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KINEMATICS OF THE PULL SHOT OF THE MALAYSIAN NATIONAL CRICKET BATSMEN

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ABSTRACT

Background: Many cricket experts have explained the pull shot technique but could not quantify the kinematics of the stroke. This study was aimed to quantify the coaching description and compare the pull shot technique of the senior, under-19 and under-16 cricket batsmen.

Methods: Eighteen Malaysian national cricket batsmen were selected for this study. Two high speed video cameras were used for capturing the pull shot action and Aerial Performance Analysis Software was used for the kinematics analysis. One way ANOVA with repeated measure was applied to examine between groups difference in biomechanics of the pull shot.

Results: Results showed the senior batsmen were significantly higher in the extension of the right knee ($P < .03$) than under-16 batsmen and the extension of the left hip ($P < .04$) than under-19 batsmen. The under-16 batsmen were significantly faster in the linear velocity of the left hip ($P < .04$) than senior and left elbow ($P < .05$) than under-19 batsmen.

Conclusion: This study confirms some coaching descriptions such as the bat angle was lesser than the 90° and higher than the 45° degrees and straighter position of the arms at bat-ball impact. The under-16 batsmen were faster in the linear velocities of the left hip and left elbow because they used light weight bat for the execution of the pull shot than the seniors and under-19 batsmen.

This study will help the coaches and cricketers to understand the kinematics of the body segments during the execution of the pull shot. Future study should be conducted to investigate the effect of the anthropometric measures on the kinematics of the pull shot.

Keywords: Pull shot, Cricket batsmen, short pitch ball, kinematics, body segments.

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INTRODUCTION

The pull shot is the response of a cricket batsman against the short pitched ball of bowler [1, 2, 3]. This shot is initiated with the back foot stride and clock wise rotation of the body segments [4]. The initial movement of a batsman is called as a loading phase of the upper body toward the stumps at the back. As the stride movement completed the lateral movement starts in the direction of bowler [5]. The pelvis of the batsmen rotates toward the bowler which brings trunk and upper body in the line of the short pitched ball [6]. The extension of the elbows brings hands and bat in the line of the short pitch ball [7, 8]. The movement of the body segments occurs in sequence which assists the batsmen to keep the position of bat in the striking zone [9]. The sequence of the body segments commenced with the movement of lower body than transferred to trunk, shoulders, arms and finally into bat at the time of impact [10]. The faster movement of the body segment increases the bat velocity [11]. DeVilliers, (2015) a top cricket batsman believes that the faster extension of shoulders and elbows are at the time of bat-ball impact for the execution of successful pull shot. On the other hand Sir Donald Bradman [1] believes that the bat angle should be lesser than 90° to execute successful pull shot. Woolmer and colleagues [12] credence that higher bat angle than from the 45° prevent the pull shot from the top edge of the ball.

Numerous coaching manuals have explained the pull shot technique [1, 13, 14, 12, 15] but unable to provide the biomechanical evidence of the stroke. An earlier study of cricket batting have investigated the reaction of batsmen while batting against the short pitch ball [16]. The movement of eyes of an international, a state and a club batsman were examined while batting against the short pitch, good length, over-pitched balls [8]. Kelly and colleagues [7] used fuzzy logic theory for explaining the body position of the batsmen while performing the pull shot. Regan [3] reviewed the visual ability of the cricket batsmen while batting against pitch ball. Head and eye movement of elite and club batsmen were examined while tracking the trajectories of short pitched, good length and over-pitched ball [17]. These studies have explained the reaction time and eye movement of batsmen against the short pitched ball but could not explained the biomechanics of pull shot technique.

There were few studies have examined the kinematics of pull shot by adopting two-dimensional or three-dimensional technique. Thus, a video analysis is required to explain the kinematics of pull shot and confirm the coaching description of the stroke. This study was aimed to confirm the coaching theories as well as to compare the pull shot technique of senior, under-19s and under-16s batsmen. It was hypothesized that the senior, under-19 and under-16 batsmen are similar in their pull shot technique.

METHOD AND MATERIAL

Purposive sampling technique was used for this study and eighteen right handed Malaysian national cricket batsmen were recruited on the recommendation of team coaches. The age of batsmen were (senior = 24.5 ± 4.2 y; under-19 = 17.5 ± 1.3y; and under-16 = 15.0 ± 0.5y). A consent letter was obtained from each batsman to insure their willingness. Data were recorded at the Malaysian Cricket association Oval, Kuala Lumpur, Malaysia. The study approval was obtained from the research committee of the Sultan Idris Education University, Malaysia.

Instruments for Data Collection

Two synchronized high speed video cameras 1080i (HDR-FX1E, Sony, Tokyo, Japan) were operated at 60 Hz to capture the pull shot action as used in the previous studies of cricket batting [18, 19]. Both cameras were positioned 13 meters away from the batting crease [19] with 1.40 meters lenses height from the ground [10]. The first camera was placed at the front on position of the batsman (parallel to batting crease) and the second was placed at the side on a position near the bowling crease. A 24 points calibration frame was recorded to determine the three-dimensional volume. The calibration volume was explained as 3m at the X-axis for the sagittal plane, 2 m Y-axis for the vertical plane and 1.5 m at Z-axis for frontal direction.

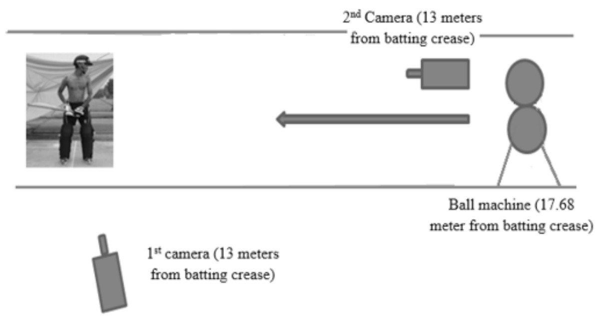

Figure 1: ***Cricket Batting Set-Up with Cameras Placement and Ball Machine***

Fifteen reflective (14mm) markers were fixed at the joint centers of the batsmen as reported by [20]. The placement of the reflective markers was explained as two markers at the mid-toe phalanges of the right and left feet, these markers were placed at the toe of shoes rather than directly at the toe of feet. Two markers were placed at the outer side of the calcaneus of the right and left ankles. Feet markers were placed to determine the linear and angular kinematics of ankle joints. Two markers were placed at the right and left sides of the lateral femoral condyle to find the flexion and extension of knee joints. Knee markers were placed at the top of the pad (parallel to the knee joint) and ankle markers at the bottom of the pads. The batsman was allowed to perform pull shot in protective gears as used in other cricket research [19]. Two markers were placed at the right and left superior iliac spine to track the linear and angular kinematics of hips joints. Two markers were placed at right and left acromio-clavicular to track the kinematics of shoulders. Two markers were placed at the lateral epicondyle to find the extension and flexion of elbows joints. Two markers were placed at the right and left radial styloid process to track the linear and angular displacements of wrists joints. Head displacement was traced by placing a marker at the temple of the helmet which represents the frontal bone of forehead. Bat blade corners and handle were digitized to find the kinematics of bat at pull shot a similar method was adopted by [18].

Procedure

A synthetic (20.12m long x 5m wide) cricket pitch was used for batting against the ball projection machine (BOLA, Stuart and Williams, UK). A ball machine was placed 17.68 meters from the batting crease (batsman performance area) with a 2.30-meter height similar to the ball release height of a fast bowler as used in the previous study [19]. The ball machine was used to control the consistency of ball speed and bounce which enable in repeated trials to be recorded. A special practice balls (BOLA, Stuart and Williams, UK) weighed 156g were used for the ball machine and an experienced cricket coach was requested to operate the equipment. The speed of the deliveries was maintained at 25 m/s to 30 m/s for short pitch deliveries as used in front foot shot [19, 21]. Each batsman performed some warm up shots against the short pitched balls which delivered from the machine for acclimatization with experimental conditions. Trials were commenced after confirming the adjustment of batsmen with batting set-up. Each ball was showed to batsmen before being fed into the ball machine to prompt the batsman to be ready. Six pull shot actions of each batsman were captured. All video footages were qualitatively assessed by qualify cricket coaches for selection the appropriate shot for further analysis.

Data processing

Video data of 1st and 2nd cameras were transferred to the computer and most successful pull shot of each batsman were selected for kinematics analysis as guided [22, 23]. Aerial Performance Analysis Software (Ariel Dynamics inc., USA) was used for the kinematics analysis of the stroke as in previous studies [18]. The selected videos of both cameras were synchronized to find the similar point then trimmed 10 frames before the start of bat back lift and 10 frames after the bat-ball impact. All selected frames of the pull shot action were manually digitized by using stick figure. A 23 points model was established for digitizing the 15 markers of the body segments and six points of the bat [18]. The ball movement was also digitized to find the ball location at bat-ball contact as shown in frames. The digitized videos of both cameras were transferred into three-dimensional coordination by using the direct linear transformation (DLT) method [24]. The raw data of three-dimensional was smoothed by using the digital low filter pass. The body segments were smoothed at 13 Hz cut-off frequency and bat at 14 Hz, as did in cricket and baseball batting [25, 18]. The actual score of the linear and angular kinematics was determined after smoothing the raw data.

The kinematics variables were defined as defined in the previous of baseball swing [26]. These kinematics variables are the stride length was defined as the toe-toe distance of the front foot and back foot in the horizontal direction of X-axis. The height of bat and center of gravity of the batsmen were considered from the ground's surface in the vertical direction of Y-axis. The head and ball distance at bat-ball impact were considered the X-axis of the horizontal direction. Linear velocities of left and right segments along with bat toe were calculated in the X-axis in the direction. The angular kinematics of the joints was defined in the following of baseball batting and 180° degree was considered as a full extension of joint angle and zero 0° degree as a full flexion [26]. Knee angles were defined as the intersection of the ankle to knee vector and knee to the hips. Hips angle were defined as the intersection of the knee to hips vectors and hips to the shoulders vectors. The right and left shoulders angle as the intersection of hips to the shoulder vectors and shoulder to elbow. The right and left and left of elbow angles as the intersection of shoulder to elbow vectors and elbow to wrist. With the interval of two months to avoid the familiarity with data analysis a random video was intra-rater technique was adopted to find digitize-re-digitize reliability of the kinematics of body segments and bat. The coefficient of variance (CV %) was applied to calculate the mean differences between the actual digitize and re-digitized data. The range was followed between 3.1 to 10.7mm for linear kinematics and 3.1 to 10.7° for angular kinematics as adopted in previous cricket batting study [18].

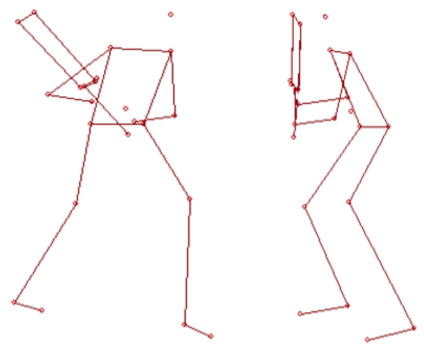

Figure 2: Position of batsman at back lift

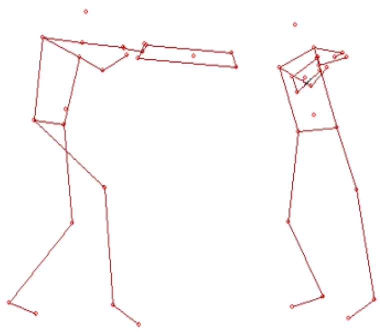

Figure 3: Position of batsman at bat-ball impact

Statistical analysis

Descriptive statistics mean and standard deviation were applied for all variables. One way analysis of (ANOVA) was applied to compare the demograpghic, temporal and velocities variables. One ways (ANOVAs) with repeated measures was applied at the condition of (3 groups x 3 levels back lift of bat, bat-ball impact and follow through) to examine the difference between-group comparison in the linear displacement and angular variables. The assumption of the normality of data, homogeneity of variance, and multicollinearity were tested as suggested by [27, 28]. Tukey's post hoc was used to find the means difference in between-group comparisons. Significant level was adjusted at ($p < .05$). The SPSS version 20 (Minitab Inc., State College, PA, USA) was used for statistical analysis.

RESULTS

Table 1 show significant difference between-group in height F (2, 15) = 6.40, $P < .01$. Tukey (HSD) post hoc revealed that under-16 batsmen (*M* = 159.83; *SD* = 9.60cm) were significantly shorter in height than senior (*M* = 174.00; *SD* = 7.32cm) and under-19 batsmen (*M* = 171.90; *SD* = 4.32cm), no significant difference between senior and under-19 batsmen. Body mass was significantly different in between group comparison F (2, 15) = 10.93, $P < .00$. Post hoc showed senior batsmen (*M* = 71.83; *SD* = 9.61kg) were significantly heavier than under-19 batsmen (M = 59.60; SD = 7.38kg) and under-16 batsmen (*M* = 52.07; *SD* = 4.13kg), and no significant difference between under-19 and under-16 batsmen.

The bat length was significantly different between group comparison F (2, 15) = 7.16, $P< .01$. Tukey's post hoc results showed that seniors (*M* = .86; *SD* = .02 m) and under-19 batsmen (*M* = .85; *SD* = .01 m) used significantly longer bat than under-16 batsmen (*M* = .83; *SD* = .02 m). The bat mass was significantly different in between group comparison F (2, 15) = 11.98, $P< .00$. Tukey's post hoc results showed that the seniors (*M* = 1.20; *SD* = .10 kg) and under-19 batsmen (*M* = 1.11; *SD* = .03 kg) used significantly heavier bat than under-16 batsmen (*M* = .96; *SD* = .10 kg).

Table 4 shows a significant difference in the right knee an-

Table 1: Height, body mass, bat length and bat mass

Variables	Senior	Under-19	Under-16		
	M(SD)	*M(SD)*	*M(SD)*	*F(2,15)*	*Sig.(P)*
Height (centimeter)	174.00(7.32)	171.90(4.32)	159.83(9.60)	6.40	.01
Body mass (kg)	71.83(9.61)	59.60(7.38)	52.07(4.13)	10.93	.00
Bat length (meter)	.86(.02)	.85(.01)	.83(.02)	7.16	.01
Bat mass (kg)	1.20(.10)	1.11(.03)	.96(.10)	11.98	.00

*Level of significant P<.05**

Table 2 showed no significant difference between groups in the back swing of the bat, total bat swing time and the stride time duration.

Table 2: The time duration of the bat swing and stride movement

Variables	Senior	Under-19	Under-16		
	M=SD	*M=SD*	*M=SD*	*F(2, 15)*	*Sig.(P)*
Bat swing time at high back lift(s)	.30(.06)	.31(.05)	.29(.05)	.26	.77
Total bat swing duration(s)	.58(.07)	.60(.06)	.58(.07)	.32	.78
Stride duration at back lift(s)	.24(.05)	.24(.05)	.22(.08)	.15	.87

The level of significant was adjusted at P .05, S (second)*

Table 3 shows no significant difference group comparison in stride length, bat height from ground, and the center of gravity height at three phases of pull shot.

Table 3: Linear displacement of the body segments at of the pull shot

Variables	Phases of shot	Senior	Under-19	Under-16		
		M(SD)	*M(SD)*	*M(SD)*	*F(2, 15)*	*Sig.(P)*
Stride length (m)	Back lift of bat	0.77(.13)	0.85(.11)	0.80(.11)	1.32	.30
	Bat-ball impact	0.72(.15)	0.85(.11)	0.81(.10)		
	Follow through	0.68(.17)	0.76(.18)	0.81(.10)		
Bat height from ground (m)	Back lift of bat	1.58(.03)	1.59(.11)	1.53(.17)	2.35	.13
	Bat-ball impact	1.16(.15)	1.25(.12)	1.07(.07)		
	Follow through	1.38(.16)	1.38(.11)	1.27(.15)		
Centre of gravity from ground (m)	Back lift of bat	0.94(.07)	1.01(.09)	0.93(.11)	2.97	.28
	Bat-ball impact	1.02(.06)	1.07(.07)	0.95(.13)		
	Back lift of bat	1.05(.08)	1.09(.07)	0.94(.09)		

**. Significant level was adjusted 0.05.*

gle in between group comparison at follow through, *F* (2, 15) = 4.30, *P* <.03. Tukey (HSD) post hoc tests revealed that the right knee angle of senior batsmen (*M* = 139. 97; *SD* = 12.81°) were significantly higher than under-16 batsmen (*M* = 120.77; *SD* = 5.81°) at follow through.

Table 4 shows a significant difference between-groups in the left hip angle *F* (2, 15) = 4.04, *P* >.04, at three phases of pull shot. Tukey (HSD) post hoc revealed that senior batsmen (*M* = 148.95; *SD* = 10.12) were significantly higher in the left hip angle than under-19 batsmen (*M* = 134.21; *SD* = 12.71°) in the left hip angle at bat-ball impact. There was no significant difference in the angles of left knee, right hip, left and right shoulders, left and right elbows, and bat angle at all three phases of pull shot.

Table 4: Angular kinematics of of the joint segments at pull shot pull shot

Variables	Phases of pull shot	Senior	under-19	under-16	*F (2, 15)*	*Sig.(P)*
		M (SD)	*M(SD)*	*M(SD)*		
Left knee angle (°)	Back lift of bat	140.35(10.03)	130.83(9.80)	134.38(9.38)	.83	.45
	Bat-ball impact	148.46(9.24)	144.39(9.88)	144.38(9.38)		
	Follow through	145.27(12.36)	142.68(8.89)	141.95(12.12)		
Right knee angle (°)	Back lift of bat	128.63(5.82)	126.91(3.71)	130.45(11.38)	4.30	.03*
	Bat-ball impact	139.97(12.81)	123.10(11.75)	122.28(8.72)		
	Follow through	148.43(15.46)	134.30(13.55)	120.77(5.81)		
Left hip angle (°)	Back lift of bat	131.65(7.93)	116.82(8.42)	115.34(7.87)	4.04	.04*
	Bat-ball impact	148.95(10.12)	134.21(12.71)	138.76(13.07)		
	Follow through	155.23(8.08)	140.64(13.26)	144.76(16.03)		
Right hip angle (°)	Back lift of bat	143.17(9.48)	142.86(13.89)	138.28(14.40)	1.2	.33
	Bat-ball impact	157.24(3.28)	155.95(9.40)	156.62(5.77)		
	Follow through	164.34(6.14)	160.71(7.91)	157.11(7.90)		
Left shoulder angle (°)	Back lift of bat	68.28(9.93)	55.90(8.85)	67.09(11.35)	.21	.81
	Bat-ball impact	67.47(8.75)	76.00(12.69)	66.74(12.97)		
	Follow through	48.75(7.16)	61.13(2051)	50.90(17.10)		
Right shoulder angle (°)	Back lift of bat	34.56(4.61)	40.63(11.56)	42.29(8.01)	.65	.53
	Bat-ball impact	49.84(9.91)	59.60(15.30)	43.95(15.22)		
	Follow through	69.64(10.66)	70.59(18.58)	71.23(19.25)		
Left elbow angle (°)	Back lift of bat	120.17(13.13)	112.34(8.64)	117.83(16.65)	.44	.65
	Bat-ball impact	146.27(9.53)	156.64(9.88)	149.96(19.04)		
	Follow through	150.38(15.62)	161.83(13.89)	152.19(13.77)		
Right elbow angle (°)	Back lift of bat	58.64(7.04)	55.54(11.26)	56.08(11.59)	.54	.59
	Bat-ball impact	116.44(7.36)	126.09(13.95)	118.65(10.08)		
	Follow through	146.46(10.01)	149.87(6.54)	145.03(17.13)		
Bat blade angle (°)	Back lift of bat	86.89(10.39)	88.82(4.63)	84.97(7.38)	0.03	.97
	Bat-ball impact	80.93(8.33)	85.09(9.28)	87.74(4.87)		
	Follow through	81.82(9.85)	78.26(12.51)	77.95(11.31)		

**. Significant at the 0.05 level.*

Table 5 showed a significant difference between group comparison in the left hip velocity *F* (2, 15) = 3.96, *P* < .04. Tukey post hoc results showed that under-16 batsmen (*M* = 1.63; *SD* = .34 m/s) were faster than senior batsmen (*M* = 1.17; *SD* = .12 m/s), and under-19 batsmen were not significantly different in left hip velocity than senior and under-16 batsmen. A significant difference was shown between group comparison in left elbow velocity *F* (2, 15) = 3.80, *P* < .05. Post hoc results showed that under-16 batsmen were faster (*M* = 2.54; *SD* = .42 m/s) than under-19 batsmen (*M* = 1.93; *SD* = .38 m/s), and senior batsmen were not significant in left elbow velocity than under-19 and under-16 batsmen.

Table 5 showed no significant difference between groups in the right hip velocity, the left shoulder velocity, right shoulder velocity, right elbow velocity, left wrist velocity, right wrist velocity, and Bat velocity between group comparisons.

Table 5: Linear velocities of the body segments at the time of bat-ball Impact

Variables	Senior	Under-19	Under-16		
	M(SD)	*M(SD)*	*M(SD)*	*F(2, 15)*	*Sig.(P)*
Left hip velocity (m/s)	1.17(.12)	1.33(.34)	1.63(.34)	3.96	.04
Right hip velocity (m/s)	.62(.21)	.62(.21)	.66(.23)	.03	.97
Left shoulder velocity (m/s)	2.16(.29)	1.90(.31)	2.20(.22)	2.14	.15
Right shoulder velocity(m/s)	.75(.14)	.76(.17)	.85(.04)	1.23	.33
Left elbow velocity (m/s)	2.13(.39)	1.93(.38)	2.54(.42)	3.80	.05
Right elbow velocity (m/s)	1.62(.26)	1.68(.18)	1.69(.23)	.17	.85
Left wrist velocity (m/s)	2.41(.32)	2.66(.52)	2.99(.50)	2.44	.12
Right wrist velocity (m/s)	2.23(.40)	2.50(.46)	2.59(.26)	1.44	.27
Bat velocity (m/s)	12.04(1.85)	12.57(1.16)	14.22(1.42)	3.40	.06

The level of significant was adjusted at 0.05* m/s (meter per second= velocity)

DISCUSSION

Many cricket experts and coaches have explained the pull shot technique but unable to provide the mechanical evidence of the stroke. Thus, this video analysis was conducted to compare the pull shot technique of three age group cricket batsmen. Results showed that senior and under-19 batsmen used longer and heavier bat than under-16 batsmen because they were physically taller and heavier. This difference occurs because senior and under-19 batsmen have become physically stronger after their adolescent period and under-16 batsmen still in their adolescent period. The current study is supported by the findings of Escamilla et al., (2009) that 22 years adult baseball batsmen played with longer and heavier bat than 14 years younger batsmen.

In the kinematics analysis, the senior batsmen was significantly higher in right knee angle than under-16 batsmen at the time of bat-ball impact and follow through. The current study showed similar percentage of the stride length with the body height as reported by Welch et al., (1995) and slightly higher than (Fortenbaugh, 2011). It is concluded that the extension of right knee depend on the stride length and senior batsmen's stride was (44%) of body height, under-19 (48%) and under-16 (49%) of their body's height that why senior's right knee more extended than under-19 and under-16 batsmen.

Although, other angular kinematics are in significantly different in group comparison but small differences in the angular kinematics which effect on the accuracy of cricket strokes (Stretch et al., 1998). The senior batsmen were also significantly higher in the extension of the left hip at impact and follow through than under-19 batsmen. The extension of left and right shoulder maintain the arms position parallel to the trajectory of the short-pitched ball. These angular positions assists the batsmen to make upright position to execute pull shot downward (Kidger, 2011). The left and right elbow extend at bat-ball impact which assists the batsmen to extend their arms to execute the pull shot before crossing the batsmen or in front of the chest. The current study supports the coaching suggestion Bradman, 1958; Andrew, 1987, Woolmer et al., 2008). The current study showed the similar extension of the left and right elbow at impact as reported in the baseball study (Escamilla et al., 2009; Inkster 2010). This study exhibited the range of bat face angle (79° to 85°) at pull shot which supports the coaching suggestions of Bradman (1958) that bat face angle should lesser than (90°) degree, and Woolmer et al., (2008) suggested bat angle should be higher than (45°) degree.

The bat swing time plays an important role in the execution of successful shot (Lund & Heefner, 2005). Result showed no significant difference between groups in bat's back swing time (senior = .30, under-19 = .31 and under-16 = .29 second) and stride time (senior = .24, under-19 = .24 and under-16 = .22 second). The current study showed longer bat swing than the baseball swing (Escamilla et al., 2009; Inkster 2010). This contradiction occurs because baseball swing occurs against a ball which pitched from 13-meters and cricket ball is delivered from 17.68 meters which increase response time of cricket batsmen than baseball batter. The baseball ball flight time is after release from bowlers is 400 m/s Cross (2009) and the short pitched ball 700 m/s (Land & Mcleod, 2000; Mann et al., 2013).

The body segments of batsmen move in the direction of bowler which assist them to judge the trajectory of the short pitched. The left hip of senior batsmen was significantly slower than under-16 batsmen. This difference may assist the senior batsmen to take longer time to anticipate the trajectory of short pitched ball than under-16 batsmen. The bat velocity of senior batsmen was (-2.17 m/s) slower than under-16 batsmen. It conclude that senior batsmen used (+0.24 kg) heavier bat than under-16 batsmen that why bat speed was slower. Current study support the finding of Headrick et al., (2012) that heavier bat swings slower than lighter bat during the execution of front foot drive. Results of this study confirmed by the findings of Taliep et al., (2007) that unskilled batsmen swung their bat faster to execute front foot stroke. It may also be concluded that senior batsmen focus on the accuracy of bat-ball contact that why they reduced the bat velocity, as suggested by Headrick et al., (2012) batsman reduce bat velocity to increase the accuracy of cricket shot

The result showed the left shoulder and left elbow of under-16 batsmen was faster than senior and under-19 batsmen. This result supported the coaching recommendations that faster shoulder contribut in the execution of successful pull shot (Bradman, 1958; Woolmer et al., 2008). The faster extension of the left assist the batsmen to bring bat in the line of pitched ball to collide with ball (Swimley, 1964; Breen, 1967). The findings of the current study support the suggestion of Cross (2009) that instantaneous straighten arms pulls the bat handle faster which increase the bat velocity at the time of bat-ball impact.

CONCLUSION

The purpose of this study was to quantify the coaching description of the pull shot and to compare the technique of senior, under-19 and under-16 batsmen. Results showed that few variables were significantly different between group comparisons. The senior and under-19 batsmen were taller, heavier, and used longer and heavier bat than under-16 batsmen, both group's batsmen were physical stronger and matured because they completed their adolescent period earlier than under-16 batsmen. During the adolescent period the physical growth spurt between the 14 to 18 years of age Malina (1994). The senior and under-19 batsmen were at the post-adolescent period so they were physically stronger and used longer and heavier bat as used baseball batter (Escamilla et al., 2009). The extension of right knee of senior batsmen was higher than under-19 and under-16 batsmen at impact and follow through because they took shorter stride. The bat angle was lesser than 90° and higher than 45° which prevent batsmen from top edge of from bat because top edge provide catch out chance for surrounding fielders of opposite team (Bradman, 1958; Woolmer et al., 2008). Surprisingly, the under-16 batsmen were faster in the linear velocity of left hip, left shoulder, and left elbow and bat than from the senior and under-19 batsmen. The senior and under-19 batsmen used heavier and longer bat than under-16 batsmen which reduce the speed of the body segments and bat. On the other hand, the larger radius increase the bat swing time and reduce bats velocity.

Recommendations

The execution of the pull shot could be captured in real match situation. This will help the researchers to analyze the response of batsman against the bowler and against the different trajectories of short pitched. It is also suggested that the pull shot should be analyzed against the faster and slower, higher and lower bounce, and also in swing and out swing short pitched ball. This analysis of pull shot will help the coaches, expertise and cricketer's to understand the pull shot technique against new and old ball, and at the bouncy and dry pitches.

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Definitions of the Abbreviations

HDV: High definition video

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