Towards a fairer scoring system in athletics

Changes for 2014

Based on the results for 2013, some of the values of A in the formula below have been modified by as much as 8% to attempt to create a more-level playing field.

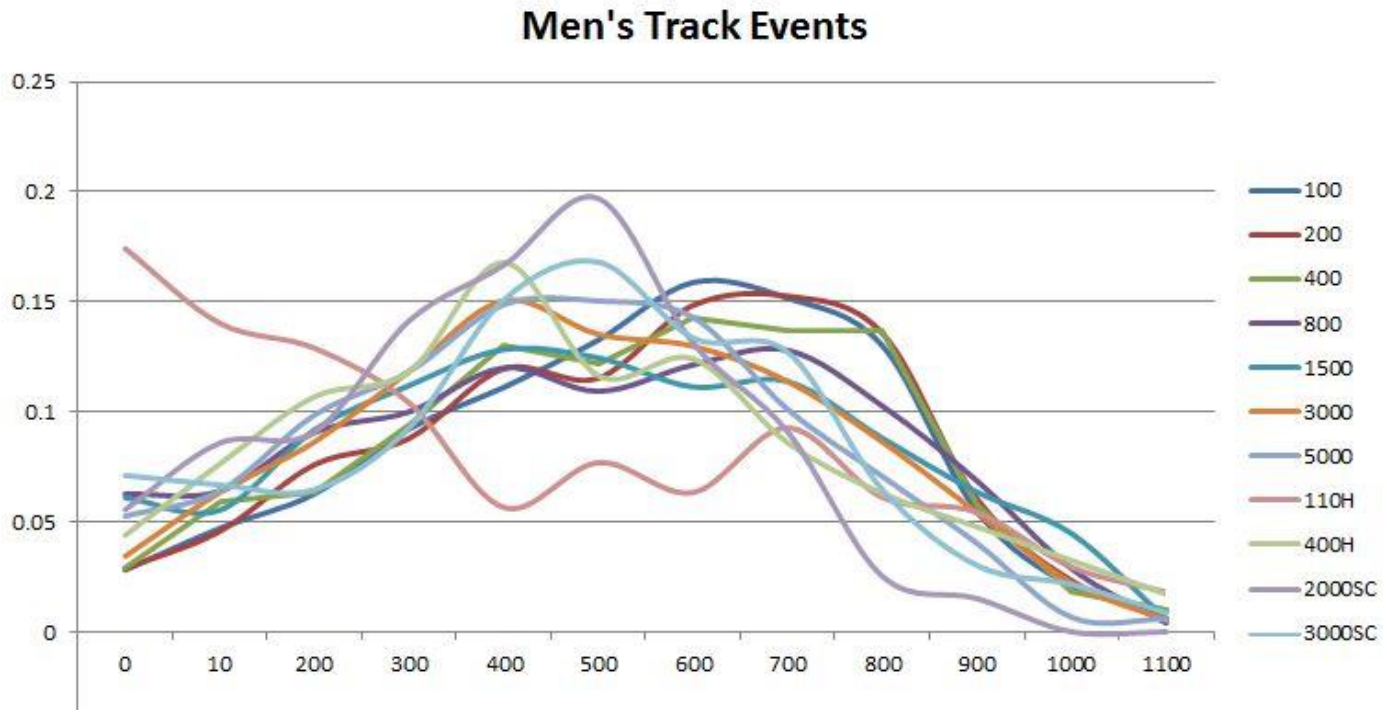
Athletics is a multi-discipline sport with many different events, from sprinting to endurance, hurdling, jumping and throwing. It is often helpful to be able to compare the results from different events, for example, to be able to determine the athlete of the match. The only comprehensive tables for senior events have been the International Amateur Athletics Federation (IAAF) tables by Dr Bojidar Spiriev, called the Hungarian Scoring Tables (http://www.iaaf.org/about-iaaf/documents/technical#scoring-tables). The scoring system used in these tables is based on the formula

$$Score = A * |P - B|^C$$

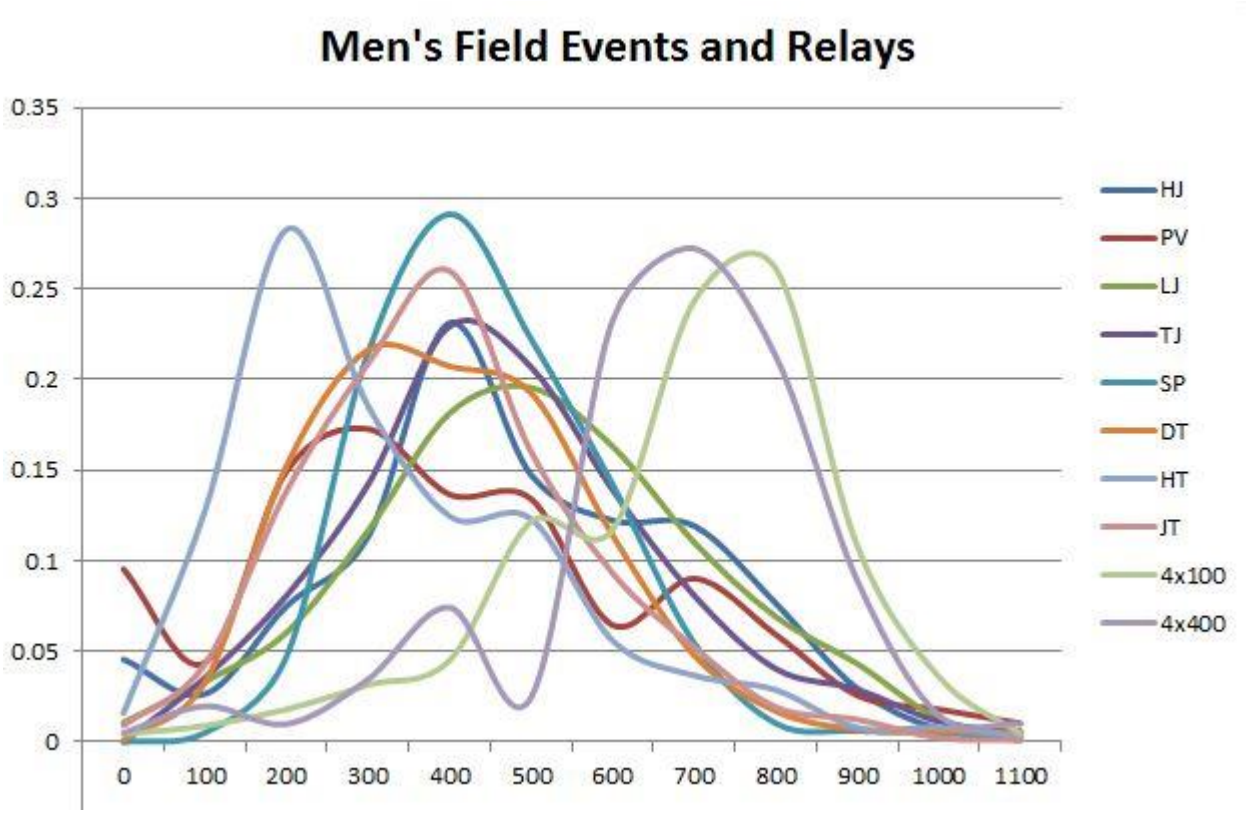
where P is the performance (in seconds or metres), B is the base performance below which no points are scored and A and C are parameters calculated for each event. These parameters are not published but it is straightforward to determine them using mathematical software. It can be established that within the Hungarian Scoring Tables, the parameter C is 2 for the running events, approximately 1.035 for the jumping events and 1 for the throwing events. I have not seen any justification for these values.

As Secretary of the Southern Athletics League, for Senior Men and Women, I incorporated the formulae into the results spreadsheet in order to determine the man/woman of the match awards. Many clubs observed that the system did not work very well as it tended to favour sprinters above all other disciplines. I set out to establish whether there was any validity in this complaint.

The advent of comprehensive ranking lists, such as the Power of Ten Rankings (http://www.thepowerof10.info/rankings/) allows us to compare the results for different events of applying the formula. Using the rankings for 2012, in my first analysis I included all athletes (over 15 years old) who were eligible to compete in the league, but I later narrowed this down to athletes between the ages of 20 and 50 (who all use the same weights for throwing and the same hurdles set-up). The following graphs indicate the spread of the scores, with the best performance gaining well over 1000 points. The scores are along the x-axis and the proportion of athletes achieving those scores are given along the y-axis.

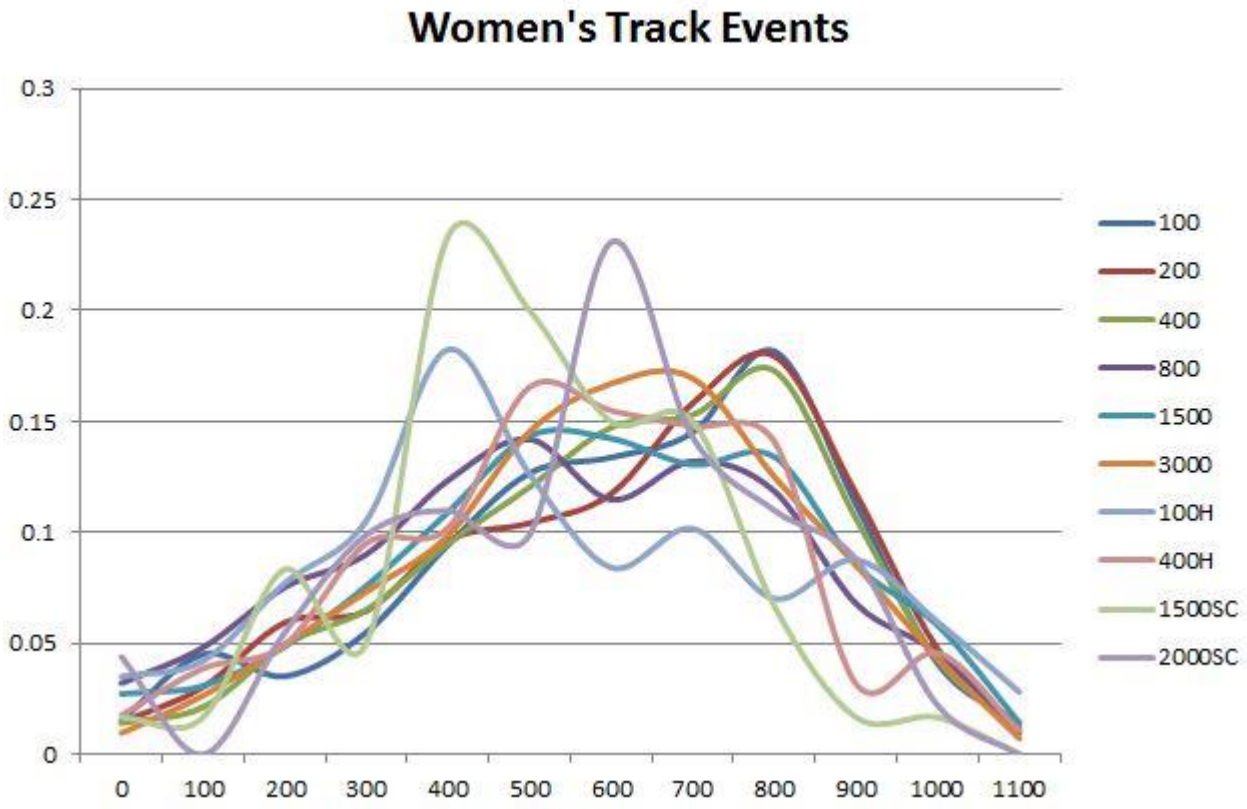


There is no clear picture emerging. The biggest anomaly is in the 110m Hurdles where the best athletes, with three strides between hurdles move significantly quicker than those who take five strides between hurdles. For the men's field events and relays we have a very different set of graphs:

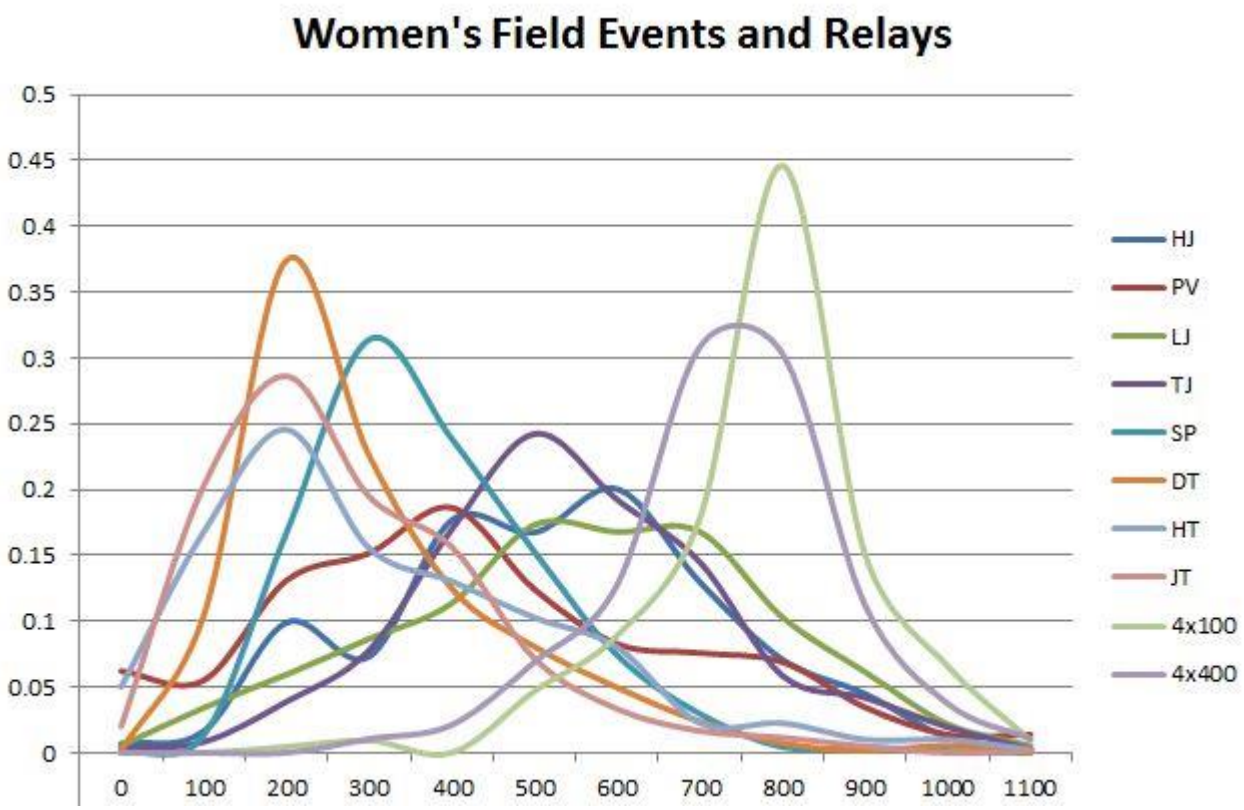


The means tend to be lower and there is a significant variation in those achieving, for example, over 700 points. The means for the throwing events are significantly lower than for the jumps, which are again significantly lower than for the track events.

The results for the women show rather similar patterns:



The women's 100m Hurdles, stands out in a similar way to the men's 110m Hurdles and there is no clear pattern for the distributions over the other track events.

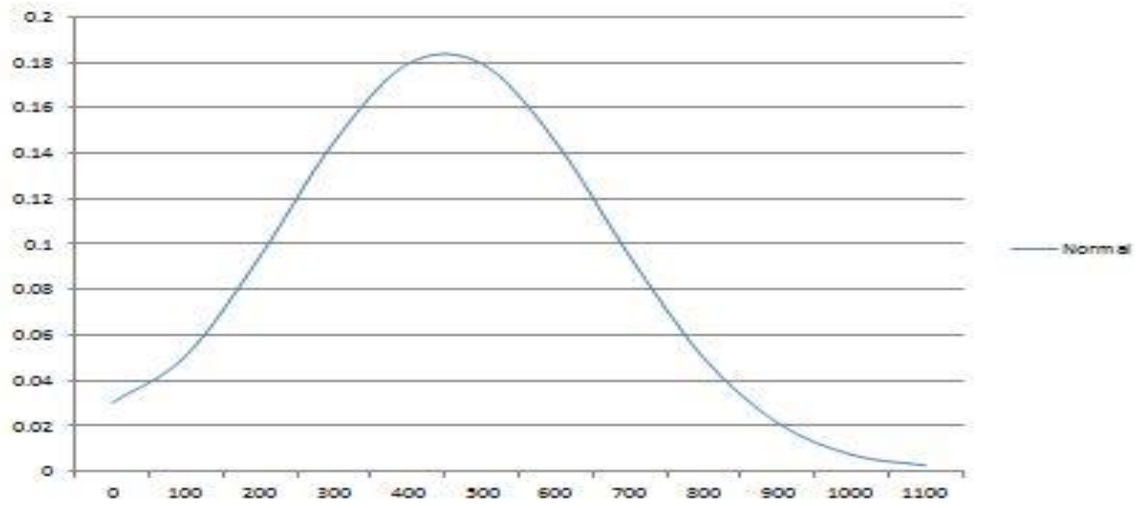


Again the throws events have significantly lower means than for the jumps events, which are again significantly lower than for the track events.

A new scoring system following the normal distribution

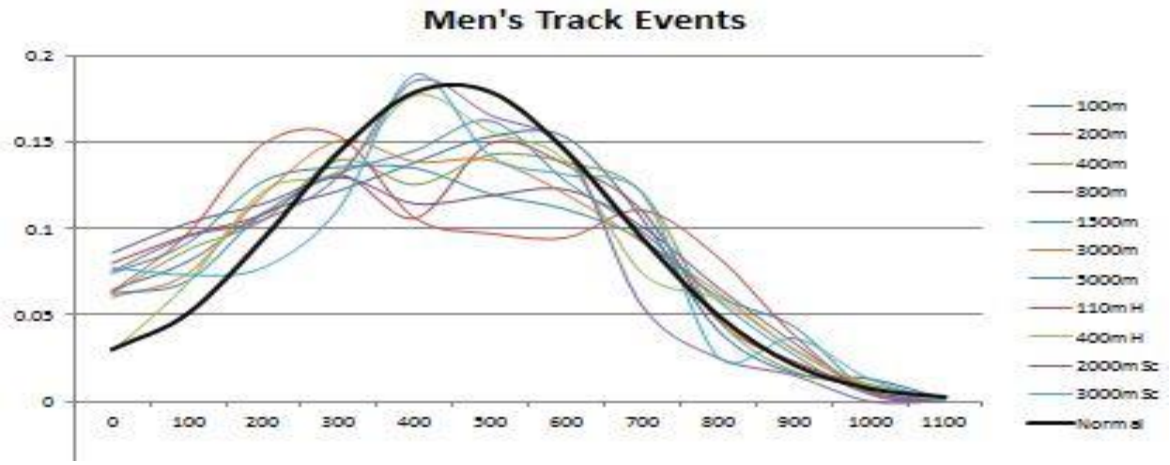
It is clear that the existing scoring system is not fair and to use it as we did in 2012 for man/women of the match results, biased the awards towards those on the track. That they went to sprinters rather than middle distance athletes is perhaps more to do with the tactical nature of middle distance races within league meetings.

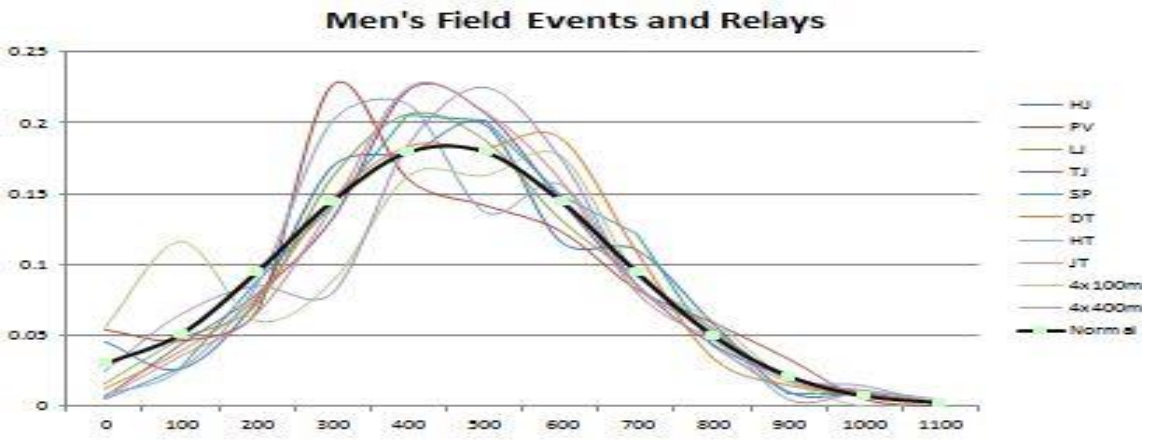
My initial reaction was to try to find a scoring method for the field events that would yield a distribution of scores that was similar to those for track events; in particular to find a scoring method for all events which gave a distribution of scores that was similar to the 400m. After some investigation I realised that this was not a sensible approach as the distribution of scores for the 400m was not a particularly smooth function. I switched to the normal distribution with mean 500 and a standard deviation such that 98% of performances would lie between 0 and 1000 points. This is the graph of that normal distribution.

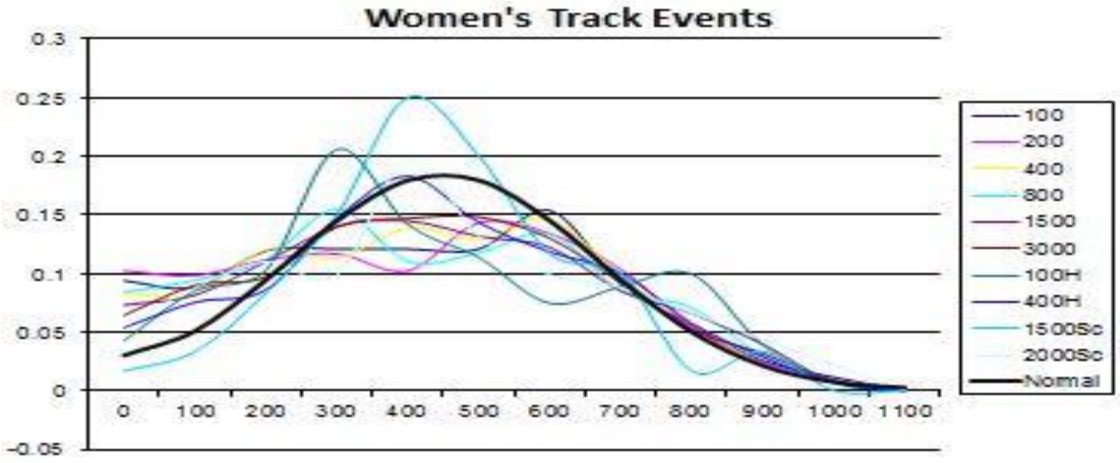


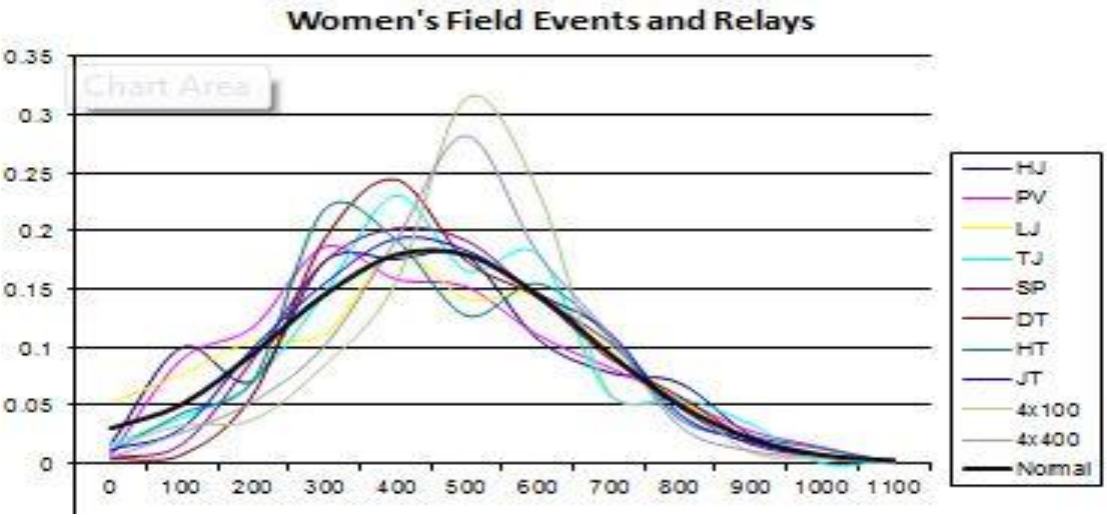
In particular, I wanted the formula to work consistently in the range of scores between 500 and 1100 points where most man/woman of the match winners would lie. Using the 2012 Power of Ten rankings data for men/women between 20 and 50 I attempted to fit the three parameters A, B and C so that the distribution of the scores would be similar to the above graph. I also imposed the constraint that the base performance B should be such that roughly 1% of the Power of Ten Rankings were inferior to B (in line with the above graph).

Using mathematical software to provide a nonlinear least-squares fit to the data, I produced a set of parameters that yield the following graphical distributions:









The graphs, which are by no means a perfect fit, are clearly a significant improvement on those for the Hungarian Scoring Tables, particularly over the range between 500 and 1100 points.

It is also instructive to compare the values of the parameters for the new scoring system with those for the Hungarian Scoring system. For the men we have

	Hungarian Scoring System			**New Scoring System**		
Men	A	B	C	A	B	C
100	24.6	17.0	2	7.6239	17.0	2.5684
200	5.09	35.5	2	2.1548	34.0	2.3925
400	0.909	81.0	2	0.2388	80.0	2.3724
800	0.1878	184	2	0.0108	190.01	2.597
1500	0.04067	385	2	0.00147	405.005	2.5743
3000	0.00815	840	2	0.00347	830.0024	2.1444
5000	0.002778	1440	2	0.00712	1400	1.86632
110H	7.41	26.0	2	5.11967	29.2	1.91288
400H	0.509	97.0	2	0.59686	100.0	1.89275
2000SC	0.01023	660	2	0.004036	659.32	2.1627
3000SC	0.004315	1020	2	0.00098	1050	2.20749
HJ	871	0.98	1.035	843.44	1.00	0.9798
PV	251.7	1.30	1.035	256.13	1.00	0.9119
LJ	188.5	2.39	1.035	174.27	2.50	1.0562
TJ	94.8	5.81	1.035	176.25	7.00	0.7872
SP	57.3	0.96	1.0091	202.51	5.00	0.6549
DT	17.4	1.50	1.0091	102.56	11.00	0.5948

HT	14.46	1.38	1.0091	102.36	7.50	0.5573
JT	13.3	1.44	1.0091	55.53	10.00	0.707
4x100	1.2013	70.0	2	1.78584	58.0	2.19126
4x400	0.05405	328	2	0.05466	283	2.14528

In the new scoring system the value of C for the track events ranges between 1.8 and 2.6, compared with 2 used in the Hungarian Scoring system. For the jumps, C ranges from 0.78 to 1.06, compared to 1.035. The biggest change comes in the throwing events where the value of C ranges from 0.55 to 0.71 compared to 1 for the old system. It is likely that this difference in the value of C used in the Hungarian Scoring system is responsible for the poor scores in the throwing events.

The results for the women show a similar pattern;

	Hungarian Scoring System			**New Scoring System**		
Women	A	B	C	A	B	C
100	7.66	23.5	2	4.3409	20.66627	2.45484
200	1.626	49.5	2	0.21285	45.01528	2.75189
400	0.268	117	2	0.22036	99.01169	2.19326
800	0.06825	250	2	0.05913	230.0098	2.08171
1500	0.0134	540	2	0.01889	472.0048	2.01312
3000	0.00254	1200	2	0.0075	1000	1.92641
100HW	3.404	31.4	2	6.301	29.12569	1.81518
400HW	0.2085	130	2	1.39055	110.0137	1.64879
1500SCW	0.0085	645	2	0.0048	641.63	2.09103
2000SCW	0.0045	880	2	0.003542	759	2.13155
HJ	951	0.749	1.035	1087.17	0.8983	1.009
PV	283.3	0.8	1.035	315.6229	0.7985	0.8767
LJ	195	1.19	1.033	197.3522	1.8997	1.0671
TJ	91.5	3	1.035	148.8764	4.9999	0.877
SPW	58.5	0.44	1.009	228.1719	3.6004	0.6213
DTW	17.5	1	1.009	162.6043	8	0.4856
HTW	15.35	1.42	1.009	98.0353	5.3999	0.5705
JTW	17.3	1.05	1.009	144.49	6.4001	0.5123
4x100	0.393	98	2	4.52014	69.95268	1.66063
4x400	0.01562	480	2	0.20026	359.9932	1.70038

There were some anomalies that had to be corrected. The shorter distance steeplechase events are non-standard for senior athletes and are generally less contested by the better athletes. The parameters for these events were adjusted with this in mind so the similar performances in the two steeplechase events for men and women attracted similar scores.

I am recommending that the Southern Athletics League adopt this new scoring system for 2013, with a review of the outcomes at the end of the season to see whether further adjustments should be made.

Incidentally, the sprints were quite hard to analyse since they were much influenced by the mixture of hand times (to the nearest 0.1 seconds) and electronic times (to the nearest 0.01 seconds). To overcome this the hand times were evenly distributed over the previous 10^{th} of a second. For example, if there were 20 hand-timed performance at 12.2, these were considered as 2 at 12.11, two at 12.12, …, and 2 at 12.20. The analysis of pole vaulting and high jumping was less satisfactory since most high jump competitions are governed by 5cm increments, with the pole vault at 10cm increments, giving large clusters of performances at 1.50m, 1.55m and so on for the high jump, and at 2.80m, 2.90m etc for the pole vault.

The following procedure can be applied to any other set of performances, given a comprehensive rankings database for each event:

1. From the database determine the base performance B which should exclude approximately 1% of recorded performances. Note the number of performances that exceed this base performance.
2. Use the normal distribution, and the number of performances to determine how many performances should score less than 100 points, 200 points and so on up to 1100 points.
3. Use the database to determine the performance which should score 100 points, 200 points, up to 1100 points.
4. Use a mathematical software package to determine the nonlinear least-squares fit to this data (or a subset of this data), by varying the values of A and C.
5. Use the calculated values of A, B and C to determine the performance required to achieve 100 points, 200 points etc.
6. Use the rankings database to determine the ranking of the performances that score 100 points, 200 points etc.
7. Compare this distribution of performances with the normal distribution.

Comparison of the two systems

The two systems can be compared by looking at the performances required to achieve a particular score. The table allows such a comparison, where "old" are the performances taken from the Hungarian scoring system:

	Men	1000	900	800	700	600	500	400	300	200	100
100	new	10.35	10.62	10.91	11.22	11.55	11.93	12.35	12.85	13.46	14.30
100	old	10.62	10.95	11.30	11.67	12.06	12.49	12.97	13.51	14.15	14.98
200	new	21.00	21.56	22.16	22.80	23.50	24.27	25.14	26.15	27.37	29.04
200	old	21.47	22.19	22.95	23.76	24.63	25.58	26.63	27.81	29.22	31.06
400	new	46.37	47.83	49.39	51.07	52.89	54.89	57.15	59.76	62.94	67.26
400	old	47.83	49.53	51.33	53.25	55.31	57.55	60.02	62.83	66.17	70.51
800	new	1:48.3	1:51.5	1:55.0	1:58.8	2:02.9	2:07.4	2:12.6	2:18.6	2:26.0	2:36.3
800	old	1:51.0	1:54.8	1:58.7	2:02.9	2:07.5	2:12.4	2:17.8	2:24.0	2:31.4	2:40.9
1500	new	3:40.6	3:48.0	3:55.9	4:04.5	4:13.8	4:24.1	4:35.8	4:49.5	5:06.3	5:29.6
1500	old	3:48.2	3:56.2	4:04.7	4:13.8	4:23.5	4:34.1	4:45.8	4:59.1	5:14.9	5:35.4
3000	new	7:58.4	8:15.3	8:33.2	8:52.3	9:13.0	9:35.5	10:00.7	10:29.5	11:04.0	11:49.9
3000	old	8:09.7	8:27.7	8:46.7	9:06.9	9:28.7	9:52.3	10:18.5	10:48.1	11:23.3	12:09.2
5000	new	13:47.1	14:18.5	14:51.6	15:26.7	16:04.2	16:44.8	17:29.3	18:19.4	19:18.1	20:33.2
5000	old	14:00.0	14:30.8	15:03.3	15:38.0	16:15.2	16:55.7	17:40.5	18:31.4	19:31.7	20:50.3
110H	new	13.47	14.31	15.20	16.15	17.16	18.26	19.47	20.83	22.43	24.50
110H	old	14.38	14.98	15.61	16.28	17.00	17.79	18.65	19.64	20.80	22.33
400H	new	49.50	52.24	55.12	58.18	61.45	64.99	68.89	73.27	78.43	85.05
400H	old	52.68	54.95	57.36	59.92	62.67	65.66	68.97	72.72	77.18	82.98
2000SC	new	5:47.3	6:02.2	6:17.9	6:34.8	6:53.0	7:12.9	7:35.1	8:00.5	8:31.1	9:11.7
2000SC	old	5:47.3	6:03.4	6:20.4	6:38.4	6:57.8	7:18.9	7:42.3	8:08.8	8:40.2	9:21.1
3000SC	new	8:42.8	9:07.4	9:33.5	10:01.4	10:31.7	11:04.9	11:41.9	12:24.4	13:15.7	14:24.2
3000SC	old	8:58.6	9:23.3	9:49.4	10:17.2	10:47.1	11:19.6	11:55.5	12:36.3	13:24.7	14:27.8
High J	new	2.19	2.07	1.95	1.83	1.71	1.59	1.47	1.35	1.23	1.11
High J	old	2.12	2.01	1.90	1.79	1.68	1.56	1.45	1.33	1.22	1.10
Pole V	new	5.45	4.97	4.49	4.01	3.54	3.08	2.63	2.19	1.76	1.36
Pole V	old	5.09	4.72	4.35	3.98	3.61	3.24	2.86	2.48	2.10	1.70
Long J	new	7.73	7.23	6.73	6.23	5.72	5.21	4.70	4.17	3.64	3.09
Long J	old	7.40	6.92	6.43	5.94	5.45	4.96	4.46	3.96	3.45	2.93
Triple J	new	16.07	14.93	13.83	12.77	11.74	10.76	9.83	8.97	8.17	7.49

Triple J	old	15.55	14.61	13.66	12.71	11.76	10.80	9.83	8.85	7.87	6.86
Shot	new	16.46	14.75	13.15	11.65	10.25	8.98	7.83	6.82	5.98	5.34
Shot	old	17.97	16.28	14.59	12.90	11.21	9.52	7.82	6.12	4.41	2.70
Discus	new	57.00	49.53	42.61	36.25	30.49	25.34	20.86	17.08	14.07	11.96
Discus	old	56.91	51.42	45.92	40.41	34.90	29.38	23.85	18.30	12.74	7.16
Hammer	new	67.23	56.94	47.52	38.99	31.38	24.72	19.04	14.39	10.83	8.46
Hammer	old	67.94	61.34	54.74	48.12	41.50	34.87	28.23	21.57	14.89	8.18
Javelin	new	69.67	61.41	53.52	46.03	38.97	32.39	26.33	20.87	16.13	12.30
Javelin	old	73.76	66.59	59.41	52.22	45.03	37.82	30.61	23.37	16.11	8.82
4x100	new	40.03	40.87	41.76	42.72	43.76	44.90	46.16	47.62	49.37	51.70
4x100	old	41.15	42.63	44.19	45.86	47.65	49.60	51.75	54.20	57.10	60.88
4x400	new	3:06.0	3:10.6	3:15.6	3:20.8	3:26.5	3:32.8	3:39.7	3:47.7	3:57.2	4:09.8
4x400	old	3:12.0	3:19.0	3:26.3	3:34.2	3:42.6	3:51.8	4:02.0	4:13.5	4:27.2	4:45.0
	Women	**1000**	**900**	**800**	**700**	**600**	**500**	**400**	**300**	**200**	**100**
100	new	11.50	11.88	12.29	12.74	13.22	13.75	14.35	15.05	15.91	17.08
100	old	12.07	12.66	13.28	13.94	14.65	15.42	16.27	17.24	18.39	19.89
200	new	23.42	24.23	25.10	26.05	27.08	28.23	29.54	31.07	32.98	35.66
200	old	24.70	25.97	27.32	28.75	30.29	31.96	33.82	35.92	38.41	41.66
400	new	52.53	54.71	57.02	59.50	62.18	65.12	68.40	72.16	76.69	82.74
400	old	55.92	59.05	62.36	65.89	69.68	73.81	78.37	83.54	89.68	97.68
800	new	2:02.6	2:07.9	2:13.5	2:19.5	2:26.0	2:33.0	2:40.8	2:49.8	3:00.4	3:14.5
800	old	2:09.0	2:15.2	2:21.7	2:28.7	2:36.2	2:44.4	2:53.4	3:03.7	3:15.9	3:31.7
1500	new	4:09.9	4:21.3	4:33.2	4:46.0	4:59.7	5:14.6	5:31.1	5:49.9	6:12.2	6:41.3
1500	old	4:26.8	4:40.8	4:55.7	5:11.4	5:28.4	5:46.8	6:07.2	6:30.4	6:57.8	7:33.6
3000	new	9:02.5	9:26.9	9:52.6	10:19.9	10:49.1	11:20.8	11:55.7	12:35.1	13:21.6	14:21.6
3000	old	9:32.5	10:04.7	10:38.8	11:15.0	11:54.0	12:36.3	13:23.2	14:16.3	15:19.4	16:41.6
100HW	new	12.82	13.74	14.71	15.73	16.82	18.00	19.28	20.73	22.41	24.54
100HW	old	14.26	15.14	16.07	17.06	18.12	19.28	20.56	22.01	23.73	25.98
400HW	new	55.98	59.32	62.82	66.49	70.37	74.52	79.02	83.98	89.66	96.64
400HW	old	60.75	64.30	68.06	72.06	76.36	81.03	86.20	92.07	99.03	108.10
1500SCW	new	4:52.0	5:09.2	5:27.4	5:46.8	6:07.8	6:30.6	6:56.1	7:25.0	7:59.7	8:45.4
1500SCW	old	5:02.0	5:19.6	5:38.2	5:58.0	6:19.3	6:42.5	7:08.1	7:37.1	8:11.6	8:56.5
2000SCW	new	6:38.3	6:55.7	7:14.1	7:33.9	7:55.1	8:18.4	8:44.3	9:13.9	9:49.5	10:36.5
2000SCW	old	6:48.6	7:12.8	7:38.4	8:05.6	8:34.9	9:06.7	9:41.9	10:21.8	11:09.2	12:10.9
High J	new	1.82	1.73	1.64	1.54	1.45	1.36	1.27	1.18	1.09	0.99
High J	old	1.80	1.70	1.60	1.49	1.39	1.29	1.18	1.08	0.97	0.86
Pole V	new	4.52	4.10	3.69	3.28	2.88	2.49	2.11	1.74	1.39	1.07
Pole V	old	4.18	3.86	3.53	3.20	2.86	2.53	2.20	1.86	1.51	1.17
Long J	new	6.48	6.05	5.61	5.18	4.73	4.29	3.84	3.38	2.91	2.43
Long J	old	6.06	5.59	5.11	4.64	4.16	3.68	3.19	2.71	2.21	1.71
Triple J	new	13.77	12.78	11.80	10.84	9.90	8.98	8.09	7.22	6.40	5.64
Triple J	old	13.08	12.10	11.13	10.14	9.15	8.16	7.16	6.15	5.13	4.09
Shot	new	14.39	12.70	11.13	9.68	8.34	7.14	6.07	5.15	4.41	3.87
Shot	old	17.11	15.45	13.80	12.14	10.49	8.82	7.16	5.49	3.82	2.14
Discus	new	50.12	41.91	34.60	28.21	22.71	18.11	14.38	11.53	9.53	8.37
Discus	old	56.12	50.65	45.18	39.71	34.22	28.73	23.23	17.71	12.18	6.63
Hammer	new	64.01	54.12	45.04	36.76	29.34	22.79	17.16	12.50	8.89	6.44
Hammer	old	64.18	57.96	51.73	45.49	39.25	33.00	26.73	20.45	14.15	7.83
Javelin	new	50.05	41.94	34.64	28.16	22.50	17.68	13.70	10.56	8.29	6.89
Javelin	old	56.80	51.27	45.74	40.20	34.65	29.10	23.53	17.96	12.36	6.74
4x100	new	44.13	45.72	47.38	49.12	50.97	52.94	55.08	57.45	60.16	63.50

4x100	old	47.56	50.15	52.88	55.80	58.93	62.33	66.10	70.37	75.44	82.05
4x400	new	3:30.4	3:39.3	3:48.8	3:58.7	4:09.2	4:20.5	4:32.7	4:46.3	5:01.9	5:21.4
4x400	old	3:47.0	4:00.0	4:13.7	4:28.3	4:44.0	5:01.1	5:20.0	5:41.4	6:06.8	6:40.0

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