A Comparative Study Depicting the Effect of Yorker and Bouncer Deliveries on the Electrical Activity in Different muscles of Bowling Arm of the Cricket Fast Bowlers

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Abstract - *The purpose of this research is to acquire and analyze the EMG activity in Biceps Brachii (BB) muscle and Palmaris Longus (PL) muscle of the bowling arm in the medium fast cricket bowlers while delivering 'Yorker' and 'Bouncer' balls. For the suggested study a total of 17 participants were recruited under the following proposed sampling method (n=17, age (years) = 25.18±2.43, weight (kg) = 68.94±6.18, and height (cm) = 174.05±4.14).Camera of a smart-phone (XIOMI- Redmi4) was used for synchronizing of timings with the EMG device (Trigno EMG wireless system, model: SP-W02A-1849, DELSYS, USA). Results shows a significant difference in the RMS values obtained for each muscle while bowling Bouncer and Yorker deliveries with p-value being 0.0 for BB-muscle and 0.008 for PL-muscle. On the basis of the inferential statistics of this study it is concluded that medium fast bowlers have higher chances of injury in BB-muscle while bowling Bouncer deliveries than Yorker deliveries.*

Key Words: Biomedical Signal Processing, Electromyography, RMS Values, Palmaris Longus & Biceps Brachii, fast bowling, Yorker & Bouncer, Statistical Analysis.

1. INTRODUCTION

Cricket is amongst the popular sports around the world and due to the ever increasing demand of viewership the players involved in this sport are exposed to more muscular activity than ever causing more chances of injuries. In a research work conducted by research team of Hazari et al. in 2016 it was found that Yorker deliveries can lead to higher risk of wrist injuries compared to that of shoulder injuries while bowling bouncer [1]. Here in this study we have tried to repeat the work done by Hazari et al. in 2016 [1] but in different location and with different environmental & physical attributes than the previous study and examine if different results are obtained or not. Cricket has three aspects namely batting, bowling and fielding. Batting and bowling are the two aspects of cricket where most of the biomechanical research is being carried out [2].

International Council of Cricket (ICC) has classified different bowling zones on the cricket pitch. From the view point of bowling, division of cricket pitch is done in terms of Yorker length (2m from batting stumps), Full length (next 4m area), Good length (next 2m) and Short length (Bouncer) area which lies anywhere around the middle of the pitch. Among various deliveries bowled by the fast bowlers, Yorker and Bouncer are the most prominent one. According to the ICC a delivery is considered to be a Bouncer if it is dropped about the centre of the pitch being targeted near the batsman's chest level, whereas a Yorker ball is referred to the delivery targeted at the toes of the batsman in the portion of the pitch named as block hall by the ICC.

In cricket bowlers don't throw the ball while delivering the ball and ICC laws on legal bowling action clearly states that a ball is a legal delivery if the bowler's elbow doesn't extend by an amount of more than 15° from the point when the bowler's bowling arm reaches the horizontal (bowling arm reaching the shoulder level) to the point when the ball is released (this is the first frame when the ball is not in contact with any part of the hand) [3]. The most common factor making fast bowlers vulnerable to shoulder injuries is the imbalance of the muscles where the eccentrically contracting external rotators are not strong enough to stabilize the concentric contraction against the internal rotators [4]. Explanations for wrist and forearm injuries in fast bowlers can be understood using similar mechanisms. In order to generate higher bowling speeds, bowlers have a tendency to jerk their wrist at the time of ball release [5]. This jerk can produce equivalent amount of strain in the muscles involved in the wrist and forearm muscles and can further cause injuries. Knowing the fact that the most frequently used fast bowling deliveries in cricket are Bouncer and Yorker, at the same time they are the toughest ones from the perspective of the muscles, it is assumed that these deliveries are related with the higher occurrences of injuries in biceps and forearm muscles [1].

For studying the pattern of muscular contraction and electrical activity of a muscle the most commonly used method is Electromyography (EMG) [6]. Another study shows that EMG signal is an increasing linear function of the load on the muscle [7]. Escamilla in 2009 suggested that to quantify and study the muscular activity during the muscle movement the basic technique that can be used is the science of Surface EMG. As far as our search is concerned very few studies have been published with a focus on the EMG based investigation of bowling arm muscular motion. The purposed study can be helpful and hold key importance for understanding the injury profile for the selected muscles and its prevention by acquiring the EMG signals and then analyzing them to study the electrical activity around the concerned muscles while bowling Bouncer and Yorker deliveries.

2. AIMS AND OBJECTIVES

The aim of the study is to examine the EMG activity in the non professional fast bowlers for the following set of objectives:

i. To record and analyze the EMG activity in the Biceps Brachii (BB) muscle while bowling a 'Yorker' and 'Bouncer' delivery.
ii. To record and analyze the EMG activity in the Palmaris Longus (PL) muscle while bowling a 'Yorker' and 'Bouncer' delivery.
iii. To statistically compare the EMG activity produced in each muscle while bowling a 'Yorker' and 'Bouncer' delivery.

3. METHODOLOGY

Informal invitation was given to a total of 17 healthy participants (college students) including 1 left handed and 16 right handed fast-medium bowlers and all these 17 participants volunteered for the purposed study. The sample size was so chosen based on the previous research works done by Ahmed et al. in 2014 [6] and Hazari et al. in 2016 [1]. Fig 1 shows one of the bowlers while delivering the ball. The mean and standard deviation (mean $\pm$ SD) of the demographics of the participating bowlers is as follows: n=17, age (years) = 25.18±2.43, weight (kg) = 68.94±6.18, and height (cm) = 174.05±4.14.

Fig -1: One of the Participants while delivering the ball

The design of the experiment to conduct the study work took place in the Biomedical Signal Processing Laboratory of the Madhav Institute of Technology & Science (M.I.T.S.), Gwalior. Due to the uncomfortable outdoor environment conditions and issues regarding the safety of equipments an indoor set-up was chosen to perform the purposed experimental work. For these above said reasons a cricket pitch of appropriate dimensions was prepared in the corridor next to the Biomedical Signal Processing Laboratory. Figure 2 shows the batting end of the pitch while bowling end is shown in the figure 3.

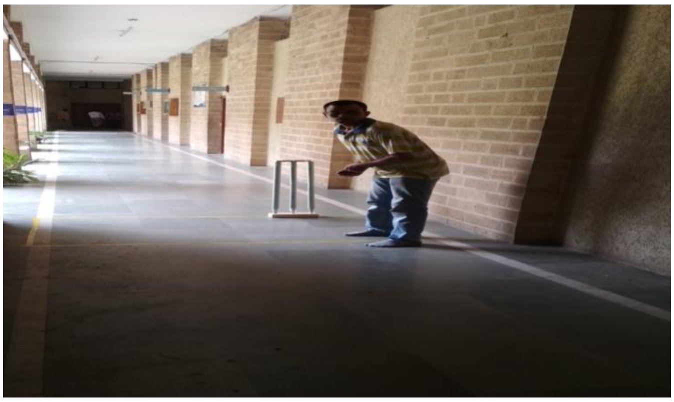

Fig -2: Batting end on the simulated cricket pitch

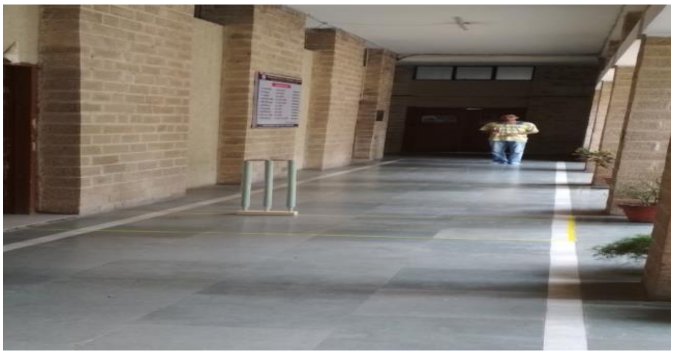

Fig -3: Bowling end on the simulated cricket pitch

As per the availability of the participant the experimental study work was conducted on different days in a time span of 3-4 weeks. Each and every participant was given an orientation session detailing about the areas on the cricket pitch, batting and bowling crease, popping crease, run-up and few other things regarding how the signals will be recorded from their muscles. Following this each bowler was given a trial period as per his requirements to adjust and get settle down with the pitch. To standardize the run-up, based on the study done by Bartlett in 1996 [8], a maximum of 14 yards was given to each participant. As stated before suitable standards and dimensions as per the ICC laws were used to make a cricket pitch. A length of 2012 cm was measured, in the selected area of the corridor, using a meter tape and accordingly the batting and bowling ends were marked. By standards, the width of a cricket pitch should be about 305 cm but the width of the corridor just came out to be approximately of same length, so the width of the corridor was considered to be the width of the pitch. At a distance of 2 m from the stumps of the batting end a horizontal line was marked using blue tape representing the Yorker length. A red tape was used to show the letter 'Y' so as to clearly indicate the bowler where the Yorker length area is on the pitch. In similar way a horizontal line was drawn, using a red tape, right in the middle of the pitch to represent the Bouncer length and then by using a blue tape letter 'B' was marked to make the short pitch area clearly visible to the bowlers. Both these areas are shown in figure 4 & 5 below.

Fig -4: Yorker length on the pitch marked as 'Y'

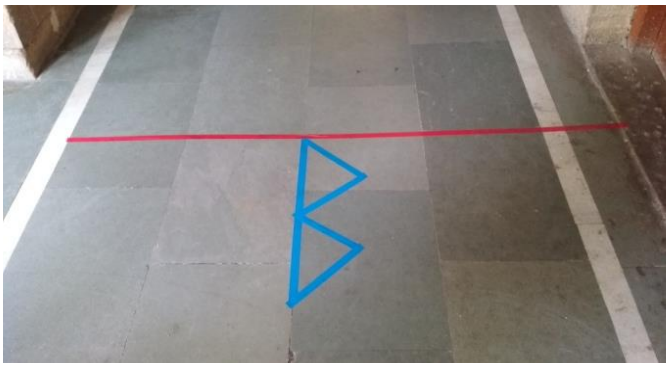

Fig -5: Bouncer length on the pitch marked as 'B'

After properly simulating the cricket pitch, the tools and the equipments that were required for the collection of the EMG data were placed as described here. Trigno Wireless sensors were used for acquiring the data, while Trigno EMG wireless system (SN: SP-W02A-1849) was placed inside the laboratory. The sensors can also be used for measuring acceleration and the system is capable of communicating data with the EMGworks Acquisition and Analysis software where 16 EMG and 48 accelerometer analog channels are generated. The sensors are having 4-channel Ag/AgCl surface electrodes which are used to measure the bio-electric potential being placed on the concerned muscle by using double sided adhesive tapes. Each EMG sensor has a transmission range of about 20 m and a battery which can be recharged approximately within 7 hours. The wireless sensor is being shown in the figure 6, while figure 7 shows the 4- channel of Ag/AgCl electrodes used on the sensor. While the figure 8 shows the Trigno EMG wireless kit. Two different channels of the system were used to acquire and represent the data from the two respective muscles. The selection of channels in relation with the positioning of each sensor is described here. Channel-1: for the sensor placed on the muscle belly of Biceps Brachii muscle. Channel-2: for the sensor positioned at the bulk of the Palmaris Longus muscle. Based on the precious study by Hazari et al. 2016 [1] the sensors were placed just about the halfway of the muscle of interest.

Fig -6: Wireless sensor used for the purpose of EMG measurement

Fig -7: 4- channel Ag/AgCl electrodes used on the sensor

Fig -8: Trigno EMG wireless system with model SN: SP-W02A-1849

The sensor placement on the respective muscles is shown in the figure 9. The entire procedure of placing the sensors and their orientation is done according to the guidelines provided by and used in the previous studies done by Hermens et al. 1999 [9].

Fig -9: Sensors placed on both the concerned muscles using double-sided adhesive tapes.

After assigning the channels to each sensor in the Trigno EMGworks Analysis software each channel was given Gain value of 300 using the 'Hardware' section of the above said software. Afterwards each bowler was asked to have few trials so as to increase the accuracy of delivering the ball in the right areas over the pitch. Once the bowler was ready to deliver the ball a 50 seconds window for both the channels was selected in the EMGworks software for acquiring the EMG raw-data from the sensors on the respective muscles of the bowler. For the concerned study, only that data which falls under the duration for which the bowler is delivering the ball holds importance. This duration is considered in between the time when the bowler first lands on his front leg, after completing his run-up, at the bowling end and the time when he releases the ball from his hand. For the purpose of matching the timing of the delivery with that of the data recorded, as seen through the software, video recording of the bowlers while they deliver the ball was done. For synchronizing the timing of EMG data in the acquisition window with that of the video recording through the mobile phone camera both the recordings (EMG recording and Video recording) began simultaneously. After beginning the recordings within few seconds the camera phone is brought out in to the corridor where the experiment was conducted and then the bowler was asked to start delivering the required ball. This process was applied until the required delivery was bowled properly by the participant within the given time frame of 50 seconds. The same procedure was used for each delivery and bowler.

Completing the acquisition of the EMG signals for each bowler the raw-data in the respective channels was saved and further analyzed using the Trigno EMGworks Analysis software. For the purposed study Root Mean Square (RMS) is taken as the EMG variable. RMS values were calculated by using two vertical cursor lines in the Analysis software, these lines mark the EMG data for the period of delivering the ball. This marking of the raw-signal for each channel is done by pairing its timing with that of the delivering the ball as seen in the respective video recording. For the selected cursor window RMS value of the EMG signal from each of the muscle for each delivery bowled by the bowlers is than easily calculated. EMG signals obtained for the Biceps Brachii muscles while delivering the respective deliveries are shown in figures 10a & 10b.

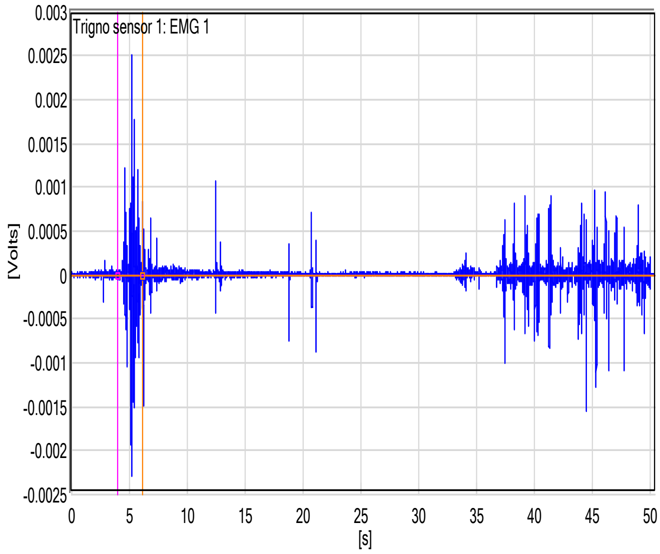

Fig -10 a: EMG raw-data obtained for BB-muscle of one of the participants while delivering Yorker ball

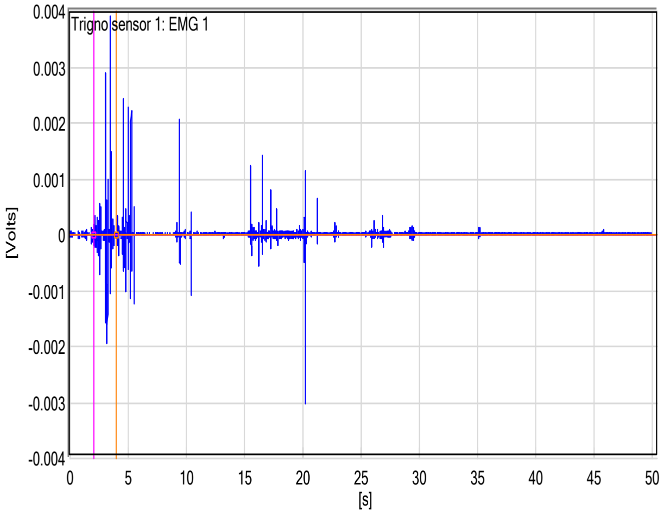

Fig -10 b: EMG raw-data obtained for BB-muscle of one of the participants while bowling Bouncer delivery

The EMG signals obtained for both the Palmaris Longus (PL) muscle while bowling the respective deliveries are shown in figures 11a & 11b.

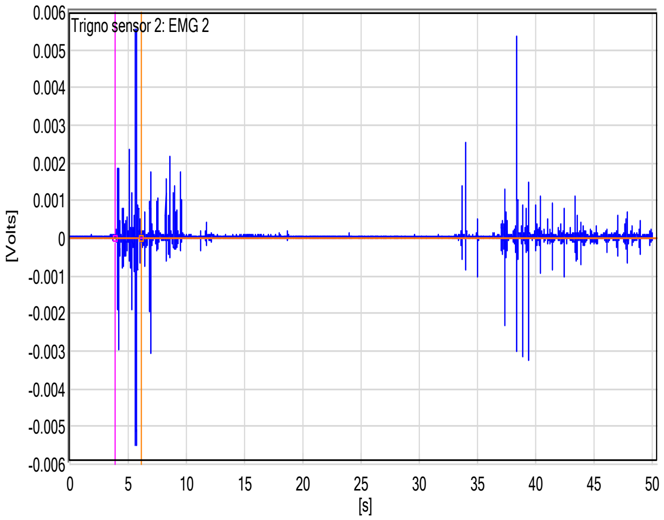

Fig -11 a: EMG raw-data obtained for PL-muscle of one of the participants while delivering Yorker ball

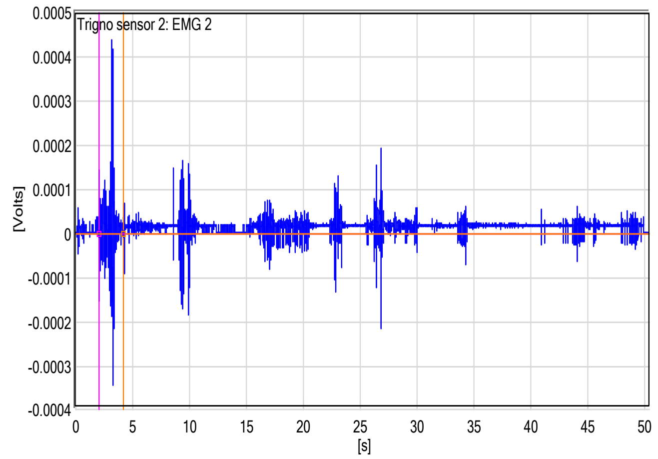

Fig -11 b: EMG raw-data obtained for PL-muscle of one of the participants while bowling Bouncer delivery

The vertical cursors used to indicate the raw data for the duration of bowling are marked in yellow and pink colours, while x-axis represent the time scale in seconds and y-axis represents the bioelectric potentials in volts for figures 10a to 11b.

4. STATISTICAL ANALYSIS

The Statistical Analysis is being done for determining if there exist any significant difference between data obtained for two deliveries for a particular muscle, i.e., for determining the difference in the electrical activity produced in a particular muscle for different deliveries.

Further the analysis is divided in to two stages, first being the test of normality to check whether the data obtained is parametric or non-parametric. Shapiro-Wilk test is used to check normality following which Friedman's test is conducted, which is the second stage, to check the statistical significance between the groups of data for both the cases. Both these tests are done using SPSS Statistics software.

Table 1 shows the RMS values of EMG data obtained for each muscle while delivering the Yorker and Bouncer deliveries. This data is used for knowing the significant difference between the EMG activities produced in both the muscles.

The descriptive analysis, determining the mean and standard deviation of data obtained for both the muscles, is also done using the SPSS Statistics software. Significant value for the Statistical analysis was taken at $p < 0.05$.

Table -1: RMS values of the EMG Data obtained for both the muscles while bowling the respective delivery.

Participants	**RMS values of EMG (in volts) for each Muscle**			
	For BB-muscle		**For PL-muscle**	
	Bowling Yorker	Bowling Bouncer	Bowling Yorker	Bowling Bouncer
Participant 1	.046050	.053224	.043486	.040562
Participant 2	.022779	.065363	.052446	.035046
Participant 3	.053821	.071957	.059010	.019095
Participant 4	.026595	.064883	.106328	.031720
Participant 5	.030729	.023257	.030683	.059225
Participant 6	.021352	.049799	.045239	.044744
Participant 7	.023582	.058815	.031879	.059138
Participant 8	.151961	.175846	.056146	.054455
Participant 9	.024021	.065598	.041815	.039873
Participant 10	.037249	.090986	.051052	.033829
Participant 11	.012325	.101772	.052983	.045142
Participant 12	.042771	.058159	.037042	.028025
Participant 13	.033164	.049022	.039022	.024861
Participant 14	.050544	.051870	.069126	.034837
Participant 15	.022150	.037810	.039491	.024657
Participant 16	.055692	.056456	.046361	.049624
Participant 17	.039461	.040474	.044435	.041185

5. RESULTS

In this section some key findings are shown which are used for determining statistical difference between data obtained for two deliveries for a particular muscle.

The Shapiro-Wilk test results, used as a measure of normality for the data obtained, are shown in table 2. Clearly, test of normality indicates that to check the Statistical difference between the data obtained while bowling the Yorker and Bouncer deliveries for the concerned muscles Non-Parametric test like Friedman's test is required.

Table -2: Result of the Shapiro-Wilk Test obtained for both muscles

Muscles	**For BB-muscle**		**For PL-muscle**	
Type of Delivery	Bowling Yorker	Bowling Bouncer	Bowling Yorker	Bowling Bouncer
p-value	0.0	0.001	0.002	0.7

The results of the Friedman's test and other descriptive analysis are given in table 3. The p-values obtained from the test are used as an indicative whether there is a significant difference between the data for both the cases or not.

Table -3: Results of the Friedman's test and descriptive analysis done for data obtained from respective muscles

Muscles	Delivery	Mean ± Std. Deviation	p-value
BB-muscle	Yorker	0.040838 ± 0.031315	0.0
	Bouncer	0.065605 ± 0.033908	
PL-muscle	Yorker	0.049796 ± 0.017588	0.008
	Bouncer	0.039177 ± 0.011936	

6. DISCUSSION

Root Mean Square (RMS) values are often used to analyze the EMG signals. In this section some important outcomes of the statistical analysis done on the RMS values, obtained from the EMG data (for the duration of delivering the ball), are discussed. Also, in this section the findings of the research work conducted by *Fakuda et al., 2010* [7] is used for relating the EMG activity with the muscular strain, as this study concludes that RMS values obtained for EMG signals are in direct relation with the load on the muscles.

6.1 For Biceps Brachii Muscle

The statistical analysis shows that there is a significant difference between the RMS values obtained for the EMG signals while bowling a Yorker delivery and that obtained while bowling a Bouncer delivery with **p-value** being **0.0**. But greater the RMS value for EMG data of a muscle higher is the load on that muscle which indicates higher electrical and muscular activity for that muscle. So for this muscle it can be inferred from the data that electrical activity is more while bowling Bouncer delivery in comparison to that while bowling Yorker delivery.

6.2 For Palmaris Longus Muscle

For this muscle there exists a significant difference between the data obtained while bowling Yorker and while bowling Bouncer deliveries with **p-value** being **0.008**. So by using the inferential statistics it can easily be observed that there is more load on this muscle while bowling Yorker delivery in comparison to that while bowling Bouncer delivery.

6.3 Overall Outcomes

From the above discussion following outcomes can easily be interpreted.

6.3.1 *Outcome 1*: Biceps Brachii muscle is more open to the risk of injuries while bowling Bouncer delivery as compared to chances of injuries while bowling Yorker delivery as load on this muscle is more during the Bouncer balls.

6.3.2 *Outcome 2*: During the Yorker deliveries Palmaris Longus Muscle shows higher electrical activity to that compared to Bouncer deliveries, so there are more chances of injury while bowling Yorker delivery than to that while bowling Bouncer delivery for this particular muscle.

7. CONCLUSION

From the findings of the statistical analysis it can be concluded that any of the considered muscle produces different electrical activity to each type of bowling, for instance there is more electrical activity in the Biceps Brachii muscle while bowling Bouncer delivery when compared to that while bowling Yorker delivery. Similarly Palmaris Longus muscle produces more electrical activity and thus more risk of injury during Yorker balls as compared to that during Bouncer balls.

8. FUTURE SCOPE

The findings of the study show that the EMG analysis holds strong importance in the field of cricket. Due to some limitations of the work, as discussed below, there are further means of analysis which can strengthen the study. These include analyzing the bowling speed of the bowlers, acceleration produced in the muscles while delivering the ball, etc. Also, further statistical analysis can be done to know if there exists any major difference in the EMG activity between the muscles of interest while bowling a particular delivery. Thus there is a wide scope for further research in the select study of work.

9. LIMITATIONS

Due to the unavailability of the equipment the speed of the ball wasn't measured. So using radar gun would make the study more efficient. Considering the limitedness of research work the acceleration of the muscles recorded while delivering the balls were not used for analysis purpose, thus analyzing the acceleration produced in the concerned muscles can enhance the study. Capturing the motion of the bowlers while they deliver the respective balls can be helpful in analyses of kinematics and kinetics of the muscles and this can help in deeper understanding of the injuries caused.

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REFERENCES

[1]. Hazari A, Warsi M, Agouris I. Electromyography analysis of shoulder and wrist muscles in semi-professional cricket fast bowlers during bouncer and yorker delivery. A cross-sectional comparative study. International Journal of Physical Education, Sports and Health. 2016; 3(6): 77-87.

[2]. Bartlett R. Movement coordination and movement variability. Sports Biomechanics, 2007; 6(2):119-120.

[3]. Marshall R, Ferdinands R The effect of a flexed elbow on bowling speed in cricket. Sports Biomech, (2003); 2(1): 65–71.

[4]. Aginsky K, Lategan L, Stretch R. Shoulder injuries in provincial male fast bowlers - predisposing factors. South African Journal of Sports Medicine. 2004; 16(1):25-28.

[5]. Cook DP, Strike SC. Throwing in cricket. Journal of sports sciences, 2000; 18(12):965-73.

[6]. Ahamed NU, Sundaraj K, Ahmad B, et al.. Surface Electromyographic Analysis of the biceps brachii muscle of cricket bowlers during bowling. Australas Phys Eng Sci Med. 2014. [Online].

[7]. Fukuda TY, Echeimberg JO, Pompeu JE, et al.. Root Mean Square Value of the Electromyographic Signal i the Isometric Torque of the Quadriceps, Hamstrings and Brachial Biceps Muscles in Female Subjects. The Journal of Applied Research. 2010; 10(1): 32-39.

[8]. Bartlett RM. The biomechanics of fast bowling in men's cricket: a review. Journal of Sports Sciences, 1996; 14(5):403-424.

[9]. Hermens HJ. European Recommendations for Surface ElectroMyoGraphy. Roessingh Research and Development, 1999, 8-11.

[10]. Ahamed NU. Surface electromyographic analysis of the biceps brachii muscle of cricket bowlers during bowling. Australasian Physical and Engineering Sciences in Medicine, 2014; 37(1):83-95.

[11]. Burden AM, Trew M, Baltzopoulos V. Normalisation of gait EMGs: A re-examination. Journal of Electromyography and Kinesiology, 2003; 13(6):519-532.

[12]. Donatelli R. Assessment of shoulder strength in professional baseball pitchers. The Journal of Orthopaedic and Sports Physical Therapy, 2000; 30(9):544-551.

[13]. Glazier PS, Paradisis GP, Cooper SM. Anthropometric and kinematic influences on release speed in men's fast medium bowling. Journal of Sports Sciences, 2000; 18(12):1013-1021.

[14]. Finch CF, Elliott BC, McGrath AC Measures to prevent cricket injuries: an overview. Sports Med, (1999); 28(4): 263–272.

[15]. Ferdinands R, Kersting U, Marshall R. A new taxonomic system for the sub-classification of cricket bowling actions. Sports Technology, 2014; 6182:37-41. Available at: http://www.tandfonline.com/doi/abs/10.1080/19346182..8 93350.

[16]. Hirashima M. Sequential muscle activity and its functional role in the upper extremity and trunk during overarm throwing. Journal of sports sciences, 2002; 20(4):301-310.