ANALYSIS OF BADMINTON SMASH WITH A MOBILE MEASURE DEVICE BASED ON ACCELEROMETRY

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A mobile measure device has been developed to measure acceleration of the upper and lower arm segment as well as of the racket. The system consists of three 2D miniature sensors and a PDA that was used to store and transfer data via WLAN. Accelerometric and kinematic data of Badminton smashs of international and national elite Badminton players were collected. The resultant acceleration of the racket showed high correlation with the ball velocity (r=.897). Differences between international and national players can be observed primarily in the mean values and standard deviation of the racket acceleration as well as in the negative acceleration of the lower arm. It is suggested that an abrupt stopping of the lower arm supports the development of high racket acceleration.

KEY WORDS: Badminton, smash, accelerometry

INTRODUCTION:

According to ball velocities badminton is one of the fastest racket sports. For the smash ball velocities up to 250 km/h are reported (Kollath, 1996; Tsai & Chang, 1998). Such high movement dynamics are normally analyzed with high effort by optometric systems such as high speed video. Due to technical limitations (e.g. high amount of light) these measures are often performed in a laboratory setting, which does not comply well with the real competition or training conditions. Alternatively, accelerometric sensors can be used to analyze the performance of the smash. Miniature sensors allow a data collection with a high sample rate and a wide measuring range. Because of the small size and weight athletes are merely limited in their performance (Kemp, Janssen, & van der Kamp, 1998). In sports biomechanics, accelerometric sensors are primarily used to analyze vibration (e.g. Hennig, Rosenbaum, & Milani, 1992, Stroede, Noble, & Walker, 1999) or movements at low velocities (e.g. Bussmann, Hartgerink, van der Woude, & Stam, 2000). For the analysis of high dynamic movements such as the smash a mobile measuring device has been developed. First results of analyses of German and international elite athletes are presented.

METHOD:

Mobile measuring device:

The measuring device consists of three two dimensional miniature sensors (Biovision) that were attached at the upper and lower arm segment as well as at the racket. Each sensor has a dimension of approx. 15x8 mm and a weight of 7g including cable and amplifier. Accelerations within a range of ±50g can be measured with an accuracy <5%. Data are transferred to a portable data logger (COMPAQ IPAQ 5440) where they can be stored or transferred via Wireless LAN to an external computer. The data logger can be fixed in a small backpack at the back of the subject. Sensors were placed at the arm segments near by the centre of gravity in a way that the accelerations following flexion and extension as well as lateral (rotational) movements of the arm were measured. Accelerations of the racket in direction of the smash as well as parallel to the head were measured. While acceleration in direction of the length of the segment and the racket is not directly related to the movement of the segment or racket, this dimension can be neglected.

Data collection:

Data of 7 subjects were collected. One subject was an international elite player. All remaining subjects performed on national level. Subjects performed series of five smashs. Additionally, for 13 subjects accelerometric as well as kinematics data were taken with two high speed video cameras (Redlake) at 250 Hz. These subjects were national elite and youth players.

Data processing:

Maximal values as well as the amount of the racket acceleration were measured for both dimensions separately. Further, the maximum resultant acceleration was determined. A high acceleration of the racket is produced by a (positive) acceleration of the arm segments that is transferred by a kinematics chain due to abruptly stopping the movement (negative acceleration). The amount of the positive and negative acceleration was calculated for the upper and lower arm segment. If kinematics data was available, additionally the ball velocity was determined.

Spearman's rank correlation analysis was used to calculate the correlations between ball velocity and racket acceleration.

RESULTS:

The correlation coefficients between the ball velocity and the acceleration parameters of the racket ranged between r=.659 und r=.897. Highest values were determined for the ball velocity and the maximal resultant acceleration of the racket.

Below, accelerometric parameters of the racket as well as of the arm segments are shown for the international elite player (table 1) and the national elite players (table 2):

Table 1: Selected parameters of the international elite player (N= number of trials)

	N	Minimum	Maximum	Mean	Std. dev.
Max. resultant acceleration of the racket [m/s^2]	5	658,74	757,36	713,63	37,58
Integral of negative acceleration of the upper arm (flexion/extension component) [m/s]	5	5,98	4,75	5,31	,48
Integral of negative acceleration of the upper arm (lateral/rotational component) [m/s]	5	5,07	4,24	4,57	,31
Integral of positive acceleration of the lower arm (lateral/rotational component) [m/s]	5	15,35	16,17	15,67	,34
Integral of negative acceleration of the lower arm (lateral/rotational component) [m/s]	5	4,14	3,77	3,98	,15

Table 2: Selected parameters of 6 national elite players (N= number of trials)

	N	Minimum	Maximum	Mean	Std. dev.
Max. resultant acceleration of the racket [m/s^2]	30	408,35	774,57	533,35	85,48
Integral of negative acceleration of the upper arm (flexion/extension component) [m/s]	30	-4,14	-,58	-2,06	,95
Integral of negative acceleration of the upper arm (lateral/rotational component) [m/s]	30	-5,85	-,66	-3,09	1,55
Integral of positive acceleration of the lower arm (lateral/rotational component) [m/s]	30	9,59	16,30	12,15	1,91
Integral of negative acceleration of the lower arm (lateral/rotational component) [m/s]	30	-2,01	,00	-,96	,51

DISCUSSION:

About 80% of the variance of the ball velocities can be explained by the acceleration of the racket. Therefore, this parameter can be used as an indicator of smashing performance. It is suggested that the remaining 20% might be explained by a non-optimal contact of the ball on the racket.

In comparison to an international elite player national Badminton players achieve lower mean racket acceleration. On the other hand the maximal value of all trials can be found in the group of the national players. More interesting, the standard deviation of the international player is nearly half of the value reached by the national athletes, even if compared to individual performances. This can also be stated if the ration of the racket accelerations in both dimensions is considered. Therefore, an international elite player can be characterized primarily by a higher stability of performance. Further differences can be observed for the negative acceleration of the lower arm segments that characterizes the transfer of movement energy on the racket.

CONCLUSION:

Based on the first analyses, the mobile measure device based on accelerometry seems to be a promising approach for the analysis of highly dynamic movement such as Badminton smashs in competitive or training conditions. Further work is required to validate the device as well as to extract crucial parameters of smashing performance. A high acceleration of the arm segments is necessary to achieve high accelerations of the Badminton racket. So far, it seems that also the abrupt stopping of the lower arm is an important feature to enhance performance.

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