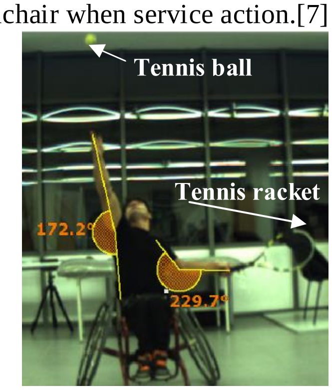

Fig.9. *Measurements of the angles in service action*

In this case, by video determining the angle values of the main elements involved in strikes they have found the following aspects:

- firstly, the subject performs a twisting of the upper torso both the forehand as well the backhand due to the rotation wheelchair is not brakes on soil, leading to higher energy consumption of the player;

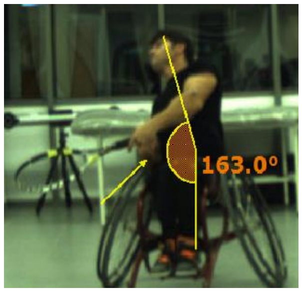

Fig.10. *Angles measurements after impact between ball and tennis racket*

- secondly, hip joints with lateral trunk muscles are required at anatomical limits, the maximum every time, to realize shot but also to return in the receiving position.

Fig.11. *Torso dorsal part of second player*

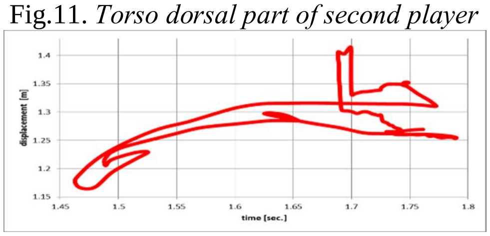

Fig.12. *Trajectory of human torso*

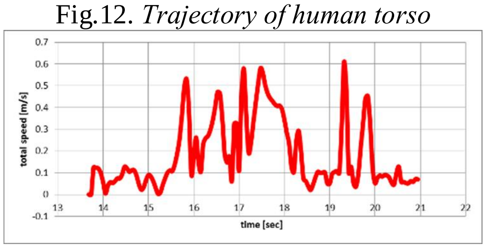

Fig.13. *Total speed of the human torso*

For the second recorded subject (right hand player) these twists are highlighted both by size and shape of the trajectories of a marker on the back of the trunk, and by their speed with which it moves when he hits the ball (speed increases almost 5 times since made preparations for hit until impact with the ball, see Figure 13).

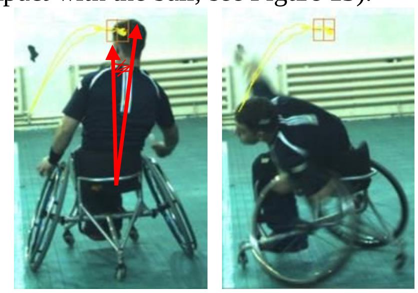

Fig.14. *Spins and twists to adjust the position during hit*

Both subjects also made movements to adjust the position wheelchair-human body assembly using the other hands, this time consuming additional time and energy.

Adjusting the wheelchair to the ground is achieved not only by rotation around the vertical axis, but it rebalances the body trunk bending forward and back, by gentle tilting while blocking wheelchair wheel (Figure 14).

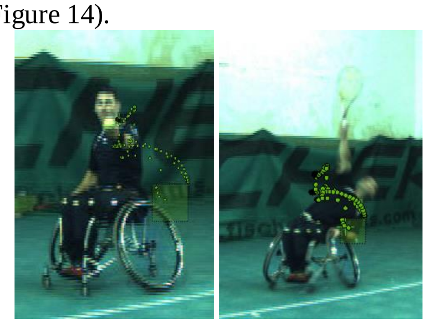

Fig.15. *The beginning and end of the service hit the subject no.2*

Moving total achieved by registered marker made by fit in a 2D space captured 0.26mx0.24m averaging, which involves rotation angles of up to 30^0 vertical axis.

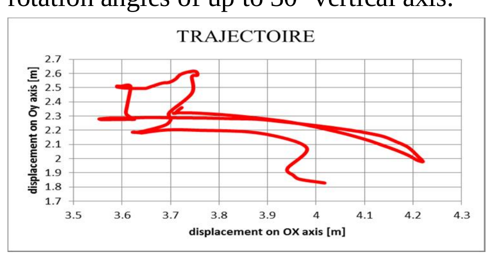

Fig.16. *The trajectory of the left shoulder during strike*

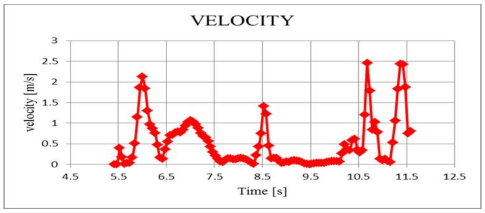

Fig.17. *Speed variation during the left shoulder hit*

Using the recording videocam no.1, sizes correlate and can also identify other subject's movements during the game (see fig.15-17).

5. Conclusions

These records have revealed the behavior of subjects in different activities in sport tennis game. By using image acquisition with high speed videocam, from three directions, each element movements involved in the action game (hand, head, shoulder, rocket and wheelchair) can be analyzed.

Analysis by processing and image analysis allowed determination trajectories, the motion limits, speeds and accelerations.

The software used (CvMob, Protrack and Kinovea) in parallel confirmed the same determination which makes the method of acquisition and processing of images to be of great help in analyzing the game of tennis athletes and also represent a method for identifying individual posture problems.[7,8,9]

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