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The Use of Intelligent Racket to Objectively Measure Abilities of a table Tennis Player with an Intellectual Impairment: A Case Study

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Abstract

The purpose of this case study was to measure abilities of a table tennis (TT) player with an intellectual impairment (II). The intelligent racket was used to objectively evaluate powerful forehand smash swing and forehand topspin movements. A 27 year-old TT player who competed in the international II championships was tested in the classification room by two international TT classifiers. The testing results in the classification sections including service, return service and basic skills were 26, 24, and 30, respectively. His score in this TT-specific test for II was 80 points out of 108 points. In addition, the average efficiency of forehand smash and topspin movements were 0.12 ± 0.02 and 0.03 ± 0.01. The decay of 27 swings in forehand smash and topspin was 19.29% and 10.25%, respectively. Offering the objective and extensive data may provide the useful evidence to confirm the abilities of this TT player with II. This case study clearly demonstrated that combination of classification testing data and swing tests evaluated by the intelligent racket was the useful approach to evaluate the abilities of TT players with II. More data collection and analysis for players with II is recommended to ensure the dual tests in classification for II in the future.

Keywords: Intelligent Racket; Intellectual Impairment; Classification; Objective Measurement; Table Tennis

Abbreviations: PFSM: Powerful Forehand Smash Movements; PFTM: Powerful Forehand Topspin Movements; TT: Table Tennis

Introduction

People with intellectual impairments (II) should have rights to participate in physical activities and sports. However, sporting opportunities for elite athletes with II are slightly restrictive than people with physical impairments and visual impairments in the Paralympic Games and hearing impairments in the Deaflympic Games because currently only three sports, athletics, swimming and table tennis (TT) have included for elite athletes with II at the Paralympic Games [1]. Thus, the development and promotion of athletes with II in fair sporting competition have been the main issue announced by VIRTUS, which is the official International Federation for athletes with II and International Paralympic Committee which is the governing body for the Paralympic Games and elite sports for athletes with impairments [1,2].

Classification for athletes with II has been discussed by several studies to avoid intentional misrepresentation by the able-bodied athletes in sporting competition which should be for real II athletes [2,3]. Particularly, the objective evidence and measurement has be proposed for a decade [3]. Thus, we recommend a new approach to measure the sport-specific abilities of a TT player with II objectively and scientifically using the modern sport technology. The purpose of this case study is to compare the classification results with the evaluation of the intelligent TT racket to clarify whether the intelligent racket is a sport-specific tool to measure the abilities of a player with II. Particularly, two essential TT skills such as swing movements in powerful forehand smash and topspin related to TT performances are measured, instead of only the powerful swing in forehand smash in the previous studies [3,4].

Review of Literature

Players with II have been allowed to compete since the 2012 Paralympic Games. After the scandal occurred in the 2000 Paralympic Games and identified later, athletes with II had been suspended to compete at the 2004 and 2008 Paralympic Games. The main problem for athletes with II was to identify whether they fit the classification criteria to confirm their true II status and prevent able-bodied players pretending II in the Paralympic programs in order to maintain the fairness of competition [1,2]. Recently, Sheu and Wu proposed that objective measurement in sport-specific classification needs to be launched in Paralympic sports to protect the real II and to identify intentional misrepresentation by providing more objective evidence [3]. They emphasized that sport technology has progressed well in the recent years and proper technological and scientific tools can be used to measure abilities of athletes more precisely [3-6].

In 2019, Sheu and colleagues developed a breakthrough TT racket to detect the movements of TT swing, speed, acceleration in real time by using the IMU sensor which includes a 3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer and Micro Electromechanical Systems sensors in the TT handle of the intelligent racket [3,7]. After proper assessment of the intelligent racket in the past few years [3,8,9] the measurement concepts have been much clearer for further explanations of athletes' abilities in para-TT [4]. A few case studies have been reported internationally to prove the usefulness and validity of the intelligent TT racket [3,4]. However, there are two significant limitations of the intelligent racket to measure TT specific skills with precise explanations. First, the database is restricted because small samples of para-TT players in national and international levels have been evaluated. Second, no study has examined the players with II to show whether the testing results from the intelligent racket are useful to identify players with II, and limited evidence to show the abilities from the TT-specific test [2]. Tweedy and his colleague strongly suggested that every sport in the Paralympic Games must have solid classification systems and scientific evidence to support the foundations of its sport classification [10,11]. This approach is fully supported by the International Paralympic Committee [11].

Methods

A 27-year-old male player with II agreed to participate in this case study. He passed the general eligibility criteria evaluated by examiners by VIRTUS. Later, he asked for classification in TT to confirm whether he is eligible as a player with II. He has played TT for over 8 years. His average training with a qualified coach is 6 hours per week (2 hours per training section and 3 training times per week). He has been in national championships for 4 years. He went to international classification in June 2023 to confirm his eligibility for competition by two international TT classifiers. After classification, he agreed to participate in TT-specific swing tests by using the intelligent racket [3,9]. He and his escort also signed the consent form to understand the testing process.

The swing tests in this study included two parts: powerful forehand smash movements (PFSM) and powerful forehand topspin movements (PFTM). The player needs to conduct 27 times of PFSM [3] and PFTM, respectively, after the proper warm-up and practice to be familiar with the tests. Due to the familiarity of the PFSM and PFTM, the player was shown the swing pattern when he practiced to ensure that he fully understood the movements. We started to test the PFSM which usually took about 15 to 20 seconds for players to complete it. After 3 minutes rested, next PFTM was evaluated. The testing procedures followed the previous study [3] which tested players with physical impairments.

Data collection included two main parts in this study, First, the training information and TT-specific test in classification were collected. Second, PFSM and PFTM were collected and transformed into efficiency results for further analysis. Before analysis, the first and last swing movements were excluded to prevent extra errors. In this study, the swing efficiency is defined as the displacement of each swing divided by time. Generally, the higher the score, the better the efficiency. In addition, we calculated every five swing movements and averaged the efficiency. Thus, we reported average E1 to E5 to cover the 25 swings. Finally, the efficiency decay is calculated by [(E1-E5)/E1]*100% in this study. Also, variance of efficiency was calculated by the formula of (standard deviation/mean)*100%.

Results and Discussion

The main testing results included two main parts. First, the classification results showed that the II player has the service, return service, basic TT skills and total scores were 26, 24, 30, and 80, respectively (Table 1). Those data revealed that this player was in the middle level in terms of performance.

Regarding the testing results of intelligent racket for this player, his playing patterns of PFSM and PFTM in Z axis were shown in (Figure 1). Generally, this playing style is consistent based on the curve types in forehand smash and topspin movements. The data of Z axis is more related to functions of forehand forward speed and acceleration which are very important to affect the abilities of the table tennis player [3,9].

When we calculated each efficiency and then transformed to E1 (swing 1 to 5), E2 (swing 6 to 10), E3 (swing 11 to 15), E4 (swing 16 to 20) and E5 (swing 21 to 25). The results appeared in (Figure 2) & (Table 2). We also revealed the data of efficiency decay and variance of efficiency in Table 2. Clearly, this player was higher in efficiency of PFSM than PFTM in E1 to E5. This demonstrated that he had better performance in powerful smash than powerful topspin. When we observed how this player performed during competition, he preferred to use the defensive style instead of attacking. When he had the good chance to attack a ball, he chose to smash instead of making a powerful topspin. This style may be less appeared in the elite able-bodied players because usually playing topspin for most elite players is more controlled a ball on the table.

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Table 1: Scores of TT Specific Test in a Player with II.

Items	Service	Return Service	Basic TT Skills	Total Scores
Score	26	24	30	80
Max score	36	36	36	108

Table 2: Efficiency of PFSM and PFTM and Related Parameters.

	E1	E2	E3	E4	E5	ED*	Variance
PFSM	0.14±0.02	0.12±0.01	0.11±0.01	0.10±0.02	0.11±0.02	19.29%	13.01%
PFTM	0.03±0.01	0.03±0.00	0.03±0.01	0.04±0.00	0.03±0.01	10.25%	11.95%

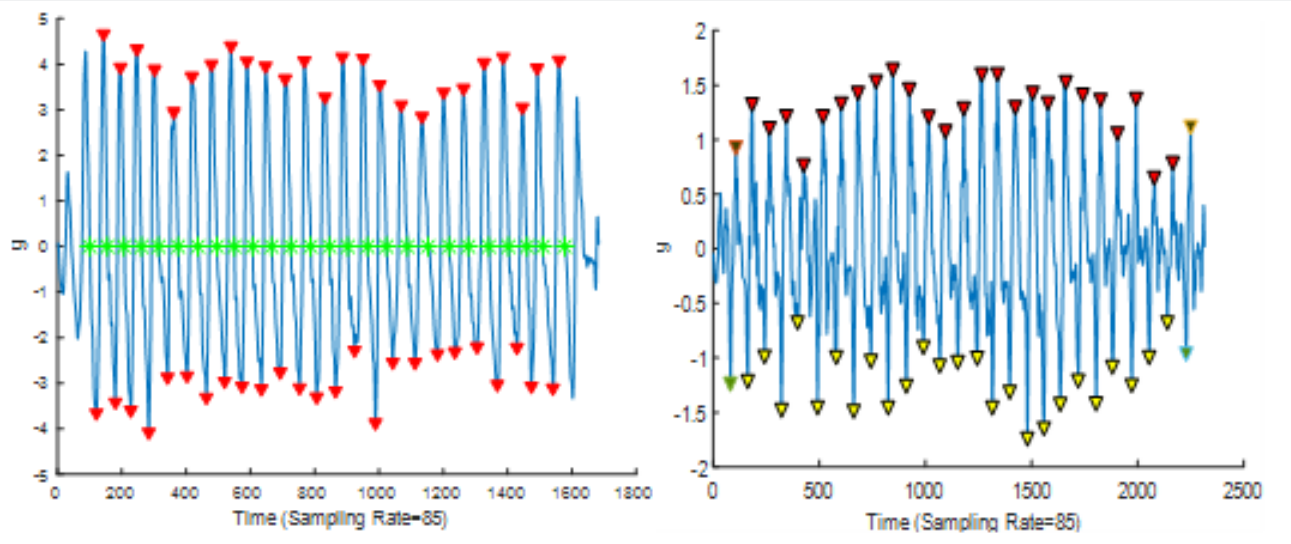

Figure 1: The PFSM (left side) and PFTM (right side) Patterns in Z axis in a Player with II.

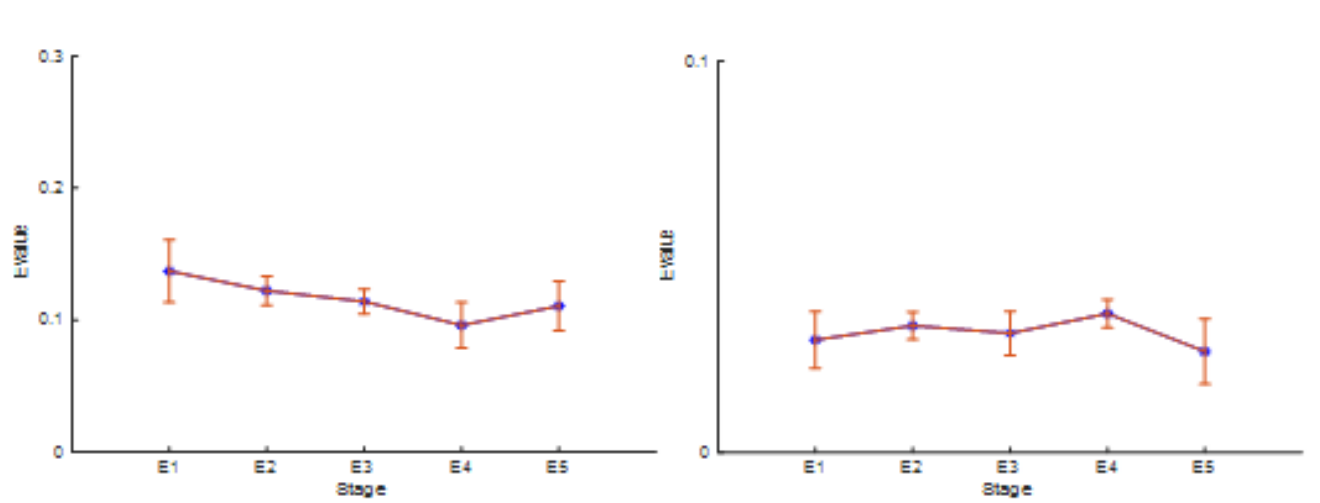

Figure 2: Efficiency Decay of PFSM (left side) and PFTM (right side) in a Player with II.

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When the testing results in classification, intelligent racket, and observation during competition were compared (Tables 1 & 2), this player shown the similar playing styles, strengths and weaknesses in TT skills consistently. This also matched the criteria of TT players with II in the classification rules of International Table Tennis Federation. TT players with II must show weakness of 3S (speed, spin, spot) and 3C (control, consistency, change) during playing [2]. Combination of above evidence, the eligibility of this player with II has been confirmed clearly. We are highly confident that his classification status as an II player can be ensured without any doubts.

We notice that this case study is the first study in the world to combine the intelligent racket and real classification. The empirical data provide promising evidence in classification for TT players with II. In this study, however, we have two significant limitations. First, this is a case study to examine a clear II player in TT. We cannot compare his data with other players with II, although we had evaluated some wheelchair TT players in the previous study [3,9]. Second, can we still evaluate II players correctly if players with borderline level such as mild II or players with severe II? This will be an important issue that needs to be answered before this scientific approach is widely applied internationally. Indeed, we recognize that more objective and scientific data for different levels of players with II needs to be collected to extensively identify the usefulness of the intelligent racket or other sport technologies. However, this milestone for TT classification must go through the initial challenging stage to prove the evidence-based classification proposed by researchers for different sports [11-13].

Conclusion

In this case study, we demonstrated that the intelligent TT racket with the PFSM and PFTM tests were useful to evaluate the abilities of a player with II and confirm his eligibility for competition. Combination of classification data and competition performance, the II status of this player will be confirmed without any doubts. Although this is only a case study, the related testing procedures, testing results for interpretation and connection of classification tests and intelligent racket tests may be useful for future studies and II classification applications. We suggest that more participants with II are needed to evaluate the validity of the tests and to distinguish the different levels of II players. Additionally, the establishment of database and artificial analysis in classification related tests is urgently essential in order to identify real II players to participate in national and international events fairly and also prevent able-bodied players from competing in para-TT.

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