Chapter 83
Analysis on Smashing Motion in Badminton

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Abstract In this paper, through the infrared monitoring of long-range system of the infrared high-speed camera QUALISYS-MCU500, we make a biomechanics analysis on badminton athletes' smashing motion and draw when badminton player is smashing the ball by hand vigorously, how to effectively strengthen the batting strength to stabilize their center of gravity and to maintain balance throughout the body. This plays a crucial role in China's badminton athletes to regulate their spiking action.

Keywords Badminton player • Smash • Arm • Mechanical analysis

83.1 Introduction

This paper is using the infrared high-speed camera to take the entire process of the badminton athletes on the field smashing the ball, and the QUALISYS-MCU500 type of high-speed video image motion capture video camera is mainly used. This set of equipment is made up by the Motion Capture Unit, target, the camera, and the corresponding software component, see Fig. 83.1. The infrared high-speed camera's working principle is as follows: put the target infrared radiation environment and the camera catches the reflected light; at this time, the computer system can detect the target corresponding numerical. Therefore, the equipment can obtain the accurate 3D movement of complex sports information [1].

83.2 Experimental Steps

Step1: Put the camera as required below in the badminton court:

1. Distance: the distance between the high-speed cameras is 15 m, with each camera from goal 10 m far.

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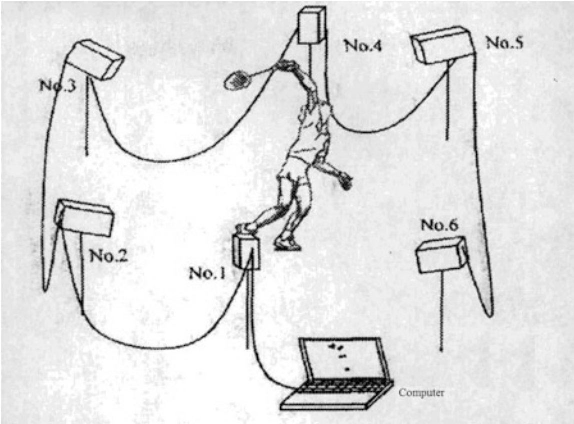

Fig. 83.1 QUALISYS-MCU500 testing schematic diagram

2. Height: each camera body height is 1.5 m.
3. Angle between adjacent cameras: the camera angle is 45 degrees.

Step2: Athletes spiking action test

Badminton players affixing mark in arm can produce the reflection of the object, so that the badminton players can try to take some tries; then, in the test, badminton players try to complete the qualified smashed ball; each of the movements has to achieve the fundamental requirement, and the action is taken down by the camera completely [2], Figure 83.2.

Step3: Data collection

The whole process is shot down and then sent to signal conditioning, in which signal pressure is under processing, and then transmit data to the data acquisition card; data acquisition card will signal the/number (A/D) and convert into the computer; through program operation and treatment, pressure data will be eventually displayed on the screen, Figure 83.3

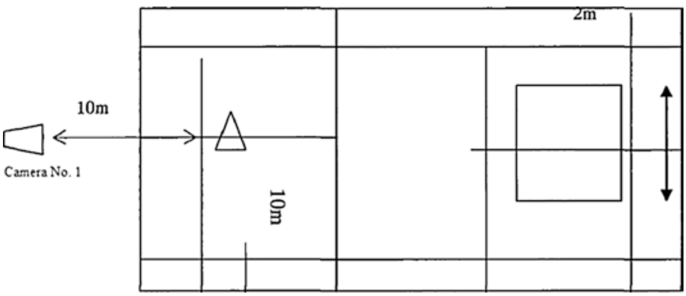

Fig. 83.2 Test site schemes

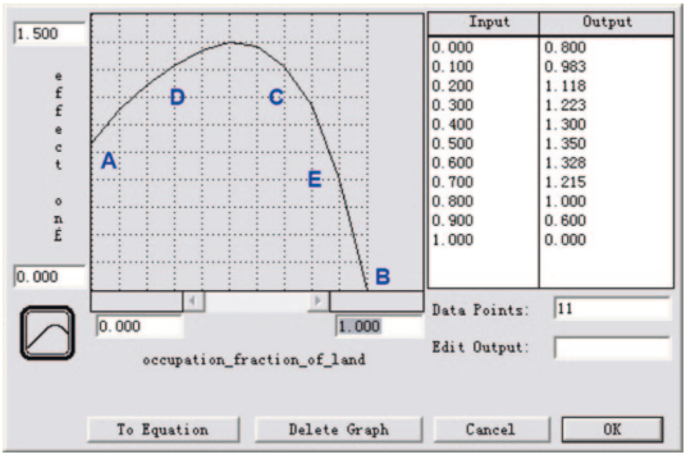

Fig. 83.3 QUALISYS software interface

83.3 Badminton Arm Movement Analysis Based on the Dynamics

When the badminton player's forehand smashes the ball, before hitting, the right foot is slightly before the left foot, and the body slightly bends forward and bends knees, the focus falls on the right foot, ready to takeoff. The rear of the body right after the jump, upper right back into the anti-bow, his right arm right elevation, shoulder and try to pull. During the shots, forearm quickly lifts out into the forearm, wrist from behind and then quickly under the direction of the ball. After smashing, the knees buffer, the right foot on the right side, the center of gravity before the right foot, left foot on the left before, and rapidly restore [3].

The right arm is set to the midpoint of the mark as a whole, so we assume there is a coordinate, and the midpoint of the arm is the origin of coordinates; then, we apply the kinetic analysis and QUALISYS to draw three-dimensional coordinates of the arm, as is shown in the figure below: Figs. 83.4, 83.5.

Among them, the establishment of the coordinate system is as the following, which can be seen in Fig. 83.6:

Arm X = (forearm X + reararm X)/2
Arm Y = (forearm Y + reararm Y)/2
Arm Z = (forearm Z + reararm Z)/2

The coordinate system, Oj, Xj, Yj, Zj (j = 0, … 3) in the standard smash the arm is straight up with each parallel to another. When the arm is straight up when spiking, athletes smash in fact is the dynamics problem. Through Kane dynamics, we can derive Eq. [4]:

$$F^{(r)} + F^{*(r)} = 0(r = 1,2,3,\ldots,7) \tag{83.1}$$

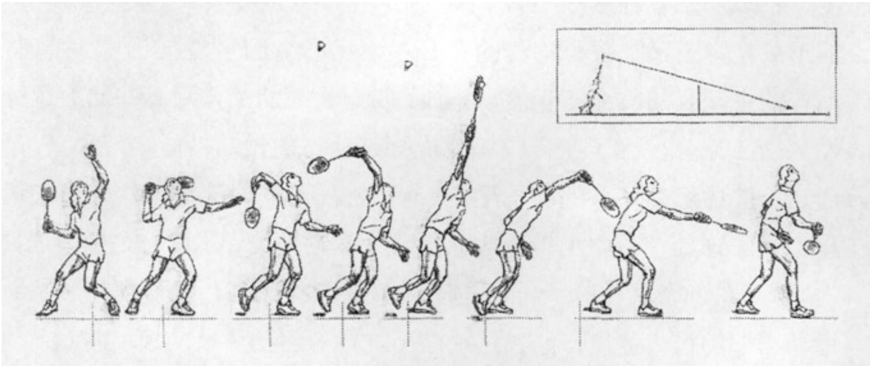

Fig. 83.4 Simple diagram of smashes on the ground ball

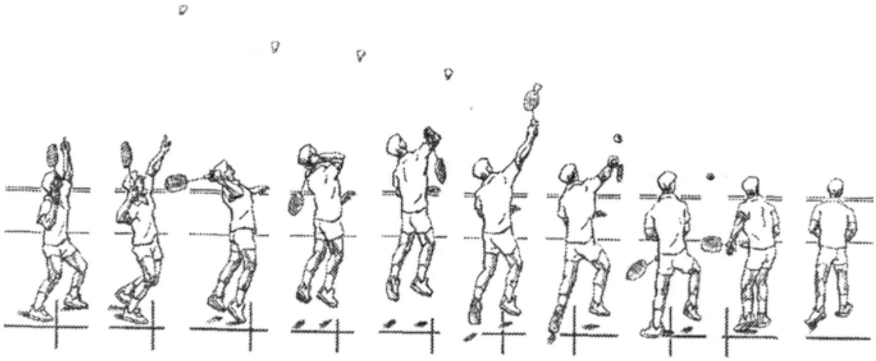

Fig. 83.5 Simple diagram of smashes when taking off

$$q\&_r = q\,\&\,(u_r, q_r) = 0(r = 1, 2, 3, \ldots, 7) \quad (83.2)$$

And then according to law and Newton's third momentum theorem, when the athletes spiking, we make a force analysis of the stress of the arm. Among them, the law of conservation of momentum is used in this paper and is conformed to the research content conditions. Because the law of conservation of momentum is stipulated in the following points: system not affected by external force or the external force is zero. System under external force is not zero, but much smaller than system internal force. System of external force is not zero force, but in a direction of component to zero, the total momentum remained the same—point momentum conservation. So when athletes shot ball, although not affected by force 0, compared with the internal system, this can be ignored. Figure 83.6.

According to the formula $p = m_1v_1 = m_2v_2$, when athletes make a smash action, first accelerating arm swing to get some momentum. Then, according to the transmission principle, the momentum generated is passed to the racket, so the racket is on a very large initial velocity. Stress analysis is shown in Figs. 83.6, 83.7.

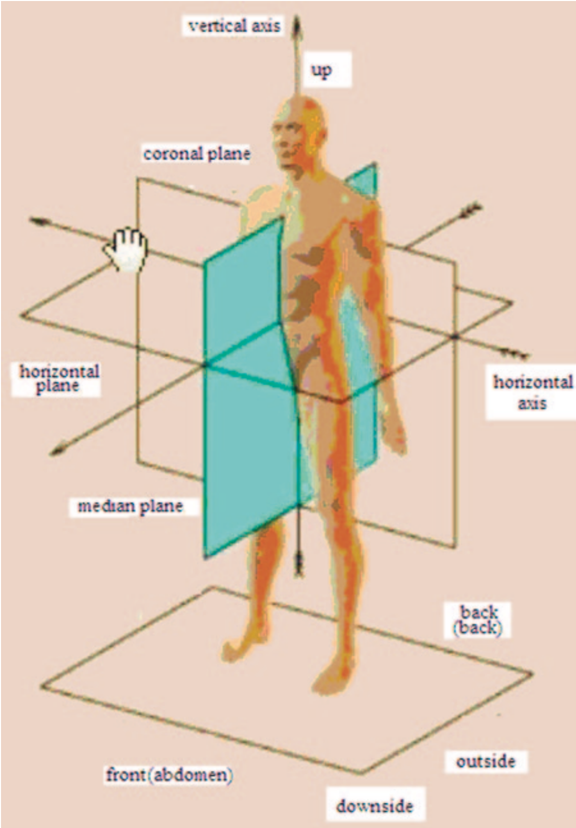

Fig. 83.6 The establishment of the coordinate system

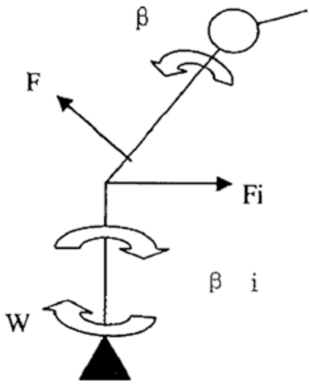

Fig. 83.7 Stress on the arm when shot

Then, again through the dynamics theory, we conclude that the stress on the arm when spiking:

$$Mt = \Delta \sum Ii\omega i = (I_1 + I_2)\omega_0 \tag{83.3}$$

Then,

$$\begin{aligned} Q &= Q_0 \\ I_1\omega &\succ I_2\omega_0 \\ w &= \tfrac{(I_1+I_2)\omega_0}{I_2}\omega_0 + \tfrac{I_1\omega_0}{I_2} \end{aligned} \quad (83.4)$$

$$\because \mathrm{I}\omega_0 = 0$$

$$\therefore Q = I_2\omega \quad (83.5)$$

Then, according to the law of conservation of energy, we further draw:

$$\begin{aligned} Q &= Q_0 \\ Q_o &= (I_1 + I_2)\,\omega_0 \\ w &= \tfrac{(I_1+I_2)\omega_0}{I_2}\omega_0 + \tfrac{I_1\omega_0}{I_2} \end{aligned} \quad (83.6)$$

Through the formula, we can easily draw $\omega \succ \omega_0$ and $I_1\omega \succ I_2\omega_0$.

Through the above formula deduction, we can get the instantaneous velocity of the upper extremity during the ball smashes on the ground and during the takeoff. Figure 83.8

Through the above two figures, we can safely draw the conclusion that when the athletes are in the spike, what instantaneous speed each arm joints can reach [5]. Table 83.1

Through interview by experts, it is drawn when the athletes are in the shots; survey results of the arm holding the racket in badminton movement's effect are given in Table 83.2

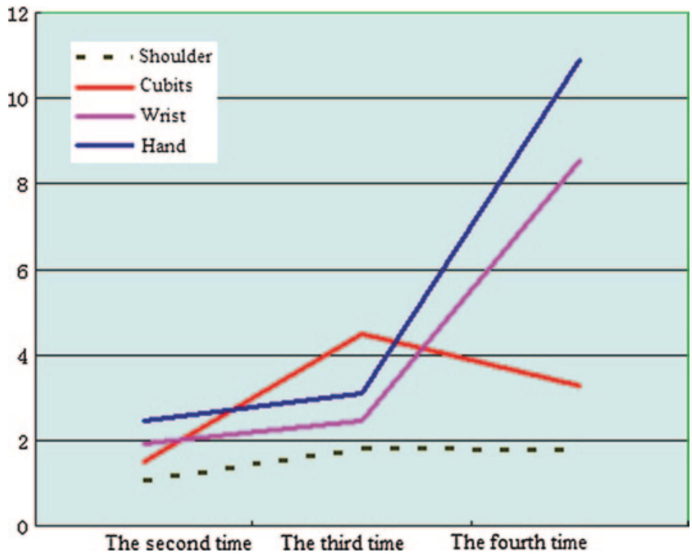

Fig. 83.8 Instantaneous velocity of each part of the upper arm (m/s)

Table 83.1 Instantaneous velocity of each part of the upper arm (m/s)

Name	The second time	The third time	The fourth time
Shoulder	1.05 ± 0.4	1.78 ± 0.8	1.76 ± 0.7
Cubits	1.5 ± 0.64	4.5 ± 2.5	3.26 ± 1.5
Wrist	1.94 ± 1.2	2.45 ± 1.5	8.56 ± 1.7
Hand	2.45 ± 1.4	3.1 ± 1.87	10.9 ± 2.5

Table 83.2 Survey results of the arm holding the racket in badminton movement's effect

	Sample	Increase hitting power	Balance	Beautiful movements	Improve hitting	Improve accuracy
Number	10	10	10	7	10	10
Percentage %		100	100	70	100	100

83.4 Conclusion

With the help of the QUALISYS-MCU500 camera, this article records the athletes' action of ball smashes and then reuses movement mechanics theory and the law of conservation of energy to analyze arm in spiking. We can get the stress of the upper arm in each part and the corresponding instantaneous speed. Through this, we can regulate the athletes' spiking action standards.

References

1. Runhua Z (2009) Kinematics analysis of college students' excellent badminton back smashing technology. Hunan Norm Univ 03:10–17
2. Shuxue Z, Sun J, Li Y (2011) Analysis of badminton shots action. J Nanjing Sports 02:25–27
3. Luo H (2011) Biomechanics analysis of badminton smashing forehand ball. Xian Sports Inst 03:254–259
4. Liu H (2004) Biomechanical study of whiplash movement technical principle. Sports Sci 11:30–32
5. Gao PC (2011) Biomechanics analysis of badminton tall condoles shot actions consistency. Xian Sports Inst 03:19–24