THE ANTHROPOMETRIC CHARACTERISTICS AND KINEMATIC ANALYSIS OF THE CRICKET PULL SHOT AMONG MALAYSIAN ELITE BATSMEN

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ABSTRACT

Empirical studies examining the relationship between anthropometric measures and kinematics of sport skills, especially cricket, are limited. The purpose of this study was to examine the anthropometric characteristics of elite Malaysian cricket batsmen and their relationship with the kinematics of the players executing the pull shot. Eighteen Malaysian national cricket batsmen from three age groups (seniors, under-19 and under-16) were selected for the study. Anthropometric measures included body composition, stature, body segment (limbs) measures and two physical strength tests. Participants performed the intended stroke against a bowling machine with 15 retro-reflective markers attached to their limbs. Their performance was videotaped. Kinematics of the stroke were analysed using Aerial Performance Analysis System. One way ANOVA analysis showed the senior and under-19 players were significantly heavier and greater limb size than the under-16 group. Factorial ANOVA comparing successful and unsuccessful pull shots between groups showed the senior batsmen's right knee and left hip were significantly more extended at bat-ball impact than the younger age groups when performing the successful pull shots. However, the under-16 batsmen showed faster limb movements and bat speed compared to other groups in successful pull shots. The head-to-ball distance was further, left elbow more extended, the bat face angle was lesser at successful pull shot than unsuccessful pull shot among all groups. Pearson correlation examining the relationship between anthropometric and kinematics of the pull shot showed the large girths of the upper body were significantly correlated with the pull shot technique. The superior upper limbs were associated with the extension of the arms joints which assisted the batsmen to execute the successful pull shot. It is suggested the cricket batsmen extended their limbs, generated higher velocities of the pelvises and upper body in order to execute the successful pull shot. Future research analysing the technique in real match situation is suggested.

CIRI-CIRI ANTROPOMETRIK DAN ANALISIS KINEMATIK PUKULAN SENTAP DALAM KALANGAN PEMUKUL KRIKET ELIT MALAYSIA.

ABSTRAK

Penyelidikan empirik yang mengkaji hubungan antara pengukuran antropometrik dengan kinematik kemahiran sukan, terutamanya kriket adalah amat terhad. Tujuan utama kajian ini adalah untuk menganalisis secara kuantitatif ciri-ciri antropometrik dan perkaitannya dengan kinematik pelakuan pukulan sentap bagi pemain (pemukul) kriket elit Malaysia. Seramai lapanbelas (18) orang pemukul dari pasukan kriket Kebangsaan Malaysia yang terdiri dari tiga peringkat umur (senior, bawah-19 tahun dan bawah-16 tahun) dipilih sebagai peserta kajian ini. Pembolehubah antropometrik adalah jisim badan, tinggi, ukuran segmen (anggota) badan dan dua ujian kekuatan fizikal. Peserta memukul bola yang dihantar oleh mesin *bowling* dengan 15 penanda retro-reflektif dilekatkan pada anggota badan mereka. Setiap aksi perlakuan memukul di rakam mengunakan kamera video. *Aerial Performance Analysis System* digunakan untuk menganalisis ciri kinematik setiap pukulan. Analisis statistik Anova satu-hala menunjukkan bahawa pemain senior dan bawah-19 tahun secara signifikan adalah lebih berat dan mempunyai anggota badan yang lebih besar dari pemain bawah-16 tahun. Statistik Anova Faktorial yang membandingkan antara pukulan sentap kategori berjaya dengan tidak berjaya antara kumpulan telah menunjukkan bahawa sudut ekstensi lutut kanan dan pinggul kiri pemain senior lebih tinggi dari pemain yang lebih muda ketika fasa impak bola-pemukul. Walaubagaimanapun, pemain bawah-16 tahun menunjukkan pergerakan anggota badan dan pukulan yang lebih pantas berbanding dua kumpulan yang lain. Jarak kepala-ke-bola lebih jauh, sudut ekstensi siku kiri lebih tinggi, dan sudut kecondongan pemukul lebih rendah bagi pukulan sentap kategori berjaya berbanding pukulan kategori tidak berjaya bagi semua kumpulan umur. Statistik korelasi Pearson yang melihat hubungan antara ciri antropometrik dengan kinematik pukulan sentap menunjukkan bahawa ukur lilit atas badan mempunyai korelasi yang signifikan dengan teknik pukulan sentap. Anggota badan yang lebih besar dapat dikaitkan dengan lakuan ekstensi sendi tangan yang membantu pemukul melakukan pukulan sentap kategori berjaya. Dicadangkan supaya pemukul mengekstensikan anggota yang terlibat, mengerakkan pelvis dan atas badan dengan lebih laju untuk melakukan pukulan sentap yang berjaya. Disyorkan agar kajian akan datang melihat teknik pukulan sentap ini dalam situasi permainan sebenar.

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CHAPTER 1

INTRODUCTION

1.1 Chapter's Overview

The first chapter of this study highlights the importance of the pull shot in cricket, it's coaching and empirical description. Subsequent part discusses the anthropometric profile of the cricket batsmen and the role of physical characteristics in the batting performance. The other parts of this chapter are the statement of the problem, purpose and significance of the study, objectives of the study, hypothesis, limitations and delimitations, operational definitions, and definitions of the terminologies.

1.2 Background of the Study

The pull shot is an attacking shot that is played at the short pitched deliveries, with the horizontal swing of the bat across the upper body of the batsman (Kelly, Curtis & Craven, 2003; Woolmer, Noakes, & Moffett, 2008; Curtis, 2010). As a fear-inducing tactic, many fast bowlers target the upper body of the batsmen with the short pitched deliveries to intimidate them and to engineer the catch out chance through the top edge of the ball from the bat (Regan, 2012). The cricket batsmen respond to the short pitched delivery in two ways either back foot pull shot or back defensive shot (ACB, 2001; Woolmer et al., 2008). The pull shot is an opportunity for a batsman to hit the short pitched ball for a boundary – four runs at one shot (De Villiers, 2015). With the panoramic change in trends of cricket in the modern era, boundaries have gained more importance to increase strike rate of the batting team (Taliep, Prim & Gray, 2010). The confidence of a batsman increases as he executes the pull shot for the boundary (Hinchliffe, 2011). The linear and angular position of the feet, knees, hips, shoulders, elbows and bat are involved in the execution of the successful pull shot. Along with the biomechanical factors, the body size of a batsman also plays an important role in executing the pull shot (Kidger, 2011).

The anthropometric measurements of the cricket players provide information to understand the specific roles of cricket players as a batsman and bowler in the overall performance of the team (Stuelcken, Pyne, & Sinclair, 2007). The results of the previous studies have revealed that anthropometric profiles of the athletes assist the coaches in assigning a specific role to players as a defender, attacker, or specific positions especially in team games (Garcia, 2007; Carvajal, Ríos, Echevarría, Martínez,

Miñoso, & Rodríguez, 2009). Furthermore, strong physical features such as height, body mass, girths, lengths, and breadths of the body segments assist players to show good performance in sports competitions (Rico-Sanz, 1998). The previous studies have examined the relationship between the anthropometric characteristics of players and their performance in many sports such as in volleyball (Bourgois, Claessens, Vrijens, Philippaerts, Van Renterghem, Thomis, Janssene, Loos, & Lefevre, 2000), baseball (Bonnette, Spaniol, Melrose, Ocker, Paluseo, Szymanski, 2008; Nakata, Nagami, Higuchi, Sakamoto, & Kanosue, 2013), cricket (Pyne, Duthie, Saunders, Petersen, & Portus, 2006; Aruparayil & Chattopadhyay, 2013). Previous studies of the baseball batting reported that batsmen with large arms and legs produce greater force at bat-ball impact than their shorter counterparts (Basile, Otto & Wygand, 2007; Bonnette, Spaniol, Melrose, Ocker, Paluseo & Szymanski, 2008; Szymanski, DeRenne, & Spaniol, 2009). In cricket batting, the stature and arm's length of the batsmen were positively correlated with the technique of the back foot off the drive (Aruparayil & Chattopadhyay, 2013). As like the anthropometric characteristics, the physical strength would increase the batting performance.

The physical strength of the upper limb increases the transmission of force from the lower body to the bat which increases the played ball velocity (Taliep et al., 2010). The strength of the lower limb maintains the stability and balance of the cricket batsmen during the execution of shots (Nunes & Coetzee, 2007). Physical strength increases the bat velocity that ultimately effects on the performance of the pull shot as proved in the study of baseball batting (Nakata, Nagami, Higuchi, Sakamoto, & Kanosue, 2013). The hand grip strength is positively correlated with the home run shot - a played ball covers the maximum distance and crosses the boundary fence (Hoffman, Vazquez, Pichardo,

& Tenenbaum, 2009). The hand grip and back strength increase the bat speed in baseball which also confirmed by (Kohmura, Aoki, Yoshigi, Sakuraba, & Yanagiya, 2008; Nakata et al., 2013). It would be considered that hand grip and back strength increases the pull shot performance as proved in the studies of baseball. However, lack of studies in cricket which examine the anthropometric characteristics of the batsmen and its relationship with the pull shot technique. Stretch, Bartlett, and Davids (2000) have proposed interdisciplinary research to examine the kinematics of the cricket batting such as the anthropometrics character of the batsmen and its effects on the back foot and front foot shots. Along with the anthropometric measures, the linear and angular movements of the body segments would play an important role in the execution of the pull shot against the short pitched ball.

Kelly et al. (2003) proposed the position of batsmen for the pull shot such as; inside the line of the short pitched ball, backfoot move across the off stump, rotation of the front foot toward the left side, full extension of the arms at impact, and bat-ball impact occurs in front of the upper body. The coaching manuals have suggested that the pull shot should be played downward onto the ground to prevent the ball being caught by the opponent surrounding fielders (Knight, 2007; Woolmer et al., 2008).

The back swing of the bat occurs back toward the stumps and completes over the right shoulder of the right-hand batsmen (Lund & Heefner, 2005). The high back lift of bat provides mechanical advantages to the cricket batsman than the low back lift in hitting the forceful shots (Stuelcken, Portus, & Mason, 2005; Knight, 2007). The high back lift enables the batsmen to hit the short pitched ball on a downward path, thus directing the shot to the ground instead of skying it (Pont, 2010). Along with the high

back lift, the short duration of the back swing assist the cricket batsmen for earlier adjustment of the body and the selection of shot (Stretch et al., 2000). The stride movement is completed before the initiation the forward swing of the bat in the direction of the short pitched ball (Biddle, 1991; ACB, 2001; Woolmer et al, 2008). The forward swing of bat occurs at the horizontal path to accomplish the trajectory of the short pitched ball (Land & McLeod, 2000). The horizontal abduction of shoulders assist the batsmen in bringing the bat across the upper body to collide with the ball in the front of the chest (Robson, 2003). The horizontal abduction of shoulders assist the batsmen in keeping the bat position parallel to the trajectory of the pitched ball (DeRenne, Stellar, & Blitzbau, 1993). The faster abduction of the left and right shoulder increase the chance of the successful baseball swing (Cross, 2009) because the faster movement of body segments enables the batsman to bring his body position earlier to the line of pitched ball (Lund & Heefner, 2005). The faster extension of the elbows helps the batsmen to execute the pull shot onto the ground and toward the square leg direction of the ground (De Villiers, 2015). The linear and angular movement of the body segments plays an important role during the execution of the pull shot.

Linear and angular movements of the body segments occur in a sequence which starts with the lower body and transfer to the upper body (Welch, Banks, Cook, & Draovitch, 1995; Stretch, Buys, Dutoit, & Viljoen, 1998). Cross (2009) has explained the sequence the body movement which starts from the rotation of the legs, hips, shoulders, arms and complete after the bat-ball impact. The historical review of the cricket batting shows that the veteran batsmen were accurate in their pull shot technique, as like all-time great batsman Sir Bradman was exceptional in his rotational movement (Shillinglaw, 2003; Renshaw, Glazier, Davids, & Button, 2005). It is

reported the right elbow angle has a positive relation with the front foot on drive technique at the back lift and bat-ball contact, as well as the height of a center of the gravity at bat-ball impact (Bagchi, 2012). Raza (2014) reported the positive correlation of ankles, knees and hips angles with front foot defense shot.

Every batsman desires to execute the pull shot against the short-pitched ball, but he cannot do this because of ineffective in the pull shot technique. A good understanding of the pull shot technique in the perspective of the mechanical principle can help the batsmen to improve their performance at the higher level of competitions. The cricket coaches and experts have explained the pull shot technique by using their personal experiences and observations. Thus, the pull shot technique has been explained in qualitative manners rather in quantitative. Therefore, without empirical facts of the pull shot it may not help the batsman to develop the good technique of the stroke.

1.3 Statement of the Problem

All-time great cricket batsman Sir Donald Bradman believes that the pull shot is an opportunity for a batsman to hit the short pitched ball for a boundary. Although, pull shot provides a boundary chance to batsman but it is an equally challenging skill to perform against the short pitched ball (Kidger, 2011). The accurate movement of the feet is a key for successful pull shot because it assists the batsman to keep his body position correctly in the line of the short pitched ball (Woolmer et al., 2008; Pyke & Davis, 2010; Headrick, Renshaw, Pinder & David, 2012). McLeod (1987) reported the vertically higher and lower forward swing of the bat against the short-pitched ball

causes an unsuccessful pull shot or miss hit. Regan (2012) stated that earlier or later bat swing would result as the unsuccessful pull shot. The descriptions of the pull shot technique were based on the anecdotal evidence of the cricket coaches and experts (Bradman, 1958; Woolmer, Noakes, & Moffett, 2008; Pyke & Davis, 2010). On the other hand, few empirical studies focused to explain the bat swing time and direction while playing the short pitched ball (McLeod, 1987; Regan, 2012). Therefore, it is essential to quantify the coaching description and further explain the kinematics of the pull shot.

Previous studies compared the anthropometric characteristics of bowlers and batsmen (Stretch & Buys, 1991; Johnstone & Ford, 2010). Koley (2011) established the anthropometric profiles of cricketers of three age groups 16-18 years, 19-21 years and 22-15 years. Few studies have examined the relationship between the anthropometric characteristics of the batsmen and their front foot and back foot off drive shots (Singh, 2012; Aruparayil & Chattopadhyay, 2013). It was reported the large muscles of the lower body produce a large force which increases the performance of the baseball batters (Adair, 1995). The purpose of anthropometric measurements of the cricket players was to investigate the role the lower and upper body segments in the batting and bowling performance (Ackland, Elliott, & Bloomfield, 2009). However, few studies have examined the anthropometric characteristics of the cricket batsmen and its relationship with the technique of the cricket shots. The anthropometric measurement help to overlook the differences in the physique of the cricketer players, during their participation at a higher level, in different age groups such as adolescents and adults (Portus, Kellett, Karppinen, & Stephen, 2013). Penn and Spartford (2012) proposed to examine the body size of the batsman and its role on the batting

performance. This study provided the anthropometric profiles of the cricket batsmen of the different age groups and its relationship with the kinematics of the pull shot.

Previous studies of cricket batting analyzed the kinematics of the front-foot shots by using videography method (e.g. Elliott, Baker, Foster, & Source, 1993; Stretch et al., 1998; Stuelcken et al., 2005; Taliep, Galal, & Vaughn, 2007). An earlier study explained the kinematics of the front foot on drive and front foot off drive shots with three-dimensional analysis with two video cameras (Elliot et al., 1993). Stretch et al. (1998) explained the linear and angular kinematics of the front-foot off drive and front foot defense shots by using the two-dimensional technique with a single video camera. Stuelcken et al. (2005) used three-dimensional video analysis with two video cameras to investigate the front-foot of drive technique of the elite cricket batsmen in real match situations. Taliep et al. (2007) examined the kinematics of the front-foot shot of the skilled and less-skilled batsmen in laboratory set-up, and shadow batting technique was used against the video simulation bowling actions. Headrick et al. (2012) used a video camera to investigate the front foot shot technique with different weighted bats of the (16.6 ± .3 years) batsmen and the stride length and bat velocity were significantly higher with light weighted bat than heavier. Raza (2014) reported the positive correlation between the angular displacements of the ankles, knees, and hips with the performance of front foot shot.

McLeod (1987) examined the bat swing path against the short pitched ball and reported the back lift is completed above the back shoulder and forward swing occured across the upper body to hit the short pitched ball in front of the chest and toward the square leg. Land and McLeod (2000) examined the eye movement of an international,

a state and a club batsmen against the trajectories of short pitched, good length and over-pitched ball and concluded the international and state batsmen were superior in batting performance against the short pitched ball than club batsmen. Kelly et al. (2003) have explained the body position of the batsmen while performing the pull shot and reported as back foot stride occurs across the off stump, the head position in the line of the ball and full extension of arms at impact. Regan (2012) reviewed the cricket batting performance against the short pitched ball and concluded the bat-ball impact occurred in front of the head with an accurate movement of the bat because faster and slower bat swing causes an unsuccessful pull or hook shot. Mann, Spratford, and Abernethy (2013) examined the head and eye movement of two elite and two club batsmen while batting against the short pitched, good length and over-pitched deliveries and concluded that elite batsmen were superior to club batsmen in their batting performance against the short pitched ball. The cricket coaches and experts have explained the pull shot technique but unable to provide biomechanical facts of the stroke (e. g. Bradman, 1958; Woolmer et al., 2008; Andrew, 1987; ACB, 2001; Pyke, & Davis, 2010). These coaching observations and anecdotal descriptions of the pull shot technique were insufficient to understand the exact mechanics of the pull shot technique. The pull shot technique is effected by various biomechanical movements such as the stride movement, pendulum (back and forward) movement of the hips, shoulder, arms and bat, flexion and extension of the joints of lower and upper body, bat speed and bat angle at the time of impact with the ball. In view of the above literature, only a few studies have explained the bat displacement the attempt of the successful and unsuccessful pull shots. Therefore, a quantitative analysis is necessary to explain the kinematics of all body segments to identify the causes of the unsuccessful pull shot. Videography analysis is essential for the pull shot technique as adopted in the previous studies of

front foot shot in cricket (Elliott et al., 1993; Stretch et al., 1998; Stuelcken et al., 2005), and in baseball swing (Escamilla, Fleisig, DeRenne, Taylor, Moorman, Imamura, Barakatt, & Andrews, 2009; Inkster, Murphy, Bower, & Watsford, 2010). This study will help the coaches, cricket experts and researchers to understand the quantitative description of the pull shot.

1.4 Purpose and Significance of the Study

The main purpose of this study was to analyze the biomechanics of the pull shot of the different age group cricket batsmen. This study attempted to quantify the coaching descriptions of the pull shot will provide the sufficient guideline to coaches to improve the pull shot technique. This study also examines the anthropometric characteristics of senior, u-19 and u-16 batsmen which help the coaches to select appropriate batsmen for Test, ODI and Twenty-20 over matches. This study will also help the cricket coaches, sports science researchers and batsmen to understand the role of anthropometric characteristics on the performance of pull shot. Normally, the pull shot techniques of batsmen are subjectively assessed by the coaches to identify their mistakes. The findings of this study will assist the coaches to assess the position of batsmen at the stance, back lift, bat-ball impact and follow through. This four phase will also help the coaches to understand the variations in the linear and angular kinematics of the pull shot from the initiation and after the bat-ball impact at follow through. Lastly, the comparison of successful and unsuccessful will help to understand the biomechanical causes of miss hit shot against the similar height of the short pitched ball.

1.5 Objectives of the Study

1.5.1 To compare the anthropometric characteristics of senior, under-19 and under 16 cricket batsmen.

1.5.2 To examine the kinematics of the pull shot of senior, under-19, and under-16 batsmen.

1.5.3 To compare the kinematics of the successful and unsuccessful pull shot of the senior, under-19 and under-16 batsmen.

1.5.4 To examine the relationship between the anthropometric characteristics and the kinematics of the pull shot.

1.6 Hypotheses

Ho1. It was hypothesized that there was no significant difference between the senior, under-19 and under-16 cricket batsmen in their anthropometric measurements.

Ho2. It was hypothesized that there was no significant difference between the senior, under-19 and under-16 cricket batsmen in the kinematics of the pull shot.

Ho3. It was hypothesized that there was no significant difference between the senior, under-19 and under-16 cricket batsmen in the kinematics of the successful and unsuccessful pull shots.

Ho4. It was hypothesized that there was no significant relationship between the anthropometric measures and the kinematics of the pull shot.

1.7 Limitations of the Study

1.7.1 The batsmen performed the pull shot on an artificial pitch and a cricket bowling machine was used to project the deliveries as a similar method was used in other cricket batting studies (Weissensteiner et al., 2011). The pull shot performed against a live bowler, on a natural pitch and in match alike conditions may provide different results.

1.7.2 The video recordings of the pull shot actions were conducted in an outdoor training area. The natural lighting during data collection may have affected the fidelity of the recordings.

1.7.3 The batsmen wore protective gears as like pads, gloves, and helmet during the experiment (Renshaw, Oldham, David, & Gold, 2007). These gears restricted the exact placement of certain reflective markers such as the toe, ankles, knees, wrists and the head.

1.8 Delimitations of the Study

1.8.1 All participants in this study were selected on the basis of their batting record and identified as specialist batsmen by the national coaches.

1.8.2 This study only involved right handed batsmen.

1.8.3 Each batsman was allowed to face up to six deliveries for warming up as well as with the adjustment of data collection set-up.

1.9 Definitions of the Specific Terminologies

Pull Shot:

The pull shot is a back foot shot which played with the horizontal bat swing across the upper body and toward the on side of the ground (Bradman, 1958; Rundell, 2009).

Successful Pull Shot.

A batsman takes back foot stride across the off stump, bring upper body in the line of the short pitched ball, swing his bat parallel to the ball's position, and hit the ball downward in the direction of square or mid-wicket side

Unsuccessful pull shot:

A cricket batsman fail to adjust his accurate position in the line of the short pitched ball as a result ball strike with the bat's handle, at the top edge of the bat's blade rather than at the face of the cricket bat.

Cross bat shots:

A cricket shot is played with the horizontal bat swing at the short pitched ball such as the pull, hook, cut and sweep shots (Rundell, 2009).

Biomechanics:

The study of the applications of the mechanical principles to the living organism (Hall, 2011).

Kinematics:

The movement of an object by considering space and time (Hall, 2011).

Anthropometry:

A study of the measurements of the human body and surface proportion such as height, weight, skinfolds, girths, lengths and widths of bones (Eston & Reilly, 2013).