Research Article

Location, Location, Location: Understanding the Impact of Shot Placements in Badminton Men's Double at 2022 World Championship

Wei-Chieh Liao[1], Yun-Dih Chia-Smith[2], Kuo-Cheng Wu[3], Chi-Chuan Lin[1], Li-An Liao[1*]

[1]Department of Ball Sports, University of Taipei. Taipei, Taiwan, R.O.C.

[2]Department of school education, Loyola University Maryland, USA

[3]Graduate Institute of Sports Training, University of Taipei. Taipei, Taiwan, R.O.C.

*Correspondence: Department of Ball Sports, University of Taipei. Taipei, Taiwan, R.O.C.

Corresponding author: Li-An Liao, Department of Ball Sports, University of Taipei. Taipei, Taiwan, R.O.C.

Abstract

Men doubles badminton is fast and considered among the most intense competition in the sport. Players must seize every opportunity and seek to take initiative to gain advantage in the rally. Shot location from the serve to the end of the point is critical and players train countless hours in order to execute the most advantageous location in the heat of competitive play. This study examined the impact of service location, location of winning points, forced /unforced errors, and the role of backcourt smash in winning performance at the 2022 Tokyo World Championships Men Doubles Semi-finals and Finals games. The authors analyzed videotapes of the matches and calculated the frequency of locations and their relationships to winning points. Results showed that when players took the initiative to create an offensive opportunity in the first three shots, they played to their strengths and held a technical advantage. Additionally, during rallies, the team who controlled the front/middle court were more likely to win the point. Implications of the study include insight for coaches to deliver essential information regarding the opponent's affinity for location and to stimulate future research using video analysis for improving men double tactics and point control.

Introduction

Malaysia has been a powerhouse in badminton for decades and the sport of badminton is its national sport. Many badminton icons such as Ong ewe hock, Koo kien keat, Tan boon heong, Cheah soon Kit, Sidek brothers, and the well-known Lee ChongWei earned respect and national honors as the competed and won all over the world. Despite their consistent high level of success, until Malaysia won an Olympic or World Championship. That is until Summer 2022! Men's doubles players Aaron Chia and Soh Wooi Yik won the first world championship in the history of Malaysia in the 2022 Tokyo World Championships. The whole country had been waiting almost 50 years for this championship moment. With a desire to continue the momentum, the Badminton Association of Malaysia (BAM) is supporting Chia and Soh in the hopes of winning the World Tour Championship later 2022 and becoming the world No. 1. Their ultimate goal is, building on their bronze medal performance in the 2020 Tokyo Olympics, is for Chia and Soh to win gold in the 2024 Paris Olympics.

As badminton's popularity and prominence grows, the badminton training system needs to become more mature and modern. It needs researchers' and coaches' immediate attention to

update their knowledge by increasing scientific research in a variety of areas. Badminton has been developing rapidly in recent years, in terms of population, market, and player performance. In recent years the rules were altered and that led to significant changes in how players approached their play. The rally score system change, where a point is awarded regardless of which side serves represented a major change. Rally score shortened the matches and created a more exciting viewing experience for the audience. In recent years badminton has become more entertaining, increasing viewership and is offered on more media outlets. One result of the new 21-point regulation is that the responses of shots are shorter, and the opponents' returns are faster, resulting in more excitement to this sport [1,2].

Badminton-scientific research has increased in recent years, particularly in the areas of technical/tactical and improving players' psychological, physical, and physiological conditions. Sports science provides a new vision for preparing for badminton competitions which is different from traditional training [3-5]. Those changes are evidenced in men's double performances and training [6]. Men's doubles are among the five disciplines with the most intense competition on both offense and defense [7] . It is not only about the basic skills of the individual but also the tacit understanding of the tactical application of the two players. Specifically, the study of doubles must focus on the fluency of rotation, the combination of technical play, and the control of each other's emotions. The intersections of these multiple components are key to winning or losing. Control the initiative in the first three shots will improve the chances of winning. To complement the new competition rally system, players' responding time to serves is relatively shorter, and the opponent's return rhythm has also become faster [2]. In recent years, doubles players have made great efforts to improve their quality of serving and changes in the route, seizing the opportunity to dominate the pace of the rally [8].

Serving to the frontcourt is the tactical application of starting the attack. Players will serve with quality to gain control, then organize the third shot's attack to restrict the opponent's reactions [8-10]. Besides serving, players also intend to gain control of the halfcourt actions and try to win the rally as soon as possible. Chen (2000) [11] indicated that speed is one of the winning components in badminton today, especially in men's doubles. Players who

can control and take the initiative at the halfcourt will have better advantages in winning. Meanwhile, when players take the initiative to create a backcourt offensive opportunity in the first three shots, whether a heavy smash or a point kill, it will display the players' strength and techniques. When taking the initiative, it is necessary to increase the proportion of heavy smashing in the backcourt, the speed of the smashing technique, the change of landing point, and the stability [12].

In recent years, game/competition analysis has been applied in many kinds of research to examine various topics related to badminton matches [13-16] . In response to the highly competitive environment, pre-match information collection is crucial to understanding the opponent and increasing likelihood of winning. This research method directs coaches and researchers to find the regulations of opponents' technique skills, specific characteristics, offense/defense tendency, tactical application, and strengths/ weaknesses in winning/losing points. Utilizing the data, coaches and researchers could develop a proper training plan and efficient match strategy for players [7].

The purpose of this study is to analyze elite players' technical skills and tactics, such as serving, receiving, and stalemate. The results can be used to provide tactical guidance and reference for a training plan for fellow researchers and coaches. Three research questions guiding the study were:

1) What is the relationship between serve location and winning the point?

2) What is the location where the most winning points and unforced errors occur?

3) What is the role of backcourt smash in controlling the match?

Method

Context

This research is based on the video-taped footage of the 2022 Tokyo World Championships Men's Doubles Semi-finals and Finals games of Aaron Chia and Soh Wooi Yik [17] (https:// badminton4u.sport). (Table 1) displays player information. The head-to-head history of three pairs are: Chia/Soh vs Ahsan/ Setiawan 3 wins:7 losses; Chia/Soh vs Rankireddy/Shetty 5wins:0

losses.

Name	Nationality	Age	Height	BWF Ranking
Aaron Chia	Malaysian	25	170 (cm)	6 (with Soh)
Soh Wooi Yik	Malaysia	24	182 (cm)	6 (with Chia)
Mohammad Ahsan	Indonesia	34	173 (cm)	3 (with Setiawan)
Hendra Setiwan	Indonesia	38	183 (cm)	3 (with Ahsan)
Satwiksairaj Rankireddy	India	22	184 (cm)	7 (with Shetty)
Chirag Shetty	India	25	187 (cm)	7 (with Rankireddy)

Table 1: Players information.

Data Collection

Researchers watched the videotapes of each match several times. During data analysis, the researchers used specific definitions the quantify location, backcourt smash, and unforced errors. The quantification was limited to the specific research question. For example, when analyzing the match for serve location, the researchers only concentrated on the time sequence of the serve, identifying the location, and following the subsequent three shots. The second author served as reliability check on data consistency. A descriptive statistic is featured based on the frequency percentages of the three pairs of players in the two games and analyzing the data in terms of players' placement and return strokes in serving/receiving, locations of winning/losing points, number of smashes and smashes to scoring ratios, and stability forced/unforced errors.

Results

Research Question 1: Serving Location

The landings of service often locate at short exterior (SE), short center (SC), short interior (SI), long exterior (LE), long center (LC), and long interior (LI) (Figure 1).
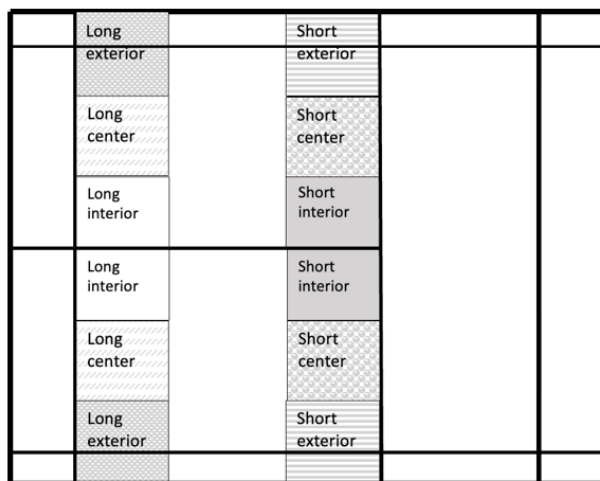

Figure 1: Possible serve locations.

Most of the three pairs' short backhand serves landed in SI, SC, and SE. The data indicated that Chia/Soh, when going up against Rankireddy/Shetty during the semi-final, they delivered 27 (44%), 28 (45%), and only 1 (1%) of total services to SI, SC, and SE. When Chia/Soh competed against Ahsan/Setiawan at the final match, they served 14 (33%) and 24 (58%) of total service to SI and SC respectively. On the other hand, Rankireddy/Shetty served 35 (62%), 6 (11%), and 4 (7%) of total services to all three short areas when going up against Chia/Soh. The other finalist, Ahsan/Setiawan served times 17 (52%), 10 (30%), and 2 (6%) of total services to SI, SC, and SO (Table 2). The game analysis indicated that Chia/Soh applied different tactics from Ahsan/Setiawan and Rankireddy/Shetty in serving. Even though doubles players mainly use short backhand serves to attempt to take the initiative, most short backhand services locate on either interior or center of the frontcourt. This strategy is implemented to shorten the distance to the receivers. Meanwhile, the reaction time for service return to these locations is the fastest for the opponent. Given an above-average service quality, when serving to the shortest distance and pushing the fastest reaction time makes it more challenging for the receivers to take the initiative. This permits the server to take the initiative at the third shot. That is why both Ahsan/Setiawan and Rankireddy/Shetty focus on SI and SC. The data shows that 52% of Ahsan/Setiawan services and 62% of Rankireddy/Shetty services at the SI, which takes up more than half of their total services. Chia/Soh intended to serve more specifically, serving much less to the SI side when against Ahsan/Setiawan (33%) and Rankireddy/Shetty (44%). The Malaysian pair preferred to serve to the SC, 58% in the final and 45% in the semi-final, about two to three times to that of Ahsan/Setiawan and Rankireddy/Shetty. It shows that Chia/Soh employed a different strategy, primarily due to the more straightforward prediction of opponents' return of serve. A tremendous amount of simulation training was adopted to achieve such effects.

The players should be aware of the purpose of the service location and combine the limit of the return of serve by opponents [18]. Regarding the tactical application in a game, it is essential to confuse the start of the opponents' service return by periodically altering the service location. To make the opponent move before his return of serve, mixed services with the LI, LC, and LE services are necessary. Chia/Soh served respectively a total of 4 times, taking up 9% of total services, 6 times, taking up 10% of total services; Ahsan/Setiawan 4 times (12%); and Rankireddy/Shetty 11 times (20%). These changes aim to confuse opponents and disrupt their preparation and thus lowering the quality of return of serve, that the changes in the location of service and the change in the speed of services can prevent the opponent from anticipating the pace and course of the serve [19]. It should also be noted that the application of tactics is specific, aiming to gain an advantage at the third shot, especially the follow-up in the front court, and gaining the initiative in the following shots to apply tactics and limit offense from opponents. The players who are most adept at this tactic are Indonesians and Malaysians. From this research, players tend to serve to SI and SC more frequently, complemented by smaller number of long serve variations. Given the intensity of men's doubles level nowadays, it is far from enough to only serve to two-thirds of the short court area. Especially for Chia/Soh, they only served once in the front court outside area when up against Rankireddy/Shetty and not at all when going up against Ahsan/Setiawan. The limited choices allow one's opponents to predict and anticipate the start for a serve from SI or SC and outpace you by speed. This could result in pressure from serving and lower service quality and stability. To a large extent, such pressure determines the final results of the game because of the new rally point system. If a player cannot keep scoring on his service, he becomes passive in his game, and the game would be a tough one to win. Therefore, it can be concluded that if a player wants to achieve world-class doubles player status, one should master short serve to the exterior side of the front court.

	Chia/Yik *vs* Ahsan/Setiawan	Ahsan/Setiawan *vs* Chia/Yik	Chia/Yik *vs* Rankireddy/Shetty	Rankireddy/Shetty *vs* Chia/Yik
Serving Location				
Short Interior	14 (33%)	17 (52%)	27 (44%)	35 (62%)
Short center	24 (58%)	10 (30%)	28 (45%)	6 (11%)
Short Exterior	0 (0%)	2 (6%)	1 (1%)	4 (7%)
Long Interior	2 (5%)	1 (3%)	0 (0%)	1 (2%)
Long Center	1 (2%)	0 (0%)	3 (5%)	5 (9%)
Long Exterior	1 (2%)	3 (9%)	3 (5%)	5 (9%)
Total	42 (100%)	33 (100%)	63 (100%)	56 (100%)

Table 2: Serve locations.

Research Question 2: Location of Winning Points and Forced/Unforced Errors

Winning Points. From video analysis, a shared finding indicated that majority of the winning points were located front and middle courts (Table 3). From the Chia/Goh *vs*. Ahsan/Setiawan, we can conclude that the focus of the match is at the front/middle court, as it is the critical site for elite men's double badminton competitions today. Although the 3-time World Championships veterans, Ahsan and Setiawan, are in their mid/late thirties and much senior to most of the players. However they still maintained the rhythm of the front court tactics, superior in terms of connection and coherence of rotation, and in control the front/middle courts winning points during the final match (83% *vs*. 65%). With their outstanding front/middle court techniques and experiences, Ahsan and Setiawan defeated many excellent young players and brought them to the final stage. Retiring is not near for this Indonesian pair [20]. The importance of front/middle court was again demonstrated in the semi-final when Chia/Goh *vs*. Rankireddy/Shetty. Compared to Rankireddy/Shetty (65%), Chia/Soh's (81%) winning points were located at the front/middle courts. This data indicated that Chia/Goh is superior to the young Rankireddy/Shetty in terms of half-court technical use, such as the awareness of net shots, the judgment of the push return, and the half-court drive attack [21].

In conclusion, having a good front/middle-court technique is equivalent to controlling the initiative. When players have an excellent ability to control the net in the frontcourt and can be aware of the net shot after the drive, they can generate a higher proportion of initiative and effect the game [22].

	Chia/Soh *vs* Rankireddy/Shetty	Rankireddy/Shetty *vs* Chia/Soh	Rankireddy/Shetty *vs* Chia/Soh	Ahsan/ Setiawan *vs* Chia/Soh
	Location of winning point			
Front court	18 (43%)	12 (32%)	8 (35%)	13 (54%)
Middle court	16 (38%)	12 (32%)	7 (30%)	7 (29%)
Back court	8 (19%)	13 (36%)	8 (35%)	4 (17%)
Total	42 (100%)	37 (100%)	23 (100%)	24 (100%)

Table 3: Location of winning point.

Forced and unforced errors. Mistakes or unforced errors are inevitable. Fortunately, through training, unforced errors can be reduced from occurring with high frequency during competitions. In addition to strengthening the practice of basic techniques, the proficiency, agility, balance, speed, and strength of the handling skills should also be highly developed. Simulating the stress in the games allows players to become accustomed to the situation when it occurs in the match. Players can respond efficiently without too many ups and downs, showing a stable state of resilience to pressure and minimizing the impact of mistakes and lead to a winning performance [20, 23]. During the semi-and final match, compared to their opponents, Chia/Soh made fewer unforced errors (with Rankireddy/Shetty 19 *vs*. 23; with Ahsan/Setiawan 11 *vs*. 19) and performed with more stability. Especially, Rankireddy/Shettys's 13 half-court unforced mistakes and Ahsan/Setiawan's 6 backcourt errors cost them the matches. During the semi-final, Chia/Soh had 8 forced errors: 4 in the frontcourt and 5 in the half-court; Rankireddy/Shetty made 10 forced errors: 4 in the frontcourt, 4 in the half-court, and 2 in the backcourt. Meanwhile, during the final match, Chia/Soh had only 2 half-court forced errors; Ahsan/Setiawan made 5: 1 in front and 5 in half-court. Although Chia/Soh was forced to make mistakes, they returned more to their opponents. This result indicated that Chia/Soh was more stable than their counterparts in speed and tactics (Table 4). This analysis reinforces the importance of reducing forced and unforced errors, which is a key to a winning performance [20]. Therefore, current elite men's double players are advised to control and oppress each other with quick attacks, strive to take the initiative to preempt the opponent, causing opponents to make mistakes, and achieve an advantage [24].

	Location of Forced error			Location of Unforced error		
	Front court	Middle-court	Back court	Front court	Middle court	Back court
Chia/Soh *vs* Ahsan/Setiawan	0	2	0	8	2	1
Ahsan/Setiawan *vs* Chia/Soh	1	4	0	9	4	6
Chia/Soh *vs* Rankireddy/Shetty	3	5	0	11	6	2
Rankireddy/Shetty *vs* Chia/Soh	4	4	2	9	13	1

Table 4: Location of forced and unforced errors.

Research Question 3: Winning Points by Smash

Semi-final. Smashes are one of the most effective scoring skill when performing from the backcourt [25]. With their physical advantage, the India pairs delivered powerful backcourt attacks during the first game in the semi-final. To defend against opponents' up to 414 KPH smashes, Chia/Soh became increasingly passive when lifting shuttlecocks to the backcourt. Chia/Soh handed 34 smash chances to Rankireddy/Shetty in the first set and allowed them to score 9 points (26%), and lost the first set to Rankireddy/Shetty by 20:22. These 9 points are the key to the loss of the first game. This tactic is obviously a strategic strength for Rankireddy/Sheddy. With their close loss in the first set, a different tactic was introduced during the 2-minute interval. To change the outcome of the game, the coach advised Chia/Soh to optimize the quality of the services and the first few shots, to strengthen the competition and bring the actions to the front/middle court [26]. Focused on their opponent's physical disadvantage, such as the higher center of gravity, lower agility, and hard to spin their body to return a shot, Chia/Soh tried not to lift. Instead they focused their attack on the body by using flat drives or exchanges. Rankireddy/Sheddy lost their physical advantage in the game when Chia/Soh kept the rallies in the front/middle court, avoided lifting, and reduced the possibility of the opponent's smashing. Chia/Soh took the game away by only giving 16 smash chances to their opponents in the second set and 19 smash chances in the third set. Chia/Soh only lost 5 points in the second set and 5 points in the third set by smashes from opponents. Compared to the first set, the loss was reduced by half. Chia/Soh took the second and the third sets by 21:18 and 21:16.

Applying advantages and understanding the opponent's weaknesses and tactics will help coaches/players develop efficient strategies during matches [27] (Table 5).

	Chia/Soh *vs* Rankireddy/Shetty	Rankireddy/Shetty *vs* Chia/Soh
Number of smashing and winning points successful		
Game 1	6/26 (23%)	9/34 (26%)
Game 2	6/19 (32%)	5/16 (31%)
Game 3	5/21 (24%)	5/19 (26%)

Table 5: Number and percentage of smashing and winning points – semi final.

Final

However, the most recent match between the two pairs was in 2022 Malaysian Open. Chia/Soh won the game by the close margin of 21:13, 20:22, 21:19. With a 3:7 head-to-head record, Chia/Soh went up against the experienced Indonesian players Ahsan/Setiawan at a disadvantage before the final. After the match, the coaching team must have researched Ahsan/Setiawan's tactics and strategies they might apply. The Malaysian squad adopted a sufficient game plan when facing their 11th match. Chia/Soh employed a different tactic to the finals compared to their previous match. When facing experienced players like Ahsan/Setiawan with very delicate net skills, Chia/Soh tried not to compete against them at the net; Instead, by giving them many smash chances to their forehand and backhand back courts to consume their stamina as much as possible. Chia/Soh lifted to the backcourt and gave their opponents 50 smash chances in the first set and 42 in the second set. As a result, every rally exceeded 20 or even 30 shots. The movement on the court consumed an abundant aerobic and anaerobic ability [28]. The intensity of such interval workouts is hard to recover for them in a shorter period as they were already 34 and 38 years of age. Meanwhile, this has reached the finals, Ahsan/Setiawan's physical strength has also been affected. With Chia/Soh's tactical application and tight defense, that would cost Ahsan/Setiawan more effort if they want to score a point by smashing from the backcourt. Chia/Soh's tactics echoed Chen's (2005) [29]. Assumption: that given in doubles games, players with similar abilities and good at both defense and offense with a rally often last for 20, 30 shots, what decides the winning point is stamina [29]. This is evidenced in the first set Ahsan/Setiawan only scored six points (12%) and four points (10%) in the second set by smashing. Chia and Soh took the game by 21:19 and 21:14 and won the first world Championship for Malaysia. Analyzing opponents' match history and tactics would help increase doubles players' winning odds. The pre-game analysis plays an important role in all level badminton matches [30] (Table 6).

	Chia/Soh *vs* Ahsan/Setiawan	Ahsan/Setiawan *vs* Chia/Soh
Number of smashing and winning points successful		
Game 1	5/18 (28%)	6/50 (12%)
Game 2	10/22 (45%)	4/42 (10%)

Table 6: Number and percentage of smashing and winning points – final.

Conclusion

Although Chia/Soh showed much less variation in their services, with their superior defense skills and ability to adjust their tactics, the winning pair delivered a victory performance. On the other hand, the younger pair Rankireddy/Shetty's physical advantage gained them the power to attack, especially smashes. They would bring their game to a different level if they could advance their front/middle-court techniques. As for the most experienced and all-rounded pair, given their age, Ahsan/Setiawan's stamina and physical endurance represents their biggest problem. Unlike traditional men's double, modern elite men's doubles techniques and tactics require more than pure speed, power, attack, the ability to last in a long rally, and all-roundedness [7]. Besides players' techniques, flexible tactics, solid mental power, and pre-match analysis can all contribute to a gold performance. The game analysis suggests that: coherence between shots, advanced level in tactical application in tight games, and crisis management, complemented by refined and delicate skills, are all evidenced in Chia/Soh performance. To be specific, much higher accuracy in serve and return, front court net skills, and active pressure in the backcourt, emphasizing active oppression, and reducing unforced errors are of utmost importance [6, 31]. This is especially important in terms of control of actions on the front/half court. A stable mental status, such as: staying calm, pushing limits, being flexible, and adopting new strategies accordingly, are also critical elements for a winning performance [32].

Preparing players with unique training when combining updated sports science technology and carefully analyzing opponents' pro-and-cons is a necessary step to help players achieve their best. This research is a starting point for finding more specific knowledge about how players' characters could have affected their games [13-15, 33]. Not only does the game analysis provide information for this particular match, but future research can confirm the role of serve, location, and winning points. More data are necessary to enrich the knowledge of players' advantages and disadvantages according to their ages, the body builds, and regions.

References

1. Phomsoupha M, Laffaye G (2015) The science of badminton: game characteristics, anthropometry, physiology, visual fitness and biomechanics. Sports Med 45: 473 - 495.

2. Tu KC(2008) The Research on Time Structure and Techniques Using Rate for Badminton Doubles, Sports Coaching Science 12: 45-54.

3. Abián P, Castanedo A, Feng XO, Sampedro J, Abian-Vicen J (2004) Notational comparison of men's singles badminton matches between Olympic Games in Beijing and London, International Journal of Performance Analysis in Sport 14: 42-53.

4. Barreira J, Chiminazzo JGC (2020) Who, how and when to perform winner points and unforced errors in badminton matches? An analysis of men's single matches in the 2016 Olympic Games. International Journal of Performance Analysis in Sport 20: 610- 619.

5. Chiminazzo JGC, Barreira J, Luz LSM, Saraiva W, Cayres J (2018) Technical and timing characteristics of badminton men's single: comparison between groups and play- offs stages in 2016 Rio Olympic Games. International Journal of Performance Analysis in Sport 18: 245-254.

6. Lei W, Yu K (2021) Research on the Techniques and Tactics of the World's Top Badminton Men's Double Combinations Based on Computer Coding Technology. Journal of Physics: Conference Series 1744: 032248.

7. Cabello D, González-Badillo JJ (2003) Analysis of the characteristics of competitive badminton. Br J sports Med 37: 62-66.

8. Carboch J, Smocek P (2020) Serve and return in Badminton: Gender Differences of Elite Badminton Players. International Journal of Physical Education, Fitness and Sports 9: 44-48.

9. Li S (2005) A comparative study of Chinese badminton men's doubles and foreign outstanding players' hair catching techniques. Journal of Wuhan Institute of Physical Education 39: 84-86.

10. Shi P(2013) Analysis of tactics in badminton doubles match based on association rules and data mining; January 2013 International Journal of Applied Mathematics and Statistics 51: 517-525.

11. Chen JS (2000) Theory and Practice of Doubles Serving and Receiving in Badminton. Sports Research Review 49: 140-147.

12. Zhou JL, Dai J (2010) Analysis of the technical and tactical characteristics of the 21-point system in men's doubles badminton. Journal of Peking University 33: 111-113.

13. Abián P, Castanedo A, Feng XO, Sampedro J, Abian-Vicen J (2014) Notational comparison of men's singles badminton matches between Olympic Games in Beijing and London. International Journal of Performance Analysis in Sport 14: 42-53.

14. Barreira J, Chiminazzo JGC (2020) Who, how and when to perform winner points and unforced errors in badminton matches? An analysis of men's single matches in the 2016 Olympic Games. International Journal of Performance Analysis in Sport 20: 610-619.

15. Chiminazzo JGC, Barreira J, Luz LSM, SaraivaWC , Cayres JT (2018) Technical and timing characteristics of badminton men's single: comparison between groups and play-offs stages in 2016 Rio Olympic Games. International Journal of Performance Analysis in Sport 18: 245-254.

16. Zhang B, Li F, Jiang W (2013) Mixed Doubles Match Technical and Tactical Analysis of World Badminton Champion Based on Mathematical Statistics. Advances in Physical Education 3: 154-157.

17. Badminton World Federation, Badminton4U.

18. Chen JS (2001) A Study of Serve and Return of Serve of World-Class Badminton Men's Doubles Players. Physical Education Journal 30: 343-354.

19. Rao BJ, Kong QX (2005) Technical analysis on the variation of drop point and stability of badminton doubles serve. Hubei Sports Technology 24: 97-98.

20. Yu X, Chen T, Xun, YD (2013) Analysis of the technical characteristics of men's doubles badminton. Journal of Physical Education 20: 86-90.

21. Shi T, Li XD, Lee Chong (2014) Wei's technical and tactical analysis in the Super Badminton Tournament. Sichuan Sports Science 33: 80-85.

22. Lu Q, Sheng Y(2010) Analysis of the technical characteristics of the outstanding men's doubles badminton player Lee Yong-dae/Jung Jae-sung. Fujian Sports Technology 29: 20-21.

23. Chen Z, Fang L, Xu SJ (2010) A study on the main scoring means and scoring ability of badminton player Lin Dan. Journal of Physical Adult Education, 2010, 26, 72-74.

24. Shen LM, Zheng H (2010) Study on the competitive characteristics and trends of modern badminton development. Journal of Huabei Coal Teachers College (Natural Science Edition) 31: 70-72.

25. Xie JM (2012) Skillful analysis on both offensive and defensive ends of badminton men's doubles. Sport Space Time 4: 125-126.

26. Yu X, Fu Q, Chen T (2013) A comparative analysis of the creation and restriction of offensive channels in men's doubles badminton between China and foreign countries. Journal of Physical Education 20: 111-115.

27. Peng ML, Tao ZX, Wang WJ, Chen FT (1994) Badminton - A coach training guide. Taipei , Republic of China, 1994, Literature, History and Philosophy.

28. Burton AW, Miller DE (1998) Movement skill assessment. Champaign, IL: Human Kinetics.

29. Cheng YM (2005) The promotion and constraints of "fast, fierce, accurate and live" technical style on Chinese badminton. Journal of Physical Education 12: 99-101.

30. Yang QL (2006) Data Collection Methods and Analysis. R.O.C. Baseball Association Class B Baseball Coaching Seminar, 33-35. Taipei County, R.O.C. (2006).

31. Gawin W, Beyer C, Hasse H, Büsch D (2013) How to attack the service: an empirical contribution to rally opening in world-class badminton doubles. International Journal of Performance Analysis in Sport 13: 860 - 871.

32. Swann C, Crust L, Jackman P, Vella S, Allen M, et al. (2017) Performing under pressure: Exploring the psychological state underlying clutch performance in sport. Journal of Sports Sciences 35: 2272-2280.

33. Torres-Luque G, Fernández-García ÁI, Blanca-Torres JC, Kondric M, Cabello- Manrique D (2019) Statistical Differences in Set Analysis in Badminton at the RIO 2016 Olympic Games. Front Psychol 10: 1-11.