Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 January 2021 doi:10.20944/preprints202012.0654.v2

An Experimental Research on Microseismic Monitoring Technology in Detecting the Contact Time of Badminton Amateurs' Lunge

Yang Yang
Department of PE
Beijing Jiaotong University
Beijing, China
yyang1@bjtu.edu.cn

Yingchun Cui*
Department of PE
Beijing Jiaotong University
Beijing, China
ychcui @bjtu.edu.cn

Wenfa Yan
Department of PE
Beijing Jiaotong University
Beijing, China
yanwenfa@bjtu.edu.cn

***Abstract*—The fast and flexible characteristics of badminton determine the necessity of a sports action, the lunge. Fast lunge has an important impact on the results of the game in actual combat. In lunge evaluation, the contact time to the ground is a key indicator. In this paper, two middle-aged male badminton amateurs with similar body shape and age are selected as the research objects. They have different skill levels so as with the contact time. The microseismic equipment is used to record the floor vibration caused by the running of the two badminton amateurs in sports. The microseismic signals of lunge are processed and analyzed by MATLAB software. And we evaluate the pro and cons of various time to touch the ground from amateurs with different skill levels. The research found that 1) Microseismic technology can detect the contact time to the ground in sports. 2) High-level badminton amateurs have obvious advantages in the footwork contact time. Microseismic technology has a certain feasibility as a tool for evaluating the footwork contact time of badminton.**

Keywords-badminton; amateurs; lunge evaluation; contact time; microseismic; feasibility

I. INTRODUCTION

As early as 2009, the survey data of the Group Department of the State General Administration of Sports showed that badminton ranked the second most popular sport among Chinese people, second only to brisk walking. In 2016, the data still showed that badminton is the second most popular sport. According to statistics released by the Table Tennis and Badminton Center of the General Administration of Sports of China, there are 250 million people playing badminton in China. It can be said that the badminton has a broad mass basis. Badminton also has the reputation of being the fastest racket sport in the world. This sport is an action with complex movements and strong technicality. With the increasing development of badminton, it is not only more abundant in content, but also the increasing difficulty of the action. The basic techniques of badminton can be roughly divided into two categories: the technique on hand and the lunge. Athletes will make quick, flexible, and changeable lunge conversions on the court according to the shuttle coming from the opponent, so that they can return the shuttle in the most reasonable way in time. If the athlete's lunge is poor and cannot be in the right place on time, it will affect the accuracy of the stroke, and even fail to receive the shuttle which resulting difficult use of the best shot technique. Even with the best stroke technique, it is difficult to use it without the good lunge. This shows the importance of lunge in badminton.

Therefore, as an important part of badminton theory and technology, badminton lunge should attract the attention of coaches, athletes, amateurs and scientific researchers. The attributes of badminton lunge include contact time, step length, the force between the foot and the ground, and the angle of the joints. Among them, contact time is a critical indicator. From the moment a foot just touching the ground to completely leaving the ground, the time spent in this process is defined as the contact time. Depart from the badminton sport, the contact time has also received extensive attention in the dynamic function research of various running sports. The average runner's contact time may be 300 milliseconds, and most amateur runner's contact time reaches 220-240 milliseconds, which is considered in a good level. The elite runner's contact time can be controlled within 200 milliseconds, or even 150 (or less). Jamaica's runner Usain Bolt contact time reached a staggering 78 milliseconds.

The more common systems for the contact time research include multi-parameter sensors placed on footwear, motion capture systems, pressure plates, high-speed camera systems, etc. The recording, analysis and evaluation of badminton lunge is an effective way to improve the badminton theory, technical system, as well as the quality of training. The existing badminton lunge acquisition and recording methods mainly include wearable sensors and high-speed cameras. Weeratungai et al. used high-speed cameras to extract the athletes' frequent movement trajectory information on the badminton court [1]. The British Mark King team used a motion capture system including 18 cameras to record the three-dimensional movement data of athletes, rackets and shuttles [2]. The Malaysian Azmin Rambely team used video analysis methods to analyze the contact time and take-off height selection of badminton players in the process of jumping and killing [3]. The Lin Hengwen team analyzed the characteristics of the use of asynchrony in badminton using video analysis methods [4]. King Zhelong et al used wearable sensors to form a network to analyze the asynchrony in badminton [5]. Chen Qi et al. used wireless sensor network to collect pace data to improve training effect [6]. In other sports, many scholars used wearable sensing devices and high-speed camera equipment to collect and evaluate athletes' sports data. Wang Yufan team reported the use of wearable sensing devices to assess the technical level of volleyball players [7]. Lee et al. used a motion capture system composed of 16 inertial sensors to track whether the rider's movements were standard and established a database of motion characteristics for the rider. Analyze and instruct the movements of [8], Basilio Pueo et al discussed the motion capture application of high-speed camera equipment in sports events [9]. The Wing-Kai Lam of the Li-Ning Sports Science Research Center was based on a synchronized force measurement platform and motion analysis system, which deeply analyzed the lunge attributed of badminton players, and showed that the contact time of skilled badminton players was better than that of unskilled badminton players [10].

The wearable sensors or high-speed camera motion capture systems currently in use provide powerful assists for the analysis of the contact time and can clearly and accurately reflect the athlete's lunge attributes. But there are also some shortcomings for wearable sensors, no matter how light wearable sensors are, it will always interfere with the performance of athletes to a certain extent, and the sensors are only suitable for training and intra-team sports analysis. It is impossible for athletes to wear sensors during the match, and it is also impossible for the opponents to wear sensors and share data. The disadvantages of high-speed camera systems are high cost, inconvenience to carry, and are greatly restricted by practical factors such as size of the field and line of sight. In view of the above shortcomings, this paper proposes a method in detecting the contact time of badminton amateurs' lunge using Microseismic monitoring technology. This method has the advantages of high accuracy, convenient deployment, no impact on the line of sight, and will not affect badminton players.

II. Research Objects and Methods

2.1 Research Objects

Two middle-aged male badminton amateurs with similar body shape and age were selected as the research objects. The details of them are as below. Badminton amateur A: height 178cm, weight 75kg, 44 years old; and badminton amateur B: height 179cm, weight 76kg, 49 years old.

2.2 Experimental Methods

(1) Experimental Equipment

The microseismic monitoring system used in this article is the Meridian Compact PH compact broadband microseismic all-in-one machine made in Canada, including a microseismic sensor and a collector. The physical map of the system is shown in Fig. 1, and the preparation process is shown in Fig.2. This system has self-power supply function, after charging in the laboratory, the system can work normally for several days. The microseismic sensor is easy to install, does not need to lock or center, and has a special small size and self-adaptive leveling system, which can significantly reduce the time and physical effort required for preparatory work and installation.

Fig. 1: Microseismic system

Fig. 2: Preparation in the laboratory

The microseismic sensor used in this experiment has higher sensitivity and a larger range than the conventional microseismic sensors. Once the sensor is set up, it will begin to establish its own meta-data. The integrated design of the data acquisition and microseismic sensor unit can ensure the continuous and high-quality data. The good performance of the instrument forms a good base for the success of the experiment.

(2) Experimental method

In order to study the difference in the contact time of the amateurs, the experimental plan is as follows: An ordinary badminton court is used as the test site, and a fixed measuring point is set as shown in Fig. 2. Badminton amateur A and badminton amateur B stand separately at position 17, according to their own exercise habits, following the order of running to position 4, position 5, position 6, position 18, position 12, position 11, position 10, and then return to position 17 each time. The design of this movement mode takes into account the range of the athletes in the game, which can truly represent the scene of the game. In order to ensure the consistency of the movement distance of the two subjects, a badminton was placed in each target position, and the touch of the badminton with their hands was taken as the standard of moving in place. During their action, their movement causes the vibration of the floor, which is transmitted to the position of the microseismic sensor through the floor and received by the monitoring system. Microseismic signals are recorded in the monitoring system. In order to ensure the stability of the experiment, each subject has carried out several experiments.

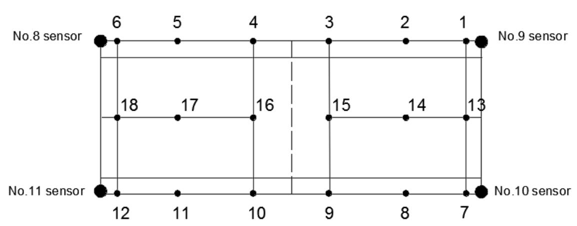

Fig. 2 Schematic diagram of the actual measurement plan of the contact time

Fig. 3 Amateur A

Fig. 4 Amateur B

2.3 Microseismic Data Analysis Method

This microseismic data processing is mainly through MATLAB signal processing and visualization modules. The analysis method is based on the classic parameter analysis method of microseismic and acoustic emission signals [11], as shown in Fig. 5. The amplitude of the vibration signal caused by lunge first increases and then decreases. Starting from the contact with the feet and the floor, the amplitude increases rapidly to the maximum, and then decreases slowly under the effect of damping. The amplitude of vibration reflects the change of energy with time. We perform ring counts based on footwork as the indicator, and extract them from the microseismic data of lunge. The ring counts is the number of times that the microseismic signal waveform exceeds the set threshold.A threshold value is set as the standard of ringing. If the amplitude of a certain vibration period exceeds the value, a count is made. The number of rings in Fig. 5 is 7, that is, the number of times that the threshold is exceeded is 7.

In this test, the sampling rate is the same, and the ring counts of the microseismic waveform signal has a close positive correlation with the signal duration. If the lunge is dragging, the ring counts of the lunge vibration is high and the contact time is long. if the lunge is fast, the ring counts of the lunge vibration is low, and the contact time is short. So, obviously, the ring counts can reflect the contact time between the athlete's foot and the floor. Contact time reflects the moving ability of athletes, and then the ring counts can reflect the technical level of athletes, and can also provide quantitative indicators for daily training.

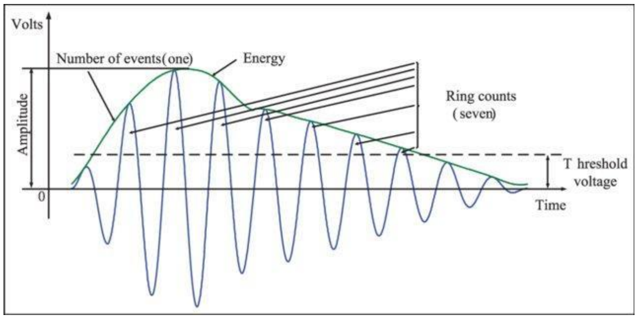

Fig. 5 Schematic diagram of the basic method of microseismic signal analysis

III. RESULT

The measured lunge vibration data of badminton amateur A and badminton amateur B are processed by MATLAB. Six typical time histories are selected to calculate the ring counts of each lunge. The ring counts of each sample function are shown in Table 1. The ring counts of the two amateurs are 1695.8 and 2592.5 in average respectively. It can be seen that the average ring counts of badminton amateur B is 34.59% longer than that of badminton amateur A.

TABLE I. THE LUNGE OF TWO AMATEURS AND THE 6 MEASURED CONTACT TIME DATA

Amateur	**Ring counts**						
	1	***2***	***3***	***4***	***5***	***6***	***Average***
A	1357	1758	1101	2169	1658	2132	1695.8
B	2695	2636	2523	2333	2336	3032	2592.5

Comparing the ring counts of the two badminton amateurs in each experiment, the ring counts of badminton amateur B is significantly higher than that of badminton amateur A. It is speculated that the lunge of badminton amateur A is relatively faster and has a shorter contact time, while B is more procrastinated and has a long contact time. If in the same game, for B has a longer contact time for each step, B's lunge time consumption is significantly higher than that of A under the same circumstances. In the game, this means that B has less time to prepare and hit the badminton, and even loses points for he can't touch the badminton. Even if he can fight back, it is possible to reduce the quality of hitting because the action is not in place. Comparing the experimental results, the lunge level of badminton amateur A is higher than that of badminton amateur B, which is basically consistent with the results of daily training and competitions. It can basically be confirmed that the microseismic method is feasible to evaluate the badminton ground contact time and then evaluate the level of the amateurs.

IV. DISCUSSION AND CONCLUSION

In this paper, we collect and analyze the micro-seismic data of the lunge of two badminton amateurs. The results show that there is a significant difference in contact time for badminton amateurs of high and low levels, and the lunge of high-level amateurs is faster. This result is basically consistent with the results and empirical judgments of daily training and competitions. It can be considered that the microseismic method provides a new tool for the lunge evaluation research of badminton technical statistics, and we look forward to further research.

This is a new method to quantify the footwork contact time of badminton players. By analyzing the vibration signal produced by the contact between the feet and the floor when the subject moves, the movement speed of the player is measured. The ring counts in vibration signal analysis is used to quantify the contact time, which provides a new idea for the study of contact time. The results of data analysis show that there is a significant correlation between contact time and ring counts. This shows that the indicators used in this paper can reflect the moving speed of the subjects, and then reflect their technical levels.

This method can help badminton athletes and amateurs to improve their technical levels. In the process of training and competition, if the vibration signal of the floor is collected by the microseismic monitoring system, and the movement speed of athletes can be quantitatively described by calculating the ring counts. The quantitative indicator of contact time can make players have a clear understanding of their own movement and direction changing speed, and then improve the movement. In addition, Long term monitoring can make athletes understand the change process of their movements, and then make targeted improvements in training.

It should be noted that this method is not only suitable for badminton, because many other sports also have the need to quantify the contact time between feet and floor. Therefore, it is natural to extend this method to other sports. In addition, besides the contact time, the vibration signal caused by the footwork of players can also provide other information. Using microseismic system to monitor floor vibration may analyze athletes' technical movements from other perspectives. It shows that microseismic monitoring and analysis have the potential to provide more comprehensive support for athletes' training and competition data analysis.

ACKNOWLEDGMENT

The authors wish to thank the reviewers for their comments help to improve this paper. In addition, the supporting of the staff of Beijing Jiaotong University gymnasium is also appreciated.

REFERENCES

[1] Kokum Weeratungai, Anuja Dharmaratne, Khoo Boon How, "Classification of spatio-temporal data represented as multiset for tactical profiling in badminton". 2nd International Conference on Image, Vision and Computing, 2018

[2] Mark King, Harley Towler, Romanda Dillon and Stuart McErlain-Naylor, "A correlational analysis of shuttlecock speed kinematic determinants in the badminton jump smash". Appl. Sci. 2020, 10, 1248. doi:10.3390/app10041248

[3] Rambley A S, Abas Wabw, "Contact time and take-off speed relationship in determining height of jump in jumping badminton smash" ISSN-Conference Proceedings Archive, 2008.

[4] Lin H W, Huang K S, Pan K M, Tsai C L, "Biomechanical analysis of badminton different forward steps" ISBS-Conference Proceedings Archive, 2015.

[5] Wang Z, Guo M, Zhao C. "Badminton stroke recognition based on body sensor networks" IEEE Transactions on Human-Machine Systems, vol. 46, pp. 769–775, 2016.

[6] Qi C, Wei H, Xiao S M, et al. "Development of Wireless Sensor Network for Data Collection and lunge Training" Procedia Engineering, vol.34, pp. 520–525, 2012.

[7] Y F Wang, Y L Zhao, Rosa H. M. Chan, and W J Li. "Volleyball skill assessment using a single wearable micro inertial measurement unit at wrist". IEEE Access. 2018, doi: 10.1109/ACCESS.2018.2792220

[8] J. Lee. "A three-dimensional motion analysis of horse rider in wireless sensor network environments" International Journal of Advanced Computer Science and Applications: 2014, vol. 5, pp. 50–55, 2014.

[9] Basilio Pueo. "High speed cameras for motion analysis in sports science" Journal of human sport & exercise , 2016. doi:10.14198/jhse.2016.111.05

[10] Lam W K, Lee K K, Park S K, Ryue J, Yoon S-H, Ryu J "Understanding the impact loading characteristics of a badminton lunge among badminton players" PLoS ONE vol. 13, 2018.

[11] Jiang K, Han L, Zhou Y, "Quantitative evaluation of the impurity content of grease for low-speed heavy-duty bearing using an acoustic emission technique" Measurement and Control. vol. 52, pp.1159-1166, 2019.