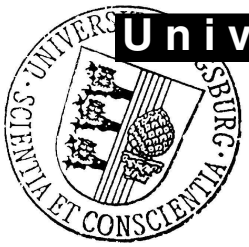

Universität Augsburg

Institut für Mathematik

Antony Unwin

Parallel Coordinates for Parallel Events — Graphical Analysis of Decathlon Results and the Decathlon Points System

Preprint Nr. 029/2007 — 11. Juli 2007

Institut für Mathematik, Universitätsstraße, D-86 135 Augsburg http://www.math.uni-augsburg.de/

Impressum:

Herausgeber:

Institut für Mathematik
Universität Augsburg
86135 Augsburg
http://www.math.uni-augsburg.de/forschung/preprint/

ViSdP:

Antony Unwin
Institut für Mathematik
Universität Augsburg
86135 Augsburg

Parallel Coordinates for Parallel Events— Graphical Analysis of Decathlon Results and the Decathlon Points System

Antony Unwin
University of Augsburg, Germany unwin@math.uni-augsburg.de

Abstract. The last revision of the points system for the Decathlon was carried out in the 1980s. This paper reviews that approach and assesses the points system in the light of thousands of top performances over the last twenty years. Predominantly graphical methods are used. Parallel coordinate plots are an ideal tool for exploring multivariate standardised data as arise in competitions like the Decathlon. The current points system has behaved consistently since its introduction. More points are awarded for some events than others and performance differences appear to be less rewarded in the four running events than in the other six.

1. Points systems for the Decathlon event

Comparing athletes' performances across different events is very difficult. Even if a method of comparison can be agreed, changes in event rules, equipment, training methods, or even the popularity of an event, can all affect the fairness of comparisons over time. The points system for the Decathlon was last revised over twenty years ago and various suggestions have been made in the literature as to how it could be amended and improved. These have tended to be based on small and and not necessarily representative datasets (e.g. Westera (2006)). The availability of an extensive record of the yearly best performances of all athletes since 1985 (www.decathlon2000.ee) offers the opportunity to assess the system in detail and to examine how it has developed over time.

1.1 History of the formulae

The first official IAAF tables were prepared for the 1912 Olympics. There have been several different systems used since then to compare performances in the ten disciplines that comprise the Decathlon. The current system was developed in the early 1980s by a committee including Viktor Trkal, who had been a prime mover in demonstrating the need for an updated system. Surprisingly, this work is not well known, although it is explained in an article in the IAAF Handbook for the Decathlon (IAAF (2001)) and in a couple of other publications. Several researchers have proposed variations of the system, seemingly without being aware of the background to the work carried out by the IAAF Technical committee.

It is worth quoting the nine basic principles the committee followed:

1. The new set of tables should be used for combined events only.
2. Results in various events should, as far as possible, yield about the same number of points if the results are comparable as to quality and difficulty.
3. The new tables should be either:
   a) a modification of the existing ones
   b) a straight line in all events
   c) slightly progressive tables in all events.
4. It must be possible to use the scoring tables for beginners, juniors and top athletes as well.
5. There will be a special scoring table for men and another table for women.
6. All the new versions of the scoring tables should be based on the statistical data for the combined events by paying due regard to the statistical data for performances by single event athletes.
7. The new tables should be applicable now and for the future.
8. It is desirable without creating other problems, that the total scores using the new tables for the top world class athletes should remain approximately the same. That is about 8500 points for the decathlon and about 6500 points for the heptathlon.
9. As far as possible the new tables must insure that a specialist in one event cannot overcome performances in the other events.

Principle 3(c) was used and not 3(a) or 3(b). 3(c) excludes regressive scoring systems (where improvements at higher levels receive *less* reward than improvements at lower levels), something that had applied to some of the events in the previously used scoring system.

Principle 6 is fairly flexible. There have been suggestions that combined events' performances should be scaled by world record performances in individual events. This could be allowed by principle 6, but was not followed. Apart from anything else, every change in a world record for one of the ten events would imply a change in the scoring system for the Decathlon.

The formulae for the ten events are all of the same form

$$P=a*|X-b|**c$$

a, *b*, and *c* are the parameters for the event, X is the performance (measured in seconds, metres or centimetres) and P is the resulting number of points. Results are always rounded down to the next whole number and added across the ten events to give the overall result. The *b* parameters were chosen to match plausible zero performances. For instance, for the long jump it was assumed that everyone could manage a step of length 220 cms and so that is worth 0 points. The *a* and *c* parameters were chosen to match performance data made available to the Technical Committee by IAAF member countries.

Figure 1 shows the points formula for the long jump. In the region of interest (i.e. jumps of at least 6 metres) the function looks almost linear, though, of course, it is not. The effect of the non-linearity can be seen from the line fitted to better performances. The official formula awards 814 points for a jump of 7 metres while the linear regression gives 818 points. For 8 metres the corresponding figures are 1061 and 1060 points. The regression awards 0 points for a jump of 3.62 metres and -343 points for the formula's baseline value of 2.2 metres.

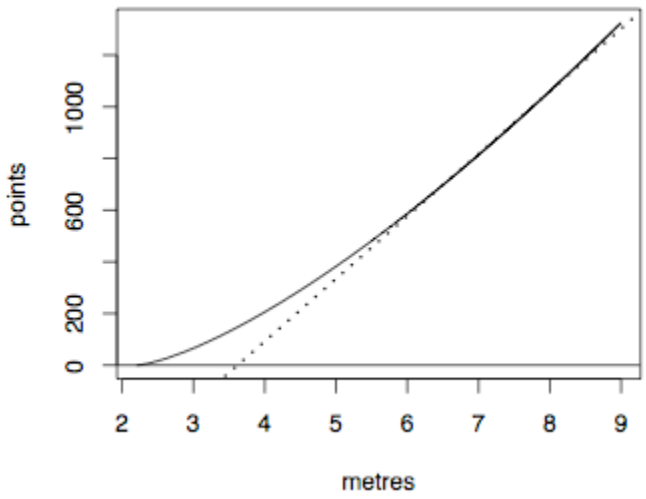

Figure 1 A graph of the points formula for the long jump with a linear fit to performances between 6 and 8.5 metres.

2. Dataset

A group in Estonia have created a webpage that provides detailed results of all top performances over the last twenty years (top means that you have to score at least 6800 points). An athlete can only appear at most once in a year, so each annual dataset can be regarded as a record of the distribution of the best athletes of that year. For this study, all performances are included which were not hand-timed and had no missing data. This leaves 7968 records over almost 22 years, from March 1985 to September 2006, with a minimum of 321 in 1985 and a maximum of 399 in 1997. (As most competitions take place between March and September, all years can be regarded as complete. For instance, in 1997, only 27 best performances were recorded in the remaining five months of the year.)

3. Parallel coordinate plots and parallel boxplots

Decathlon data are intrinsically ten-dimensional and so they are difficult to visualize (Cox and Dunn (2002)). Parallel coordinate plots were introduced by Inselberg (e.g. Inselberg (1999)) for just such multivariate structures. Each variable has its own vertical axis in parallel to all others. Individual cases are represented by broken line segments connecting the case values on successive axes. Interactive tools to rescale individual axes, to reorder the variable axes, and to highlight sets of cases are invaluable for exploring the information in the dataset to best effect.

Parallel boxplots are used to show the one-dimensional marginal distributions of the individual variables. They should be distinguished from boxplots by group displays, where distributions of a single variable are compared by group, so that each case only appears in one boxplot. With parallel boxplots, each case appears in every boxplot.

4. Total scores

Figure 2 shows that the distribution of total scores for all scoring over 6800 points has changed little since the new points system was introduced.

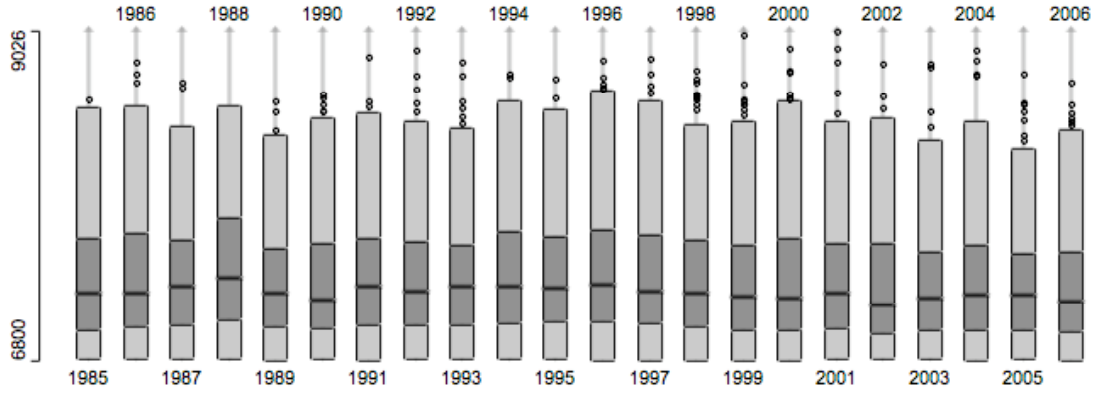

Figure 2 Boxplots for the distributions of total points scores for the years 1985 to 2006. Each boxplot is on the same scale, so they are directly comparable.

Although the points system should be valid for all standards of athlete (principle number 4), there is most interest in the top performances. Another way to look for changes over time is to plot the top performances for each year. Figure 3 shows the 1st, 10th, 20th, 30th so on up to the 100th best performance each year. Again the results show no obvious trend.

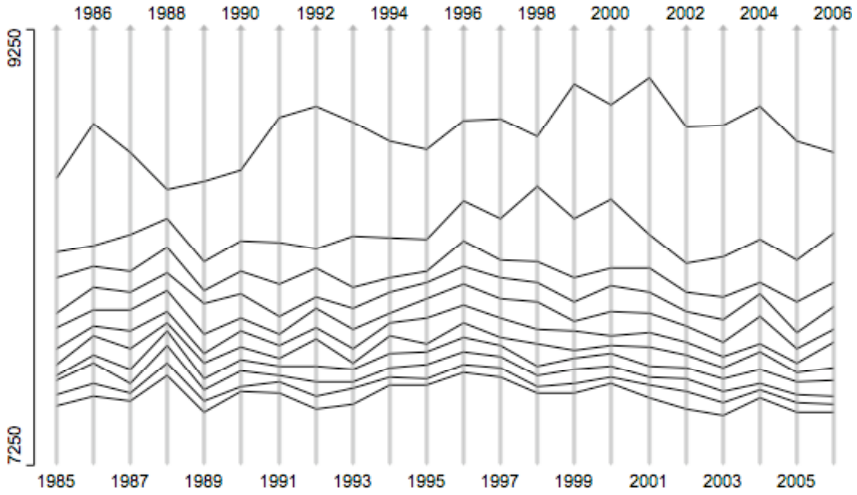

Figure 3 The 1st, 10th, 20th, 30th, … 100th best scores each year.

5. Scores for individual events

Figures 4 and 5 show parallel boxplots of the individual points scores for the ten events in 1985 and 2006. The axes are all to the same scale in both plots. The pattern in 2006 is very similar to the pattern in 1985: the javelin has the lowest median and the 110m hurdles the highest.

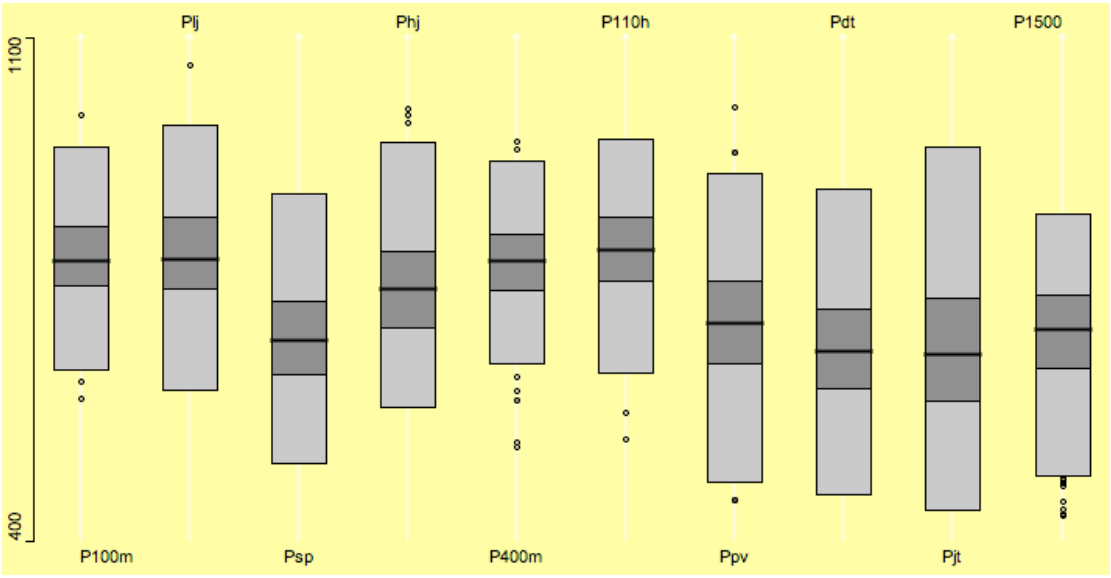

Figure 4 Boxplots of the points scores for the ten Decathlon events in 1985

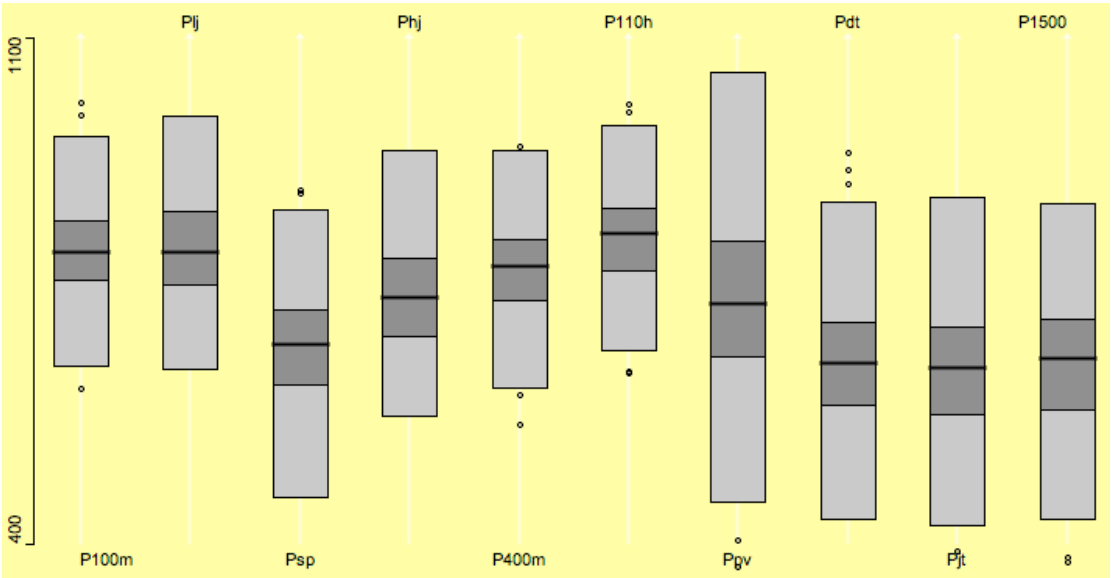

Figure 5 Boxplots of the points scores for the ten Decathlon events in 2006

The distributional patterns over the years for the individual events can be investigated by drawing parallel coordinate plots for particular ranks. Figures 6 and 7 show the displays for the 25th and 200th best performances in each event respectively. Both plots are individually common-scaled (i.e. all the axes have the same scale) with ranges of 250 from low to high. The points scores are again surprisingly stable. The four events with the low scores are the 1500 metres and the three throwing events (Discus, Javelin and Shot Put). The two events which are in the middle in Figure 7 are the High Jump and the Pole Vault.

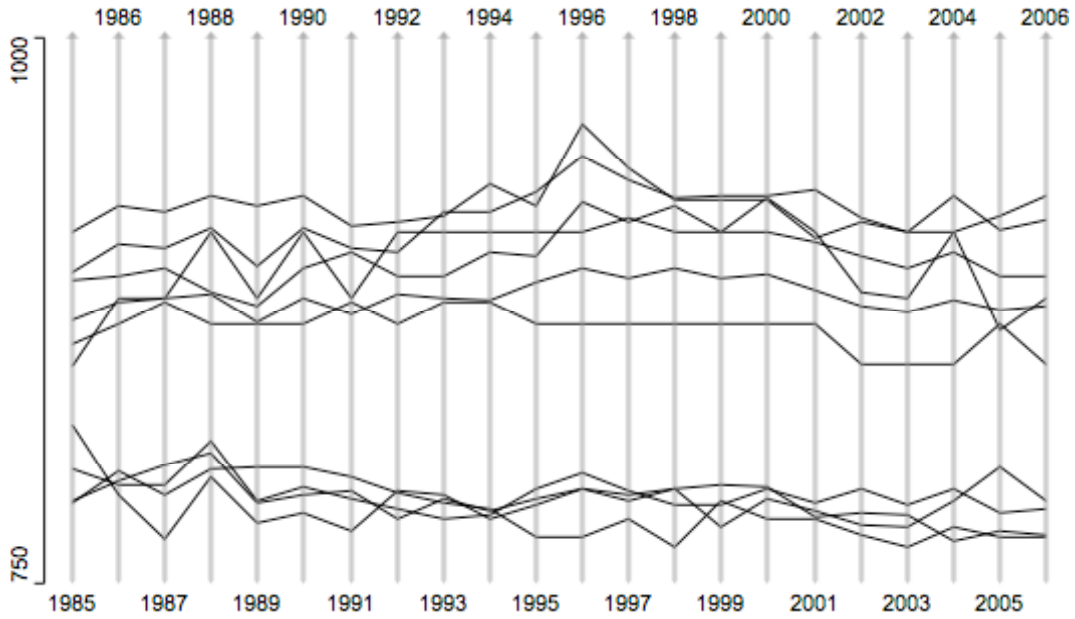

Figure 6 The 25th best performances by year for each of the 10 events.

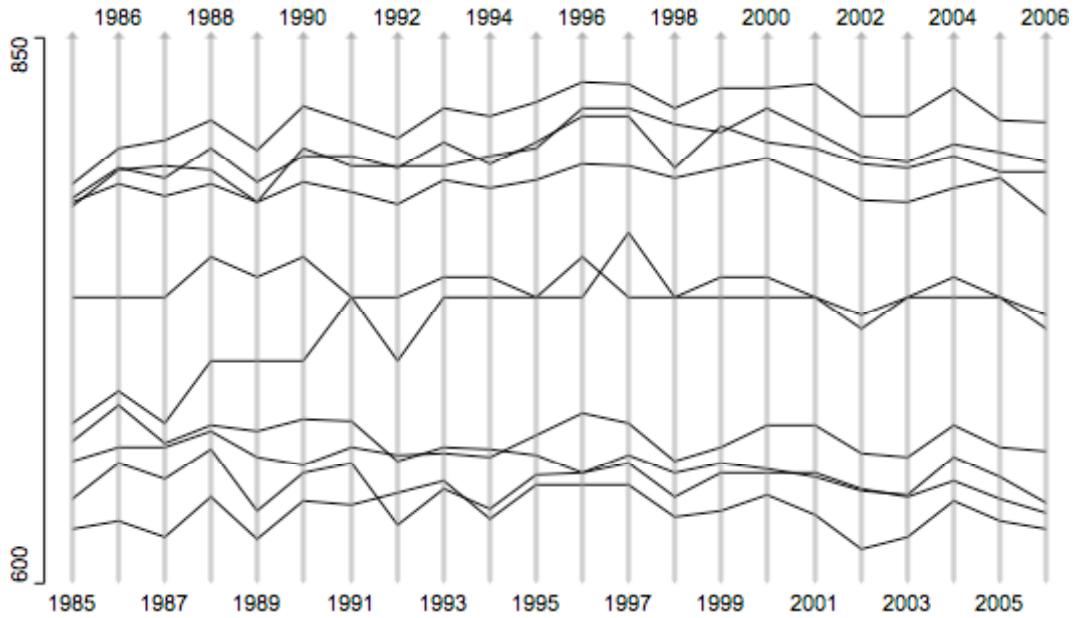

Figure 7 The 200th best performances by year for each of the 10 events.

The fact that performances in one event receive more points than performances in another is not ideal (Principle number 2), but will not necessarily affect results. Points awarded for differences in performance may. Figure 8 shows the differences in points received for the best and 10th best performances in each event by year. Aside from a couple of outliers in the Pole Vault and the Javelin, the graphs show random and equivalent patterns with no obvious trends over time. The average difference per event between the 1st and the 10th best was 77 points, with the four running events having lower differences on average (nearer 50 points) and the six other events higher (nearer 90). As individual best performances can be highly variable, consider instead the differences for the 10th and 50th best performances, shown in Figure 9. The average difference per event is about 68 points, with the four running events having averages of about 15 less and the other events up to 15 more.

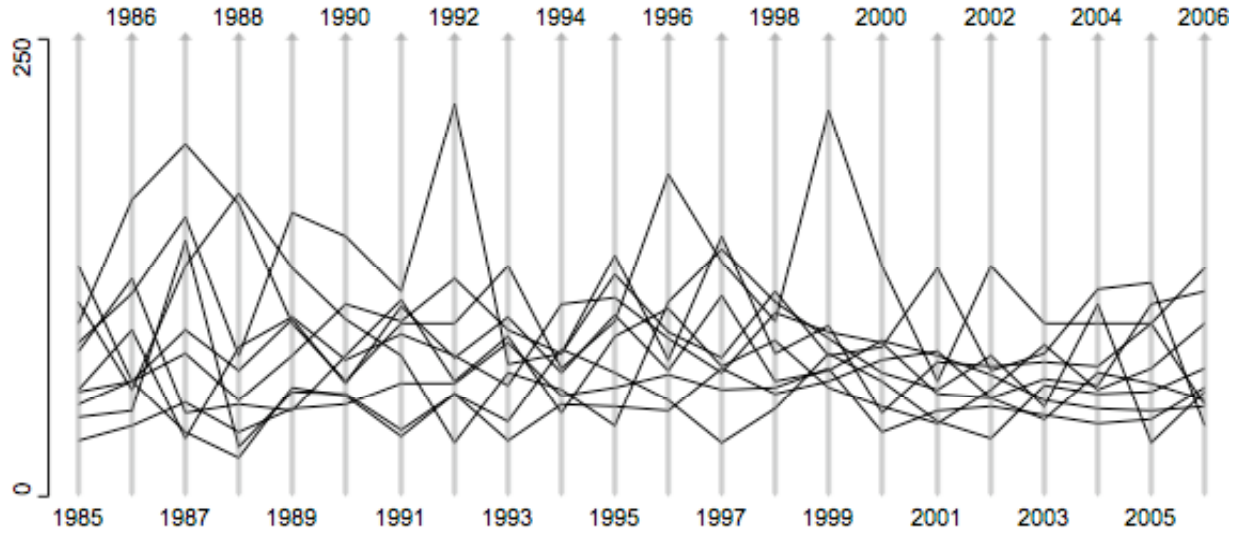

Figure 8 Differences in the 1st and 10th best performances each year by event

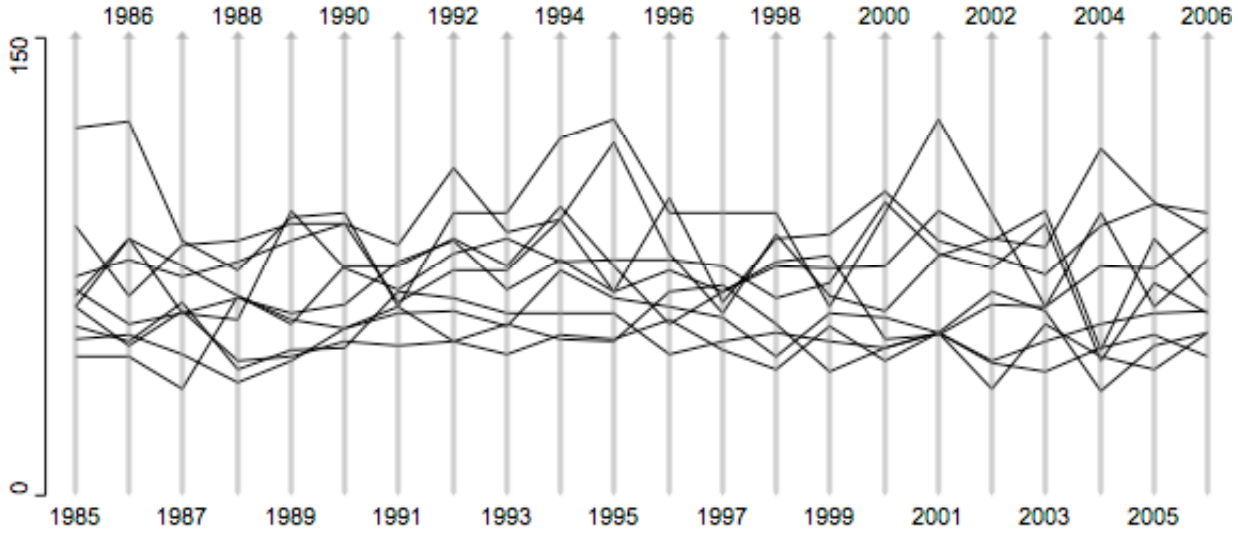

Figure 9 Differences in the 10th and 50th best performances each year by event

6. Conclusions

Parallel coordinate displays are an ideal tool for exploring multivariate data and are especially suitable for Decathlon data. In this paper they have been used to show that the current points formulae have behaved consistently over the twenty years or so they have been in operation. There are some clear differences in the numbers of points awarded by discipline, but there is little evidence that this has affected results unfairly. It is the differences in scores within disciplines which matter, not the absolute scores, and it appears that the four running events are less discriminating than the others.

Acknowledgements

Thanks to Viktor Trkal, Rick Wicklin for constructive discussions, to the group at Decathlon2000 for their excellent website www.decathlon2000.ee and, in particular, to their statistician, Enn Endjärv, and to my former colleague, Martin Theus, for the software Mondrian (http://stats.math.uni-augsburg.de/Mondrian/).

References

Cox, T., Dunn, R. (2002) An Analysis of Decathlon Data. *The Statistician*, 51(2), 179-187.

IAAF (2001) *Scoring Tables for Combined Events*

Inselberg, A. (1998) Visual Data Mining with Parallel Coordinates. *Computational Statistics*, 13(1), 47-63.

Westera, W. (2006) Decathlon, towards a balanced and sustainable performance assessment method. *New Studies in Athletics*(March/April), 37-48.