Biomechanical analysis of the 7th World Championships in Athletics Seville 1999

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ABSTRACT

The authors present the findings of a biomechanical research project carried out at the 7th World Championships in Athletics Seville 1999. This project was focused on the sprint events only. The objectives of this project have been: to analyse the performance in the 100 m to 400 m sprints, to produce reference values for training programming and obtain a methodology based on two dimensional video system ready for the kinematic analysis of competition. In the following the results of the men's and women's sprint finals are illustrated and interpreted.

AUTHOR

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1. Introduction

The men's and women's 100, 200 and 400m sprint events at the Seville World Championships were analysed as part of the Biomechanical analysis project for the throwing and running events at the 1999 IAAF World Athletics Championships. This project was approved by the International Amateur Athletic Federation and financially supported by the Spanish Interministerial Commission of Science and Technology (CICYT) and, for running events, by the Higher Sports Council (CSD) of Spain. To carry out the filming process, we relied on the support of the Biomechanics research teams from the Physical Education National Institutes of León and Lleida, the Faculties of Physical Activity and Sports Sciences at the Universities of Granada and Valencia, and the European University of Madrid

This kind of analysis has been carried out at major competitions for more than a decade, as it provides coaches and athletes with very useful information as an aid to training programmes and competition preparation. The race analysis of the top athletes in the world in each speciality serves as a reference for assessing technique and rationalising the results achieved. The results of the World Championships in Rome 1987 (Landry, 1987), Moravec and coll., (1988); of Athens 1997, Brüggemann and coll. (1997) and those of the Seoul Olympic Games (1988) published by Susanka and coll. (1989 a, b and c) and of Brüggemann and coll. (1990), have served as a reference for designing the experimental procedure for the different events.

Outstanding results were achieved in the World Athletics Championships Seville 1999

in the men's 100 and 400m sprints. Maurice Green's result was only 0.01s slower than his own world record, and Michael Johnson achieved a new world record with a time of 43.18s, 0.11s faster than the former record. The results will be disseminated world-wide and coaches will be in a better position to design training strategies in line with current world trends.

2. Objectives

The objectives of this study were:

1. To carry out an analysis of the performance of the men's and women's 100, 200 and 400m finalists at the World Athletics Championships in Seville, based on biomechanical variables.
2. To disseminate the results of the study to coaches and athletes all over the world for their knowledge and use as reference values for training preparation.
3. To obtain a methodology based on two dimensional video photogrammetric procedures that would assist in the kinematic analyses of the competitions.

3. Material and methods

3.1 Subjects

The sample consisted of:

- 24 men, finalists of the 100, 200 and 400m sprint events.
- 24 women, finalists of the 100, 200 and 400m sprint events.

3.2 Instrumentation

3.2.1 Filming instrumentation

100m sprint events

- 6 SVHS video cameras, Panasonic MS1\MS4\MS5\625 AG-DP800HE.
- 4 digital high-speed video cameras, Kodak Motion Corder Analyzer SR 500C.

200m sprint events

- 5 SVHS video cameras, Panasonic MS1\MS4\MS5\625 AG-DP800HE.
- 4 digital high-speed video cameras, Kodak Motion Corder Analyzer SR 500C.

400m sprint events

- 8 SVHS video cameras, Panasonic MS1\MS4\MS5\625 AG-DP800HE.
- 4 digital high-speed video cameras, Kodak Motion Corder Analyzer SR 500C.

3.2.2 Instrumentation for the analogic recording of filming

For all sprint events:

- 2 SVHS video recorders: JVC HR-S7000EH.
- 2 5in/4out Kramer Vertical Interval Switchers.
- 2 Time code generators.
- 2 Colour TV monitors.
- Wiring for connecting cameras to the recording systems.

3.2.3 Instrumentation for the digital recording of filming

For all the filming:

- 4 Video walkman Hi-8 (Sony).
- 2 Notebooks (Pentium II 350 MHz).

3.2.4 Data analysis system

Analogic video:

- 2 Panasonic AG-7350 video recorders.
- 1 computer with a Video Capture Board.
- 1 computer monitor.

Digital video:

- 1 Pentium III computer with the following components:
- Miro DC30 Video Capture Board.
- Adobe Premiere Video editing software.

3.2.5 Data processing system

- Excel software with calculus routines developed by the Laboratory of Sports Biomechanics of CARICD.

3.3 Procedures

3.3.1 Filming

Analogic video cameras, operating at 50 Hz, were placed perpendicular to the running direction for filming the athletes when passing through markers placed at the following distances:

- 100m event: every 10 metres.
- 200 and 400m events: every 50 metres.

Digital high-speed video cameras, operating at 100 Hz, filmed the athletes passing through the following distances:

- 100m event: From the start to 15m and from 50m to 65m.
- 200 and 400m events: From 100m to 115m for both events and from 150m to 165m for the 200m and from 350m to 365m for the 400m.

Figure 1 presents the location of the cameras for the 100m events; figures 2 and 3 present the location of cameras for the 200m and 400m events respectively.

Prior to the races, the markers at each distance were filmed and, later on, the athletes were filmed passing them.

3.3.2 Recording of the pictures

Each camera was connected to a recording system in which the pictures of the athletes passing the markers were video taped. Odd number cameras were connected to recording system number 1 and even number cameras were connected to recording system number 2. The signals of the cameras filming the athlete were recorded by the switcher mechanism for each system. At the same time that the signal was video taped, a time code was inserted on the magnetic tape that later would be displayed for the time analysis. The time codes of both recording systems were synchronised in order to identify the corresponding moments in each event.

Digital cameras were connected to their processors for downloading data to the notebook in digital format: tif or bmp.

3.3.3 Data analysis and results output:

The footage of both systems was processed the same way in the laboratory:

The video tape pictures of both the action and the markers were captured and stored in a computer using the Video Capture Board. Avi files were created with video editing software to be analysed, using the resources of the programme. Sequences were digitised in order to register the time codes at the instant that each athlete passed the previously filmed markers along the running track. The anatomical reference point to digitise was the hip. The markers were displayed in the monitor and superimposed on the sequence of the athlete running.

The data was entered in a calculus routine, developed in the Laboratory of Sports Biomechanics.

Time data was processed to obtain the following information:

1. Interval times for 10 or 50m sections depending on the race.
2. Times at the end of each section throughout the race.
3. Comparison of the time intervals between athletes in 10 or 50m sections.
4. Differences in the winner's time.
5. Relative time of each section.
6. Evolution of the speed curve throughout the race.
7. Maximum mean speed and sections in which it is achieved.
8. Time intervals from 30 to 50m (100m race).
9. Time intervals from 80 to 100m (100m race).
10. Time intervals every 100 metres (200m race).
11. Time intervals every 100 and 200 metres (400m race).
12. Reaction times from the official timing.

In the following the results are presented in the order:

1. 100 m final men (pp. 28-35)
2. 100 m final women (pp. 36-43)
3. 200 m final men (pp. 44-47)
4. 200 m final women (pp. 48-51)
5. 400 m final men (pp. 52-55)
6. 400 m final women (pp. 56-59)

4. Results

4.1 Results of the men's 100m final

Sprint coaches are accustomed to handling data on split times as shown in Table I. This table presents individual data for the different athletes which allows the results of the race to be interpreted and comparisons to be made between the athletes. The fastest time was clocked by the present world record holder Maurice Greene (USA) with 9.80s. Surin who came in second, clocked some split times which were lower than Greene's up to the 50m point from when Greene obtained an advantage of 0.04 s (Tables 1 and 2). Montgomery, who was third in Athens with a time of 9.94s, only achieved a time of 10.04s in Seville and came sixth. By observing the data presented in Table 1 and Figure 1, he can be seen to obtain a poorer time between 10 and 30 metres and although he recovered well at the end he was not able to win a medal.

These conclusions are reflected in Figure 1. Greene lost the world record at the start, and clocked the worst time of all the participants in the 10-20m stretch; but then he obtained a progressively better time than all his opponents. The bronze medallist, Chambers had a good start, but lost ground to the first two athletes and began to fall away from them beyond the 60 metres mark, after which his split times were worse. Table 2 shows the differences in each split time with regard to the winner, with negative values representing the best times and positive values those which are slower. Table 3 shows the accumulated times of each athlete as the race develops, showing the place each one held throughout the race. For example, Surin was first up to the 70 metre mark, at which point he was caught by Greene.

The accumulated times for the 30 to 50m stretches give an idea of how each athlete accelerated, and from 50 to 80m how they decelerated. Table 4 shows how the athletes who won the races were the ones who obtained the best times over these 20 metres. This could be interpreted as meaning that those athletes who manage to obtain a good time over this stretch, seem to be the ones most likely to win. Table 5 shows that the first two at the finish lost less time than the rest of the athletes, that is to say, they were capable of maintaining their speed up to the end, and Thompson, although he recorded a good time, was not able to overcome the disadvantages he suffered in the first 10 metres and in the 30 to 50m stretch.

Table 6 and Figure 2 show the speeds achieved. The highest average speed recorded was that clocked by Greene (11.90 m/s), which he achieved between the 50 and 60m marks. No athletes ran slower than 11.36 m/s in their best stretches, which means running the fastest 10m stretch in less than 0.88s. Average running speeds between 9.77 and 10.20 m/s were reached. The evolution of average speed in each section by each athlete is shown in Figure 2. Table 7 shows the maximum speed of each athlete and the stretch where it was achieved. Table 8 details the reaction times provided by the IAAF, where the best time was clocked by the silver medallist who later reached his average speed ten metres before the others (Table 7).

Table 1: Time intervals for each section (s)

100m FINAL MEN											
NAME	0-10m.	10-20m.	20-30m.	30-40m.	40-50m.	50-60m.	60-70m.	70-80m.	80-90m.	90-100m.	OFFICIAL TIME
GREENE, Maurice (USA)	1.73	1.03	0.92	0.88	0.86	0.84	0.85	0.85	0.85	0.86	**9.80**
SURIN, Bruny (CAN)	1.75	1.00	0.91	0.89	0.85	0.85	0.86	0.86	0.86	0.88	**9.84**
CHAMBERS, Dwain (USA)	1.73	1.02	0.92	0.90	0.86	0.85	0.87	0.89	0.89	0.90	**9.97**
THOMPSON, Obadele (BAR)	1.77	1.02	0.92	0.91	0.88	0.86	0.86	0.88	0.88	0.88	**10.00**
HARDEN, Tim (USA)	1.73	1.02	0.92	0.90	0.89	0.86	0.87	0.89	0.89	0.91	**10.02**
MONTGOMERY, Tim (USA)	1.76	1.04	0.93	0.89	0.89	0.86	0.87	0.88	0.89	0.89	**10.04**
GARDENER, Jason (GBR)	1.77	1.02	0.92	0.90	0.89	0.87	0.88	0.89	0.89	0.90	**10.07**
STREETE-THOMPSON, Kareem (CAY)	1.80	1.02	0.94	0.90	0.90	0.88	0.88	0.89	0.93	0.93	**10.24**

Table 2: Differences from the winner's time in each section (s)

100m FINAL MEN										
NAME	0-10m.	10-20m.	20-30m.	30-40m.	40-50m.	50-60m.	60-70m.	70-80m.	80-90m.	90-100m.
GREENE, Maurice (USA)	1.728	1.03	0.92	0.88	0.86	0.84	0.85	0.85	0.85	0.86
SURIN, Bruny (CAN)	0.025	-0.03	-0.01	0.01	-0.01	0.01	0.01	0.01	0.01	0.02
CHAMBERS, Dwain (USA)	0.002	-0.01	0.00	0.02	0.00	0.01	0.02	0.04	0.04	0.04
THOMPSON, Obadele (BAR)	0.037	-0.01	0.00	0.03	0.02	0.02	0.01	0.03	0.03	0.02
HARDEN, Tim (USA)	0.006	-0.01	0.00	0.02	0.03	0.02	0.02	0.04	0.04	0.05
MONTGOMERY, Tim (USA)	0.036	0.01	0.01	0.01	0.03	0.02	0.02	0.03	0.04	0.03
GARDENER, Jason (GBR)	0.040	-0.01	0.00	0.02	0.03	0.03	0.03	0.04	0.04	0.04
STREETE-THOMPSON, Kareem (CAY)	0.069	-0.01	0.02	0.02	0.04	0.04	0.03	0.04	0.08	0.07

Table 3: Times at the end of each section (s)

100m FINAL MEN										
NAME	10m.	20m.	30m.	40m.	50m.	60m.	70m.	80m.	90m.	100m.
GREENE, Maurice (USA)	1.73	2.76	3.68	4.56	5.42	6.26	7.11	7.96	8.81	9.67
SURIN, Bruny (CAN)	1.75	2.75	3.66	4.55	5.40	6.25	7.11	7.97	8.83	9.71
CHAMBERS, Dwain (USA)	1.73	2.75	3.67	4.57	5.43	6.28	7.15	8.04	8.93	9.83
THOMPSON, Obadele (BAR)	1.77	2.79	3.71	4.61	5.50	6.36	7.22	8.10	8.97	9.86
HARDEN, Tim (USA)	1.73	2.75	3.67	4.57	5.46	6.32	7.19	8.08	8.97	9.88
MONTGOMERY, Tim (USA)	1.76	2.80	3.73	4.62	5.51	6.37	7.24	8.12	9.01	9.90
GARDENER, Jason (GBR)	1.77	2.79	3.71	4.61	5.50	6.37	7.25	8.14	9.03	9.93
STREETE-THOMPSON, Kareem (CAY)	1.80	2.82	3.76	4.66	5.56	6.44	7.32	8.21	9.14	10.07

Table 4: Section times from 30m to 50m (s)

TIMES From 30 metres to 50 metres 100 metres MEN			
NAME	LANE	PLACE	30-50
GREENE, Maurice (USA)	5	1	1.74
SURIN, Bruny (CAN)	6	2	1.74
CHAMBERS, Dwain (USA)	4	3	1.76
THOMPSON, Obadele (BAR)	1	4	1.79
HARDEN, Tim (USA)	3	5	1.79
MONTGOMERY, Tim (USA)	8	6	1.78
GARDENER, Jason (GBR)	7	7	1.79
STREETE-THOMPSON, Kareem (CAY)	2	8	1.80

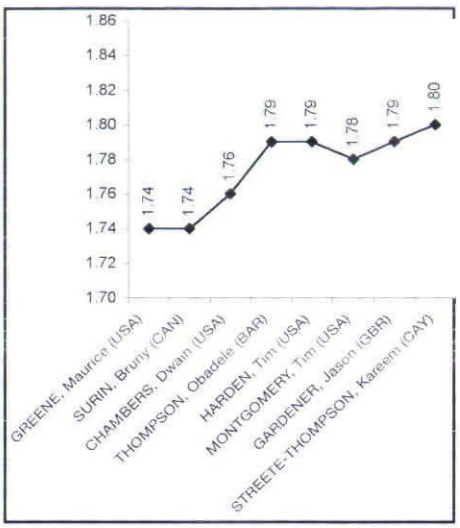


Table 5: Section times from 80m to 100m (s)

TIMES From 80 metres to 100 metres 100 metres MEN			
NAME	LANE	PLACE	80-100
GREENE, Maurice (USA)	5	1	1.71
SURIN, Bruny (CAN)	6	2	1.74
CHAMBERS, Dwain (USA)	4	3	1.79
THOMPSON, Obadele (BAR)	1	4	1.76
HARDEN, Tim (USA)	3	5	1.80
MONTGOMERY, Tim (USA)	8	6	1.78
GARDENER, Jason (GBR)	7	7	1.79
STREETE-THOMPSON, Kareem (CAY)	2	8	1.86

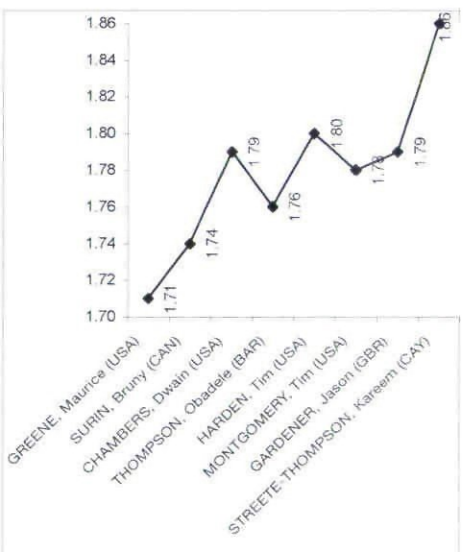


Figure 1: Individual time intervals (s)

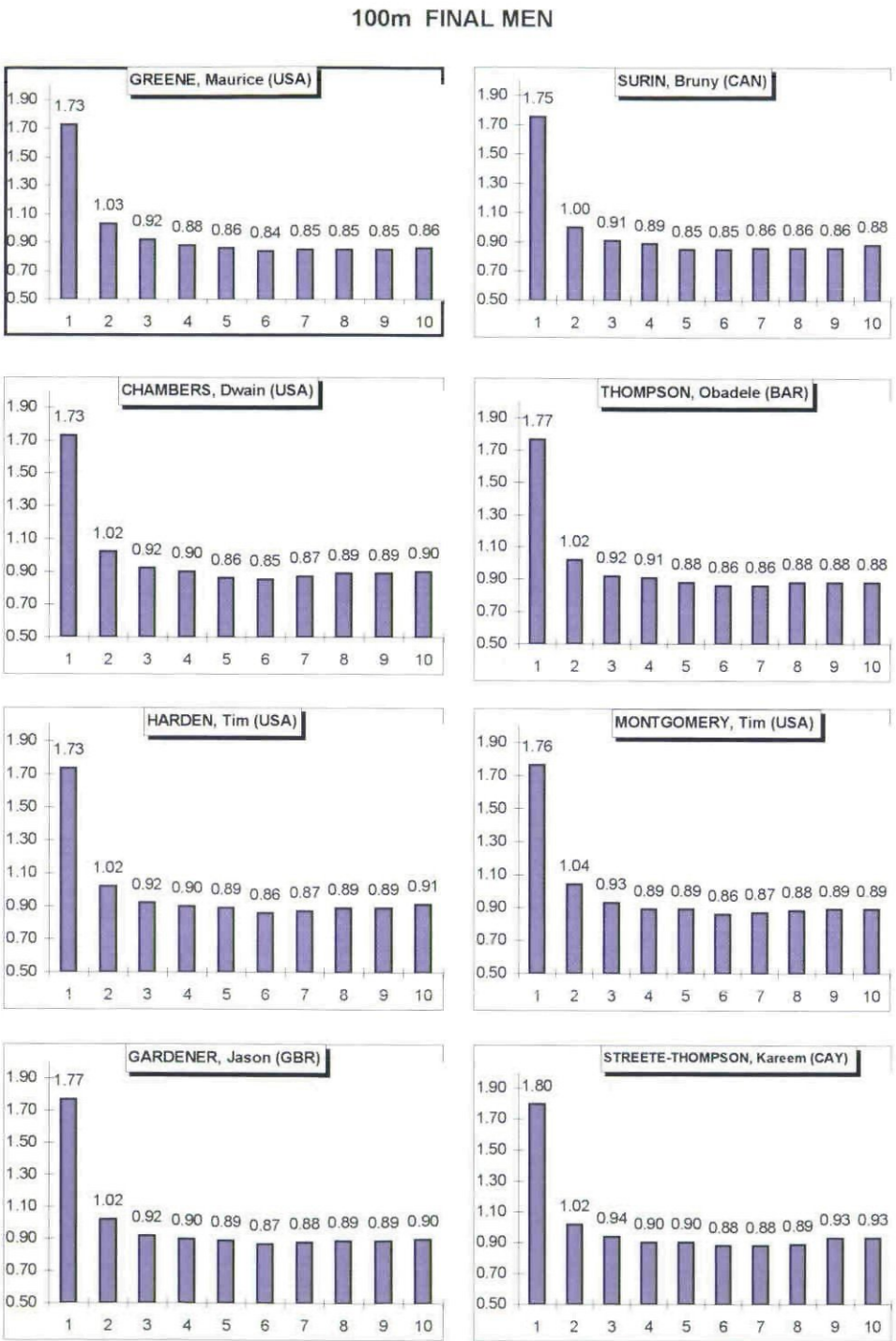


Table 6: Average section velocity (m/s)

100m FINAL MEN

NAME	0-10m.	10-20m.	20-30m.	30-40m.	40-50m.	50-60m.	60-70m.	70-80m.	80-90m.	90-100m.	Mean V.
GREENE, Maurice (USA)	5.79	9.71	10.87	11.36	11.63	11.90	11.76	11.76	11.76	11.63	**10.20**
SURIN, Bruny (CAN)	5.70	10.00	10.99	11.24	11.76	11.76	11.63	11.63	11.63	11.36	**10.16**
CHAMBERS, Dwain (USA)	5.78	9.80	10.87	11.11	11.63	11.76	11.49	11.24	11.24	11.11	**10.03**
THOMPSON, Obadele (BAR)	5.67	9.80	10.87	10.99	11.36	11.63	11.63	11.36	11.36	11.36	**10.00**
HARDEN, Tim (USA)	5.77	9.80	10.87	11.11	11.24	11.63	11.49	11.24	11.24	10.99	**9.98**
MONTGOMERY, Tim (USA)	5.67	9.62	10.75	11.24	11.24	11.63	11.49	11.36	11.24	11.24	**9.96**
GARDENER, Jason (GBR)	5.66	9.80	10.87	11.11	11.24	11.49	11.36	11.24	11.24	11.11	**9.93**
THOMPSON, Kareem (CAY)	5.56	9.80	10.64	11.11	11.11	11.36	11.36	11.24	10.75	10.75	**9.77**

WIND SPEED	-0.1 m/s
TEMPERATURE	30°
HUMIDITY	34%

Table 7: Maximum velocity section (m/s and m)

100 metres FINAL MEN

NAME	Max s.	Section
GREENE, Maurice (USA)	11.90	50-60
SURIN, Bruny (CAN)	11.76	40-50 50-60
CHAMBERS, Dwain (USA)	11.76	50-60
THOMPSON, Obadele (BAR)	11.63	50-60 60-70
HARDEN, Tim (USA)	11.63	50-60
MONTGOMERY, Tim (USA)	11.63	50-60
GARDENER, Jason (GBR)	11.49	50-60
STREETE-THOMPSON, Kareem (CAY)	11.36	50-60 60-70

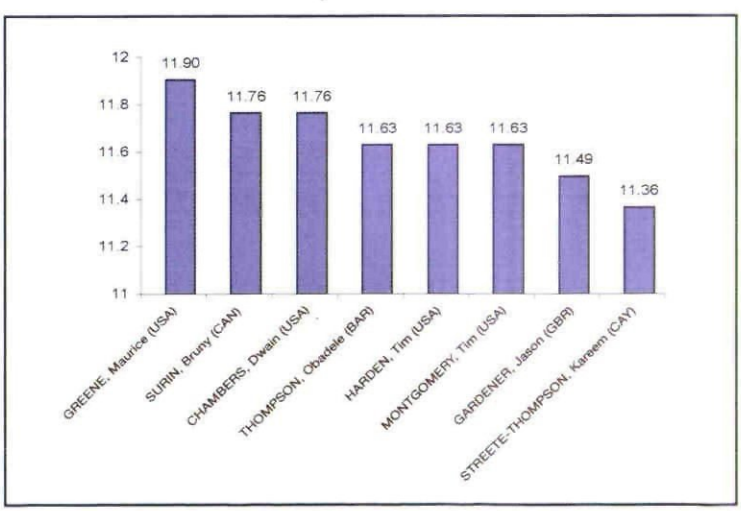


Figure 2: Individual velocity sections (m/s)

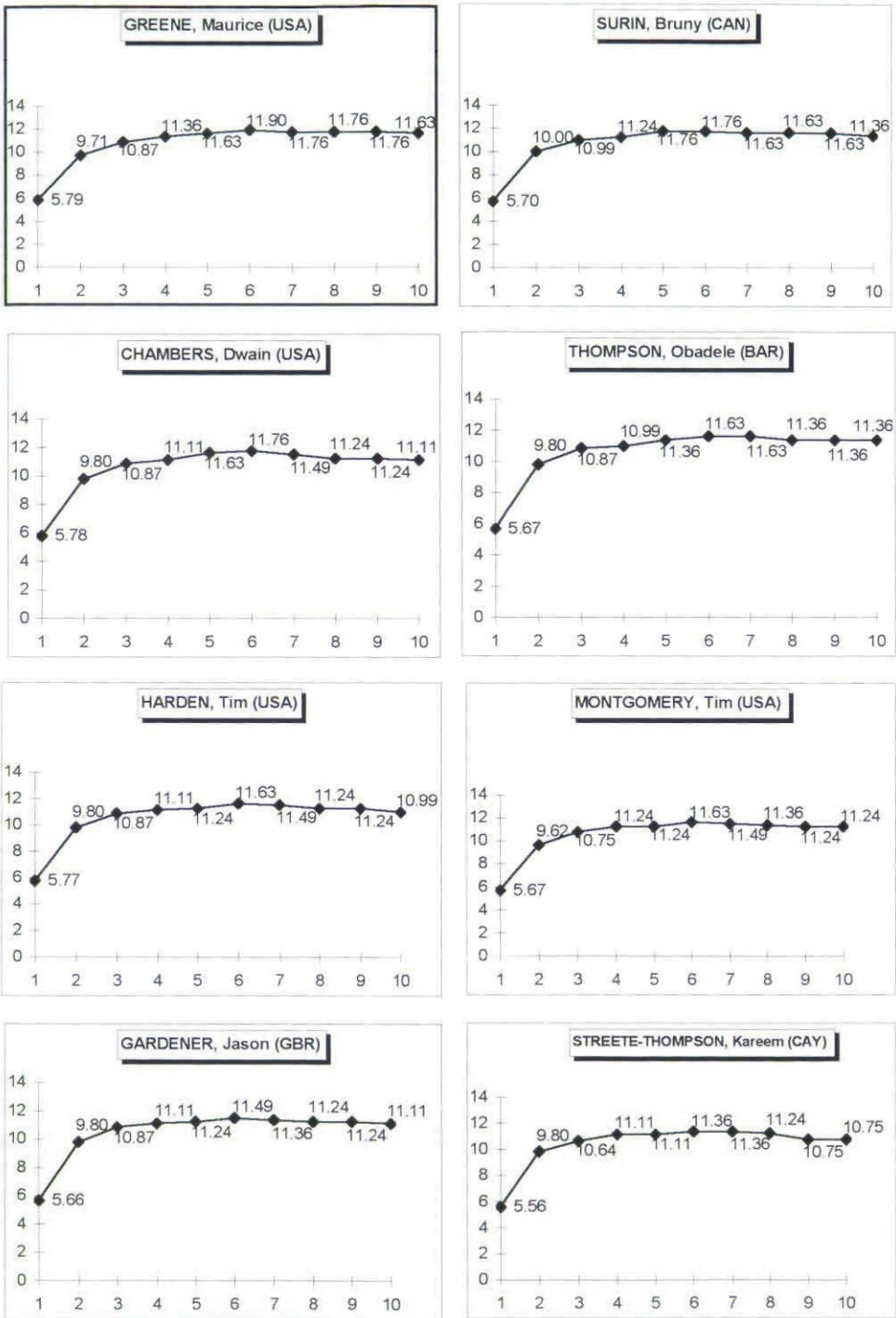


Table 8: Official reaction times (s)

100m FINAL MEN	
NAME	R.T.
GREENE, Maurice (USA)	0.132
SURIN, Bruny (CAN)	0.127
CHAMBERS, Dwain (USA)	0.140
THOMPSON, Obadele (BAR)	0.145
HARDEN, Tim (USA)	0.136
MONTGOMERY, Tim (USA)	0.136
GARDENER, Jason (GBR)	0.142
THOMPSON, Kareem (CAY)	0.173

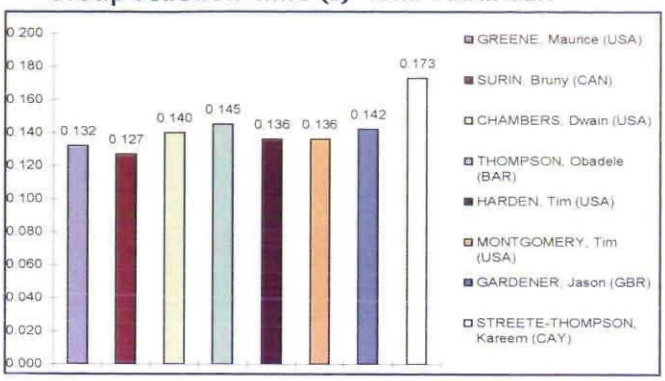
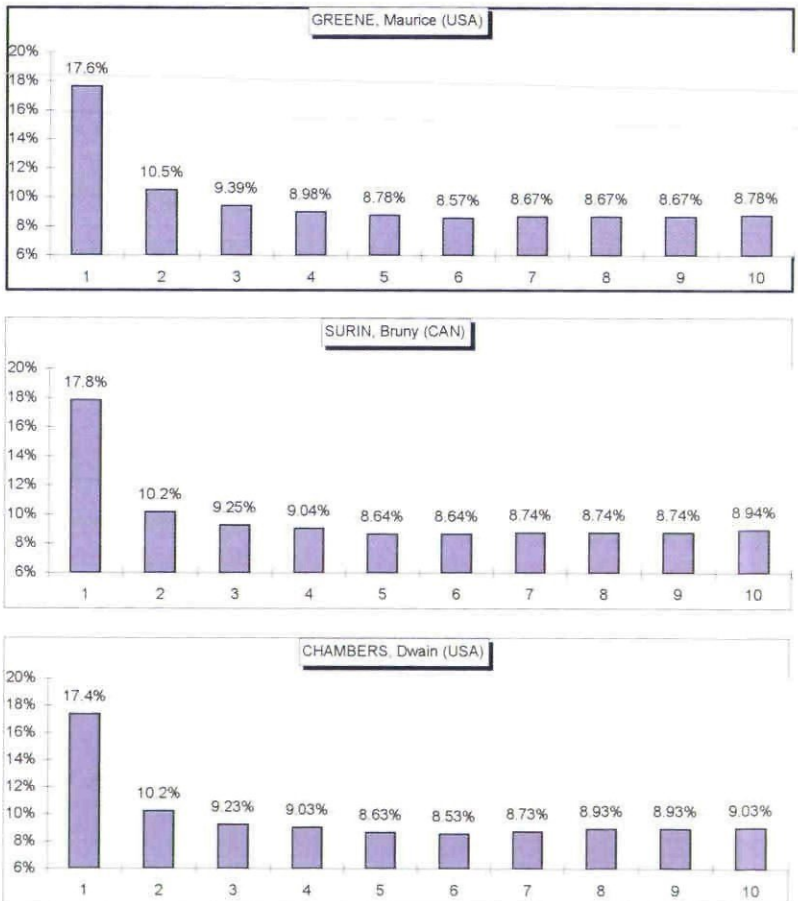
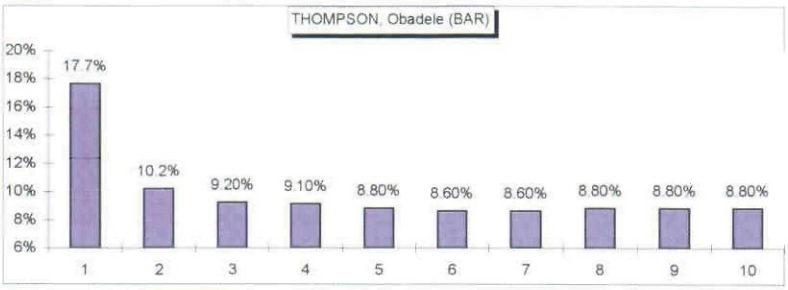


Figure 3: Individual percentages of each section from total (%)

100m FINAL MEN




THOMPSON, Obadele (BAR)
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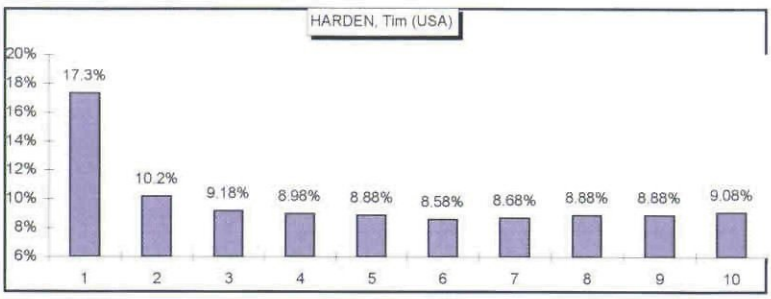
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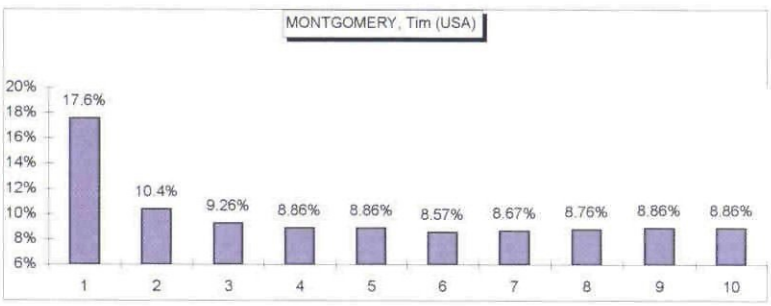
MONTGOMERY, Tim (USA)
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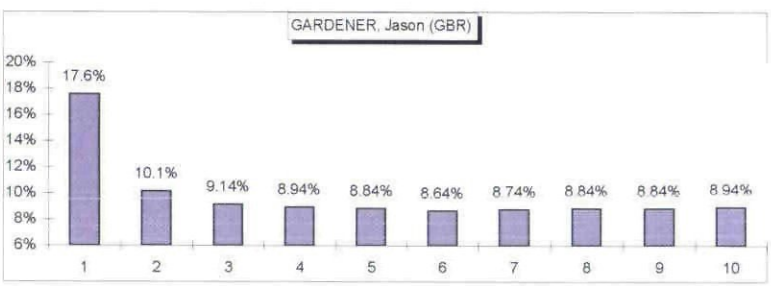
GARDENER, Jason (GBR)
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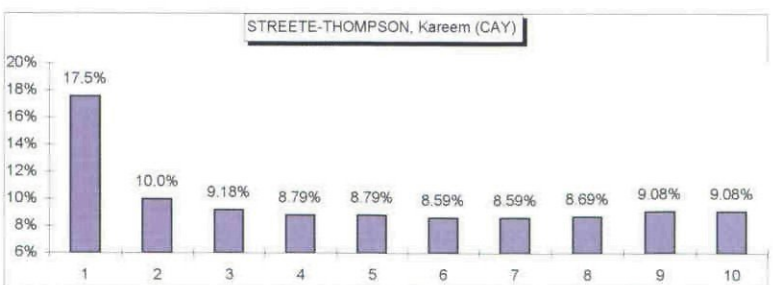
STREETE-THOMPSON, Kareem (CAY)
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17.5%
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9.18%
8.79%
8.79%
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8.59%
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9.08%
9.08%
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4.2 Results of the women's 100m final

The same results were analysed in the women's races. The partial times with reference to every 10 metres are shown in Table 9 and Figure 4. The winner of the women's race stands out with an average maximum speed of 10.87 m/s in the fastest stretch (50 - 60m) (Table 14 and 15 and Figure 5) and at the end she recorded a time which was 0.09s faster than the silver medallist (Tables 9 and 10). The bronze medallist recorded her best 10m split time ten metres before her opponents (Figure 15) This athlete achieved two split times which were better than those of Marion Jones, in the 40 - 50m stretch and the 70 - 80m stretch, and one split time (70 - 80m) superior to that achieved by Inge Miller, the silver medallist (Table 10).

Just as in the men's race the first three women past the finishing line recorded the best times between 30 and 50m, which could be taken to suggest that at this point the race was already decided (Table 12); after this they remained in the same running order (Table 13). In both races the time differences between the first three and the rest were quite considerable.

Table 9 shows that Thanou lost the silver medal in the first 10 metres, and until the 30 to 40m mark was in last position in spite of recording better split times than her rivals (Table 11). Lastly, it is worthy of mention that she had the best reaction time of the championships, including the men (according to official data) with a recording of 0.116s (Table 16).

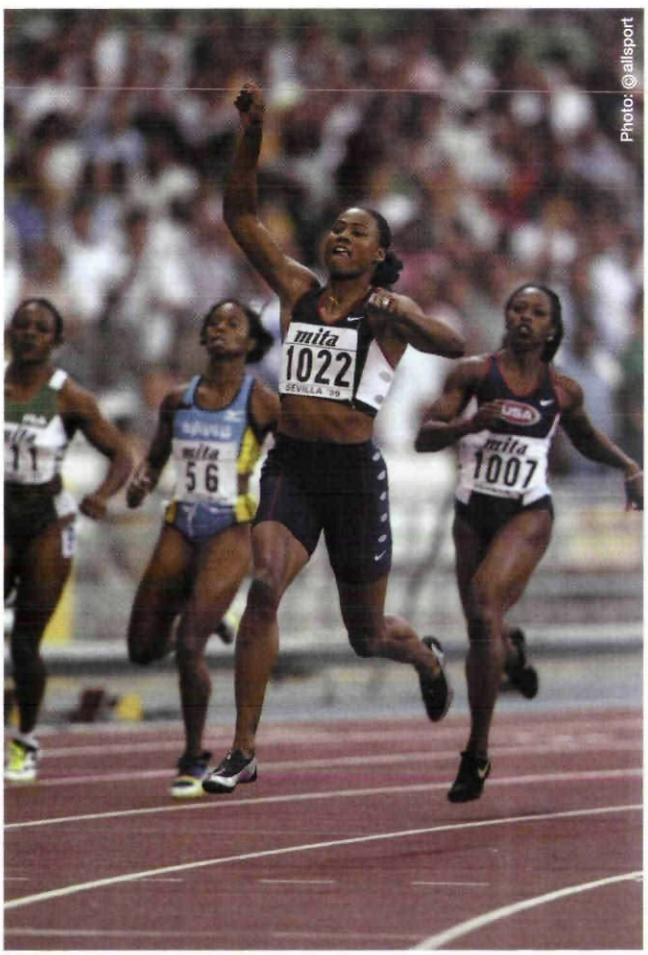


Photo: @allsport

Table 9: Time intervals for each section (s)

100m FINAL WOMEN											
NAME	0-10m.	10-20m.	20-30m.	30-40m.	40-50m.	50-60m.	60-70m.	70-80m.	80-90m.	90-100m.	OFFICIAL TIME
JONES, Marion (USA)	1.83	1.10	0.99	0.95	0.94	0.92	0.94	0.96	0.97	0.98	**10.70**
MILLER, Inger (USA)	1.83	1.11	1.03	0.96	0.94	0.94	0.95	0.96	0.97	0.97	**10.79**
THANOU, Ekaterini (GRE)	1.89	1.11	1.01	0.95	0.93	0.95	0.95	0.95	0.98	1.00	**10.84**
TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)	1.83	1.11	1.01	0.98	0.96	0.96	0.96	0.97	0.99	1.04	**10.95**
DEVERS, Gail (USA)	1.84	1.10	1.00	0.98	0.95	0.97	0.97	0.98	1.00	1.03	**10.95**
ARRON, Christine (FRA)	1.84	1.12	0.99	0.98	0.96	0.95	0.96	0.98	1.01	1.02	**10.97**
STURRUP, Chandra (BAH)	1.86	1.13	1.01	1.00	0.98	0.96	0.98	0.99	1.00	1.02	**11.06**
NKU, Mercy (NGR)	1.85	1.11	1.03	1.00	0.97	0.97	1.00	1.01	1.02	1.05	**11.16**

Table 10: Differences from the winner's time in each section (s)

100m FINAL WOMEN										
NAME	0-10m.	10-20m.	20-30m.	30-40m.	40-50m.	50-60m.	60-70m.	70-80m.	80-90m.	90-100m.
JONES, Marion (USA)	1.83	1.10	0.99	0.95	0.94	0.92	0.94	0.96	0.97	0.98
MILLER, Inger (USA)	0.00	0.01	0.04	0.01	0.00	0.02	0.01	0.00	0.00	-0.01
THANOU, Ekaterini (GRE)	0.06	0.01	0.02	0.00	-0.01	0.03	0.01	-0.01	0.01	0.02
TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)	0.00	0.01	0.02	0.03	0.02	0.04	0.02	0.01	0.02	0.06
DEVERS, Gail (USA)	0.01	0.00	0.01	0.03	0.01	0.05	0.03	0.02	0.03	0.05
ARRON, Christine (FRA)	0.01	0.02	0.00	0.03	0.02	0.03	0.02	0.02	0.04	0.04
STURRUP, Chandra (BAH)	0.03	0.03	0.02	0.05	0.04	0.04	0.04	0.03	0.03	0.04
NKU, Mercy (NGR)	0.02	0.01	0.04	0.05	0.03	0.05	0.06	0.05	0.05	0.07

Table 11: Times at the end of each section (s)

100m FINAL WOMEN										
NAME	10m.	20m.	30m.	40m.	50m.	60m.	70m.	80m.	90m.	100m.
JONES, Marion (USA)	1.83	2.93	3.92	4.87	5.81	6.73	7.67	8.63	9.60	10.58
MILLER, Inger (USA)	1.83	2.94	3.97	4.93	5.87	6.81	7.76	8.72	9.69	10.66
THANOU, Ekaterini (GRE)	1.89	3.00	4.01	4.96	5.89	6.84	7.79	8.74	9.72	10.72
TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)	1.83	2.94	3.96	4.94	5.90	6.86	7.82	8.79	9.78	10.82
DEVERS, Gail (USA)	1.84	2.94	3.94	4.93	5.87	6.84	7.82	8.79	9.79	10.83
ARRON, Christine (FRA)	1.84	2.96	3.95	4.93	5.89	6.84	7.80	8.78	9.79	10.81
STURRUP, Chandra (BAH)	1.86	2.99	4.00	5.00	5.98	6.94	7.92	8.91	9.91	10.93
NKU, Mercy (NGR)	1.85	2.96	3.99	4.99	5.96	6.93	7.93	8.94	9.96	11.01

Table 12: Section times from 30m to 50m (s)

TIMES From 30 metres to 50 metres			
100 metres WOMEN			
NAME	LANE	PLACE	30-50
JONES, Marion (USA)	5	1	1.89
MILLER, Inger (USA)	3	2	1.90
THANOU, Ekaterini (GRE)	4	3	1.88
TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)	1	4	1.94
DEVERS, Gail (USA)	6	5	1.93
ARRON, Christine (FRA)	2	6	1.94
STURRUP, Chandra (BAH)	7	7	1.98
NKU, Mercy (NGR)	8	8	1.97

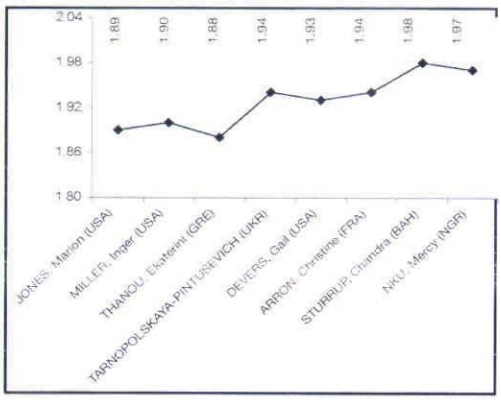


Table 13: Section times from 80m to 100m (s)

TIMES From 80 metres to 100 metres			
100 metres WOMEN			
NAME	LANE	PLACE	80-100
JONES, Marion (USA)	5	1	1.95
MILLER, Inger (USA)	3	2	1.94
THANOU, Ekaterini (GRE)	4	3	1.98
TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)	1	4	2.03
DEVERS, Gail (USA)	6	5	2.03
ARRON, Christine (FRA)	2	6	2.03
STURRUP, Chandra (BAH)	7	7	2.02
NKU, Mercy (NGR)	8	8	2.07

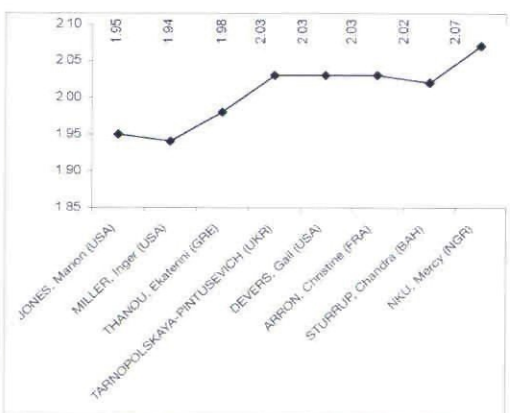


Figure 4: Individual time intervals (s)

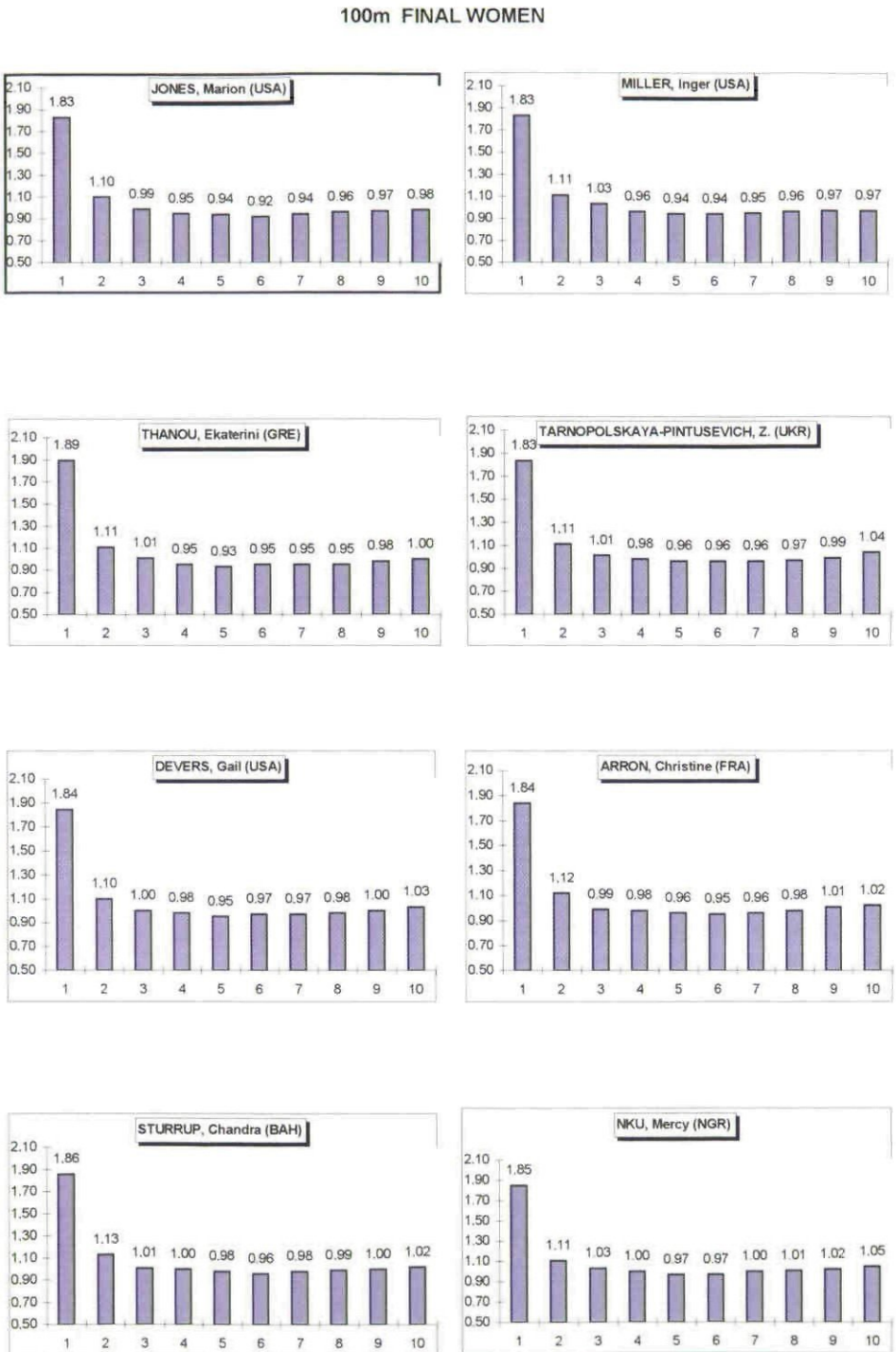


Table 14: Average section velocity (m/s)

100m FINAL WOMEN

NAME	0-10m.	10-20m.	20-30m.	30-40m.	40-50m.	50-60m.	60-70m.	70-80m.	80-90m.	90-100m.	Mean V.
JONES, Marion (USA)	5.46	9.09	10.10	10.53	10.64	10.87	10.64	10.42	10.31	10.20	9.35
MILLER, Inger (USA)	5.46	9.01	9.71	10.42	10.64	10.64	10.53	10.42	10.31	10.31	9.27
THANOU, Ekaterini (GRE)	5.28	9.01	9.90	10.53	10.75	10.53	10.53	10.53	10.20	10.00	9.23
TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)	5.45	9.01	9.90	10.20	10.42	10.42	10.42	10.31	10.10	9.62	9.13
DEVERS, Gail (USA)	5.42	9.09	10.00	10.20	10.53	10.31	10.31	10.20	10.00	9.71	9.13
ARRON, Christine (FRA)	5.44	8.93	10.10	10.20	10.42	10.53	10.42	10.20	9.90	9.80	9.12
STURRUP, Chandra (BAH)	5.39	8.85	9.90	10.00	10.20	10.42	10.20	10.10	10.00	9.80	9.04
NKU, Mercy (NGR)	5.41	9.01	9.71	10.00	10.31	10.31	10.00	9.90	9.80	9.52	8.96

WIND SPEED	0.1 m/s
HUMIDITY	30%
TEMPERATURE	30°

Table 15: Maximum velocity section (m/s and m)

100 metres FINAL WOMEN

NAME	Max s.	Section
JONES, Marion (USA)	10.87	50-60
MILLER, Inger (USA)	10.64	40-50 50-60
THANOU, Ekaterini (GRE)	10.75	40-50
TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)	10.42	40-50 50-60 60-70
DEVERS, Gail (USA)	10.53	40-50
ARRON, Christine (FRA)	10.53	50-60
STURRUP, Chandra (BAH)	10.42	50-60
NKU, Mercy (NGR)	10.31	40-50 50-60

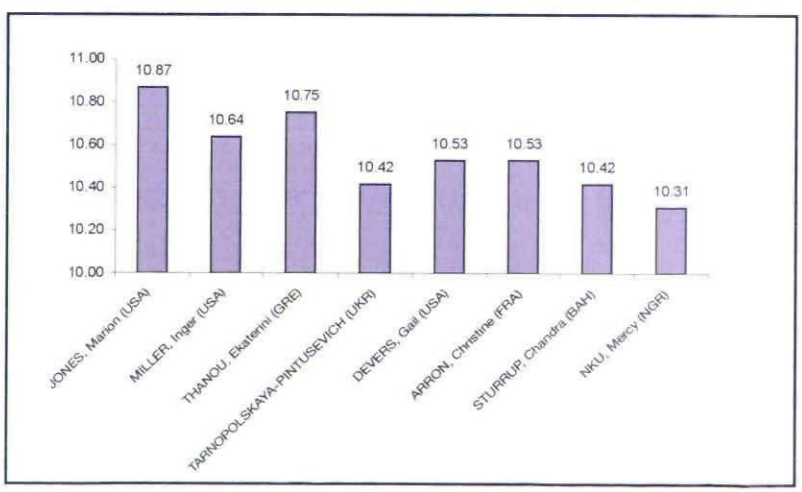
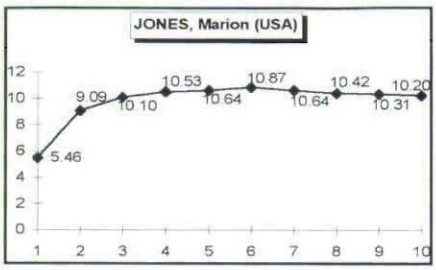
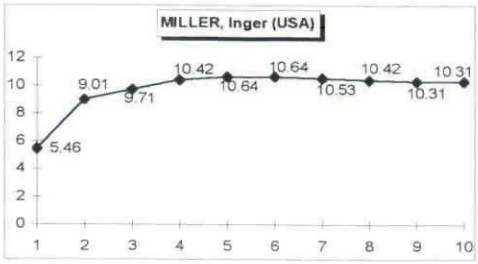
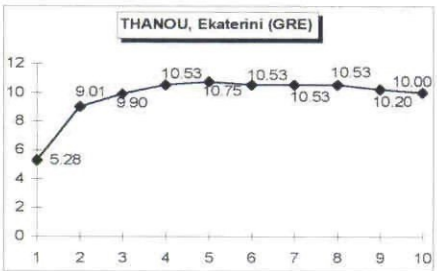


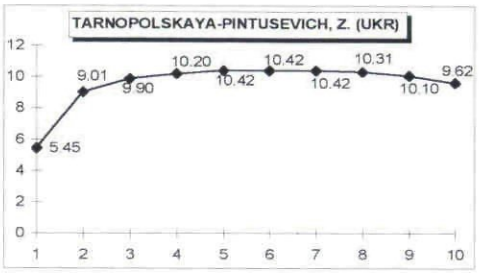
Figure 5: Individual velocity sections (m/s)

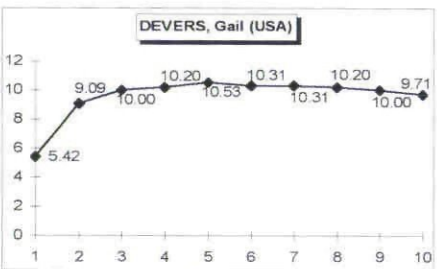
100 metres FINAL WOMEN











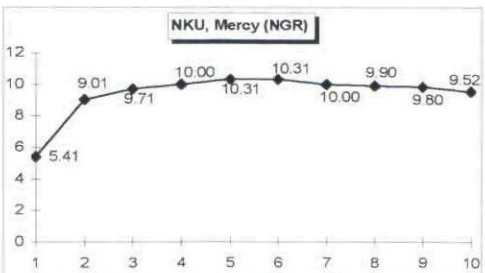


Table 16: Official reaction times (s)

100m FINAL WOMEN	
NAME	R.T.
JONES, Marion (USA)	0.120
MILLER, Inger (USA)	0.129
THANOU, Ekaterini (GRE)	0.116
TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)	0.135
DEVERS, Gail (USA)	0.125
ARRON, Christine (FRA)	0.162
STURRUP, Chandra (BAH)	0.134
NKU, Mercy (NGR)	0.152

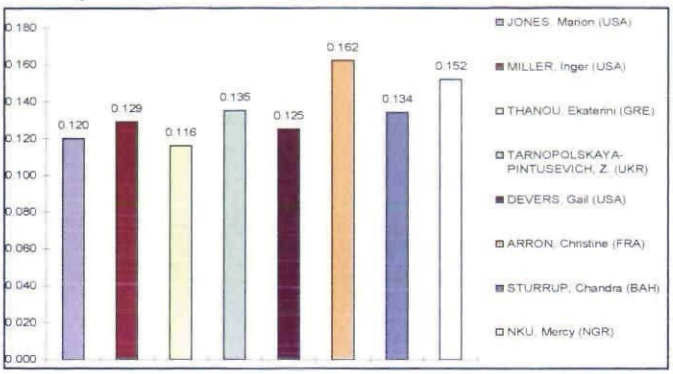
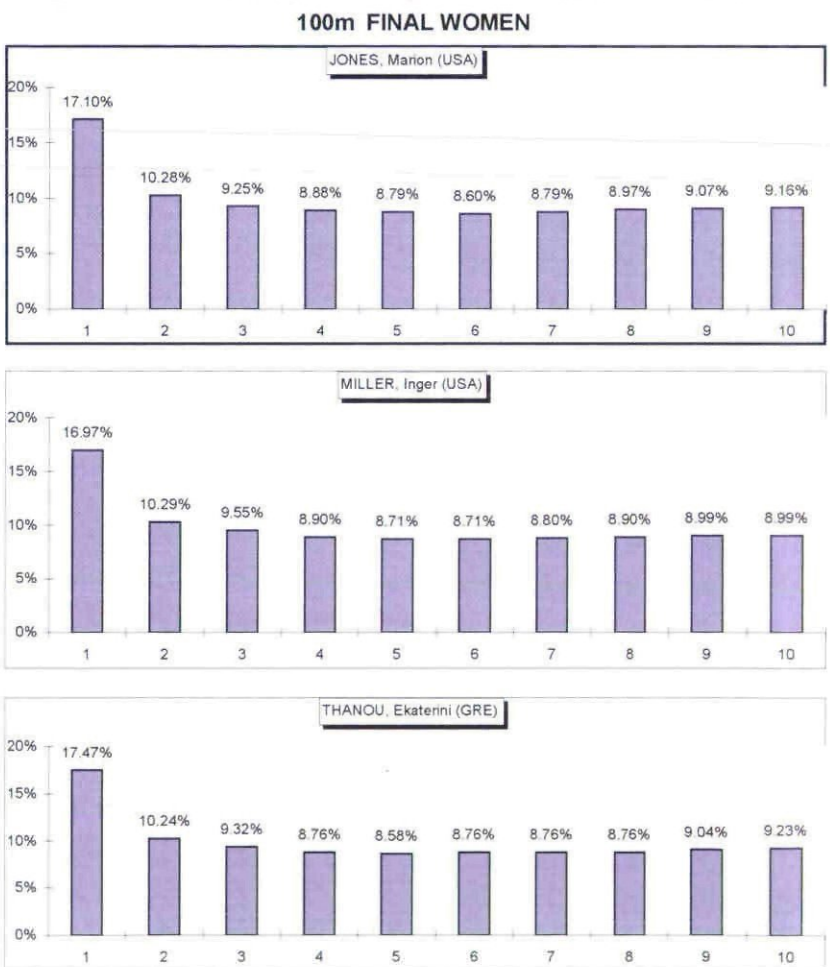


Figure 6: Individual percentages of each section from total (%)




TARNOPOLSKAYA-PINTUSEVICH, Z. (UKR)
20%
15%
10%
5%
0%
16.76%
10.14%
9.22%
8.95%
8.77%
8.77%
8.77%
8.86%
9.04%
9.50%
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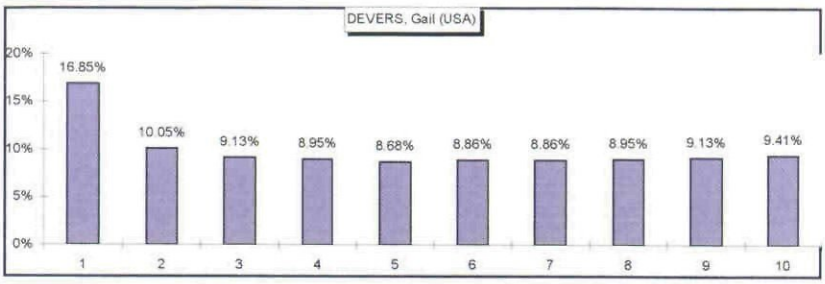
DEVERS, Gail (USA)
20%
15%
10%
5%
0%
16.85%
10.05%
9.13%
8.95%
8.68%
8.86%
8.86%
8.95%
9.13%
9.41%
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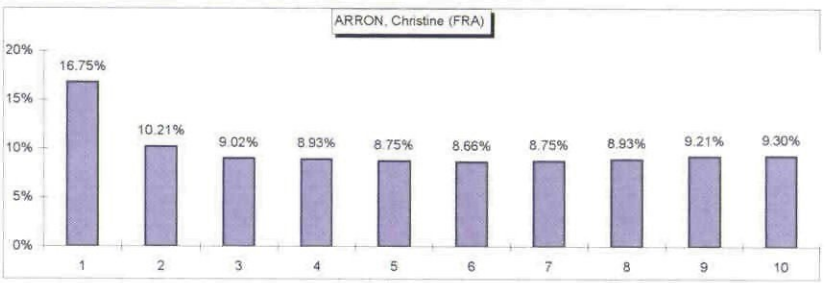
ARRON, Christine (FRA)
20%
15%
10%
5%
0%
16.75%
10.21%
9.02%
8.93%
8.75%
8.66%
8.75%
8.93%
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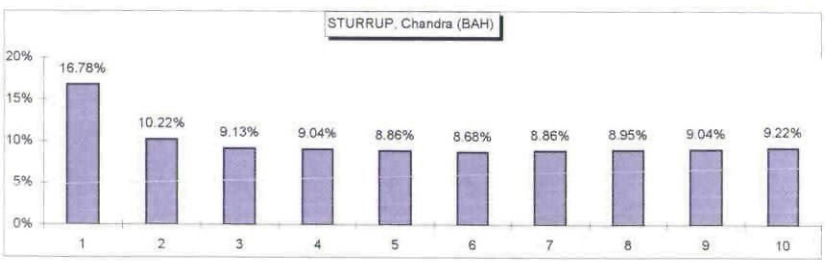
STURRUP, Chandra (BAH)
20%
15%
10%
5%
0%
16.78%
10.22%
9.13%
9.04%
8.86%
8.68%
8.86%
8.95%
9.04%
9.22%
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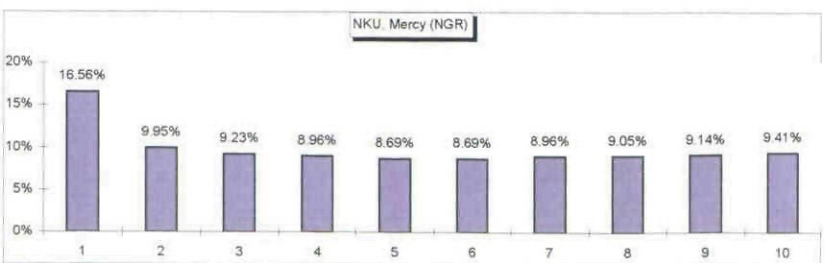
NKU, Mercy (NGR)
20%
15%
10%
5%
0%
16.56%
9.95%
9.23%
8.96%
8.69%
8.69%
8.96%
9.05%
9.14%
9.41%
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4.3 Results of the men's 200m final

The time intervals in the 50m stretches can be seen in Table 17. The second and third athletes to finish had better times at the 50 to 100m stretch than the winner, but the latter, from that point until the end of the race, retained first place and achieved a better average speed between the 150 and 200m mark, clocking splits of 0.05, 0.13 and 0.20s less than his opponents. Only Da Silva, Obikwelu and Thompson had better split times than Greene, which were achieved in every case in the 50 to 100m sector of the race (Table 20). Da Silva achieved the fastest average speed per stretch with 11.26 m/s, compared with 11.09 m/s achieved by Greene. The average speeds in the men's 200m are between 9.77 m/s for the slowest athlete and 10.05 m/s which was achieved by Maurice Greene, the fastest athlete. (Table 21 and Figure 7). When the athletes reached the 150 metre mark the race was practically decided, except for the 5th and 6th places which were decided in the last 50 metres (Table 18). Table 19 shows the split times for each 100 metres stretch. Maurice Greene's reaction time in the 100m was better than in the 200m with a difference of 0.012s according to official data (Table 22).

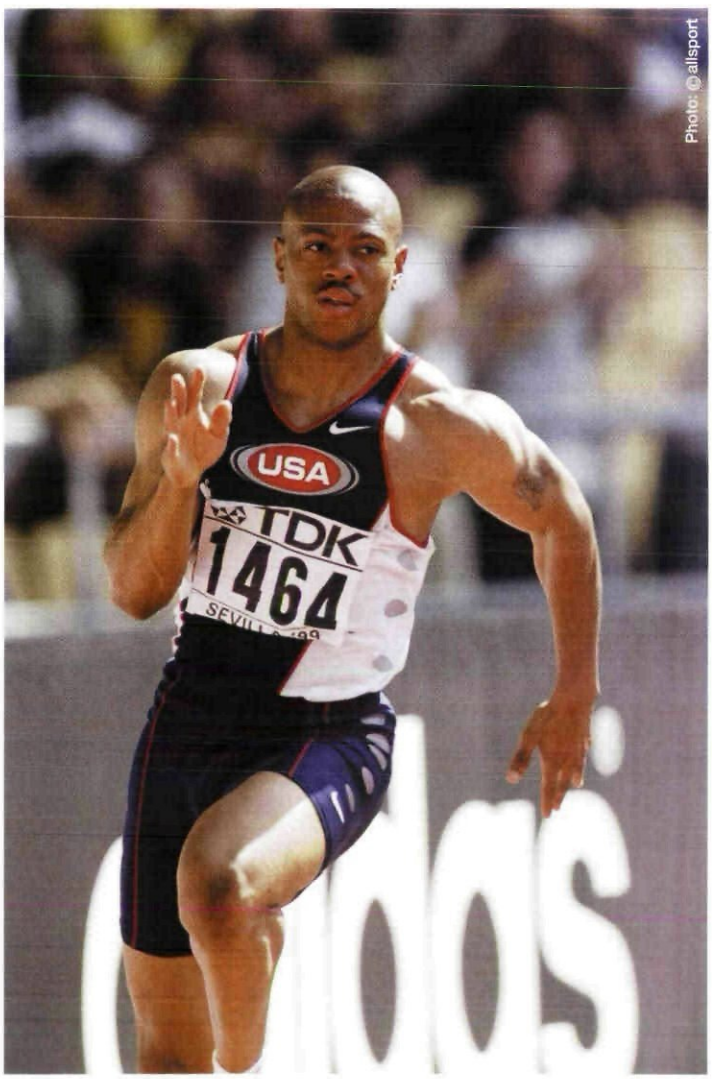


Table 17: Time intervals for each 50 m-section (s)

200m FINAL MEN					
NAME	0-50m	50-100m	100-150m	150-200m	OFFICIAL TIME
GREENE, Maurice (USA)	5.74	4.51	4.69	4.96	19.90
DA SILVA, Claudinei Quirino (BRA)	5.88	4.44	4.67	5.01	20.00
OBIKWELU, Francis (NGR)	5.83	4.45	4.74	5.09	20.11
THOMPSON, Obadele (BAR)	5.82	4.49	4.76	5.16	20.23
URBAS, Marcin (POL)	5.89	4.55	4.78	5.08	20.30
LITTLE, Kevin (USA)	5.84	4.51	4.82	5.20	20.37
GOLDING, Julian (GBR)	6.07	4.69	4.75	4.97	20.48
FREDERICKS, Frank (NAM)	0.00	0.00	0.00	0.00	DNS

Table 18: Time at the end of each 50 m-section (s)

200m FINAL MEN				
NAME	50m	100m	150m	200m
GREENE, Maurice (USA)	5.74	10.25	14.94	19.90
DA SILVA, Claudinei Quirino (BRA)	5.88	10.32	14.99	20.00
OBIKWELU, Francis (NGR)	5.83	10.28	15.02	20.11
THOMPSON, Obadele (BAR)	5.82	10.31	15.07	20.23
URBAS, Marcin (POL)	5.89	10.44	15.22	20.30
LITTLE, Kevin (USA)	5.84	10.35	15.17	20.37
GOLDING, Julian (GBR)	6.07	10.76	15.51	20.48
FREDERICKS, Frank (NAM)	0.00	0.00	0.00	0.00

Table 19: Time intervals for each 100 m-section (s)

200m FINAL MEN		
NAME	0-100m	100-200m
GREENE, Maurice (USA)	10.25	9.65
DA SILVA, Claudinei Quirino (BRA)	10.32	9.68
OBIKWELU, Francis (NGR)	10.28	9.83
THOMPSON, Obadele (BAR)	10.31	9.92
URBAS, Marcin (POL)	10.44	9.86
LITTLE, Kevin (USA)	10.35	10.02
GOLDING, Julian (GBR)	10.76	9.72
FREDERICKS, Frank (NAM)	0.00	0.00

Table 20: Differences from the winner's time in each 50 m-section (s)

200m FINAL MEN				
NAME	0-50m	50-100m	100-150m	150-200m
GREENE, Maurice (USA)	5.74	4.51	4.69	4.96
DA SILVA, Claudinei Quirino (BRA)	0.14	-0.07	-0.02	0.05
OBIKWELU, Francis (NGR)	0.09	-0.06	0.05	0.13
THOMPSON, Obadele (BAR)	0.08	-0.02	0.07	0.20
URBAS, Marcin (POL)	0.15	0.04	0.09	0.12
LITTLE, Kevin (USA)	0.10	0.00	0.13	0.24
GOLDING, Julian (GBR)	0.33	0.18	0.06	0.01
FREDERICKS, Frank (NAM)				

Table 21: Average velocity in the 50-section (s)

200m FINAL MEN					
NAME	0-50m	50-100m	100-150m	150-200m	Mean V.
GREENE, Maurice (USA)	8.71	11.09	10.66	10.08	10.05
DA SILVA, Claudinei Quirino (BRA)	8.50	11.26	10.71	9.98	10.00
OBIKWELU, Francis (NGR)	8.58	11.24	10.55	9.82	9.95
THOMPSON, Obadele (BAR)	8.59	11.14	10.50	9.69	9.89
URBAS, Marcin (POL)	8.49	10.99	10.46	9.84	9.85
LITTLE, Kevin (USA)	8.56	11.09	10.37	9.62	9.82
GOLDING, Julian (GBR)	8.24	10.66	10.53	10.06	9.77
FREDERICKS, Frank (NAM)					

TEMPERATURE	31°
HUMIDITY	0.38
WIND	1.2m/s

Figure 7: Average velocity in the 50-sections (m/s)

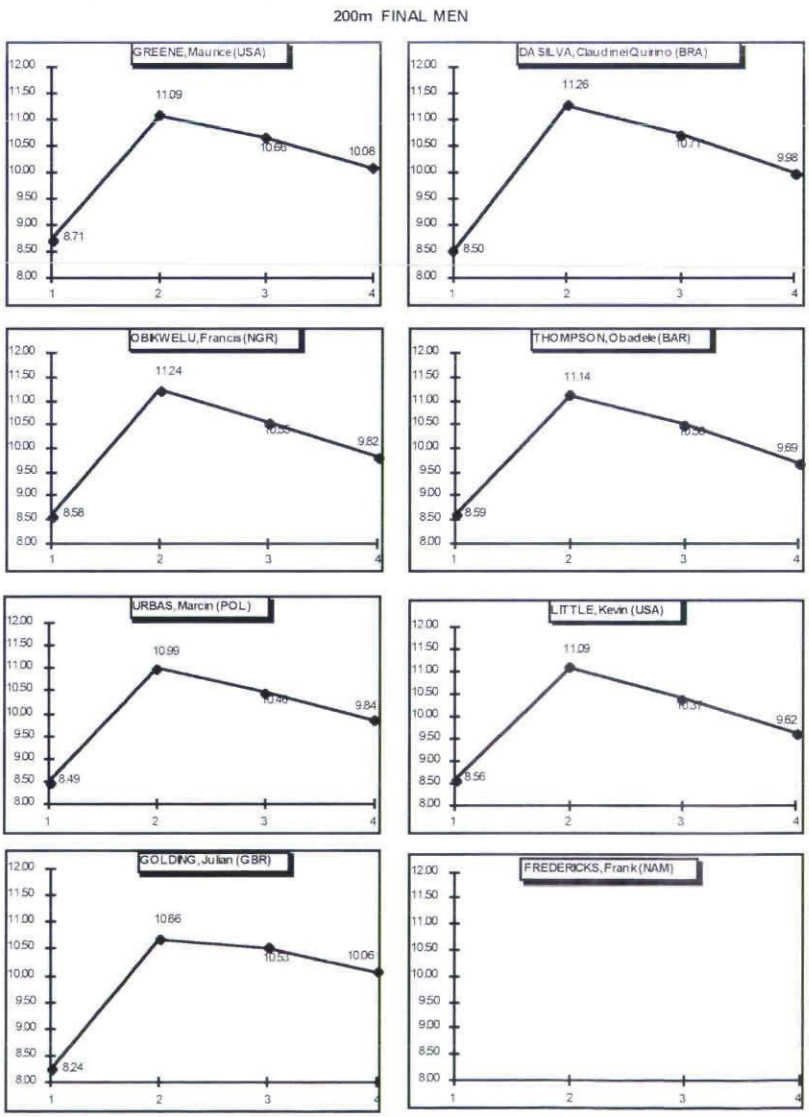


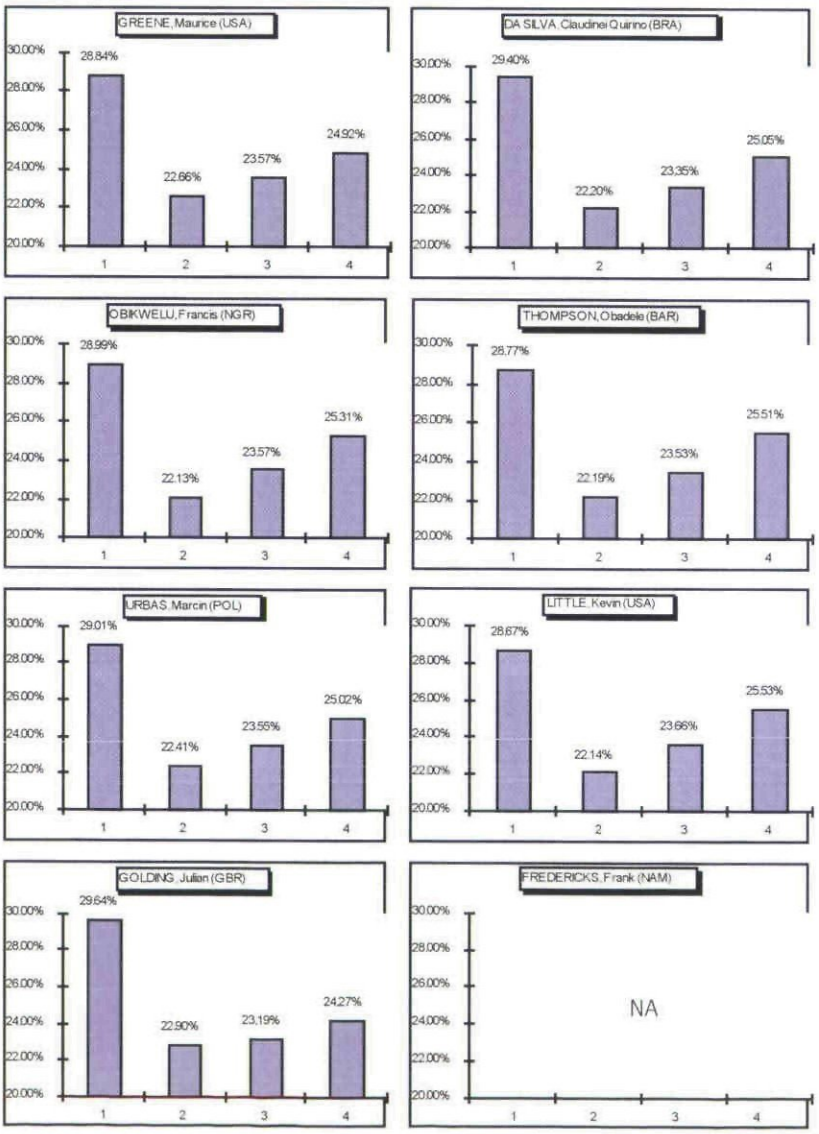
Table 22: Official reaction times (s)

200m FINAL MEN

NAME	R.T.	NAME	R.T.
GREENE, Maurice (USA)	0.144	THOMPSON, Obadele (BAR)	0.134
DA SILVA, Claudinei Quirino (BRA)	0.138	URBAS, Marcin (POL)	0.131
OBIKWELU, Francis (NGR)	0.174	LITTLE, Kevin (USA)	0.159
THOMPSON, Obadele (BAR)	0.134	GOLDING, Julian (GBR)	0.131
		FREDERICKS, Frank (NAM)	NA

Figure 8: Individual percentages of each 50 m-section from total (%)

200m FINAL MEN



4.4 Results of the women's 200m final

Miller clocked a 0.45s advantage over the silver medallist (Table 23). Her split times over the whole race were better than those of any of her rivals except for the opening stretch where Ferguson (placed 5th) was 0.02s faster (Tables 24, 25 and 26). Table 23 show the evolution of the split times of each athlete. The second and third places were decided in the last stretch (Table 24). Maximum speeds were produced in the 50 to 100m stretch with the average maximum speed of 10.12 m/s by Miller and average minimum speed of 9.63 m/s (Tables 27 and Figure 9). The best average speed for the race was clocked by Miller with 9.19 m/s, as well as the best reaction time, of 0.124s, which was less than that for any of the men in the same event (Figure 28).

Photo: ©allsport

Table 23: Time intervals for each 50 m-section (s)

200m FINAL WOMEN					
NAME	0-50m	50-100m	100-150m	150-200m	OFFICIAL TIME
MILLER, Inger (USA)	6.16	4.94	5.13	5.54	21.77
MCDONALD, Beverly (JAM)	6.31	4.97	5.29	5.65	22.22
FRAZER, Merlene (JAM)	6.29	4.97	5.28	5.72	22.26
PHILIPP, Andrea (GER)	6.24	5.02	5.31	5.69	22.26
FERGUSON, Debbie (BAH)	6.14	5.03	5.32	5.79	22.28
YUSUF, Fatima (NGR)	6.30	5.07	5.31	5.74	22.42
HEWITT, Lauren (AUS)	6.28	5.14	5.38	5.73	22.53
CAMPBELL, Juliet (JAM)	6.31	5.19	5.37	5.77	22.64

Table 24: Time at the end of each 50 m-section (s)

200m FINAL WOMEN				
NAME	50m	100m	150m	200m
MILLER, Inger (USA)	6.16	11.10	16.23	21.77
MCDONALD, Beverly (JAM)	6.31	11.28	16.57	22.22
FRAZER, Merlene (JAM)	6.29	11.26	16.54	22.26
PHILIPP, Andrea (GER)	6.24	11.26	16.57	22.26
FERGUSON, Debbie (BAH)	6.14	11.17	16.49	22.28
YUSUF, Fatima (NGR)	6.30	11.37	16.68	22.42
HEWITT, Lauren (AUS)	6.28	11.42	16.80	22.53
CAMPBELL, Juliet (JAM)	6.31	11.50	16.87	22.64

Table 25: Time intervals for each 100 m-section (s)

200m FINAL WOMEN		
NAME	0-100m	100-200m
MILLER, Inger (USA)	11.10	10.67
MCDONALD, Beverly (JAM)	11.28	10.94
FRAZER, Merlene (JAM)	11.26	11.00
PHILIPP, Andrea (GER)	11.26	11.00
FERGUSON, Debbie (BAH)	11.17	11.11
YUSUF, Fatima (NGR)	11.37	11.05
HEWITT, Lauren (AUS)	11.42	11.11
CAMPBELL, Juliet (JAM)	11.50	11.14

Table 26: Differences from the winner's time in each 50 m-section (s)

200m FINAL WOMEN				
NAME	0-50m	50-100m	100-150m	150-200m
MILLER, Inger (USA)	6.16	4.94	5.13	5.54
MCDONALD, Beverly (JAM)	0.15	0.03	0.16	0.11
FRAZER, Merlene (JAM)	0.13	0.03	0.15	0.18
PHILIPP, Andrea (GER)	0.08	0.08	0.18	0.15
FERGUSON, Debbie (BAH)	-0.02	0.09	0.19	0.25
YUSUF, Fatima (NGR)	0.14	0.13	0.18	0.20
HEWITT, Lauren (AUS)	0.12	0.20	0.25	0.19
CAMPBELL, Juliet (JAM)	0.15	0.25	0.24	0.23

Table 27: Average velocity in the 50-section (s)

200m FINAL WOMEN					
NAME	0-50m	50-100m	100-150m	150-200m	Mean V.
MILLER, Inger (USA)	8.12	10.12	9.75	9.03	9.19
MCDONALD, Beverly (JAM)	7.92	10.06	9.45	8.85	9.00
FRAZER, Merlene (JAM)	7.95	10.06	9.47	8.74	8.98
PHILIPP, Andrea (GER)	8.01	9.96	9.42	8.79	8.98
FERGUSON, Debbie (BAH)	8.14	9.94	9.40	8.64	8.98
YUSUF, Fatima (NGR)	7.94	9.86	9.42	8.71	8.92
HEWITT, Lauren (AUS)	7.96	9.73	9.29	8.73	8.88
CAMPBELL, Juliet (JAM)	7.92	9.63	9.31	8.67	8.83

Figure 9: Average velocity in the 50-sections (m/s)

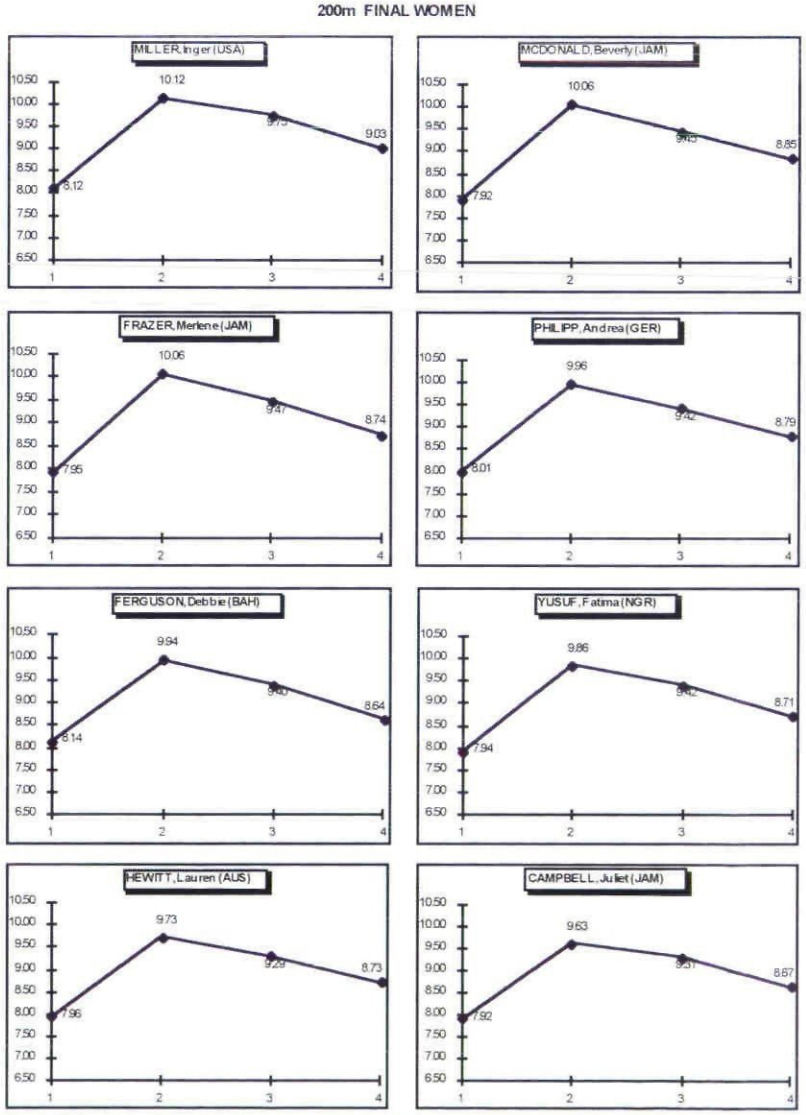


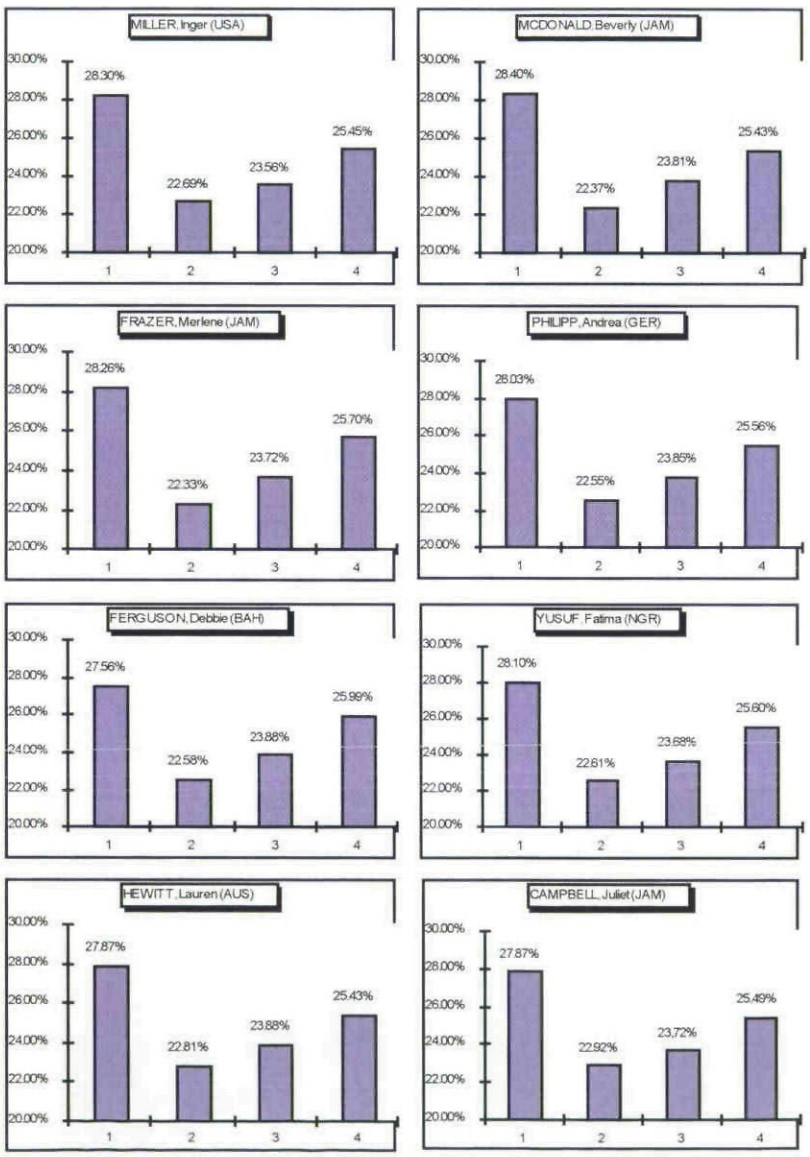
Table 28: Official reaction times (s)

200m FINAL WOMEN

NAME	R.T.	NAME	R.T.
MILLER, Inger (USA)	0.124	FERGUSON, Debbie (BAH)	0.168
MCDONALD, Beverly (JAM)	0.135	YUSUF, Fatima (NGR)	0.147
FRAZER, Merlene (JAM)	0.277	HEWITT, Lauren (AUS)	0.132
PHILIPP, Andrea (GER)	0.136	CAMPBELL, Juliet (JAM)	0.143

Figure 10: Individual percentages of each 50 m-section from total (%)

200m FINAL WOMEN



4.5 Results of the men's 400m final

In this event Michael Johnson broke the world record with a time of 43.18s (the previous world record stood at 43.29s) he was 1.11s faster than the silver medallist (Tables 29), with an average race speed of 9.26 m/s (Table 34). At the 200m mark he was in third place with an accumulated time of 21.22s, 0.09s slower than the silver medallist who was in first place at that point in the race (Table 32). In the 200 to 250m stretch Johnson clocked 0.12s less than the athlete with the best 200 split time and his maximum average speed was 10.08 m/s. All his rivals, except Young, ran stretches which were faster than Johnson (Table 33), but from the 200m mark he moved into first place (Tables 30 and 31) clocking spectacular average speeds between the 200 and 400m marks (Table 29). In Figure 11 Johnson maintained a speed plateau over the 200 - 250 and 250 - 300m stretches avoiding the loss of speed, which was much more accentuated in his rivals. Furthermore, his average speeds in the remaining stretches to the finishing line were higher than the rest. Table 35 shows the official reaction times.

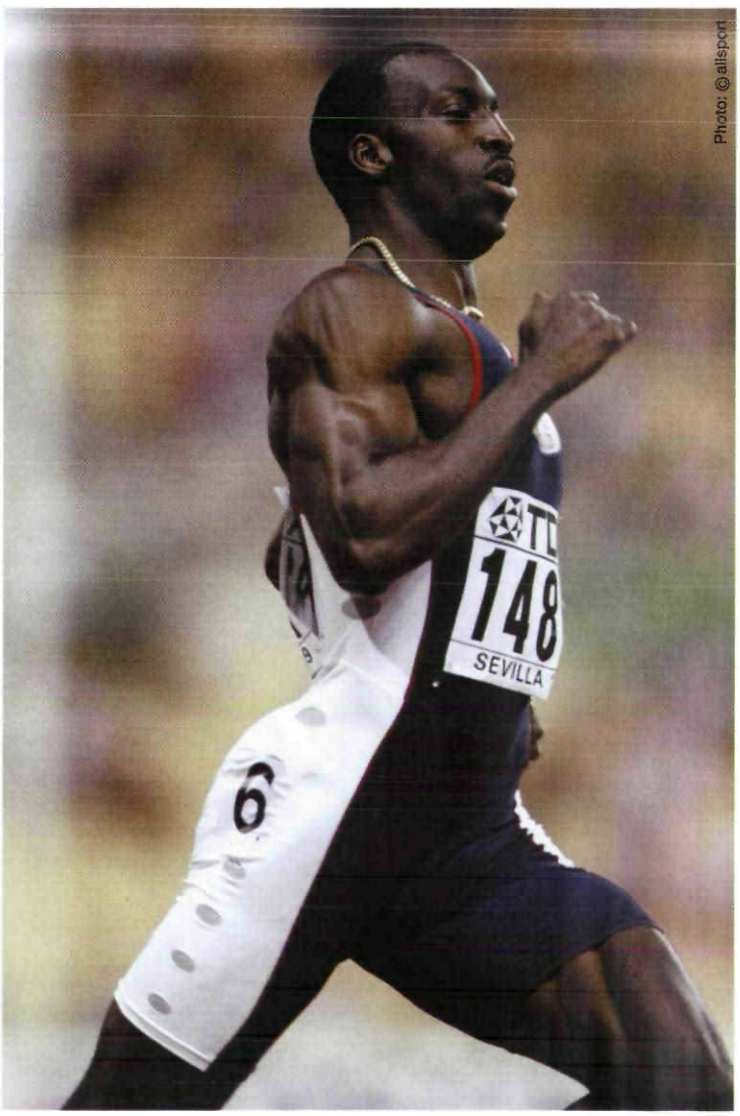


Photo: ©allsport

Table 29: Time intervals for each 50 m-section (s)

400m FINAL MEN									
NAME	0-50m.	50-100m	100-150m	150-200m	200-250m	250-300m	300-350m	350-400m	OFFICIAL TIME
JOHNSON, Michael (USA)	6.14	4.96	5.00	5.12	5.20	5.24	5.52	6.00	**43.18**
PARRELA, Sanderlei Claro (BRA)	6.22	4.90	4.91	5.10	5.41	5.56	5.83	6.36	**44.29**
CÁRDENAS, Alejandro (MEX)	6.00	4.99	5.02	5.18	5.39	5.53	5.86	6.34	**44.31**
YOUNG, Jerome (USA)	6.15	5.01	5.00	5.17	5.26	5.36	5.82	6.59	**44.36**
PETTIGREW, Antonio (USA)	6.09	4.91	5.02	5.17	5.38	5.58	5.90	6.49	**44.54**
RICHARDSON, Mark (GBR)	6.08	4.90	5.04	5.26	5.38	5.61	5.89	6.49	**44.65**
HAUGHTON, Gregory (JAM)	6.03	4.98	5.04	5.17	5.38	5.65	6.07	6.75	**45.07**
BAULCH, Jamie (GBR)	6.14	4.92	4.98	5.25	5.47	5.69	6.08	6.65	**45.18**

Table 30: Time intervals for each 100 m-section (s)

400m FINAL MEN				
NAME	0-100m	100-200m	200-300m	300-400m
JOHNSON, Michael (USA)	11.10	10.12	10.44	11.52
PARRELA, Sanderlei Claro (BRA)	11.12	10.01	10.97	12.19
CçRDENAS, Alejandro (MEX)	10.99	10.20	10.92	12.20
YOUNG, Jerome (USA)	11.16	10.17	10.62	12.41
PETTIGREW, Antonio (USA)	11.00	10.19	10.96	12.39
RICHARDSON, Mark (GBR)	10.98	10.30	10.99	12.38
HAUGHTON, Gregory (JAM)	11.01	10.21	11.03	12.82
BAULCH, Jamie (GBR)	11.06	10.23	11.16	12.73

Table 31: Time intervals for each 200 m-section (s)

400m FINAL MEN		
NAME	0-200m	200-400m
JOHNSON, Michael (USA)	21.22	21.96
PARRELA, Sanderlei Claro (BRA)	21.13	23.16
CçRDENAS, Alejandro (MEX)	21.19	23.12
YOUNG, Jerome (USA)	21.33	23.03
PETTIGREW, Antonio (USA)	21.19	23.35
RICHARDSON, Mark (GBR)	21.28	23.37
HAUGHTON, Gregory (JAM)	21.22	23.85
BAULCH, Jamie (GBR)	21.29	23.89

Table 32: Times at the end of each 50 m-section (s)

400m FINAL MEN								
NAME	50m	100m	150m	200m	250m	300m	350m	400m
JOHNSON, Michael (USA)	6.14	11.10	16.10	21.22	26.42	31.66	37.18	43.18
PARRELA, Sanderlei Claro (BRA)	6.22	11.12	16.03	21.13	26.54	32.10	37.93	44.29
CÁRDENAS, Alejandro (MEX)	6.00	10.99	16.01	21.19	26.58	32.11	37.97	44.31
YOUNG, Jerome (USA)	6.15	11.16	16.16	21.33	26.59	31.95	37.77	44.36
PETTIGREW, Antonio (USA)	6.09	11.00	16.02	21.19	26.57	32.15	38.05	44.54
RICHARDSON, Mark (GBR)	6.08	10.98	16.02	21.28	26.66	32.27	38.16	44.65
HAUGHTON, Gregory (JAM)	6.03	11.01	16.05	21.22	26.60	32.25	38.32	45.07
BAULCH, Jamie (GBR)	6.14	11.06	16.04	21.29	26.76	32.45	38.53	45.18

Table 33: Differences from the winner's time in each 100 m-section (s)

400 m: FINAL MEN				
NAME	0-100m	100-200m	200-300m	300-400m
JOHNSON, Michael (USA)	6.14	4.96	5.00	6.00
PARRELA, Sanderlei Claro (BRA)	0.08	-0.06	-0.09	0.36
CÁRDENAS, Alejandro (MEX)	-0.14	0.03	0.02	0.34
YOUNG, Jerome (USA)	0.01	0.05	0.00	0.59
PETTIGREW, Antonio (USA)	-0.05	-0.05	0.02	0.49
RICHARDSON, Mark (GBR)	-0.06	-0.06	0.04	0.49
HAUGHTON, Gregory (JAM)	-0.11	0.02	0.04	0.75
BAULCH, Jamie (GBR)	0.00	-0.04	-0.02	0.65

Figure 11: Average velocity in the 50-sections (m/s)

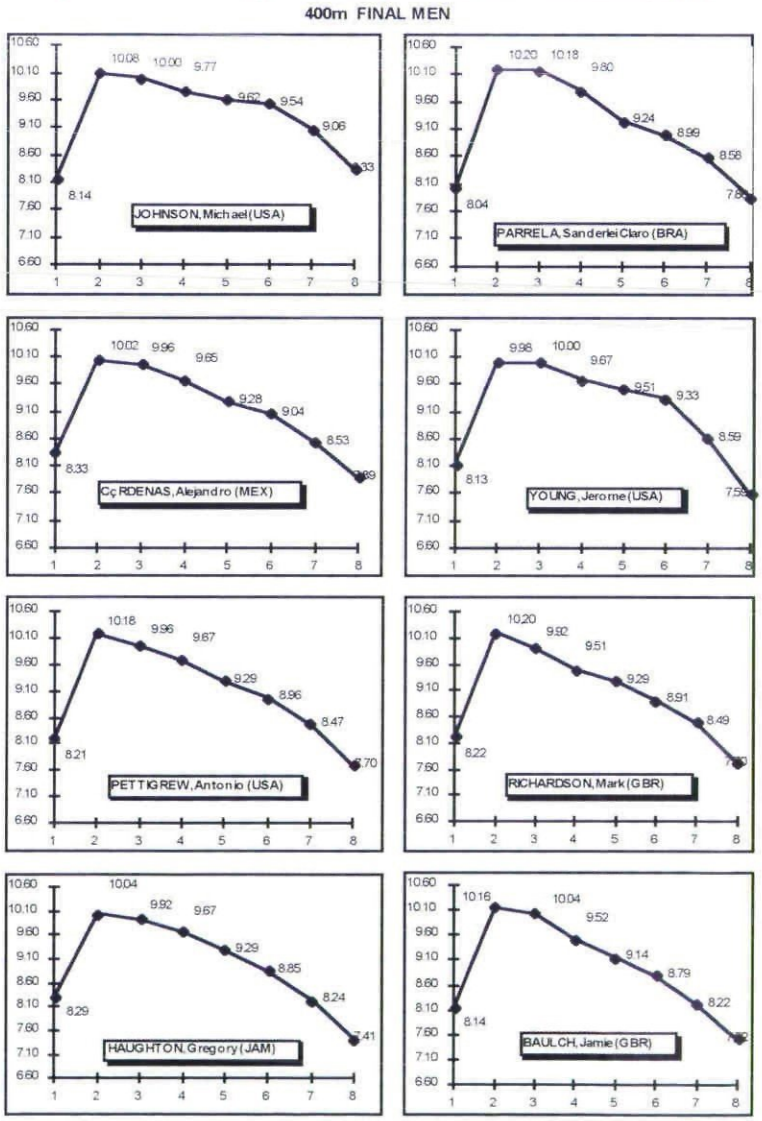


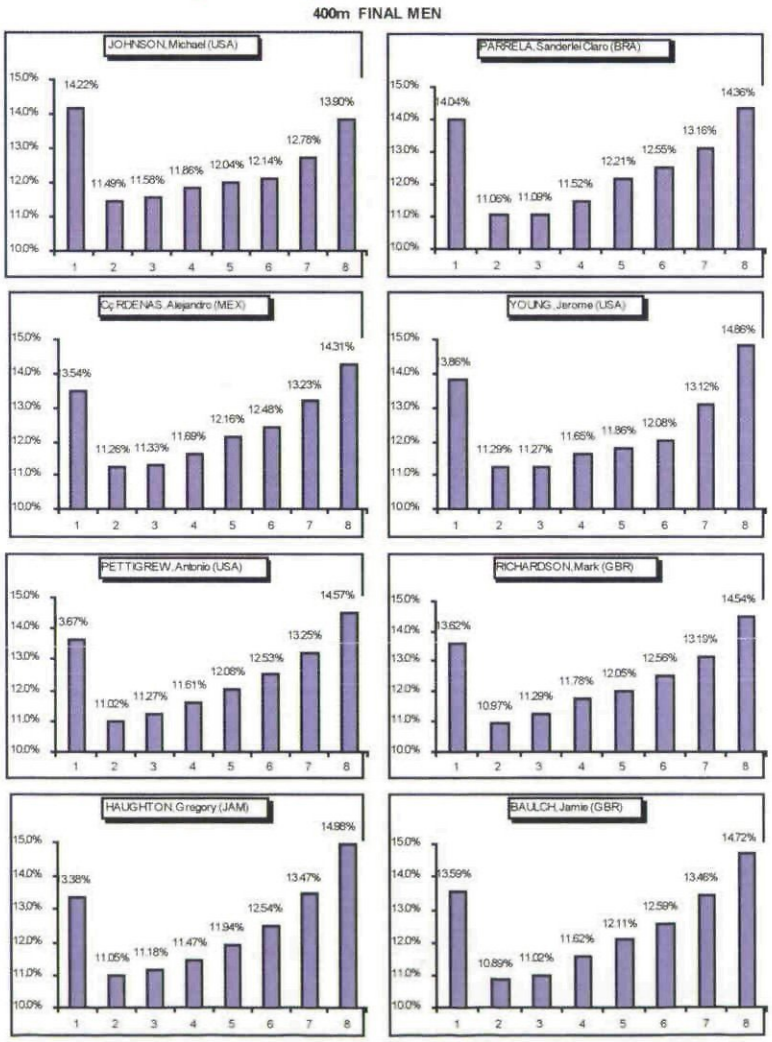
Table 34: Average velocity in the 50-sections (m/s)

400m FINAL MEN									
NAME	0-50m.	50-100m	100-150m	150-200m	200-250m	250-300m	300-350m	350-400m	Mean V.
JOHNSON, Michael (USA)	8.14	10.08	10.00	9.77	9.62	9.54	9.06	8.33	9.26
PARRELA, Sanderlei Claro (BRA)	8.04	10.20	10.18	9.80	9.24	8.99	8.58	7.86	9.03
CÁRDENAS, Alejandro (MEX)	8.33	10.02	9.96	9.65	9.28	9.04	8.53	7.89	9.03
YOUNG, Jerome (USA)	8.13	9.98	10.00	9.67	9.51	9.33	8.59	7.59	9.02
PETTIGREW, Antonio (USA)	8.21	10.18	9.96	9.67	9.29	8.96	8.47	7.70	8.98
RICHARDSON, Mark (GBR)	8.22	10.20	9.92	9.51	9.29	8.91	8.49	7.70	8.96
HAUGHTON, Gregory (JAM)	8.29	10.04	9.92	9.67	9.29	8.85	8.24	7.41	8.88
BAULCH, Jamie (GBR)	8.14	10.16	10.04	9.52	9.14	8.79	8.22	7.52	8.85

Table 35: Official reaction times (s)

400m FINAL MEN	
NAME	R.T.
JOHNSON, Michael (USA)	0.150
PARRELA, Sanderlei Claro (BRA)	0.169
CÁRDENAS, Alejandro (MEX)	0.133
YOUNG, Jerome (USA)	0.171
PETTIGREW, Antonio (USA)	0.284
RICHARDSON, Mark (GBR)	0.218
HAUGHTON, Gregory (JAM)	0.168
BAULCH, Jamie (GBR)	0.148

Figure 12: Individual percentages of each 50 m-section from total (%)



4.6 Results of the women's 400m final

The women's event did not show such considerable differences as witnessed in the men's event. Freeman, the winner, beat Rücker by 0.07s and she, in turn, beat Graham by 0.18s (Table 36). Rücker was slower over the first 100m than Freeman by 0.24s (Table 37). During the following stretches of the race both clocked similar split times, differing by 0.01 or 0.02s, but in the last 100 metres the silver medallist stood out with split times 0.08 and 0.09s faster than the winner (Table 37 and Table 40). If Rücker had been able to knock at least 0.07s off the opening 100m stretch she could have won. Table 39 shows that Rücker did not gain second place until the last 50 metres. Tables 37 and 38 show the times per interval of 100 and 200m, respectively. Rücker achieved a 0.17s advantage over the winner in the last 100m sector (Table 40) and all the athletes, except Kotlyarova, achieved a better split time than Freeman between 50 and 100 metres (Table 36). Speeds are shown in Figure 13 and Table 41. The best average was 8.05 m/s and the worst 7.89 m/s. Table 42 shows the official reaction times.

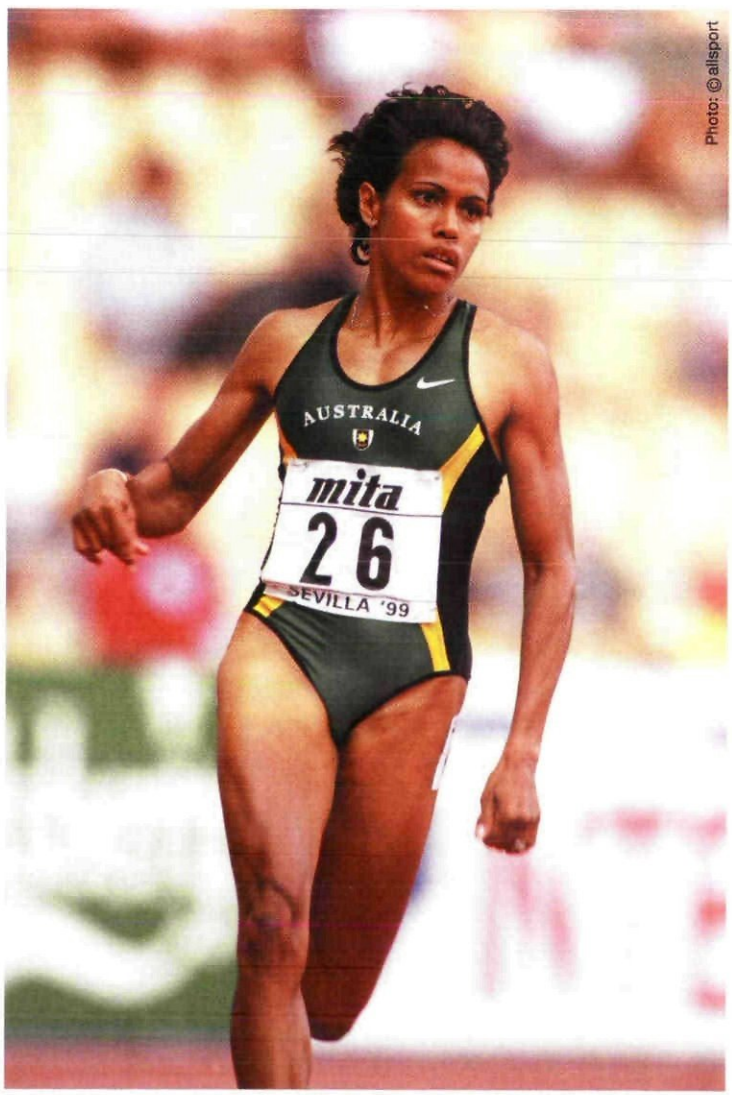


Photo: ©allsport

Table 36: Time intervals for each 50 m-section (s)

400m FINAL WOMEN									
NAME	0-50m.	50-100m	100-150m	150-200m	200-250m	250-300m	300-350m	350-400m	OFFICIAL TIME
FREEMAN, Cathy (AUS)	6.56	5.63	5.68	5.92	6.08	6.10	6.53	7.17	**49.67**
RÜCKER, Anja (GER)	6.80	5.61	5.69	5.93	6.06	6.12	6.45	7.08	**49.74**
GRAHAM, Lorraine (JAM)	6.61	5.50	5.62	5.86	6.19	6.34	6.60	7.20	**49.92**
OGUNKOYA, Falilat (NGR)	6.55	5.59	5.68	5.84	6.13	6.16	6.68	7.40	**50.03**
MERRY, Katharine (GBR)	6.68	5.56	5.71	5.96	6.13	6.33	6.75	7.40	**50.52**
NAZAROVA, Natalya (RUS)	6.70	5,59	5.75	6.05	6.38	6.44	6.62	7.08	**50.61**
BREUER, Grit (GER)	6.81	5.58	5.70	5.99	6.20	6.23	6.67	7.49	**50.67**
KOTLYAROVA, Olga (RUS)	6.86	5.65	5.72	6.03	6.31	6.28	6.56	7.31	**50.72**

Table 37: Time intervals for each 100 m-section (s)

400m FINAL WOMEN				
NAME	0-100m	100-200m	200-300m	300-400m
FREEMAN, Cathy (AUS)	12.19	11.60	12.18	13.70
RÜCKER, Anja (GER)	12.41	11.62	12.18	13.53
GRAHAM, Lorraine (JAM)	12.11	11.48	12.53	13.80
OGUNKOYA, Falilat (NGR)	12.14	11.52	12.29	14.08
MERRY, Katharine (GBR)	12.24	11.67	12.46	14.15
NAZAROVA, Natalya (RUS)	12.29	11.80	12.82	13.70
BREUER, Grit (GER)	12.39	11.69	12.43	14.16
KOTLYAROVA, Olga (RUS)	12.51	11.75	12.59	13.87

Table 38: Time intervals for each 200 m-section (s)

400m FINAL WOMEN		
NAME	0-200m	200-400m
FREEMAN, Cathy (AUS)	23.79	25.88
RÜCKER, Anja (GER)	24.03	25.71
GRAHAM, Lorraine (JAM)	23.59	26.33
OGUNKOYA, Falilat (NGR)	23.66	26.37
MERRY, Katharine (GBR)	23.91	26.61
NAZAROVA, Natalya (RUS)	24.09	26.52
BREUER, Grit (GER)	24.08	26.59
KOTLYAROVA, Olga (RUS)	24.26	26.46

Table 39: Times at the end of each 50 m-section (s)

400m FINAL WOMEN								
NAME	50m	100m	150m	200m	250m	300m	350m	400m
FREEMAN, Cathy (AUS)	6.56	12.19	17.87	23.79	29.87	35.97	42.50	49.67
RÜCKER, Anja (GER)	6.80	12.41	18.10	24.03	30.09	36.21	42.66	49.74
GRAHAM, Lorraine (JAM)	6.61	12.11	17.73	23.59	29.78	36.12	42.72	49.92
OGUNKOYA, Falilat (NGR)	6.55	12.14	17.82	23.66	29.79	35.95	42.63	50.03
MERRY, Katharine (GBR)	6.68	12.24	17.95	23.91	30.04	36.37	43.12	50.52
NAZAROVA, Natalya (RUS)	6.70	12.29	18.04	24.09	30.47	36.91	43.53	50.61
BREUER, Grit (GER)	6.81	12.39	18.09	24.08	30.28	36.51	43.18	50.67
KOTLYAROVA, Olga (RUS)	6.86	12.51	18.23	24.26	30.57	36.85	43.41	50.72

Table 40: Differences from the winner's time in each 100 m-section (s)

400 m FINAL WOMEN				
NAME	0-100m	100-200m	200-300m	300-400m
FREEMAN, Cathy (AUS)	6.56	5.63	5.68	7.17
RÜCKER, Anja (GER)	0.24	-0.02	0.01	-0.09
GRAHAM, Lorraine (JAM)	0.05	-0.13	-0.06	0.03
OGUNKOYA, Falilat (NGR)	-0.01	-0.04	0.00	0.23
MERRY, Katharine (GBR)	0.12	-0.07	0.03	0.23
NAZAROVA, Natalya (RUS)	0.14	-0.04	0.07	-0.09
BREUER, Grit (GER)	0.25	-0.05	0.02	0.32
KOTLYAROVA, Olga (RUS)	0.30	0.02	0.04	0.14

Figure 13: Average velocity in the 50-sections (m/s)

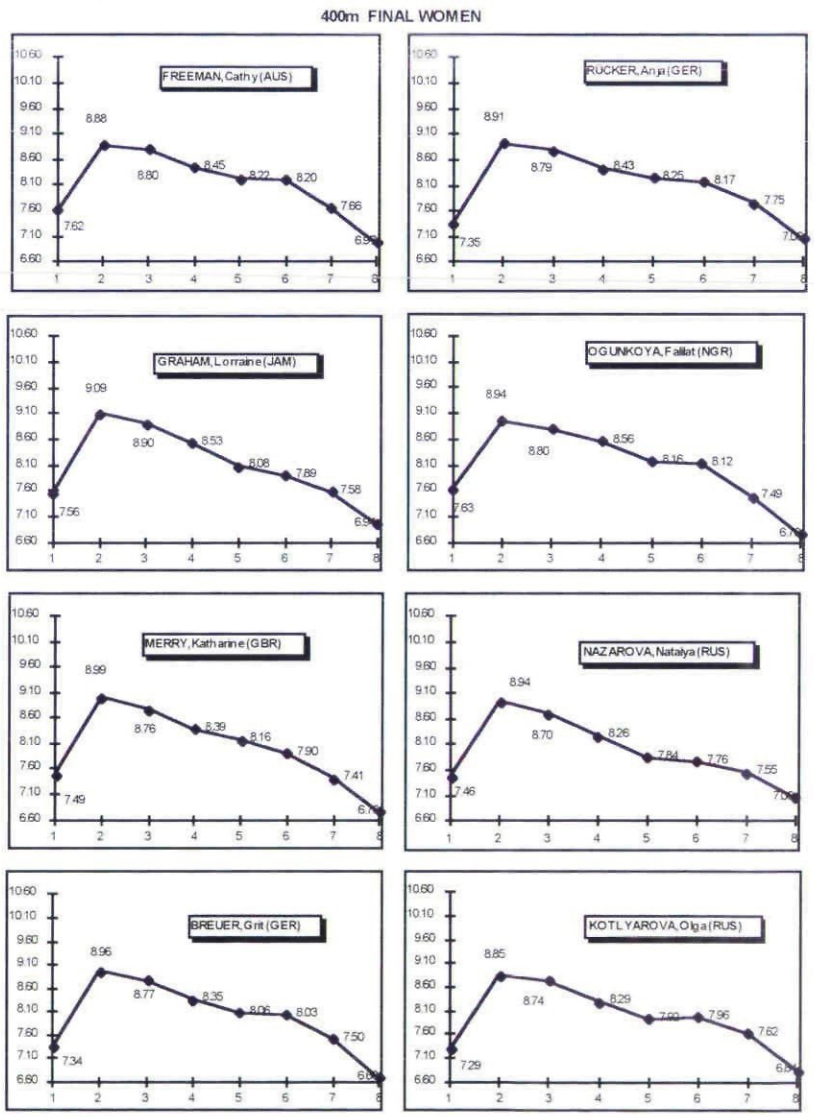


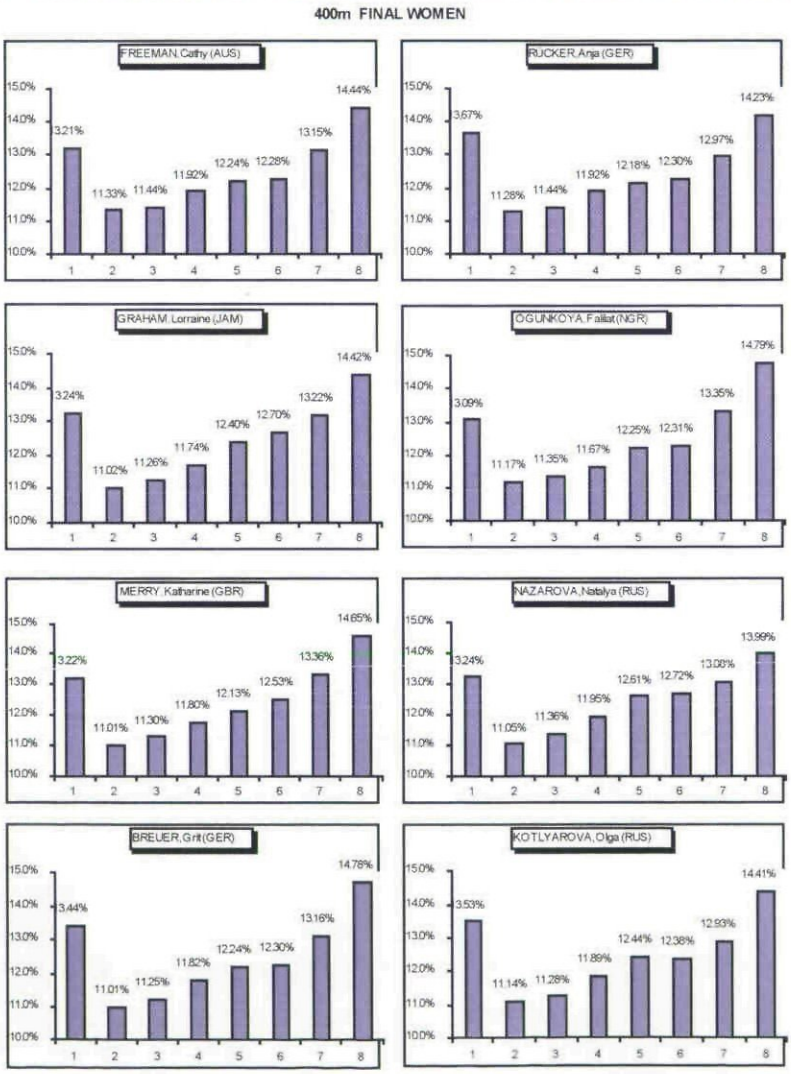
Table 41: Average velocity in the 50-sections (m/s)

400m FINAL WOMEN									
NAME	0-50m	50-100m	100-150m	150-200m	200-250m	250-300m	300-350m	350-400m	Mean V.
FREEMAN, Cathy (AUS)	7.62	8.88	8.80	8.45	8.22	8.20	7.66	6.97	8.05
RÜCKER, Anja (GER)	7.35	8.91	8.79	8.43	8.25	8.17	7.75	7.06	8.04
GRAHAM, Lorraine (JAM)	7.56	9.09	8.90	8.53	8.08	7.89	7.58	6.94	8.01
OGUNKOYA, Falilat (NGR)	7.63	8.94	8.80	8.56	8.16	8.12	7.49	6.76	8.00
MERRY, Katharine (GBR)	7.49	8.99	8.76	8.39	8.16	7.90	7.41	6.76	7.92
NAZAROVA, Natalya (RUS)	7.46	8.94	8.70	8.26	7.84	7.76	7.55	7.06	7.90
BREUER, Grit (GER)	7.34	8.96	8.77	8.35	8.06	8.03	7.50	6.68	7.89
KOTLYAROVA, Olga (RUS)	7.29	8.85	8.74	8.29	7.92	7.96	7.62	6.84	7.89

Table 42: Official reaction times (s)

400m FINAL WOMEN	
NAME	R.T.
FREEMAN, Cathy (AUS)	0.193
RÜCKER, Anja (GER)	0.203
GRAHAM, Lorraine (JAM)	0.182
OGUNKOYA, Falilat (NGR)	0.157
MERRY, Katharine (GBR)	0.193
NAZAROVA, Natalya (RUS)	0.176
BREUER, Grit (GER)	0.176
KOTLYAROVA, Olga (RUS)	0.185

Figure 14: Individual percentages of each 50 m-section from total (%)



5. Conclusions

1. The kinematic analysis of sprint events has made it possible to study the performance of the best sprinters who participated in the 1999 World Championships in Seville.

2. The data offers both individual and group results, to help the coach to assess the performance of each athlete and be able to select the competition strategy, which is the most suitable.

3. A methodology has been designed to permit the kinematic analysis of sprint events, which will permit the dissemination of the results just a few hours after the competition.

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7. References

Ae, M.; Ito, A.; Suzuki, M. (1992) "The Scientific Research Project at the III. World Championships in Athletics: Preliminary reports. The men's 100 metres". New Studies in Athletics, 7 (1), 45-52.

Brüggemann, G. P.; Koszewski, D.; Müller, H. (1997) "Biomechanical research project Athens 1997 - Final report". Meyer & Meyer Sport. (UK).

Brüggemann, G. P.; Glad, B. (1990) "Time analysis of the sprint events". Final report Seoul 1988.

Landry, D. (1987) "Roma 87. "The 2nd World Championships in Athletics provide a basis for comparison". New Studies in Athletics, 3, 29-47.

Moravec, P.; Ruzicka, J.; Susanka, P.; Dostal, E.; Kodejs, M.; Nosek, M. (1988) "The 1987 International Athletic Foundation/IAAF Scientific Project Report: Time analysis of the 100 Metres events at the II World Championships in Athletics". New Studies in Athletics, 3, 61-96.

Susanka, P.; Moravec, P.; Dostal, E.; Ruzicha, J.; Barac, F.; Vcelak, F.; Nosek, M.; Jardik, M. (1989a) "Fundamental motor abilities and selected biomechanical variables related to performance in 100 m. OG. Seoul". Report IAF.

Susanka, P.; Moravec, P.; Dostal, E.; Ruzicha, J.; Barac, F.; Nosek, M.; Jardik, M. (1989b) "Problems of optimal pace distribution in the 400 m. events. OG Seoul 1988". Report IAF.

Susanka, P.; Moravec, P.; Dostal, E.; Ruzicha, J.; Barac, F.; Nosek, M.; Jardik, M. (1989c) "Fundamental motor abilities and their relation to the performance in 200 m. OG Seoul 1988". Report IAF.

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