iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** XI **Month of publication:** November 2016

DOI:

www.ijraset.com

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Volume 4 Issue XI, November 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Kinematics of Usain Bolt's 100 m performance: A Review

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Abstract: ***The sprint event viz, 100m is considered as the blue riband event in the world, as athlete tries to cover the maximum distance in the shortest possible time. This study was aimed to review the kinematics of Usain Bolt's 100m performance. Bolt is considered as the world's highest profile athlete, through his success in the field of athletics, he has revolutionised the sprint mechanics by his record breaking performances and has owned the name world's fastest man and lightning bolt. In this study the kinematics and physical characteristics of his best three performances was brought into light with the help of data retrieved from the official website of IAAF, research papers and from many other citations. The 20 cm longer stride length, higher stride frequency and high velocity helps him to maintain his momentum in the last stage of the 100 m race than his other counterparts of the race, and finally makes him superior than other rivals. This longer stride length, higher frequency and high velocity may be the reason, which makes him faster than other athletes of the world.***
Key Words: Kinematics Mechanics, and Sprints.

I. INTRODUCTION

The 100 m sprint was officially introduced in the Modern Olympic Games in 1896, in Athens, Greece. The inaugural event was won by Thomas Burke, of the Unite States, with a timing of 12.00 seconds, (IAAF, 2009). This event is considered as the most attractive event of the athletics at the major championships, as almost all the spectators witness this event with full zeal and enthusiasm. The primary motive of this event is to cover the maximum distance in minimum possible time, and thus making it the world's blue riband event of the athletics.

The athlete who owns the record in 100 m event is given a prominent title, world's fastest man. The world's fastest sprinters run 100 m in just below 10 seconds. They run with an average velocity of 10 m/s, and take approximately 45 steps to complete the 100 m race, (Brüggeman, Koszewski and Müller 1999). The sprinters experience four different phases of speed during this short time and least number of steps they take, with reaction speed phase at the time of start, the acceleration phase, maximal speed phase and speed maintenance phase, (Smith, 2005). The current world record holder of the 100 m race is Usain Bolt of Jamaica with a timing of 9.58 s, and also holds the current 200m world record of 19.19 s both the world records set at Berlin in 12th International Association of Athletics Federations (IAAF), World Championships in Athletics 2009. The 100 m sprints performance of the Usain Bolt is of physical interest, because he achieves his speed and acceleration within no time as compared to the other 100 m sprinters. In this respect, the people of 21st century are enjoying the golden era of the athletics, especially because of the record breaking performance being given by the Usain Bolt, and has revolutionised the sprint mechanics. In the last 8 years of his career, he has improved the 100 m world record twice from 9.79 s to 9.69 s and from 9.69 s to 9.58 s (IAAF, 2013). The 10 s barrier in 100 m was broken in 1968 summer Olympic Games in Mexico. After that the record has been improved by 0.37 s from (1968 – 2009), with an increase in the performance by 3.72%.

Mann and Herman (1985) have conducted a similar research and have found that the performance of the 100 m sprints depends upon the sprinting speed, stride length, stride frequency, and joint velocities. These kinematic parameters of the 100 m sprints are mutually dependent on each other; increase in both the parameters simultaneously is very difficult due their interdependency. Thus making change in one parameter will lead to the improvement of sprint velocity, as long as the other parameter does not change similarly (Hunter at el., 2004). Increasing frequency will lead to the decrease in stride length and vice versa. Thus the increase in the stride frequency is directly proportional to the decrease in the stride length, especially at the initial acceleration phase of the race (Mackala, 2007). Hunter et al. (2004) and Bezodias et al. (2008) have studied that relative importance of developing a long stride length or high stride rate remains inconsistent. Bezodias et al. (2008) have revealed that the stride frequency is the main contributor to the increase in velocity of sprint performance. However, Mero and Komi (1985), Gajer et al. (1999), Shen (2000) and Mackala

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(2007) have revealed that the stride length was more significant than stride frequency. Therefore, it is not clear how the kinematic parameters interact with each other. In context of the above research, the present study is structured to review the kinematics of Usain Bolts 100 m sprint performance.

II. STEREOTYPE OF USAIN BOLT

Physically Usain Bolt is 196 cm in height, thus making him worlds one of the tallest sprinter. Bolt's height is about 20 cm, 18.7 cm and 16.6 cm greater than the average height of the other counterparts of the 100 m (2012 Beijing Olympic Games, 2009 Berlin World Championships in Athletics and 2012 London Olympic Games). Despite of having greater height, Bolt has got heavy mass of about 93 kg which also makes him heavy contingent in terms of mass. Bolt was having higher body mass than his other rivals, Beijing 14.8%, Berlin 12.3% and 10.7% in London.

III. PERFORMANCE OF USAIN BOLT IN BRIEF

Usain Bolt is considered as the sprint king, he has won 9 Olympic gold medals viz, 3 gold medals at 2008 summer Olympic games in Beijing, 3 gold medals at 2012 summer Olympic games in London and 3 gold medals at 2016 summer Olympic games in Rio de Jenerio and has also 11 world athletic championship gold medals to his credit, viz, 3 gold medals at the 2009 world athletic championships in Berlin, 2 gold medals at 2011 world athletic championships in Daegu, 3 gold medals at 2013 world athletic championships in Moscow and 3 gold medals at 2015 world athletic championships in Beijing, besides this he has also won a gold medal in relay race at common wealth games held at Glasgow, Scotland in 2014 respectively. Since Beijing Olympics 2008, he has lost only one 100 m final at Daegu, South Korea due to false start, since then he has ruled the 100 m, 200 m and 4 X 100 m relay races. He became the only sprinter in the world to defend his Olympic titles thrice in a row at three consecutive summer Olympics viz, 2008, 2012 and 2016. He made a clean sweep of triple treble of gold medals in Olympics thus has own the title "Lightening Bolt". He has also won three 100 m gold medals in world athletic championships out of his four appearances, the only time he could not won his 100 m gold medal was at Daegu world athletic championships 2011, because of his false start that lead him to the disqualification in the final. Bolt has completed all his fastest 100 m races at an average of 41.13 strides. He starts his race with smaller baby steps at the beginning of the race and covers 2.45 meter with one stride. Stride length which is inversely linked to the frequency, which is 0.30 Hz lower (IAAF, 2009). Each 100 m section of Beijing was similar to that of Berlin and London. The average difference is 0.02, however clear differences were seen in the first 10 meters and last 10 meters. Bolts first 10 meters at Berlin was slower by 0.04 s to that of Beijing Olympics 2008, which cost him about 0.07 s compared to the time needed for the last 10 m in Berlin, so, if Bolt had started the 100 m race at Berlin world championship in the same way as he did at Beijing Olympics, then he would have definitely improved his 100 m performance to sub 9.50 s. Another significant difference was found in the last 10 meters of the race, (IAAF, 2009). As per the above facts, it is evident that Bolt would be able to cover first 10 m in 1.85 s. As per the analysis made by his coach Glen Mills at Beijing Olympics 2008, the way Bolt was running at Beijing Olympics, he could have finished his 100 m race in just 9.52 s, if he had not slowed down to start pre mature celebration of his victory from the 80 meters, as none of the other athletes was close to him. This pre mature celebration cost him to finish in 9.69 s.

IV. STATISTICS OF BOLT'S THREE BEST 100 M PERFORMANCES

Table 1: Statistics of Bolt' 100 m performance with timing, since 2008

Year	Event	Competition	Venue	Place	Time (Seconds)
2008	100 m	Olympic Games	Beijing, China	Ist	9.69
2009	100 m	World Athletic Championships	Berlin, Germany	Ist	9.58
2011	100 m	World Athletic Championships	Daegu, South Korea	Disqualified	----------
2012	100 m	Olympic Games	London, United Kingdom	Ist	9.63
2013	100 m	World Athletic Championships	Moscow, Russia	Ist	9.77
2015	100 m	World Athletic Championships	Beijing, China	Ist	9.79
2016	100 m	Olympic Games	Rio de Janeiro, Brazil	Ist	9.81

1. Data retrieved from IAAF –Berlin 2009.
2. Data from https://en.wikipedia.org/wiki/Usain_Bolt

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The data retrieved from the sources presented in Table 1, shows the Bolt's statistics of 100 m performance since 2008. The table reveals that Bolt's has given his best performance sub 9.70 s in 2008 Olympic Games in Beijing, 2009 world athletic championships and 2012 Olympic Games in London respectively. In this paper the kinematics of these three best performances were taken into account.

Table No: 2 Usain Bolt's Physical Characteristics:

Parameters	Olympic Games Beijing 2008	World Championship Berlin 2009	Olympic Games London 2012
Age in years	22	23	26
Body Mass (Kg)	90	90	93
Body Height (m)	196	196	196
BMI (kg/m^2)	23.4	23.4	24.2

1. Data retrieved from Mackala, K., and Anti, M., (2013).
4. Data retrieved from www.BBC.uk/sport/olimpics/2012/athletes

Table 2, reveals the morphological characteristics of Usain Bolt's three best performances in 100 m.

Table No: 3 Numerical characteristics of selected kinematic variables in the 100 m sprint of usain Bolt.

Kinematic variables		Olympic Games Beijing 2008	World Championship Berlin 2009	Olympic Games London 2012
Time [s]		9.69	9.58	9.63
Velocity [m/s]		10.32	10.44	10.38
Stride Frequency[H]		4.24	4.23	4.29
Number of Strides	All	41.1	40.92	41.4
	Take off from Left Leg.	20.7	20.1	20.9
	Take off from Right Leg.	20.4	20.8	20.5
Stride Length (meter)		2.43	2.47	2.41

1. Data retrieved from Mackala, K., and Anti, M., (2013).
2. Data retrieved from IAAF –Berlin 2009.

Table 3, reveals the basic kinematic parameters of Usain Bolt's three best performances in 100 m

Table No: 4 Statistics of the above three performances

Kinematic parameters		Average	SD	V
Time [s]		9.63	0.06	0.57
Velocity [m/s]		10.38	0.06	0.58
Stride Frequency[Hz]		4.25	0.03	0.76
Number of Strides	All	41.13	0.25	0.61
	Take off from Left Leg	20.57	0.42	2.02
	Take off from Right Leg.	20.57	0.21	1.01
Stride Length (meter)		2.44	0.03	1.25

1. Data retrieved from Mackala, K., and Anti, M., (2013).
2. Data retrieved from Waren Doscher.
4. Data retrieved from IAAF –Berlin 2009.

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Table 4, reveals the average performance of Usain Bolt's three best performances. The table reveals that Bolt completed all three fastest 100 m races at an average of 41.13 strides, with a stride frequency of 4.25 HZ, and with a running velocity of 10.38 m/s.

V. DISCUSSION

The 100 m sprints event is very individual and mainly depends upon the athlete's morphological and kinematic parameters. The study reveals that that the impact of the Usain Bolt's biological characteristics viz, body height and body mass son the stride length and stride frequency gives him an edge to be faster in the 100 m event, because of the above characteristics Bolt attained the title, sprint king of 100 m. The longer limbs enable him to propel very fast during sprinting. The high stride frequency makes him to maintain the fast speed till the finishing line. The study also reveals that Bolt takes just 41.13 strides on average to complete 100 m race, an average stride length of 2.44 m, average stride frequency of 4.25 Hz and with an average velocity of 10.38 m/s. Bolt's body height and lower limbs make him faster than other rivals and moreover his 20 cm longer stride length helps him in the last stage of the race to propel fastely towards victory (Mackala and Mero 2013). As mentioned above, it is clear that stride length has a great impact on the stride frequency; change in one parameter may affect another (Hunter et al., 2000). The elongated stride length is attained with the help of strength and power, and this stride length ultimately leads to the production of high velocity during sprinting (Hunter et al., 2004). Thus Bolt's strength and power may be the reason for his higher stride length and high velocity at the time of sprinting.

VI. CONCLUSION

The main purpose of the study was to review the kinematic characteristics of the Usain Bolt's 100 m performance. The study reveals that following kinematic characteristics viz, stride frequency, stride length, time and velocity define an efficient performance of Bolt in 100 m race. On the basis of the above mentioned data, the study reveals that Bolts higher stride frequency and longer stride length helps him maintain the top speed till the finishing line. In context of the above study, it is noteworthy that the main focus in the 100 m race should be on the optimal interaction between stride frequencies and stride length, which would finally lead to the production of high velocity. Thus, coaches and trainers should ponder upon the certain training programmes, which would help the athletes to develop their strength and power, so that they can enhance their stride length and stride frequency and there by ultimately helping them to maintain the velocity throughout the race.

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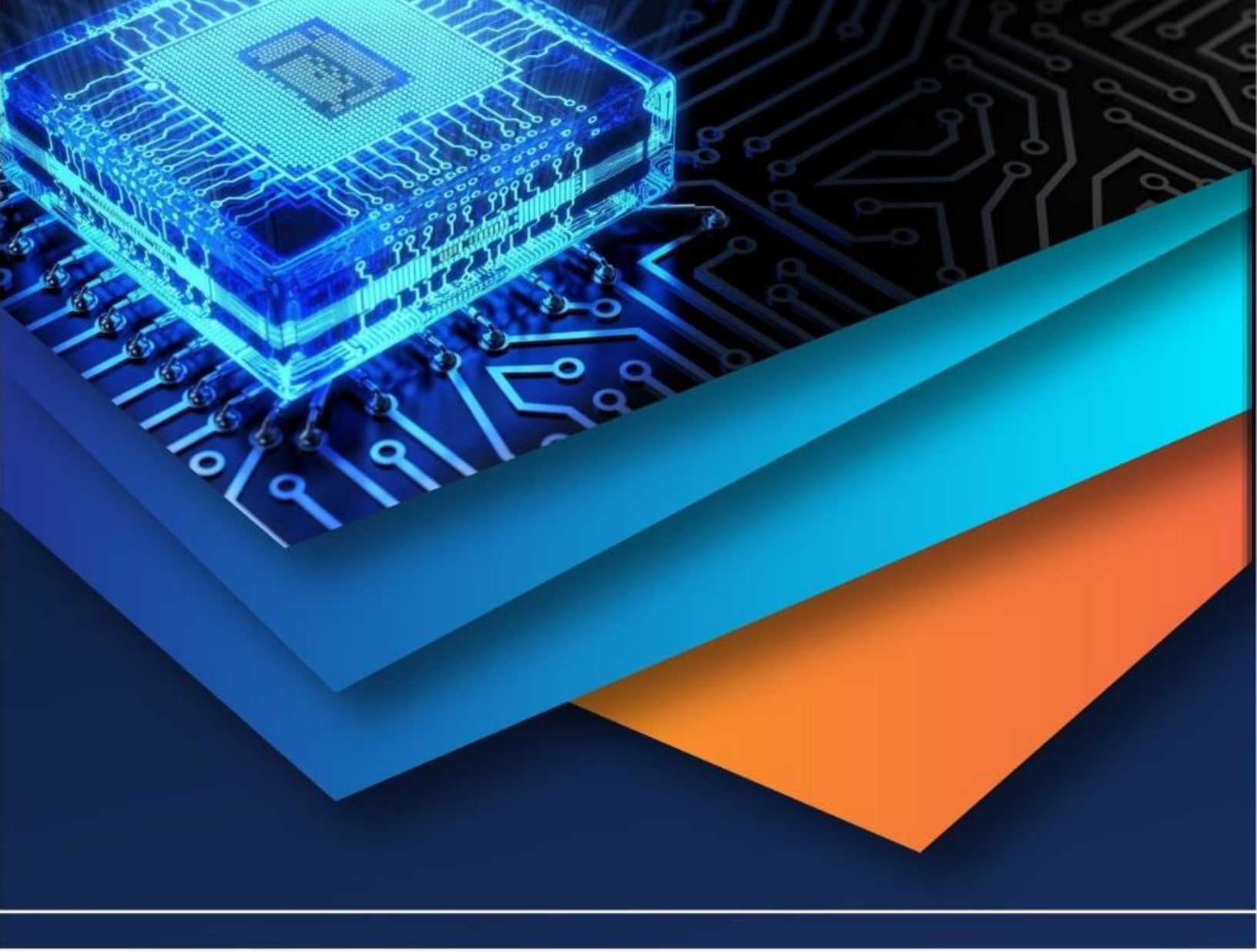

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