WHAT WOULD IT TAKE TO BREAK THE WORLD RECORD IN THE MEN'S TRIPLE JUMP

Philip Graham-Smith[1] and Paul Brice[2]

Aspire Academy, Doha, Qatar[1]
British Athletics, Birmingham, UK[2]

The purpose of this study was to bring together 30 years of athlete support and applied research into the horizontal jumps and develop a strategy for an elite athlete to challenge the World Record which has stood for over 27 years. Data on an elite triple jumper who has jumped over 18m was collected in a Diamond League competition and in training. Approach speed, phase distances, technical analysis and anthropometrical data were utilised to develop an interactive 7 segment model from which a new World Record was reconstructed. This study demonstrates a process of how to utilise biomechanical data and implement it into a high-performance setting, providing the coach with clear, objective and meaningful data from which they can set criteria to assist in developing performance.

KEY WORDS: TRIPLE JUMP, WORLD RECORD, MODEL, PROCESS

INTRODUCTION: The men's triple jump World Record was broken twice in successive jumps by Jonathan Edwards at the 1995 IAAF World Championships in Gothenburg, setting a new distance of 18.29m. Since then, 5 athletes have managed to jump over 18m with the closest being 18.21m registered by Double Olympic Gold and 4 times World Champion Christian Taylor. With advances in sports science and technology to monitor athletes over the last 27 years, it begs the question why the World Record become is so elusive. Having supported Jonathan Edwards throughout his career and developing normative data for approach speeds, phase distances (Graham-Smith & Lees, 2000; 2002) and physical attributes of speed, strength, power and reactive strength (Graham-Smith and Brice, 2010) the emphasis shifts to question how is biomechanical data being utilised to inform decision making and developing strategies to enhance performance.
The aim of this study was to utilise data collected in competition and training environments to develop technical and physical performance indicators for an elite triple jumper to theoretically challenge the World Record, and demonstrate how it can be translated into coaching practise.

METHODS: The performance of an elite male triple jumper was captured on 4 high speed video cameras, (Casio Exilim, 240fps) at a Diamond League event in 2018. Cameras were set up to record the sagittal plane in each take-off and landing into the sand pit. Approach speed data was collected using a Laveg LDM 300C device positioned at the end of the pit (Figure 1), providing split times for 11-6m, 6-1m and the average of 11-1m, peak speed and speed at 1m from the board. Small strips of white tape placed at 1m intervals provided a calibration reference to determine hop, step and jump distances from positions of the toe in each take-off. The effective distance was calculated by adding the toe-to-board distance to the measured official distance. From this the average speed (11-1m) was plotted against a regression equation with effective distance to examine how well his speed was being utilised.

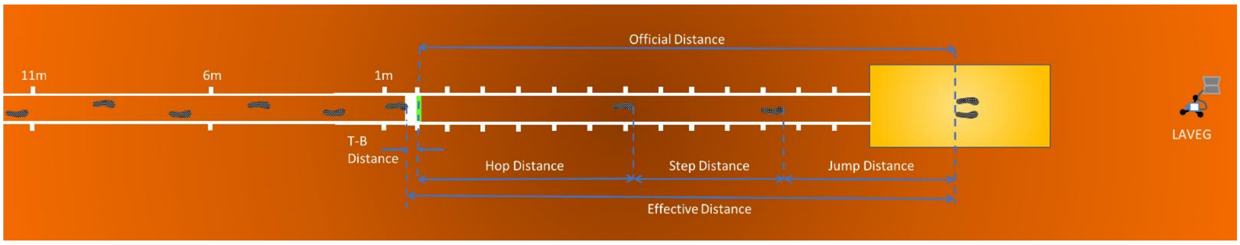

Figure 1: Measurement of Phase Distances and relationship to Official and Effective Distances

The athlete's technique was analysed from the video footage recorded at the Diamond League and from full approach training jumps. The angles of the trunk, hip, knee and ankles of both legs at key instants throughout the jump were measured using Quintic Biomechanics software version 31. A 7 segment model (trunk-head-arms formed one segment and thigh, shank and foot for both legs) was developed utilising segmental data from De Leva (1996) and scaled to the athlete's height and limb lengths. Entering these angles and segment lengths into the model allowed us to estimate the location of the centre of mass (CM) relative to the toe of the take-off leg at the instants of touchdown and take-off from the last step through to landing in the sand pit. From this, take-off, flight and landing distances were determined for each aspect of the jump (Figure 2). Timings of the flight phases allowed us to determine the horizontal and vertical velocities at take-off and touchdown, and the changes during contact of his best performance with an effective distance of 17.92m (Table 1). The peak speed and speed at 1m from the board from the Laveg was used to cross-check with the model. The model was then used to extend the effective distance to 18.35m (allowing a notional 5cm at the board) to create a new World Record of 18.30m by adopting what appeared to be his preferred phase ratio.

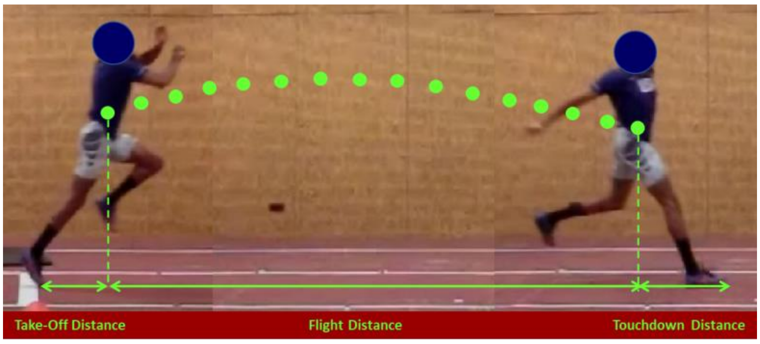

Figure 2. Touchdown, Take-off and Flight distances

RESULTS & DISCUSSION: Approach speed and phase distances from the Diamond League event are presented in Table 1. The first thing to consider is how well he utilised his approach speed. When plotting his approach speed (11-1m) against effective distance it can be seen that he jumps slightly further than the predicted distance based on our regression equations (Figure 3a, Graham-Smith and Lees, 2002). This indicates that he had good speed utilisation and that his technique, control and distribution of effort through the three phases was effective. His approach speed is within a range that could reasonably attain the World Record, although an average speed (11-1m) of 10.88m/s is what would be expected. His hop, step and jump distances map onto the phase distance lines (Figure 3b), albeit that the hop and jump distance are reversed because he is a jump-dominant jumper (Jump % is 2% greater than the Hop %). This demonstrates that there wasn't an imbalance of effort in his phase distribution. With the exception of rounds 1 and 5 it would seem like a phase ratio of around 34.0: 29.5: 36.5 is appropriate for him. Giving him a notional 5cm toe-to-board to avoid a foul, to break the World Record he would need an effective distance of 18.35m. Based on his phase ratio this would be broken down into a 6.24m hop, 5.41m step and a 6.70m jump (assuming zero loss in the landing).

Table 1
Approach apeed and phase breakdowns in competition

Round	Effective Distance (m)	Approach Speed 11 - 6 m (m/s)	6 - 1 m (m/s)	Ave. 11-1m (m/s)	Hop Distance (m)	Hop (%)	Step Distance (m)	Step (%)	Jump Distance (m)	Jump (%)
1	NJ	10.24	10.52	10.38	5.79		5.09			
2	17.46	10.37	10.51	10.44	5.84	33.4	5.28	30.2	6.34	36.3
3	17.92	10.32	10.63	10.48	6.09	34.0	5.32	29.7	6.51	36.3
4	17.60	10.30	10.51	10.40	5.89	33.5	5.19	29.5	6.52	37.0
5	16.71	10.47	10.55	10.51	6.20	37.1	5.06	30.3	5.45	32.6
6	17.75	10.40	10.57	10.48	6.07	34.2	5.16	29.1	6.52	36.7

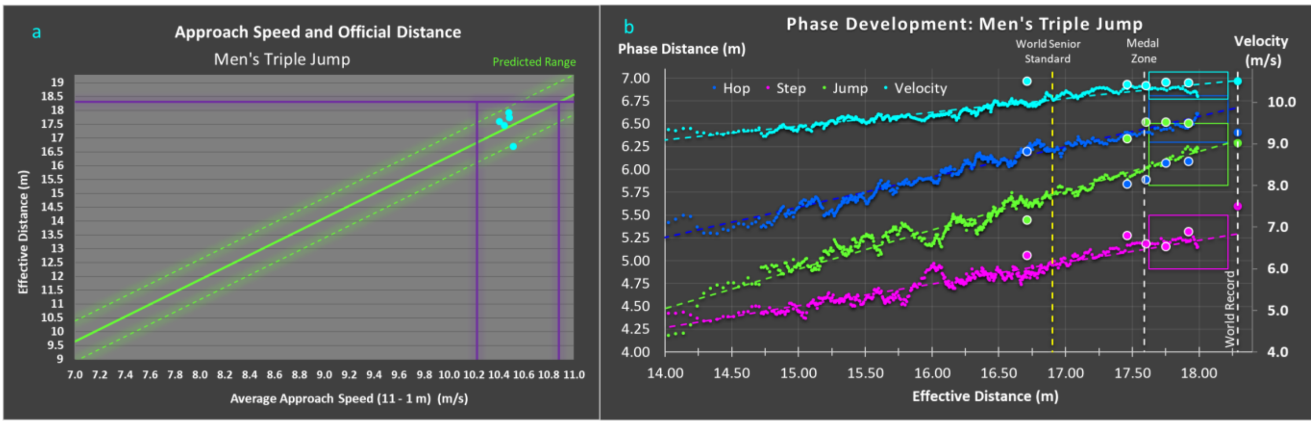

Figure 3: Graphical representation of approach speed and phase distance data against effective distance. Regression lines based on continuation of the work of Graham-Smith and Lees (3,4)

The model and breakdown of the 17.92m performance can be seen in Figure 4. Given his ability to utilise speed well and demonstrating good technical ability and control, the option to increase approach speed was investigated. Assuming that he adopts similar landing and take-off positions (this is fairly consistent in training) and that the losses in horizontal velocity are similar to his 17.92m performance (-0.32m/s, -0.51m/s and -2.37m/s) then a world record performance could be achieved primarily by increasing his speed into the last step from 10.7m/s to 11.0m/s. A small reduction in last step length to 2.00m (Figure 4) would mean that that he contacts the board with zero vertical velocity rather than -0.10m/s. To attain the phase ratio of 34.0: 29.5: 36.5 in an 18.35m performance the increase in speed would extend his hop by 15cm without any need to generate more vertical impulse. His landing vertical velocity would increase slightly from -2.67m/s to -2.76m/s and he would need to develop a little more vertical impulse to increase the step distance by 9cm. In reality most of this could come from his ability to resist hip and knee flexion in response to a slightly greater impact force. The hop-step distance would now be 11.66m, leaving a jump of 6.70m to break the World Record. Having carried the extra 0.3m/s horizontal speed through to the jump take-off the vertical landing and take-off velocities would be similar requiring a total gain in vertical velocity of 4.90m/s to add the extra 18cm to the jump.

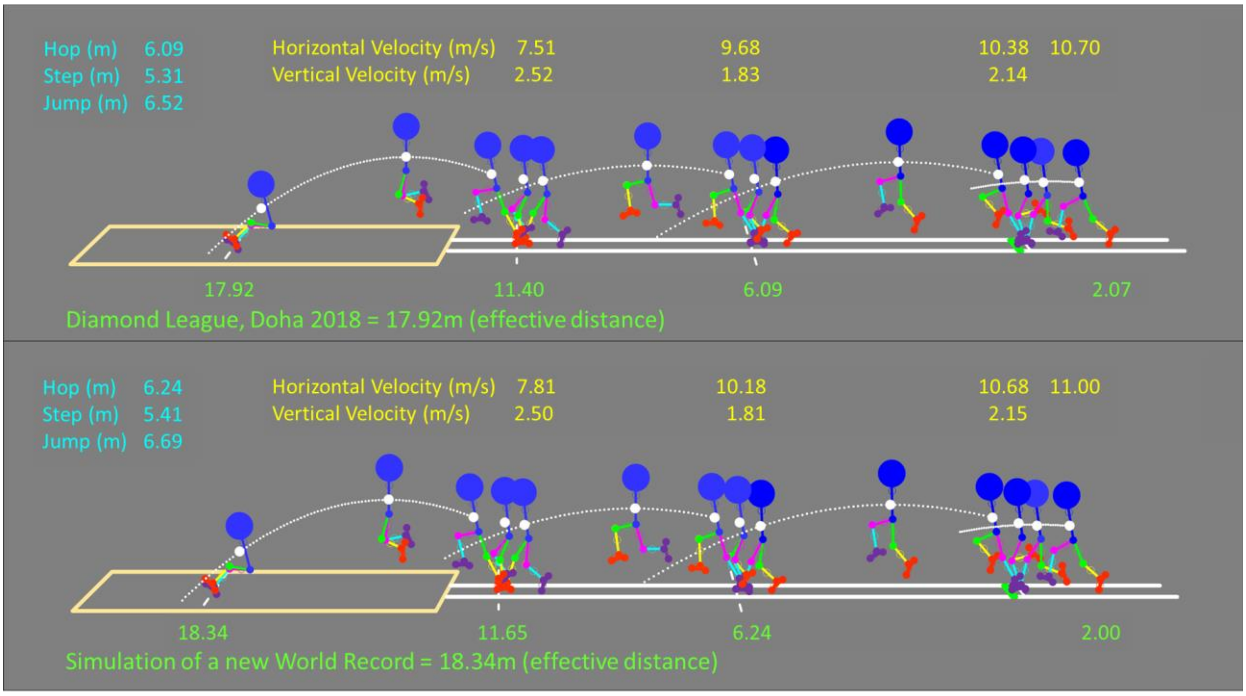

Figure 4: Technical analysis of the 17.92m Diamond League performance and simulation of a World Record Jump

There are numerous velocity combinations that could lead to a new World Record, but as a coaching strategy this one is plausible, providing easily quantifiable observations in training and competition. An alternative strategy would be to achieve the phase distances by developing greater vertical velocities at take-off. The downside to this is that as the CM goes higher it leads to much greater vertical impact forces which need to be controlled, and this would also be compounded by greater losses in horizontal speed. The development of more horizontal speed on the runway would be a safer and more realistic option. An approach speed of over 11.0m/s is not unreasonable for an elite triple jumper as Hay (1995) reported speeds of upto 11.3m/s for Mike Conley when he adopted a jump dominated technique. To ensure the athlete has the ability to control greater landing forces in the step take-off it would also be prudent to assess his physical attributes. Based on normative data on 38 national squad horizontal jumpers in the UK, it would be expected that he would attain at least the 'above average' level against normative data in Table 2. These tests were previously designed and implemented through discussions with National Coaches and the normative data utilised to monitor athlete's jump-specific physical development (Graham-Smith and Brice, 2010).

Table 2
Physical profile requirements

	Speed			**Strength (Isometric Squat)**		**Power**	**Reactive Strength**			**Horizontal Jumps**		
							Drop Jump 40cm					
Elite Triple Jumper	Time 0-20m (s)	Time 0-40m (s)	Time 20-40m (s)	Peak Force (N)	Peak Force / BW	CMJ Jump Height (m)	Contact Time (s)	Jump Height (m)	Reactivity Index	SLJ (cm)	4 Bounds & Jump (m)	4 Hops & Jump (L & R)
Excellent	2.57	4.55	1.95	5923	7.33	0.65	0.175	0.66	4.03	333	17.91	17.88
Above Average	2.65	4.68	2.02	5133	6.47	0.59	0.210	0.58	3.38	316	16.95	16.86
Average	2.74	4.82	2.08	4343	5.61	0.52	0.244	0.49	2.73	299	15.99	15.85

CONCLUSION:

The athlete's ability to utilise his approach speed and attain distances that are slightly greater than expected provides confidence in suggesting an increase in approach speed is a viable option. Had his speed utilisation being less effective, the focus would have been directed to technical errors and his ability to control landing forces. The data and qualitative analysis of his landings suggested his technique was robust as he avoided collapsing at the hip and knees. Providing the coach and support team with clear criteria allows them to focus on specific aspects of the performance, e.g. approach speeds, last step length and phase distances and measure these regularly both in full approach training jumps and competition.

This study has attempted to demonstrate how biomechanical support to athletes works in the high-performance environment, where data is collected routinely in training and in competition and subsequently informs discussions with coach, athlete and support team when planning performance development. Effective biomechanists should assist the coach in developing a technical model of performance, measure appropriate metrics and work alongside the S&C coach and physiotherapist to conduct supplementary assessments to determine if the athlete has the correct physical attributes to deliver the performance.

REFERENCES:

De Leva, P. (1996) Adjustments to Zatsiorsky-Seluyanov's Segment Inertia Parameters. *Journal of Biomechanics*, 29, 1223-1230.

Graham-Smith P, Lees A. (2000). Developmental aspects of the triple jump. *The Coach*, 3, Autumn 2000, 48-55.

Graham-Smith P, Lees A. (2002). Finding the 'balance' in the horizontal jumps – part 1 utilising speed. *The Coach*, 10, May / June, 30-33.

Graham-Smith P, Brice P. (2010). Speed, strength & power characteristics of horizontal jumpers. Presented to the *International Society of Biomechanics in Sport*, University of Northern Michigan, Marquette. July 20th – 23rd, 2010.

Hay JG. (1995). The case for the jump-dominated technique in the triple jump. *Track Coach*, 132, 4042-4048.