A Case Study of Para Table Tennis Athlete's Functional Ability

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Abstract: Reach is an important performance aspect for para table tennis athletes under the seated classifications of 1 and 2. The aim of this pilot study was to define the effective reach of Class 1 and 2 para table tennis athletes. Three players, 3 from Class 1 and 2 took part in this investigation. During the static assessment, players were asked to perform full reach from a seated position across the table tennis table, with the area outlined as Sweep Area (SA). In the dynamic assessment, players hit a series of balls propped up along the perimeter of the SA. The average SA for Class 1 and 2 were 0.560±0.08m^2 and 0.640±0.04m^2 respectively. The average Right and Left Tipping Angle (RTA, LTA) on the frontal plane were ±20.7° and ±22.0° for Class 1, and 49.3° and 36.0° for Class 2. Class 1's average Sweep Time (ST) was 4.92±0.98s, whereas Class 2's average ST was 3.69±0.58s. There is a difference in RTA between Class 1 and 2 players. For future work more samples are needed to understand the athletes' Range of Motion (ROM). Findings will serve as important considerations for training design, game strategy and equipment usage.

1 BACKGROUND

Para table tennis is similar in play to regular table tennis where the primary objective is to prevent the opponent from hitting a return ball. Para table tennis allows athletes with physical limitations play with their mobility aid like a clutch, prosthesis or wheel chair. Paralympic Table Tennis, particularly for Class 1 and 2 players is an area with limited research within academic literature. Current studies in Sports science on Para Sports has a strong emphasis on terrestrial and aquatic locomotive strategy for Para athletes (Dingley et al., 2014) and (Bernardi et al., 2013), strategic demands of Para team sports (Hegde and Standal, 2013) or a generic strength training requirements for Para-Athletes (Borges[1] et al., 2014). Studies that attempt to investigate a specific class of athlete in Para sport are still limited moreover for Para Table Tennis. For the purpose of fair play, the International Table Tennis Federation (ITTF) Classification code (Federation, 2010) classifies players into categories, dependent on their available joint and movement range. For the class 1 and 2 category, it covers players with only limited upper body mobility, usually the arms and shoulders. The Class 1 and 2 players play the game with modified movements using push pull movements from their arms and shoulders against the wheel chairs to reach for the ball. The return technique is a limited forehand or backhand using a bat strapped to their hands. A distinguishing difference between the class 1 and 2 athletes is the limitation of the upper body and arm movements. Class 1 players usually have little or no elbow extension and functional triceps. Both classification of players have no sitting balance and requires the non-playing arm to maintain their balance. The varying levels of upper body mobility also require the players to develop an individualised movement strategy on their existing wheel chair. There are some who anchor their arms on the wheel chair push handle or to be restrained by a chest belt. Apart from trying to maximise their reach, these athletes have to battle the fear of falling off their chair.

2 OBJECTIVE

The objective of the study is to measure and characterise the effective reach of class 1 and 2 para table tennis players. The findings are to be used to influence training design, play strategy and provide design inputs for an athlete specific Para Table Tennis concept chair.

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3 METHODS

3.1 Data Capture: Reach Perimeter

Six Para Table Tennis Player from the National Table Tennis team, three from both Class 1 and 2 classifications volunteered for the study. Given the nature of the sport, the population size for these 2 classifications are very limited. All the players had at least 2 years of international competitive experience in para table tennis. They were seated on their competition chair with their sternum referenced to the centre line of the table as it is the most common seating preparation for Class 1 and 2 (Huang et al., 2010). With shoulders parallel to the table edge, the most superior position of the acromion was then used to position the player, 300mm away from the table (Figure 2). This distance is necessary to accommodate the player's chair and arm space. Subsequently each of the players drew a perimeter that represented their maximal reach on a piece of paper attached to the table. The perimeter was drawn with a marker attached to their hands. The total reachable area on the table by the player defined as Sweep Area (SA). This measurement is approximated using the mid-point Riemann method in 100mm increment from the identified perimeter on the paper. This calculated area is normalised in terms of percentage of the player's playing area. This percentage is defined as Percentage of Table (POT).

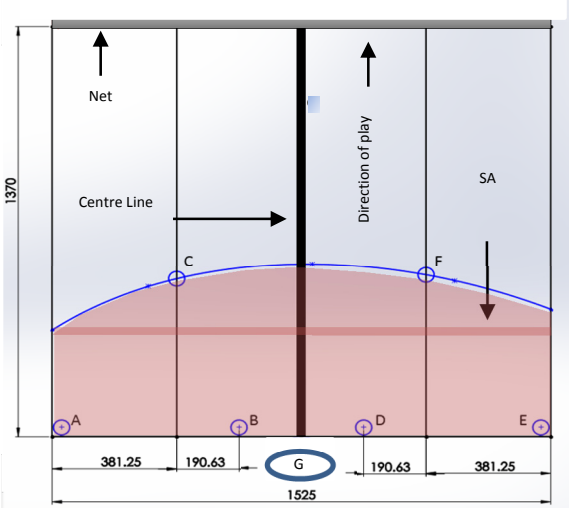

Figure 1: Schematic of player, SA and ball position. Player is seated position at G. 6 positions for the player to hit the return shots. A, Maximum Backhand Reach (MBR); B, Near Table Backhand (NTB); C Intermediate Backhand Reach (IBR); D, Near Table Forehand (NTF); E, Maximum Forehand Reach (MHR) and F, Intermediate Forehand Reach (IFR).

The players were also measured on their maximum tipping angle of the spine when seated (See figure 2). This tipping angle is defined as Right Tipping Angle (RTA) and Left Tipping Angle (LTA). The players were seated and required to perform a maximal reach to the right and left side along the frontal plane to the point where each player felt that they may fall over from the side. The respective tipping angle is defined as the angle between the player's spine from the seated position to the maximal reach position on the frontal plane. The measurement was performed using a 2-D video analysis software (Kinovea version 0.8.15, Creative Commons Attribution) with video footage taken from a camera placed directly behind the players while executing the reach.

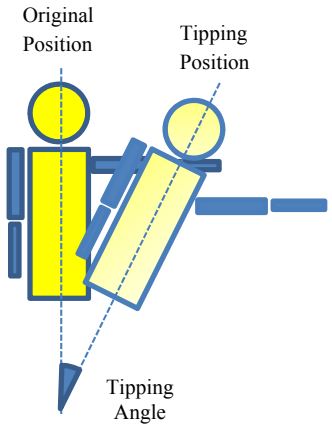

Figure 2: Schematic of maximum reach to right on frontal plane from original position to tipping position. Tipping angle is measured with reference to spine between the 2 positions.

After the static measurements, all the players were required to perform forehand and back hand strokes shots on balls placed in 6 different positions along the perimeter defined by each individual player. Using the marking as a guide, the table tennis balls were propped up to 40mm high and positioned on designated positions along this perimeter. The strokes were made in succession over 5 trials and the players were required to hit the ball over the net and land it on the opposite table like a table tennis game. This sequence of movement aims to replicate the full table area covered around the table by players in a rally during competition. The task starts from near to far table as a measure of their manoeuvrability within their functional reach range. The time taken to complete the task is the Sweep Time (ST). There were 6 positions and each position is meant for the player to execute a forehand or backhand

return to the opponent's half. The return was deemed successful when 3 consecutive balls can be returned from that location; otherwise it would be brought closer to the point in which the player is able to perform the shot. The successful return positions are subsequently defined as: Maximum Forehand Reach (MFR), Maximum Backhand Reach (MBR), Intermediate Forehand Reach (IFR), Intermediate Backhand Reach (IBR), Near Table Forehand (NTF) and Near Table Backhand (NTB). To reduce the learning effect of the trial, players were given sufficient time to practise the hitting the sequence of shots until they were ready for a timed session.

3.2 Statistical Analysis

This is an exploratory study on a special population where the existing sample size is very limited. A non-parametric Kruksal-Wallis and Mann-Whitney U-test was performed on the 2 groups of participants at α=0.05 on SA, POT, ST, RTA and LTA.

4 RESULTS

The results are presented in Table 1 for Class 1 and 2 players. The SA for all participants was found to be less than 50% of POT from the stationary position. The Class 1 players understandably have the lowest SA compared to the Class 2 participants. This applies to total ST when compared to the same group of players.

Table 1: Table of Results for Para table tennis reach parameters.

	Class 1, n=3	Class 2, n=3
Average SA,m^2	0.56±0.08	0.64±0.04
POT, %	26.9	30.5
Average ST, s	4.92±0.98	3.69±0.58
Average right tipping angle, RTA, °	20.7±4.78$^+$	49.3±8.06$^+$
Average left tipping angle LTA,°	22.0±2.94	36.0±11.9

* Kruskal-Wallis test, p=0.05 between all three groups of players.

$^+$ Denotes significance in Mann-Whitney test, p=0.05 between Class 1 and Class 2 players.

Significant differences were not found using the Kruskal-Wallis test for all the test parameters in the three groups.

Difference between Class 1 and 2 players' RTA was found to be marginally significant (p = 0.05) using the Mann-Whitney U-test. (Although the Kruskal-Wallis test did not show significance (p = 0.078) for RTA). From the 9 pairs derived base on three participants each from Class 1 and 2 players, the rank-biserial correlation r, calculated using the Wendt formula was equal to 1 for RTA showing the correlation (Kerby, 2014).

From the results there is an indication that RTA as a differentiating factor between the 2 Classes of players.

5 DISCUSSION

5.1 Quantification of Result and Functional Requirement

This study has provided a quantitative platform on the ability of para table tennis players to complete a series of movement on the basis of their functional reach range.

In RTA where there are significant differences between Class 1 and 2 players, the contribution may be made by the class 2 player's higher wrist, elbow and shoulder strength compared to the other group. Another possible contribution can come from a particular Class 2 player who wears a chest strap during training and competition as a safety device. The chest strap used is elastic, allows the player to lean his weight fully to extend the reach.

For future studies, the anthropometrical contribution of each athlete should be taken into consideration, particularly the arm length. It is possible that this variable may influence SA measurements and subsequently inter participant data.

What was not expected is that ST for all players were not significantly different. A likely explanation would be the normalising effect of the SA between the 2 groups of participants. With the Class 1 players having a lower SA, effort by Class 1 players can be considered higher as they took approximately the same time to complete the reach task within a smaller area. In addition, the arm length of each player was not taken into consideration during this study. The contribution of the arm length may possibly have an effect on both SA and ST but ST may increase as load on arms may increase as a result of the increased arm length. Normalising the ST and SA into a ratio in table 2, the ratio expresses the rate of area coverage by each classification of players. This ratio can possibly be a useful

descriptor and estimate on each player's ability, which in turn be training targets to achieve a higher ratio to reflect a more effective area coverage by a player.

Table 2: SA and ST ratio for 2 groups of players.

	Class 1, n=3	Class 2, n=3
Average SA,m^2	0.560	0.640
Average ST, s	4.92	3.69
SA/ST ratio	0.114	0.173

More data points are required to explore the relationship between SA and ST. The reality of the game requires players to have good functional reach to allow them to make tactical switch between forehand and backhand movement (Huang et al., 2010). These results can provide the basis for training intervention for the coaches to monitor the players' reach ability and agility around the table. Any physical conditioning work or therapy to improve their joint range can be assessed if it translates into improved functional range and agility.

5.2 Future Work

5.2.1 Coaching Application

The authors intend to extend the test to more participants to subsequently refine the test method to enhance its reliability. For the functional assessment to be readily accepted during training by both coaches and players, a simple operational procedure is essential. The authors are exploring how the test can be implemented via a digital device to achieve this goal.

In terms of a training test set, coach and players would have a quantitative platform to assess the reach ability for a new or existing player. Together with targeted strength and flexibility training, the kinematic quantification provides a clear objective for the team to act on. In addition, the data can be used to assess the reach ability of opponents during competition.

The study has provided a framework to quantify the movement and ability of Class 1 and 2 Para Table Tennis players. The methods are designed with practicality of implementing the assessment during training, so that it is possible to conduct when required by coaches.

Despite participants being grouped into the two classification groups, the ability of the participants within each group do vary. For future work we intend to perform test-retest reliability analysis to determine the efficacy of this test for this population group.

5.2.2 Concept Chair

Key parameters which the concept chair can improve would be SA and ST for Class 1 and 2 players. Results of this study will be used as a benchmark of the players' current ability with their existing competition chair. The information will then be compared against any equipment modification to improve the players' SA and time. Figure 2 illustrates a concept chair with possible improvement for anchoring the players' arms during play, rotational movements and anti-tipping measures.

The first concept is to explore the impact of seats on the players. The players are all using a fabric covered foam type seat, where the functionality is targeted at improving comfort during day to day use instead of competitive table tennis. The authors are exploring different methods to improve this interface to increase the angular speed of the players' torso during play. For Class 1 players who have limited control over their torso, the solution needs to assist the player to move while seated.

Another possible conceptual solution is to modify the existing push handle of the player's chair. This is illustrated in Figure 2. This modification is expected to allow players to anchor on the chair to improve the range of RTA and LTA. Although players are already anchoring on the existing chair handle, the new conceptual solution aims to improve on the placement of this handle on the chair.

Figure 3: Visualisation of concept chair with modified push handle.

Lastly the third concept that the authors are looking at is implementing is a safety hand rest for the players. Toppling over the chair during the game is a real situation during the game when the players over reach. Some form of safety anchor apart from the push handle is necessary to prevent side tipping. With the anchor, the authors hope to provide the players with more confidence during play when reach to the sides.

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