INFLUENCE OF THE RACKET ON THE SMASH MOTION IN BADMINTON

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The purpose of this study was to analyze the influence of the racket on badminton smash motion. An experiment was carried out using three badminton rackets of different mass and gravity center position. The smashes of 12 males were selected for the analysis. Performances were recorded by twelve motion capture cameras. In this study, we analyzed a position in the vertical direction of each marker and considered a series of the flow of the smash motion. Then, we calculated the standard deviation to analyze a difference of the smash motion. As a result, a difference in dispersion of the smash motion was observed depending on using the rackets. In addition, some inexperience persons could be close to motions of experience by changing the rackets. Therefore, the result showed that it was very important to select a racket suitable for them.

KEY WORDS: Human motion, Motion capture, Badminton smash motion

INTRODUCTION: Sports are closely related to people. Many professional sports are established, and sport watching is taken root as entertainment. Many athletes are produced for the world, and the public's interest in them is very high. Furthermore, there is great interest in the relationship between sports and health. This is the reason why there is the background factor that the importance of sports and exercise is recognized to maintain our health (Okabe & Yamanaka, 2015). Therefore, many people of a wide age are playing sports in recent years (MEXT, 2013). There are many sports using tools such as rackets and bats among sports. In such sports, choosing a tool is very important. For example, with proper racket for your physical, muscle strength and skill, it make you relaxed and get easy to hit a ball. However, with improper racket, it get hard to control the racket, which might cause to injure. Thus, finding the proper tools for you seems to lead to an increase in competition level.

Previous studies analyzed only the swing motion for professional athletes and students (Hashiguchi & Koike, 2014; Tou et al., 1993). On the other hand, little is known about the influence of difference in tools on the swing motion. In this study, we focus on the relationship between tools and human. The purpose was to analyze the influence of the racket on human motion. The subject of sport was badminton, and the subjects performed smash motion in the experiment because this motion is easy to show the change due to the difference of the tools. An experiment is carried out using three badminton rackets of different mass and gravity center position.

METHODS: The subjects were twelve males (height, 1.72±0.06 m; mass, 63.4±9.3 kg). Six males of the subjects were badminton players from club team of university, the others were beginner at badminton. In the experiment, three badminton rackets of different mass and gravity center position is used. Table1 shows the specifications of the rackets (https://www.wilson.co.jp/badminton/rackets_badminton/; http://www.yonex.co.jp/badminton/racquets/).

Figure1 shows the schematic drawing of experiment setup. Three-dimensional coordinate of 37 reflective markers fixed on the subjects (Pennestri & Valentini, 2010) were obtained with twelve motion capture cameras (Optitrack Flex3**,** 100 Hz). In one experiment, the researcher threw the shuttle, and the subjects hit a smash twice in a row toward the target. This experiment was carried out three times for one racket, and the same was done for three rackets. Furthermore, two more sets of the above series of experiment was carried out by changing the order of the rackets. Their initial position was set to 3.8m away from the target in Y-axis direction. After the shuttle was thrown, subjects can move freely and hit a shuttle. In

accordance with the badminton competition rules, the target was installed at a height of 1.55m from the floor. It is the same height of the net.
To investigate for the influence of the racket on smash motion, the standard deviation (hereinafter called "stdev") of smash motion at the time of using each racket is examined. It is calculated for displacement of the marker of the wrist joint after selecting five data without loss. Only the vertical component is analyzed because it represents the most feature of smash motion. Then, to evaluate the stdev of each racket quantitatively, “the sum of stdev” is used. It is the sum of stdev per unit time (0.01s) in a certain time section.

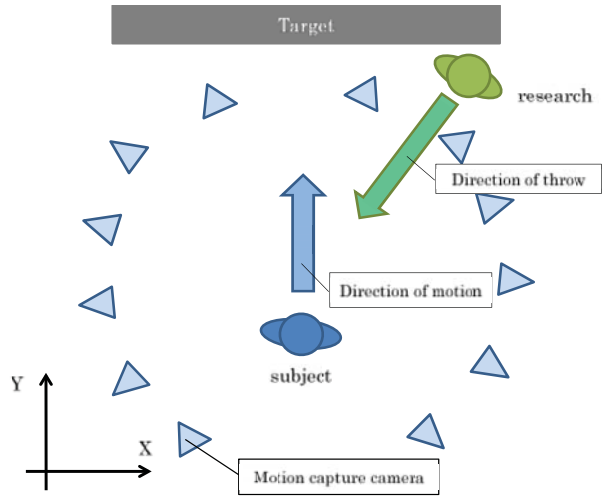


Figure1: Schematic drawing of experiment setup

Table1 Specification of each racket

	A Racket	B Racket	C Racket
Length[m]	0.674	0.674	0.675
mass[kg]	0.083	0.083	0.093
Gravity center position [m]	0.320	0.300	0.285

RESULTS&DISCUSSION: We explain the basic flow of the smash motion in badminton (Kawano, 2016). As an example, Figure2 shows the time history of displacement of a marker of the wrist joint of subject9 who is badminton inexperienced person at the time using each racket. The vertical extension line in Figure2 represents “a moment when he hits the shuttle” (hereinafter called "Impact"). In addition, Figure3 shows the motion posture at each time of smash motion of subject9.
Between 0s and 0.7s, the racket is in a state of being held (Figure3; t= 0s ~ 0.7s). At the time of using B racket, it can be confirmed that the displacement of marker decreases at about 1.5s (Figure2). This is because the subject moves the weight backwards and makes a position to swing the racket (Figure3; t= 0.7s ~1.5s). We refer to this motion as take-back motion. Subsequently, the displacement of marker is rising because subject’s arm is stretched for the impact. This tendency is common to badminton players.
However, the take-back motion is not seen when using A, C racket. It can be confirmed that the racket is swinging up, with the displacement of marker hardly decreasing from 1.0 to 1.5s (Figure2). This tendency is common to other beginner at badminton. As explained above, the smash motion is different depending on using the racket.
To investigate the above phenomenon in detail, the stdev of smash motion at the time of using each racket is calculated. Figure4 shows the time history of the average value of the displacement ± stdev, when subject9 uses each racket. Further, in order to evaluate the swing-up motion, the sum of stdev from the end time of the take-back motion (1.5s) to the time of the impact (2.0s) is used (Figure4). Table3 shows the sum of stdev of all subjects. Subjects 1 to 6 are badminton players and 7 to 12 are beginner at badminton.
Firstly, the stdev of badminton players is explained. When five of them use C racket and the others use B racket, sum of stdev is the smallest. It is considered that this is because the using racket is usually used by them or close to it. On the other hand, it is assumed that rackets with large values of stdev is unsuitable for each badminton player.
Secondly, the stdev of beginner at badminton is explained. Whichever racket is used, it is confirmed that the stdev value is very small from just before the impact (1.9s) to the impact

(2.0s) (Figure4). This tendency is common with badminton player. Additionally, when two of beginner at badminton use C racket, three of the others use B racket and the other use A racket, sum of the stdev is the smallest. This is because the using racket is suitable for them. As an example, when subject9 used B racket, he performs a take-back motion in the vicinity of 1.5s (Figure4). It can be confirmed that the stdev value of take-back motion is small. This is because the B racket is lighter than the A, C racket, subject9 is easy to handle B racket. As a result, it is considered that he can perform the take-back motion stably when using the B racket.

As stated above, changing the rackets causes a difference in smash motion and the volume of stdev. Moreover, there are cases in which beginner at badminton are moving closer to badminton player depending on the racket. Therefore, matching of racket proves to be very important for improvement of exercise capacity.

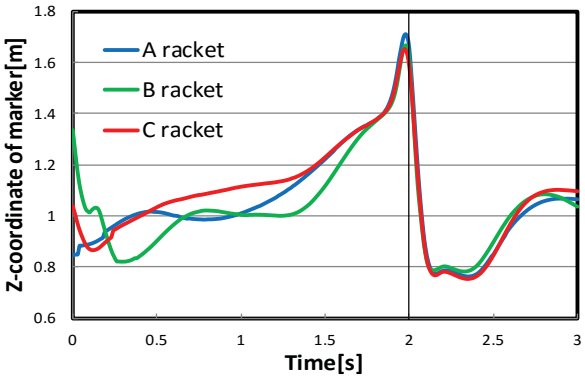


Figure2: Displacement of a marker of the wrist joint (Subject9)

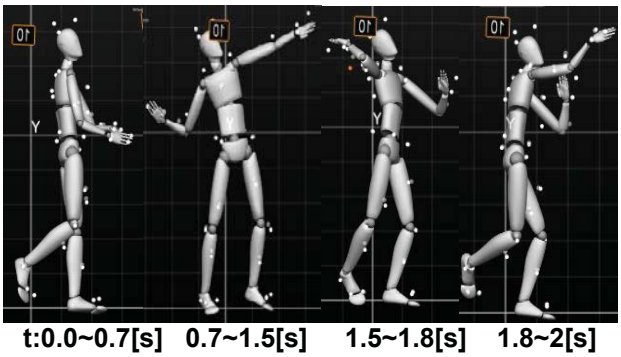
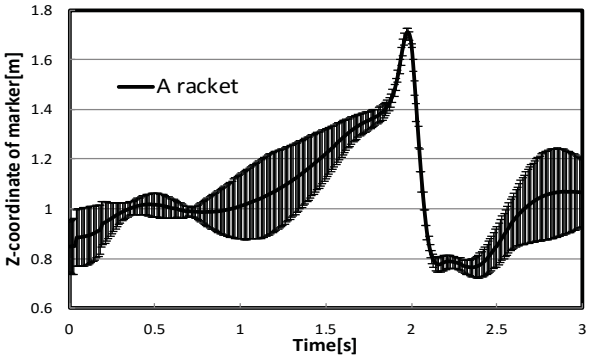
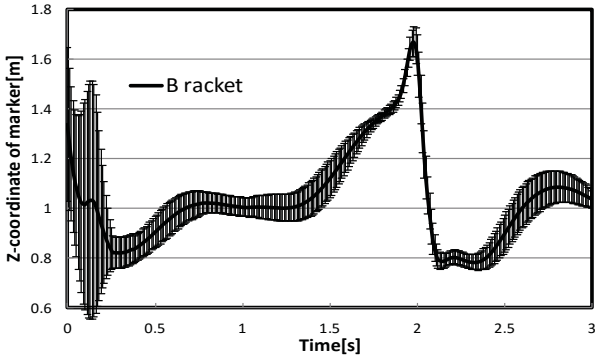


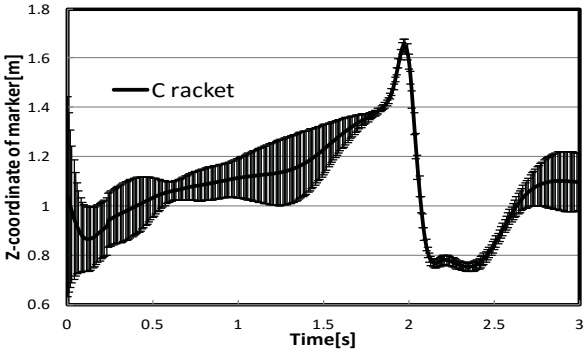
Figure3: 3-DCG of human body(Subject9)

(a) A racket



(b) B racket





(C) C racket

Figure4: Stdev of displacement of a marker of the wrist joint (Subject9)

Table3 The sum of the stdev of each racket

Subject	A Racket	B Racket	C Racket
1	1.794604	1.799890	1.699645
2	2.352890	2.848356	2.010057
3	1.772747	1.477741	1.638807
4	2.255224	2.486193	1.350110
5	2.218269	2.286483	1.729441
6	2.118995	2.411473	1.269655
7	1.723081	2.671071	2.622229
8	1.414950	1.906511	1.301680
9	2.119914	1.329789	2.363826
10	1.219547	1.271470	1.488396
11	1.481511	1.800012	1.402779
12	1.018944	0.727995	1.149735

CONCLUSION: The purpose of this study was to analyze the influence of difference of racket on badminton smash motion. The results of the smash motion at the time of using each racket were compared, and the characteristic of each motion were examined.
As a result, changing the rackets causes a difference in smash motion and the stdev value. Furthermore, the stdev of badminton player has been the smallest when the using racket is usually used by them or close to it. The stdev of beginner at badminton is different depending on the racket. It is considered that the stdev has been the smallest when the using racket is suitable for them. Moreover, there are cases in which beginner at badminton are moving closer to badminton player depending on the racket. Thus, matching of racket proves to be very important for improvement of exercise capacity.
As stated above, it is shown that the most suitable racket could be provided objectively by presenting the sum of stdevs.

REFERENCES:

Hashiguchi, T., & Koike, S. (2014, August). Dynamics analysis of jump-smash-motion in badminton (In Japanese). Dynamics and Design Conference 2014, Japan.

Kawano, T. (2016, August). Influence of racket on human motion during badminton smash motion (In Japanese). Dynamics and Design Conference 2016, Japan.

Ministry of education, culture, sports, science and technology Japan [MEXT]. (2013). Poll on physical fitness and sports [Adobe Acrobat Document] (In Japanese). Retrieved from http://www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2013/08/23/1338732_2.pdf

Pennestri, E., & Valentini, P.P. (2010). Dual Quaternions as a Tool for Rigid Body Motion Analysis, The Archive of Mechanical Engineering, 57, 187-205.

Okabe, S., & Yamanaka, A. (2015, November). Essay of present-day sports: Contemporary sports in Japan (In Japanese). The Bulletin of Nara bunka women's college, 46, 161-169.

Tou, H., Abe, K., & Katoh, K. (1993). Three-dimensional cinematographical analysis of the badminton forehand smash : movent of the forearm and hand (In Japanese). Japan J. Phys. Edus., 38, 291-298.