

**ANALYSIS OF STROKE DISTRIBUTION BETWEEN PROFESSIONAL,
INTERMEDIATE AND NOVICE SQUASH PLAYERS**

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DEDICATION

“To my beloved mother and father, FARIDAH MUSTAPHA and ABDUL GHANI MOHAMED, family, colleagues and friends whom much support me in doing this study. Without all of you, I will not be where I am today”

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ABSTRACT

The purpose of this study was to analyse the distribution of strokes of three different levels of players in squash game which were the professional elite, intermediate and novice players. Quantitative method and experimental repeated measures design were employed for data collection. A total of 5 players with an average age of 21.27 ± 5.22 years old were involved as sample for each level of players. Every type of shots for both forehand and backhand strokes performed by players were recorded. There were 15 types of shots executed by the players during games. The most common types of shots performed were identified and distribution of strokes was verified by coaches and experts. Recorded videos were then analysed using hand notational analysis while inferential statistics were conducted using SPSS version 16. Results showed that there were significant differences in backhand strokes between groups while there was no significant difference recorded in forehand strokes. Notational analyses data indicated that the most shots performed were backhand drive (BHDV) followed by forehand drive (FHDV) and both forehand and backhand cross-court drive (FHXCDV and BHXCDV). There were only five types of shots frequently performed and were found significant for all three levels: forehand drive (FHDV), forehand cross-court drive (FHXCDV), backhand drive (BHDV), backhand cross-court drive (BHXCDV) and backhand drop (BHDP). The results of this study showed that the backhand shots and shot selection during games might pose as the contributing factors to differentiate between three different levels of players. This study also generated playing pattern profiles of three levels of squash players which could provide essential knowledge for the coaches to recognize the ability of their players and thus improve the efficiency of training method and enhance the skills and playing strategies of their athletes.

ABSTRAK

Objektif utama kajian adalah untuk menganalisis taburan pukulan bagi tiga tahap permainan yang berbeza dalam skuasy iaitu profesional elit, pertengahan (*intermediate*) dan pemain baru (*novice*). Kaedah kuantitatif dan eksperimen secara berulang digunakan bagi pengumpulan data. Sejumlah 5 orang pemain dengan purata umur adalah 21.27 ± 5.22 tahun terlibat sebagai sampel bagi setiap tahap pemain. Setiap jenis pukulan untuk kedua-dua *forehand* dan *backhand* yang dihasilkan oleh pemain direkod. Terdapat 15 jenis pukulan yang dihasilkan semasa permainan. Pukulan yang paling banyak dihasilkan dikenalpasti dan taburan jenis pukulan disahkan oleh jurulatih dan pakar. Data yang direkod kemudian dianalisis menggunakan *hand notational analysis* manakala semua data statistik inferensi diproses menggunakan perisian *SPSS version 16*. Hasil dapatan kajian menunjukkan bahawa pukulan *backhand* mencatatkan perbezaan yang signifikan di antara kumpulan manakala tiada perbezaan yang signifikan direkodkan bagi pukulan *forehand*. Data *notational analyses* menunjukkan bahawa jenis pukulan yang mencatatkan jumlah tertinggi ialah *backhand drive* (BHDV) diikuti dengan *forehand drive* (FHDV) dan kedua-dua *forehand* dan *backhand cross-court drive* (FHXCDV dan BHXCDV). Hanya terdapat lima jenis pukulan yang paling kerap dihasilkan dan signifikan bagi ketiga-tiga kumpulan: *forehand drive* (FHDV), *forehand cross-court drive* (FHXCDV), *backhand drive* (BHDV), *backhand cross-court drive* (BHXCDV) dan *backhand drop* (BHDP). Dapatan kajian mendapati bahawa pukulan *backhand* dan pemilihan jenis pukulan ketika permainan merupakan faktor-faktor yang membezakan corak permainan bagi tiga tahap pemain. Kajian juga menghasilkan profil corak permainan bagi setiap pemain di mana profil tersebut boleh digunakan sebagai sumber pengetahuan oleh jurulatih untuk mengenalpasti kebolehan pemain mereka dan merangka jadual latihan yang lebih teratur dan berkesan untuk memantapkan lagi kemahiran sedia ada dan membentuk strategi permainan bagi para pemain.

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LIST OF ABBREVIATIONS

NSC	National Sport Centre is the sport committee that responsible in the development of the athletes in national squad.
SRAM	Squash Racket Association Malaysia is the sport association that responsible in all squash activities in Malaysia.
BJSS	Bukit Jalil Sport School is the development centre that gathers all potential athletes in Malaysia.
LIPT	Higher Educational Institutional Sports League as a platform for universities squash players represents their respective universities.
FHS	Forehand Serve
FHDV	Forehand Drive
FHV DV	Forehand Volley Drive
FHXCDV	Forehand Cross-court Drive
FHVXCDV	Forehand Volley Cross-court Drive
FHB	Forehand Boast
FHVB	Forehand Volley Boast
FHDP	Forehand Drop
FHVDP	Forehand Volley Drop
FHXCDP	Forehand Cross-court Drop
FHVXCDP	Forehand Volley Cross-court Drop

LIST OF ABBREVIATIONS

FHLB	Forehand Lob BHLB Backhand Lob
FHXCLB	Forehand Cross-court Lob
FHVXCLB	Forehand Volley Cross-court Lob
FHBM	Forehand Back Mirror
BHS	Backhand Serve
BHDV	Backhand Drive
BHVDV	Backhand Volley Drive
BHXCDV	Backhand Cross-court Drive
BHVXCDV	Backhand Volley Cross-court Drive
BHB	Backhand Boast
BHVB	Backhand Volley Boast
BHDP	Backhand Drop
BHVDP	Backhand Volley Drop
BHXCDP	Backhand Cross-court Drop
BHVXCDP	Backhand Volley Cross-court Drop
BHXCLB	Backhand Cross-court Lob
BHVXCLB	Backhand Volley Cross-court Lob
BHBM	Backhand Back Mirror

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Analysis in sports' main objective is to identify the problems or key factors that lead to the success or failure of the athlete's performance. Sport scientist generate new findings and information to be shared with the sports practitioners such as coaches, human movement professional, psychologist, physiologists and even the athletes themselves. The qualitative and quantitative analysis in sports has wide ideas in describing the performance's characteristics through observations. The purpose of the observations is to search for desired outcome and performance criterion.

Sports performance involving human movement systems includes the skeletal, muscular, respiratory and circulatory, nervous and also digestive systems. The movement in racket sports involves alternating movement by repetition of start and stops of running, speeding, bending and hitting (Girard & Millet, 2008). Performance generally occurs from the combination and interaction between tactical, technical, physiological and psychological skills. Athletes have to move rapidly, change techniques and tactics quickly to perform well and this activity describe patterns of coordination and body movement control.

The human movement system is a complicated system that involves all the systems and body components (such as muscles, bones, connective tissues, molecule and also blood cells). The movement patterns developed from the self-organization of both physical and biological systems of human body (Glazier *et al.*, 2003). Human

movement is a combination of linear and angular motion (Woo, 1993). The motion comprises of different stops and poses, changes of motion direction, turns, jumps, lunges and side-steps (Vučković, 2005). Past biomechanical studies analysing the segmental coordination of a sporting skill have employed various kinematic measures to quantify movement. Sports game is an exercise requiring physical effort, flexibility, speed, endurance and a high degree of hand-eye-footwork co-ordination.

Figure 1.1 on page 3 describes the framework of sport performance. Sports sciences can be divided into several sub-discipline such physiological, sociological, psychological, performance analysis, notational analysis and biomechanics (Glazier, 2010). Notational analysis in particular focusing on video analysis to improve performance by analysing the key indicators that leads to the success in particular sports. Performance indicators (performance parameters) are the variables that define the features of a performance that will contribute to the results or outcomes of that performance. There are several types of performance indicators such winners, errors, strength, weaknesses, technical and also tactical aspects and it is depends on the unique characteristics of the game itself.

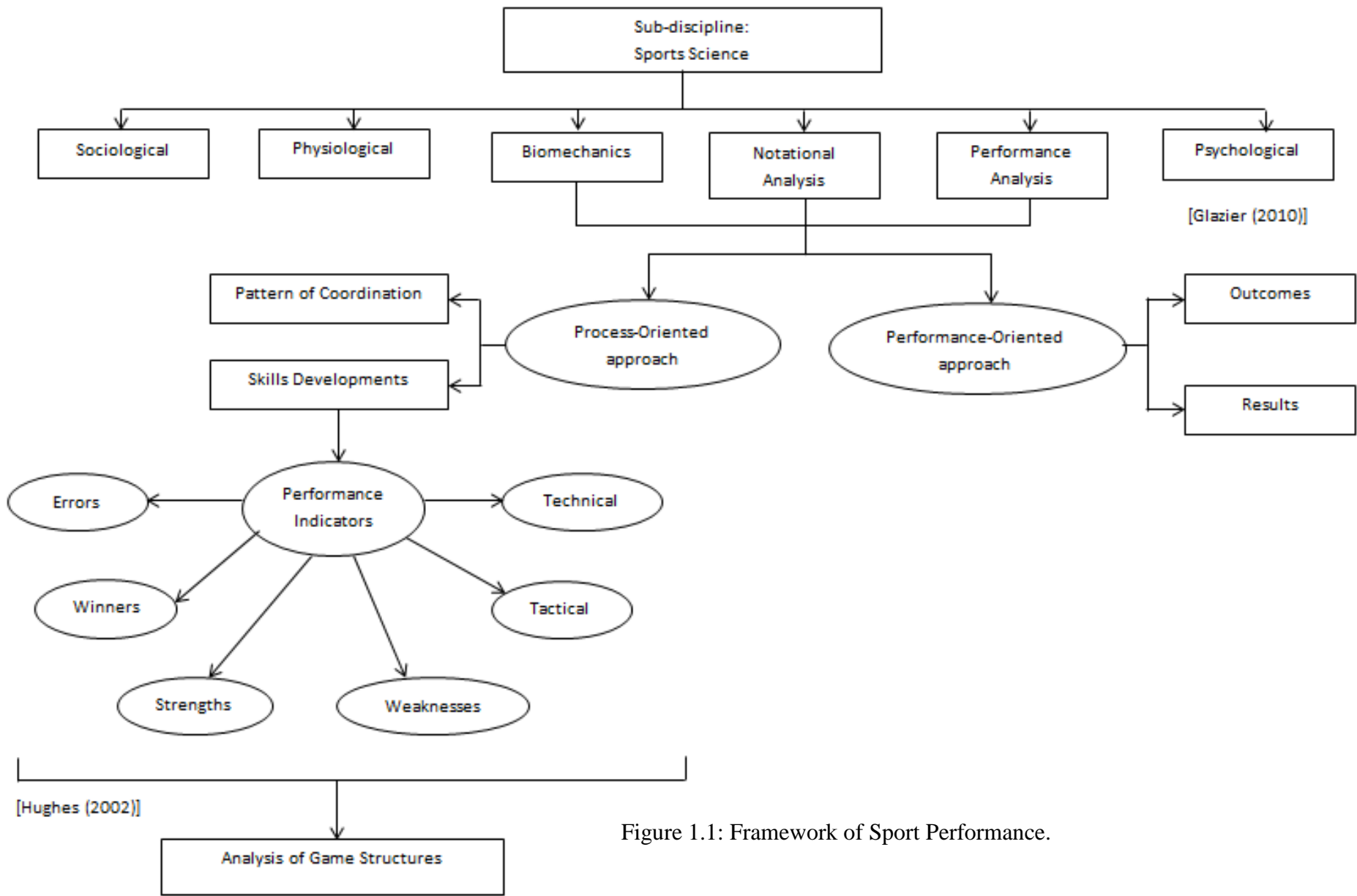


Figure 1.1: Framework of Sport Performance.

Sports game are known by many types and classification. Generally, according to Read & Edwards (1992), formal sports game in game classification can be divided into three parts; net and wall games, invasion games and striking/fielding games. Under these three parts of game classification is sub-groupings by the game ended or rules of scoring (Figure 1.2 on page 5 for detail). Net games can be categorized into non-volley (table tennis), volley and bounce (tennis) and non-bounce games (badminton and volleyball). The wall games categorized as volley and bounce (squash and fives). The invasion games can be categorized as goal throwing (netball, basketball and handball), try scoring (rugby) and goal striking (hockey and soccer). The striking and fielding games can be categorized into wicket (cricket) and base-running (baseball and softball).

Even though there are differences in all of these games, the performance indicators used are very much alike. All the factors that lead to the performance enhancement during games such as rally length, winners, errors, shot distribution, shot selection, shot execution, defensive and attacking shots, service, passing, tackling, shots, goals and set pieces are involved for the thorough analysis of the match (Hughes & Bartlett, 2002) and to provide positive feedback to players and coaches for better understanding and to improve performance.

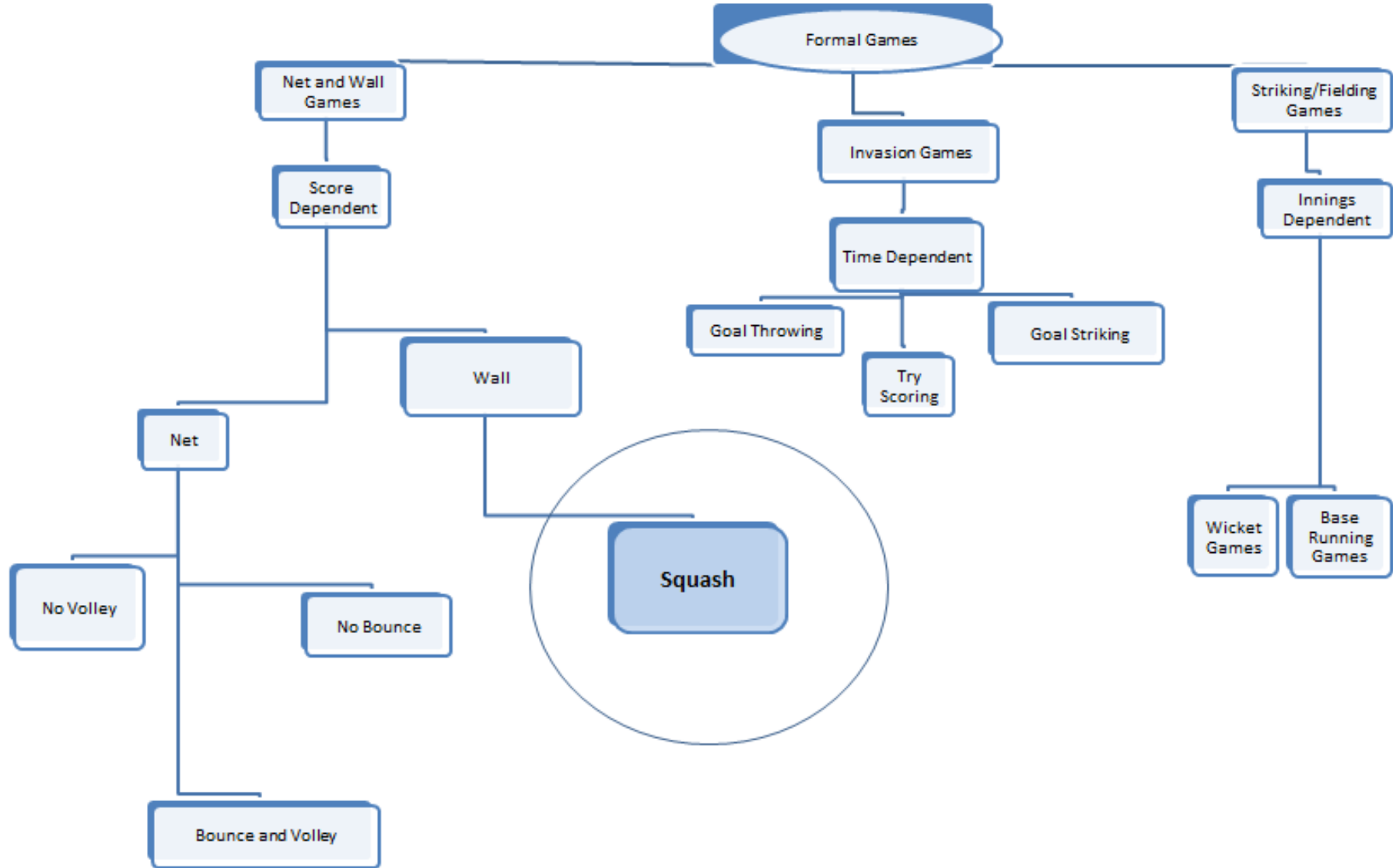


Figure 1.2: Game Classifications (Read & Edwards, 1992)

The most important objective in notational analysis is to obtain the characteristics of most effective techniques and tactics in certain sports. Playing pattern in sports contain the playing techniques and tactics of the athletes. The way they performed their skills and implement their own game strategy indicates their playing standard.

The focus of this study was the distribution of strokes among three different levels in squash game which are professional elite, intermediate and novice players. The playing patterns were observed through strokes distribution using notational analysis. Notational analysis is the process of collecting, recording the activity and movement formed by players during play and then analysing and assessing the recorded data to provide an outcome and feedback for evaluation. According to Hughes (2004) there are lists that need to be followed in order to assist the notational analysis such as defining performance indicators, determining which indicators are important, verifying the reliability of the data obtained, certifying that the amount of data gathered sufficient to define performance profiles, comparing sets of data and so on. (Figure 1.3 below)

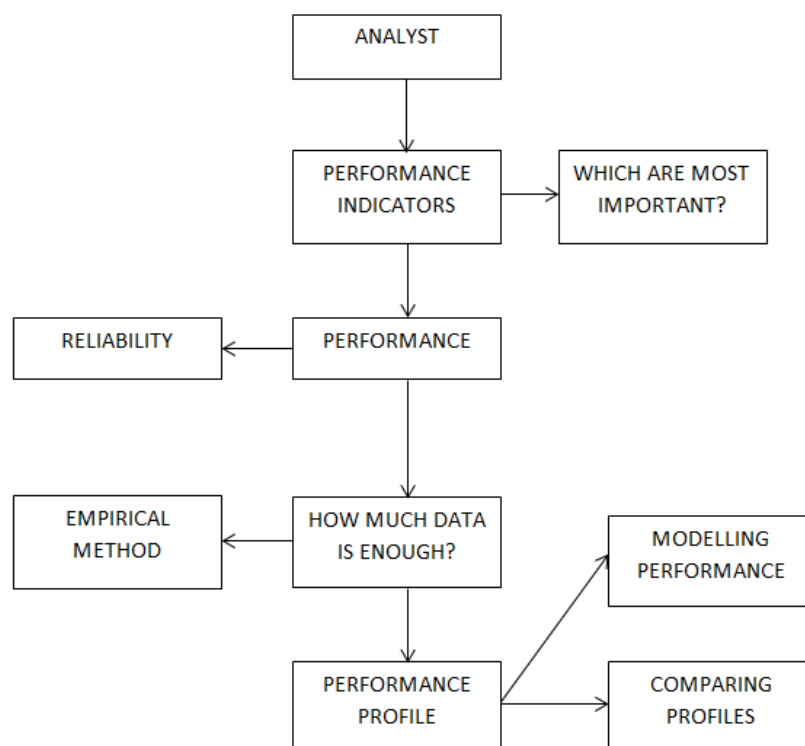


Figure 1.3: Chart of the steps in Notational Analysis (Hughes, 2004)

Defining the performance indicators as the first step is very crucial to outline the important variables that reflect the playing pattern of the players. Skills in sports have variety of reasons to be executed, for example to score a goal (soccer, handball, netball and etc.), hitting target (shooting and archery), make the opponent out of position to gain points (squash, tennis, badminton and table tennis) and also defence (boxing and wrestling). Identifying the main purpose of the certain skills in games can help the athletes to be successful and perform well during competitions. It is also important for the coaches and sports biomechanists to gain knowledge and focus on the improvement of the athlete's performance (Ellis, 2003).

Figure 1.4 below illustrates the important factors that can influence the outcome in squash. There are many factors that contribute to the success of the performance during games such as rally length, winners, errors, shot distribution, shot selection, shot execution, defensive and attacking shots and also the service. In shot selection, it can be divided into two parts, the forehand and backhand. In this two major part, there are various kinds of shots that can be executed by the players such as a drive, power drive, volley drive, volley power drive, drop, boasting, short boasting, cross-court, volley cross-court drop, volley cross-court, cross-court drop, volley drop, lob, and cross-court lob and so on. These entire shots are very important performance indicators as a core to the tactical strategies of a player during game.

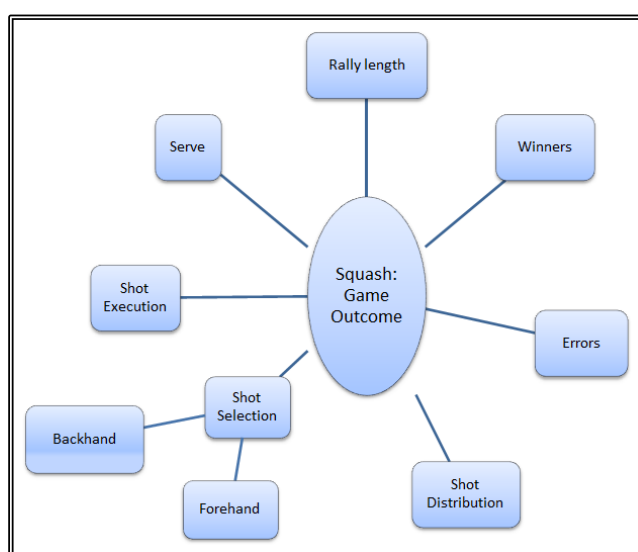


Figure 1.4: Factors that contribute to performance in squash game.

Second step in progression during notational analysis is to determine the important indicators that lead to the success of the players. Playing pattern in this study is defined as the shots produced by the players during play. Shots in squash according to McGarry & Franks (1995) are identified as serve, drive, volley drive, cross-court drive, volley cross-court drive, boast, volley boast, drop, volley drop, cross-court drop, volley cross-court drop, lob, cross-court lob and volley cross-court lob (Figure 1.5 below). Thereby, the important performance indicators for this study is decided to be the fifteen possible shots including the back mirror and serve shot.



Figure 1.5: Shots selection in Squash

Playing patterns always depend on the players and their opponent. According to the Oswald (2006) the elements that demonstrates playing pattern are the position of the players in court, types of stroke, the direction of stroke and also the effectiveness of the shots. Squash game are consists two major strokes during playing, the forehand and the backhand. The forehand stroke is easier to perform compared to backhand stroke because of the body stance and hand of a player is in a comfortable position to make shots without having to cross between the position of the hands and legs. Players often use the forehand stroke because the forehand stroke was the most basic strokes compared to other strokes.

However, in real game situation, the opponent always attacks the weak point of the players and the weaker part of most players is at the backhand area. The backhand is always a difficult stroke to be executes and it is the fragile part of most players (Tolentino, 2009). Backhand area has always been targeted by the opponent during game as that area is the least favoured by the players. Players without strong backhand strokes will have to work extra hard to win a point during rally. Performing attacking stroke in squash requires proper stroke technique, body posture, angle and target area at the front wall to make the trajectory of the ball complicated and deep thus create challenging situation for the opponent to return shot. By utilising an effective stroke, players can easily control a game and wins rally. Both forehand and backhand includes all type of shots and it is depends on where the ball lands during play, either at the forehand area or backhand area. The playing pattern is formed by players using all the identified shots according to the situation and the return shot by the opponent.

The results of performance analysis always play important roles in giving feedback to the players and coaches. It can emphasize the use of the techniques and tactics during a match and enhance the performance.

1.2 Background of Study

Performance in squash depends on many factors in a game, among which tactical and technical strategies clearly plays an important roles. According to Kapidžic *et al.* (2009), based on a guideline that could contribute to the quality of a game, one of it is the improvement from the aspect of technical-tactical elements. During games, players execute variety of strokes to defeat their opponent. Players may use different strokes in different situation depending on the ball retrieved by the opponent to the many side of the court. According to Vuckovic *et al.* (2006), players may use different types of strokes for different situation or same strokes for same situation. The selections of stroke during a game are based on the player's observation towards the opponent's game strategies and leads to the selection of the most effective stroke in that situation.

Squash has one tactical play named basic play. Vuckovic *et al.* (2006) define basic play in squash as the playing strategies that use the back area of the court and players force their opponents to the back of the court far away from T-area (centre of the court). At the back area of the court, the player has the lowest chance of hitting a winning shot. There are many other strategy and of the most common executed by the players is the ball has to be closely to the side wall and this could avoid difficult return or attacking shot from the opponent. Players always return to the centre of the court (T-position) after hitting a serve or delivering the shot while playing because the position was strategic as it is at the centre and player can observe the opponent's next shot and planned for the next movement.

Research by Vuckovic *et al.* (2006) investigate the difference in the percentage of strokes executed in specific segments of the court by two groups of players of different quality. The world ranked players playing strategies are more accurate and efficient. Results of the study shows that the playing tactics of players of different quality are almost the same. Two groups of different quality executed the strokes that aim the ball to the back area of the court. Both groups realize the importance of the basic tactical strategies to accomplish high performance standard.

It seems that the individual tactical and technical capability strategies are the only factors that differentiate these groups of players.

Based on the international tournament (National Sport Centre Series No.6 one star in 2009) video observation using hand notational analysis, most of the elite player played almost 62% on the backhand side of the game and the players with higher skill of backhand stroke have advantage whether during attacking or defensive situation in the game. Players also played most of the strokes on the backhand area during National Junior Circuit Sportexcel (2011) and National Junior Championships (2011) and some of the players lost points because they had been attacked on their backhand area continuously. Both situations clearly justify that backhand is a crucial factor that influenced the performance of players during game.

To date, many studies on squash only focusing on analysing the tactical strategies and game play by the athletes. Research by Hong *et al.* (1996) in comparison of the game strategies employed by national and international squash players in competitive situation by notational analysis studied more on the game strategies. Study by Hong *et al.* (1996) and Hughes (1985, 1986) analysed the differences in patterns of play between players at different competitive levels. Study by McGarry & Franks (1994) also focusing on the tactical strategies. In spite of many researches (more as discussed in Chapter 2) that investigate tactical and technical indicators, there are still lacks of study that analysed the playing pattern in squash that focus on the shot selection and strokes distribution by three different levels during play.

Selection of shots during a game is very important at which it can determine whether the return produced can achieve any degree of success in the game. Most athletes normally struggling to improvise their shots selection technically and tactically during rally. Crespo & Higuera (2001) pointed out that the ability to hit the ball with great power is a characteristics of the current game. Beginners and younger players still need to develop this ability among other skills which might separate them from the professional elite players.

Reviews on some of the literatures of performance analysis generated a lot of information regarding the playing pattern analysis (more as detailed in Chapter 2). Many of the articles and journals that have been written describe the playing patterns on the tactical and technical movement such as the position of the ball landing in the court (Vuckovic, 2006), the movement pattern of the players (Racz *et al.*, 2010) and also the shot selection (Vuckovic *et al.*, 2012). This study also concentrate on the playing pattern of shot selection in squash but the focus group were among three different levels of playing, the professional elite, intermediate and novice players. The shot selection executed by the players will be analysed and compared to each group to create the playing pattern profiling.

Some of the study parameters that involves playing patterns are summarized in the Table 1.1 on page 13. Based on these summarized data, it verifies that research towards performance analysis in squash especially playing patterns focusing on shot selections are still insufficient and need to be studied to understand the patterns and factors that lead to the success of squash performance.

Table 1.1: Study parameters that involved playing patterns

AUTHOR	TYPES OF SPORT	SAMPLE SIZE	POPULATION	PARAMETERS
Knudson (1991)	Tennis	12	Advanced and Intermediate	Pattern of forces and peak loads on the hand
Landlinger et.al (2010)	Tennis	13	Elite and High-performance	Kinematics variables and timing patterns
Vuckovic et.al (2005)	Squash	30	Professional and National	Motion analysis (work-rate) pattern
Vuckovic et.al (2006)	Squash	30	Professional and National	Playing efficiency and stroke distributions
Murray and Hughes (2001)	Squash	6	Elite	Tactical performance profiling
Vuckovic et.al (2012)	Squash	15	World's top players	Tactical shot selection
Racz et.al (2010)	Racket Sports	-	Elite players	Tactical and movement analysis
Hughes, M.T., Howells, M., Hughes, M. (2006)	Squash	2	Elite players World and Austrian Top	Performance profiling
Oswald (2006)	Badminton	40	players.	Playing pattern and comparisons
Tong, Y.M. and Hong, Y. (2000)	Badminton	11	Top Single's Hong Kong	Playing pattern of world's top single badminton players
Sofwan et.al (2012)	Field Hockey	10	Olympic Qualifying Team	Playing Pattern between winning and losing team
	Beach			Techniques and Tactics: Comparison of male and female
Koch, C. and Tilp Markus (2009)	Volleyball	29	Teams in Grand Slam 2005	playing characteristics
O'donoghue, P and Ingram, B. (2001)	Tennis	252	Grand Slam Singles	Notational analysis of elite tennis strategy
				Differences in game patterns between male and female youth
Costa et.al (2012)	Volleyball	19	Youth National Team	volleyball Modelling Competitive Squash Performance from Quantitative
McGarry, T. and Franks, M. (1995)	Squash	3	Elite players	Analysis

1.3 Statement of Problems

Research conducted in racket sports have grown in the area of performance and notational analysis. Squash specifically is an ideal sport for performance analysis because the nature of the game that played indoor and restricted to a small area and the rallies are easily recorded and recognized than the other sports. As the field of notational analysis is becoming more acknowledged, it is more exciting to extend the knowledge and databases to create the possible performance profiling and predict the near future of the performance analysis. This area needs more attention by all sport scientists to communicate and interact with the athletes and coaches and also to develop performance and design indicators that can be evaluate qualitatively and quantitatively in a game (Hughes & Bartlett, 2002).

Tunney (2001) expressed three main components in his writing ABC's of squash; Accuracy, Balance and Control. Accuracy can be defined as the exact position/placement of the ball during rally. Playing shots with high accuracy is much better than playing with power as accurate shots can effectively make the opponent out of their position and create chances for players to win a rally. Balance is the component in the follow-through phase; the ability to maintain body stability after hitting the ball and preparing for the next action. Control in terms of physical is the sufficient fitness to sustain the rally during game and maintain to make movement after executes one shots to another in turn. In terms of mental, control is the ability to focus in game and playing our own game without been effected by the opponent's playing rhythm.

There are several factors that contribute to the success of delivering good accuracy, balance and control shots during a rally. Factors such as the distance between the ball and racket, optimum strike point of the ball between feet, knees and waist, strong racket skills and proper stroke techniques to produce the shots influenced the outcome of a rally (Tunney, 2001). In consequence, to sum up based on the study by Tunney (2001), the tactical and technical of skills are the most important factors to execute an efficient shot to win rallies. When comparing the standard of playing between the professional elite players, national junior players and

the university players, there is apparent difference in terms of the physical fitness, movement, technical and tactical aspects. However, the selection of shot will always be the same. The choice of shot will always depend on the game situation and opponent's reaction on that very moment of the game.

There are five basic shots in squash which are drive, cross-court, drop, boast and lob. Figure 1.6 below describe further all these five shots.

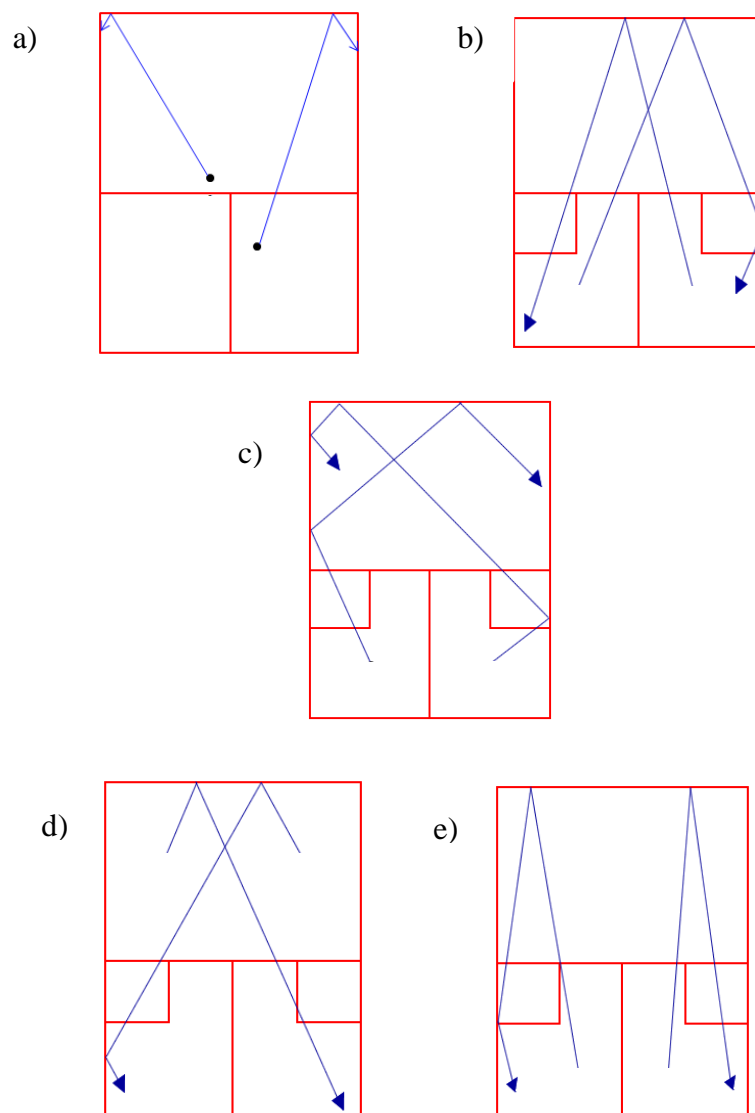


Figure 1.6: a) Drop. b) Cross-court. c) Boast. d) Lob. e) Drive
 [pictures were from Titan Sports: <http://www.titansport.co.uk/squash%20tips/>]

All of these type of shots was defined and explained according to McKenzie (1993). Figure 1.6a on page 15 describes drop shot outline. Drop shot is a shot that is played just above the tin and bounces low near the front of the court. It is a shot that softly bounce at the front of the wall (McKenzie, 1993). This shot usually played when the opponent is out of position (far from “T” and front court). T is an area at the centre of the court. It is a control area at which a player can effectively prepare for rally.

Figure 1.6b on page 15 describes cross-court shot. Cross-court shot is a shot that after striking the front wall will creates a “V” shape and lands in the opposite side of the court from which it was played (McKenzie, 1993). This shot is to distract the opponent rhythm of play and drags them to play at the different area after a long rally.

Figure 1.6c on page 15 describes a boast shot. Boast shot is a shot that hits side walls or the back wall before hitting the front wall. Most boasts are sidewall boasts (McKenzie, 1993). Attacking boast is played when you are in front of your opponent, usually called short boast. Short boast is played when the opponent is at the back of the court and the shot will land at the front of the court so that the opponent will have to make extra effort to return the ball.

Figure 1.6d on page 15 describes lob shot. Lob shot is a shot that hit upward and softly on the front wall that curves high and lands deep at the back area of the court (McKenzie, 1993). This shot usually played when you are far from the ball and have to run all out to retrieve the ball, while your opponent awaits you to make the shots and they are already preparing for the next attacking shot.

Figure 1.6e on page 15 describes drive shot. Drive shot is a standard groundstroke, flat and firm shot with good length. It is a shot that after hitting the front wall, it will bounce back behind the service box (McKenzie, 1993). An effective drive will have two aspects; depth (good length) and tight to the sidewall. Good length will drive the ball at the back corners of the court and ideally the second bounce will creates “nick” shot. Nick shot is a shot when the ball hits the intersection between the floor and any sidewall or back wall and immediately off

bounces and roll at the floor (McKenzie, 1993). This is usually a winner for players. By hitting the ball tight to the sidewall, your opponent will be forced to return their shot off the wall and plays defensive shot.

Volley shot such as volley cross-court, volley drive, volley power drive, volley cross-court drop nick and volley drop occurs when the players hits the ball directly without bouncing at the floor (before the ball hit the floor). It is a shot in which the ball is struck on air before it bounces on the floor.

Players played using all of these shots and generate their own pattern and shots distribution. Different players performed different style of playing according to their opponents' response shots (Vuckovic *et al.*, 2006). Therefore, a research should be conducted in order to identify the playing pattern between these three different standards in term of strokes distribution and shots selection. McGarry & Franks (1995, 1996) found a consistent pattern in shot selection responses to certain types of shot when playing against same opponent but were unable to verify an individual pattern of play against other opponents. Strategically, shots return to the back left (backhand) of the court is always been played as a safe play or basic play (Vuckovic *et al.*, 2006). It is also defensive playing pattern to conquer the 'T' area (center of the court) while the opponent reaching the ball at the back of the court. Conquering 'T' area give players an advantage to control the rhythms of the game by attacking shot with volley to pressure the opponent (Vuckovic *et al.*, 2009). The cross-court shots also always been made to change the opponent's rhythms during rallies. Murray & Hughes (2001) outlined the importance of tactical plans in tactical performance profiles based on database. It is important for the players to understand their strengths and weaknesses in order to strategically plan their tactical game. According to Hughes & Bartlett (2002), a comparison with previous performances and with team members or opponents are important to enable a complete explanation and understanding of the data from the analysis.

Therefore, the aim of this research is to analyse the distribution of strokes between three different levels of playing (professional elite, intermediate and novice players) based on their shots selection during play and generate playing pattern profiles.

1.4 Significance of Study

Science in sports has been particularly beneficial in improving the fitness, tactical, technical and performance of the athletes. Sports analysts concerned to do research to understand human motion and expand maximum potential of the athlete's performance. Pattern of skilled performance in sports has always related to the development of sports performance. According to Lees (2003) notational analysis comprises five main function; (i) analysis of movement, (ii) tactical evaluation, (iii) technical evaluation, (iv) database development and modelling, and (v) educational use for coaches and players. All of them definitely have great influence and impact on the improvement of performance in racket sports.

As a coach or notational analyst, there will be need to assess and evaluate athletes to identify the key factors of their performance. Coach especially should be able to differentiate between what is important and what is not, strengths and weaknesses, winners and errors and etc. All of the information could be provided by notational analyst by generating performance profile of their athletes.

The analysis of performance always gives feedback that will guide and direct the coaches and players to enhance their understanding in the respective sports. The findings of this study can be vital for successful player development, improved performance or prevent injury. The results also may be helpful for a coach to implement accurate timing in executing proper techniques and tactics during a game to enhance the players' performance and game results. The notational analysis study by Ming *et al.* (2008) stated that the most repeated stroke used in badminton was lob followed by net, clear and smash and it is supported by the study conducted by Tong & Hong (2000) who had also done the notational analysis into playing pattern and found out that lob was the most frequent shot followed by smash, net and clear. Both studies were performing different investigation on the same field and yet the outcomes were still similar. It showed that even if the procedures and methods were different but through notational analysis, the data obtained were still valid and supported each other. The feedback of analysis gives rationale and significant data to the coaches and players for their performance. This research will contribute to a

better coaching perspectives and help beginners and developing young players to understand their weaknesses and abilities thus could improve their performance in game.

The findings of this research will also contribute to the playing pattern profiling of the players themselves. Statistics on sport performance indicates that performance profiling should be included to look for commonalities and diversities of playing pattern (Brisson & Alain, 1996). The results and data will be arranged and compiled as athlete's playing pattern profiles. Databases could offer knowledge about distribution of strokes and choice of shots of players during games. Performance profiling of many groups in the same sports could provide better information in order to understand and develop strategic game plan.

According to Button & Davids (1999), a profiling needed a small group of athletes to perform an action several times to create generalization reaction hence identifying the similarities and differences among groups. The performance profile data of fifteen squash players; five professional elite players, five intermediate players and five novice players are included throughout this research. Identifying the similarities and differences between patterns of play would help in identifying the features characteristic for excellent players.

The result of analysis can be used for the development of the training strategies and method for the sake of the players. Basic understanding of the playing pattern in this study will aid the recreational and other novice squash players, coaches and also educators in the design and training programs with the aim for optimum results and performances. Information gained on the results may also provide optimal strategies in training periodization following a competition. The findings may also enhance the understanding of possible benefits linked with the sports biomechanists and performance analysis.

1.5 Objectives of Study

The main objective of the study is to analyse the playing pattern of three different levels of playing; the professional elite, intermediate and novice players based on distribution of strokes.

This study also embarks on the following objectives:

- i. To analyze the distribution of strokes in backhand and forehand area between professional elite, intermediate and novice players during game.
- ii. To design playing pattern profiles based on strokes distribution of players during games.
- iii. To provide profiles of players as a contribution and reference to create ideal training program, game strategies and playing style of players.

1.6 Hypothesis of Study

It is hypothesized that:

1.6.i.1 HA1: There are significance differences in the distribution of backhand and forehand strokes between groups during game.

1.6.i.2 HA2: There are significance differences in the types of shot execute between groups during game.

1.6.i.3 HA3: There are significance differences in the most frequent shot produce between groups during game.

1.6.i.4 HA4: There are significance differences in the playing pattern between groups during game.

1.7 Research Questions

In order to address research objectives, a series of research question are prepared:

- i. What is the distribution pattern in backhand and forehand strokes during game?
- ii. Are there any differences in the distribution of backhand and forehand strokes by players during game?
- iii. Are there any differences in types of shot executed between groups?
- iv. What are the most frequent shot executed by players during game?
- v. Are there any differences in most frequent types of shot executed between groups?
- vi. What is the playing pattern of three different levels of playing?
- vii. Is the playing pattern of three different levels of playing are similar?

1.8 Delimitations

i. Only fifteen squash players (n=12 males and n=3 females) aged 14 to 30 years old (mean \pm standard deviation; 21.27 ± 5.22 years) were involved as subjects in the current study. The professional elite players are all Malaysia representatives and selected during CIMB Nicol David Kuala Lumpur Open 2012 tournament. The national junior players were selected from the national junior squad and currently under the development training programme by the National Sport Centre (NSC), Squash Racket Association Malaysia (SRAM) and Bukit Jalil Sports School (BJSS). The university players were selected during Higher Educational Institution Sports League tournament (LIPT) and all players were representing their respective universities throughout Malaysia. Criteria of selecting the players was explained in Chapter 3, section 3.3 on page 40.

- ii. Observation and analysis of the playing pattern during the game will only focus on the strokes distribution and shots selection during matches.
- iii. The camera position is only being placed at the frontal view of the court and ensures that the whole court area was recorded.

1.9 Limitations

- i. The observation and performance analysis concentrated only on the fifteen selected squash players and the playing pattern were focusing on the shot selection during game.
- ii. Data of this study may be influenced by the players' opponent during their matches.
- iii. Data obtained and total matches that been recorded depended on the players' performance and achievement during game.
- iv. The software used; Microsoft Excel 2010 and Statistical Product and Service Solution version 16.0 (SPSS) were used to analyse and determine the playing pattern.

1.10 Conclusion

This chapter had discussed regarding the problems, objectives and hypothesis of this study. Main objective was to analyze the playing pattern of three different levels of playing; the professional elite, intermediate and novice players based on distribution of strokes. All data recorded were included shot selection, distribution of strokes, shots response, winner and error shots performed by players during games. All of data recorded were then analysed for playing pattern. At the end of the study, playing pattern profiles were created.

1.11 Operational Definition

The following terms are used in this study:

Professional elite players	Professional squash players in the national squad that representing the country and currently have world rankings.
National junior players	Junior squash players that under development training program of NSC, SRAM and BJSS.
University Players	Squash players that representing their respective universities throughout Malaysia.
Shot	Stroke made during playing game by the players such as serve, drive, volley drive, cross-court drive, volley cross-court drive, boast, volley boast, drop, volley drop, cross-court drop, volley cross-court drop, lob, cross-court lob and volley cross-court lob.
Playing Pattern	Tactical strategies in stroke distribution and shots slelection played by the players during game.
Notational Analysis	Analysis of performance that can be quantified objectively to measure main parameters.
Serve	Shot played to begin new game or performed after players have gained points.
Drive	Shot played straight to the back of the court.
Volley	Shot played directly without bouncing at the floor first.

Cross-court	Shot performed and land at the opposite side of the court.
Boast	Shot that hit side walls first before hitting front wall.
Drop	Shot played just above tin and bounces near front court.
Lob	Shot played by hit upward and curves high and then lands deep at the back court.
Back Mirror	Shot played by hitting back mirror first before hitting front wall.

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