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Application of Technology in Precision Measurement of Players with Impairments: True Abilities or Intentional Misrepresentation

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Abstract

The purpose of this short article is to propose the technological support in para sports, especially in classification, to provide the objective measurement to make right classification decisions, to test real abilities of athletes with impairments to reduce the numbers of borderline players and prevent intentional misrepresentation. The intelligent table tennis racket (ITTR) is developed and proposed to use as the objective measurement of related-table tennis skills in the para table tennis classification. ITTR is a valid and reliable instrument to measure the speed, swing efficiency and pattern of the powerful forehand stroke. The useful approach can provide essential evidence for the future classification and the progressive development of para sports.

Keywords: Intelligent racket; Para sport; Classification; Objective measurement; Technology

Introduction

In Para sports, athletes with impairments need to go through classification in order to receive classes and attend fair competition [1]. However, when table tennis (TT) athletes with intellectual impairments (II) or physical impairments (PI) are in borderline areas in terms of their impairments are closed to the minimal criteria or athletes may not reveal their potential and abilities and may pretend cooperation in classification (i.e., intentional representation in classification) [2]. The difficulties of providing fair and objective classification results may appear in many para sports. Thus, without proper objective measurement of classification in para sports, especially in the sport-specific approach, unfair competition may be observed sometimes during matches. This means that athletes may take an advantage on purpose or be in disadvantage by the unfair classification evaluation.

In the recent years, technology applied in several sports has become popular [3,4]. For example, an application of artificial intelligence in video analysis of performance during matches [5,6] or scientific measurement of physiological and biomechanical profiles in athletes with II or PI are often seen in the world-wide publications [7,8]. Combination of science and technology in specific able-bodied or para sport for elite athletes is essential in training and competition [3]. Many countries devote plenty of resources trying to win medals in Olympic and/or Paralympic Games.

In this short article, we would like to share the technological knowledge of intelligent table tennis racket (ITTR) and how to apply it to the able-bodied and para table tennis field. Particularly, this important task will help the international sporting federation to consider the breakthrough step to apply in training and classification for table tennis players with II and PI and also help to achieve objective measurement in table tennis classification for players with II or PI.

Intelligent Racket: Measurement Concept and Application

Under the support of "precision sport science project" by the Ministry of Science and Technology in Taiwan, Sheu and colleagues developed the ITTR with current technology in 2019 [4,9,10]. One inertial measurement unit (IMU) sensor is set on the inner handle space without significantly changing the weight of the ITTR. A force sensitive resistor (FSR) sensor is embedded between the wood and plastic of the TT racket to sense the position of the hitting point on the racket. The IMU sensor includes a 3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer which are MEMS (Micro Electromechanical Systems) sensors. The IMU and FSR sensor data are gathered into a low power consumption microcomputer (Cortex-M3 series) and all data are transmitted to the computer by high-speed 2.4G RF module [9,10]. One 2.4G RF module is connected to the microcomputer and the other 2.4G RF module is embedded in the USB Dongle plugged to PC host, so as to build an innovative internet of things (IoT) TT system.

Using the ITTR, the hitting position, speed, efficiency, wrist stability, strength and explosive force parameters of table tennis (TT) are recorded and analyzed [11,12]. The breakthrough TT equipment for able-bodied TT and para-TT may enhance the levels of training and increase the precise measurements in players' performances and abilities. They suggest that ITTR can be useful for para-TT classification. Theoretically, the higher the class in wheelchair or standing players, the faster speed and higher power in forehand and backhand strokes. Even though this technological support in para-TT is still in the early stage for wider application, the related testing methods have been developed and evaluated for players with PI in a case study [12]. Thus, if the concept of ITTR is exploratory application project, the database of testing results for II and PI should be developed solidly in order to identify eligible para players more precisely.

Objective Measurement in Classification is Urgently Needed

Classification for TT players with II include three main parts: sport intelligence test (i.e., cognitive test), TT-specific test, and observation during competition [13]. The TT-specific classification system for players with II is more based on the framework of 3S (speed, spin and spot) and 3C (control, consistency and change) principles. When the 3S & 3C principles have been transferred to the practical test to evaluate an athlete whether he or she reaches the minimal impairment criteria and TT-related criteria, a series of testing parts (i.e., service, return service, basic TT skills and control test, short match, and/or advanced test) (Table 1) and observation during competition are conducted by authorized international TT classifiers [1,2,13]. Though the processes have been standardized since 2010 and over 200 hundred players have been classified by the system, only one empirical study has proved that the general credibility of the TT-specific test for most II players was valid and useful [2]. In addition, when the main components were used to classify borderline players, 8 out of 87 players were reaching the category based on the proposed testing results and main cut-off criteria in two components (Table 2) [2,13]. Regarding the test for players with II, the fundamental problem is the quantification of each testing item related to TT skills. The scoring category in each testing item of "basic skills and control" is None, Poor, Reasonable and Good, and then is transferred to 0 to 3 points, respectively. Practically, this approach may be acceptable in the previous period because no precision equipment was used to directly measure the essential and functional TT skills, such as forehand and backhand strokes in order to collect and quantify the objective data. Scientifically, this transformation from the ordinal category to the detailed numbers for further statistical analysis may be problematic and unpersuasive. Offering number in testing items cannot be recognized as an objective way [14]. On the other hand, international classifiers rely on their experience, discussion, observation and video recording and brief analysis to decide whether players are eligible after the complete classification process. Logically and scientifically, the whole quantitative process to complete the international classification card may not be solid enough to evaluate players in terms of their true functional abilities. Thus, when a player without II may try to fool classifiers, they may show certain international representation behaviors in classification, or a borderline player with II may not reach the minimal criteria, this becomes an ambiguous issue whether the current classification process and measurement can provide objective and signification evidence to support it in order to keep classification accurately. Classification should offer an opportunity for real players with II to complete fairly [1].

Table 1: Testing items in TT-specific test for players with II.

Testing Items in Service	Definition for Scoring (0-36 points in testing)
1. Long Back Spin to Backhand	0: wrong service and wrong location of the ball or missed the service.
2. Long Back Spin to Forehand	
3. Short Back Spin to Backhand	
4. Long No Spin to Body	1: poor control in service or poor location of the ball.
5. Fast Ball to Forehand	
6. Long Side Spin to Backhand	2: good control in service and good location of the ball. Each testing item has tested for three times.
Testing Items in Return Service	**Definition for Scoring (0-36 points in testing)**

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1. Long Back Spin to Backhand	0: wrong control in stroke and miss the ball. 1: poor control in stroke or poor location of the ball. 2: good control in stroke and good location of the ball. Each testing item has tested for three times.
2. Long Back Spin to Forehand	
3. Short No Spin to Forehand	
4. Long Top Spin to Forehand	
5. Fast Ball to Backhand	
6. Long Side Spin to Backhand	
Basic Skills & Control Items	**Definition for Scoring (0-36 points in testing)**
1. Forehand Stroke & Rally	None: wrong stroke and cannot control the ball on the table. Poor: poor stroke and/or may not consistently control the ball on the table. Reasonable: may do the stroke and/or reasonable control of the ball on the table. Good: good stroke and good control of the ball on the table. "None, Poor, Reasonable, and Good" are transferred to scores for further calculation, they are 0, 1, 2, and 3 points, respectively. Each testing item needs to be conducted for several repetitions.
2. Backhand Stroke & Rally	
3. Forehand Top Spin & Rally	
4. Backhand Top Spin & Rally	
5. Forehand Back Spin & Rally	
6. Backhand Back Spin & Rally	
7. Forehand Side Spin & Rally	
8. Forehand and Backhand Stroke & Rally	
9. Forehand and Backhand Back Spin & Rally	
10. Forehand Top Spin around 2/3 Table & Rally	
11. Service and Attack & Leg Movements	
12. High Ball Attack & Leg Movements	

Note: Even the quantitative data are offered in the international classification card, the testing results ranging from 0 to 108 points may not prove the real abilities or intentional misrepresentation of a player with II.

Table 2: Main cut-off points for borderline players with II in TT-specific tests.

Component	Maximal Scores	Cut-Off Scores
Service & Return Service	72 points	Over 60 points
Basic Skills and Control	12 items are good (i.e., 36 points)	≧8 items are good & ≧3 items are reasonable (i.e., ≧30 points)
Note: Quantify testing components may not show the true abilities of an II player if the player does not do the best during classification.		

For many years, the International Paralympic Committee (IPC) has promoted the evidence-based practice, especially in classification [14,15]. However, most para sports in the Paralympic programs may not provide enough scientific evidence to answer the essential question [3]. Understanding the measuring concept and meaning of ITTR, the ITTR may provide the direct direction in measurement of functional abilities of elite TT players whether they are able-bodied, PI or II. For example, a case study in wheelchair player with PI showed the forehand swing pattern for 25 powerful swing movements and the related changes of figure (Figure 1) [12]. The continuous swing pattern in Y axis and Z axis of 3-axis accelerometer revealed the speed of swing, time period for each swing, and wavelength (peak to trough). The detailed calculation in this player such as swing efficiency values (wavelength divided by swing time) in average each 5 times can be judged for a certain class and be used to prevent intentional misrepresentation during testing (Table 3) [12]. Of course, other TT-related skills including backhand stroke, forehand topspin and backhand topspin are also required to be measured carefully to have more information to interpret data more precisely. An application of ITTR may partially support the classification process when objective measurement of TT-related strokes and swings and recording detailed data completely. When a player does not intend to show his or her real abilities, the collected data can be compared with the database and also reveal a signal to the classifiers to compare the different patterns with

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norms. Through this example in para-TT, the proper use of the current technology is promising in para sports, especially in the classification process to finally offer fair results for para-athletes. We suggest that the similar approach is also useful for other para sports, but more cooperation among different experts including classifiers, coaches, and engineers in a specific sport is essential to develop sport-specific measurement instruments and testing methods with proper technological support. We believe that the wide application of technological knowledge and objective measurement in different para sports will be approaching in the near future more successfully.

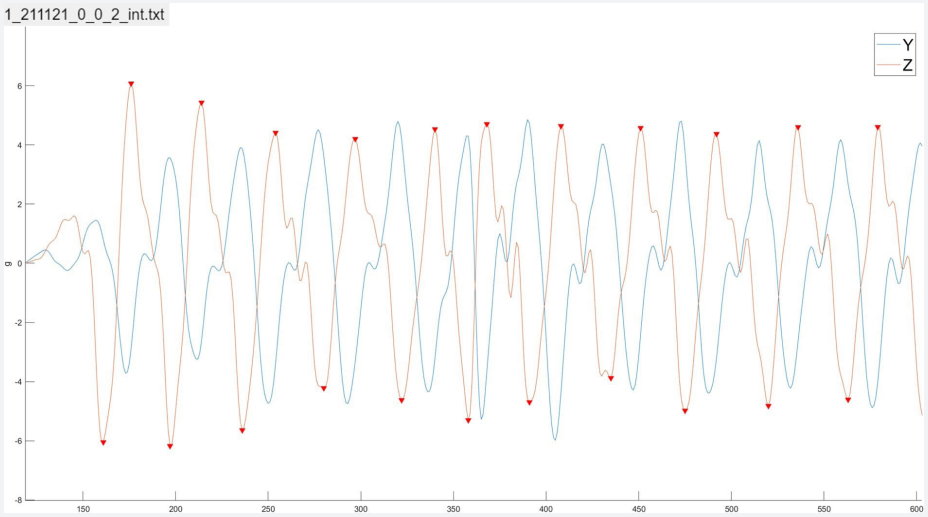

Figure 1: The Use of ITTR to Show the Forehand Swing Pattern (Y axis in blue line & Z axis in orange line) in a Wheelchair Player with PI.

Table 3: The swing efficiency values of the forehand stroke in a wheelchair player.

	5-Jan	10-Jun	15-Nov	16-20	21-25	Mean	SD	**Variance**
Player	0.1644	0.1747	0.1592	0.1316	0.1474	0.1488	0.0276	18.54%

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