

Home advantage in the Olympic games

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Abstract.

This paper investigates the extent of home advantage in the Olympic games. The number and type of medals won by each country in the Modern Olympics is analysed. The total number of medals and gold medals won are highly correlated, and many countries show a highly variable performance as measured by the percentage of total medals won. There is a large home advantage or host country affect. The home country wins about three times their away percentage of medals, and about twice their average in the games immediately before and after their home games. There is also evidence that the mix of medals is richer, with home teams winning a proportion of gold medals higher than both their historical average and the proportion available.

1. Introduction

The Olympic games vies with the World Cup of soccer as the World's premier sporting event. The ancient games began at Olympia with a single foot race, and continued for 12 centuries until abolished in 394 AD. The modern Olympics began in 1896, and like its predecessor, the event list has steadily grown. Also like its predecessor, the first modern games did not allow women to compete. However they have steadily increased their participation until they now make up 30% of the competing athletes. These two effects have seen an increasing number of medals awarded. In 1896, 122 medals including 44 gold were awarded. One hundred years later athletes competed for 841 medals including 271 gold.

Success on the sporting field is becoming increasingly important for competing nations. While no official tables are kept, unofficial tallies of the number of gold, silver and bronze medals won by each country are keenly recorded in the media. Final tallies are used by governments to measure the success of sporting policies and allocate funding. How well can Australia expect to perform at the Sydney Olympics? This question could be answered by a detailed analysis of each sport in order to accumulate the total chances of each country winning or placing. For example Dyte and Clarke [1, 2] demonstrate for tennis and soccer a method that could be used to calculate medal chances in most team sports with a knockout or tournament structure. A model is fitted to official rankings to predict a chance of winning any match, and the complete tournament is then simulated to generate probabilities of final finishing positions. In individual events, while several papers have been written predicting winning times and world records [3-5], there is little in the literature giving an athletes chance of winning or achieving a certain place. Perhaps some of the methods used in horse racing could be adapted. However, clearly an approach that requires detailed investigation in each sport is a very large study. Perhaps the conference as a whole could undertake such a study for the 2004 results with each participant looking at a different sport. This study simply investigates the past global results.

Stefani has carried out several studies [6, 7] into performance at the Olympic games, but from the point of improvement in the various sports. A recent paper [8] uses neural networks and regression to model the number of medals countries won at the Atlanta Olympics, based on various economic variables such as area, population and length of rail road track. Sommers [9] also looks at the Atlanta games, and measures the success of nations per unit of population.

Table 1 shows the venues for each of the modern games. Seventeen countries have hosted the games – four countries twice and the USA four times. The modern games had a chequered beginning. The Paris and St.Louis games in 1900 and 1904 were overshadowed by the Paris Universal Exhibition and the Louisiana Purchase Exposition and were not a success. (At the St Louis games in 1904, only 12 nations attended and the USA won 84% of the medals). Interim games were held in 1906 in Athens in an attempt to revive the flagging

Olympic movement. While the IOC does not recognise these as official and they are not numbered in sequence, Wallechensky [10] not only includes them but credits them with helping to save the Olympic movement. An Olympiad is a period of 4 years starting with an Olympics, so the numbering was also upset by the World Wars. Thus while Sydney will be held in the 27th Olympiad it will be the 24th official modern games.

Table 1.
Venues for the Modern Olympic Games.

Olympiad	Year	City	Country	Number of countries to win medals	Number of Medals
I	1896	Athens	Greece	10	122
II	1900	Paris	France	18	276
III	1904	St. Louis	U.S.A.	9	282
	1906	Athens	Greece	19	226
IV	1908	London	Great Britain	19	323
V	1912	Stockholm	Sweden	18	309
VI	1916	Berlin	Germany	Cancelled	
VII	1920	Antwerp	Belgium	22	435
VIII	1924	Paris	France	26	366
IX	1928	Amsterdam	Netherlands	33	327
X	1932	Los Angeles	U.S.A.	27	348
XI	1936	Berlin	Germany	32	388
XII	1940	Tokyo Helsinki	Japan Finland	Cancelled	
XIII	1944	London	Great Britain	Cancelled	
XIV	1948	London	Great Britain	33	409
XV	1952	Helsinki	Finland	43	459
XVI	1956	Melbourne	Australia	39	470
XVII	1960	Rome	Italy	45	464
XVIII	1964	Tokyo	Japan	42	498
XIX	1968	Mexico City	Mexico	43	525
XX	1972	Munich	Germany	46	596
XXI	1976	Montreal	Canada	41	613
XXII	1980	Moscow	U.S.S.R.	36	631
XXIII	1984	Los Angeles	U.S.A.	46	687
XXIV	1988	Seoul	South Korea	52	739
XXV	1992	Barcelona	Spain	64	815
XXVI	1996	Atlanta	U.S.A.	78	841
XXVII	2000	Sydney	Australia		

Of the 17 countries to host the Olympics, 14 have won their greatest ever percentage of available medals at home. In studying the performance of countries in the Olympics, the effects of home ground advantage arise. The existence of home advantage in sport is well documented, but most study centres around team sports. It is well known that home teams win a majority of the matches at home. The causes of home advantage are usually listed as positive effects for the home side due to ground familiarity and a partisan crowd, and negative effects on the visitors mainly due to travel. Clearly such effects are present during an Olympic games.

While the games are awarded to a host city, the causes of home advantage apply to all athletes from the home country. In Sydney, visiting athletes will suffer from change in season and time zones, while Australian athletes will have a home crowd to spur them on. While most research on home advantage has been within country, Stefani [11, 12] shows that in soccer the effects increase once international travel is involved. While there appears to be little research on the effects of home advantage in individual sports, the performance of

French and Spanish tennis players in the French Open is a good example of players performing better on home or near home soil.

There are some other reasons peculiar to the Olympics why the home country can expect to do better than usual. The home country has some choice in the sports that will be offered, and naturally includes sports in which it excels or has a special interest. The host country also fields larger teams and competes in a larger range of events than usual. In addition boycotts have marred several games, reducing the strength of competition. Since no country has boycotted its own games, this has advantaged the home team.

2. Analysis and discussion

The data analysed in this paper consist of the final gold silver and bronze medal tallies of all competing countries. Although unofficial, such tables are of great interest during the conduct of the games, usually published in order of the number of gold medals won. Results can be collected from various print and web sources. For example, Wallechinsky [10] has details for all events up to 1984. The data used here were collected by undergraduate students and consist of the gold, silver and bronze medal tallies for all countries that won medals – a total of 841 observations. There were no data on the countries that competed but won no medals. Table 1 also shows the total number of countries that won medals, and the total number of medals awarded.

There are many factors that could be taken into account when analysing the data. The increasing number of medals awarded means that most strong countries will increase their medal tally throughout the period. For this reason we generally model here the percentage of available medals won by each competing country. Boycotts in particular years will obviously affect the strength of competition. More subtle effects arise with the amalgamation or separation of countries. For example, a field event might now see many strong competitors from countries previously part of the USSR. Such effects would generally strengthen individual events by increasing the number of competitors, but may weaken or strengthen team events, since players are spread more thinly over more teams. To allow for such effects is beyond the scope of this paper. We merely seek to measure in a global way the overall performance of countries and the effect of home advantage.

Total medals versus gold medals.

While many countries measure their success by the number of gold medals won, there is a larger percentage of random element present in this measure than in the total number of medals won, and the latter may be a preferable measure. Figure 1 shows the total number of medals won each year against the number of Gold for Australia, with the home performance marked with a +. This illustrates the strong relationship between the two measures that exists for most countries. For Australia, the correlation between the total number of medals and the number of Gold medals is 0.87. The correlation between Gold and Silver is 0.71, and between Silver and Bronze is 0.69. For the stronger USA, these figures rise to 0.95, 0.92 and 0.90.

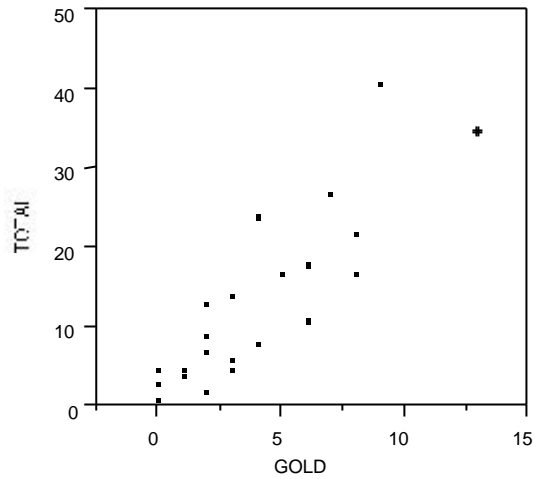


Figure 1. Total number of medals won against number of gold medals won for Australia

Performance over time

When the performance of a single country is investigated over time, most countries show some trend in performance. The number of gold medals won by the USA is shown in Figure 2, with home performances marked with a +. This appears to demonstrate a steady increase in success by the USA, with outstanding performances when on home territory.

However when the increasing number of medals awarded is taken into account the story is not so rosy. Figure 3 gives the number of medals won by the USA as a percentage of the medals available. While this is distorted by the performance in St Louis, it shows what now appears to be a slightly decreasing trend. Again, the home performances stand out, with the exception of Atlanta, which now appears as a poor performance.

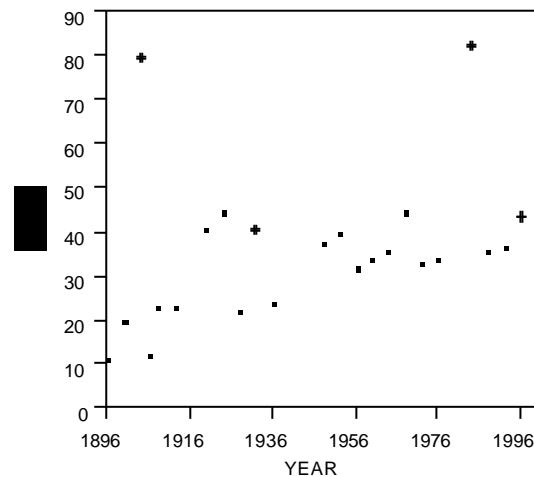


Figure 2. The number of gold medals won by the USA each year

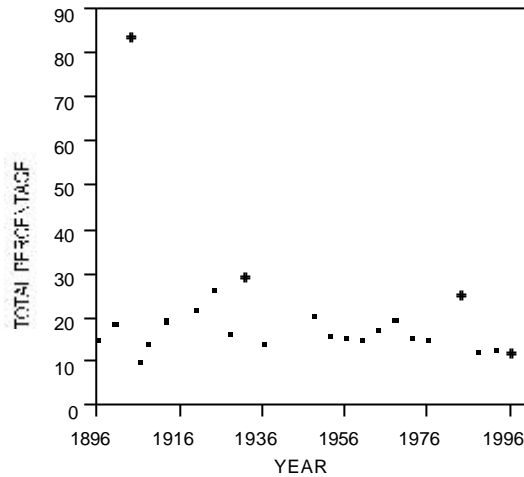


Figure 3. Number of medals won by the USA as a percentage of medals available.

Australia's performance

The performance of Australia in all Olympics is shown in Table 2. The percentage of all medals that Australia has won is given in Figure 4. A smoothing spline highlights the changes in performance. Such rises and falls are often attributed in the media to events such as the establishment of the Institute of Sport. This was proposed following the performance in Canada, where Australia failed to gain a gold medal. While the figures show that Australia's performance has improved over the years, the huge variation in performance to be expected from year to year demonstrates the folly of attempting to predict a tally for an individual country. However home performance is again an obvious outlier, with Australian winning over 50% more medals than its next most successful games.

Table 2.
Australia's Olympic performance

Year	Gold	Silver	Bronze	Total	Percentage of available medals won.
1896	2	0	0	2	1.64
1900	4	0	4	8	2.90
1906	0	0	3	3	1.33
1908	1	2	2	5	1.55
1912	2	2	3	7	2.27
1920	0	2	1	3	0.69
1924	3	1	2	6	1.64
1928	1	2	1	4	1.22
1932	3	1	1	5	1.44
1936	0	0	1	1	0.26
1948	2	6	5	13	3.18
1952	6	2	3	11	2.40
1956	13	8	14	35	7.45
1960	8	8	6	22	4.74
1964	6	2	10	18	3.61
1968	5	7	5	17	3.24
1972	8	7	2	17	2.85
1976	0	1	4	5	0.82
1980	2	2	5	9	1.43
1984	4	8	12	24	3.49
1988	3	6	5	14	1.89
1992	7	9	11	27	3.31
1996	9	9	23	41	4.88

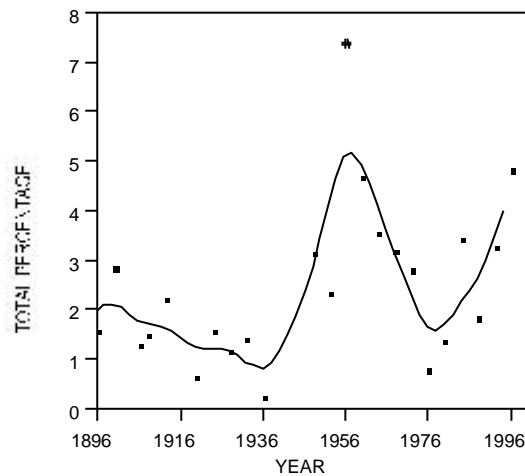


Figure 4. Percentage of available medals Australia won each year

Comparison of home to away performance.

In order to compare the home and away performance we concentrate on the percentage of available medals won for the 17 countries who have hosted a games. There are several ways of estimating home performance. Table 3 lists the teams that have hosted games, along with their average home performance and away performance. There is clearly a large home advantage. Canada is the only country to do worse at home, and the median ratio is 3.5. Thus 50% of host countries win more than 3.5 times their historical average of medals. Since the original data only includes Olympics where that team won medals, there may be away games where the team won no medals that are not included. If anything, the figures underrate the effect of home advantage.

Table 3
Percentage of available medals won by host countries at home and away

Country	Percentage of available medals won		Ratio Home:Away
	Away	Home	
Australia	2.3	7.4	3.2
Belgium	1.3	8.1	6.0
Canada	2.1	1.8	0.9
Finland	3.3	4.8	1.4
France	5.0	23.7	4.8
Great Britain	5.3	25.3	4.8
Germany	6.6	14.8	2.2
Greece	0.4	26.8	62.3
The Netherlands	1.7	5.8	3.4
Italy	4.3	7.8	1.8
Japan	3.1	5.8	1.9
Korea	1.2	4.5	3.6
Mexico	0.4	1.7	3.9
Soviet Union	16.9	30.9	1.8
Spain	0.5	2.7	5.1
Sweden	4.5	21.0	4.7
USA	17.0	37.9	2.2

The high home advantage for Greece in Table 3 demonstrates that the early Olympics, where a few powerful countries were very successful, can distort figures. Various combinations can be tried, but the overall pattern remains. For example, restricting the data to the games after Melbourne, and excluding data from the boycotted games at Moscow and Los Angeles, gives the results shown in Table 4. The USA is now the only team to do worse at home, Germany does the same, but most countries perform much better. Canada is now 40% better at home. Again the median performance is high at 2.5 times better at home.

Table 4.
Percentage of available medals won at home and away by host countries at Olympic games 1960-1976, 1988-1996.

Country	Percentage of available medals won		Ratio Home:Away
	Away	Home	
Italy	3.1	7.8	2.5
Japan	3.7	5.8	1.6
Mexico	0.2	1.7	8.6
Germany	6.7	6.7	1.0
Canada	1.3	1.8	1.4
Korea	1.3	4.5	3.4
Spain	0.7	2.7	4.2
USA	15.8	12.0	0.8

Trends in performance coupled with a bias in the selection process for host cities could distort the above averages. For example, if a rising performance in sport were a factor in gaining selection as host country, home teams would generally perform better at home than they had

historically. Comparing the percentage of medals won at their home games, with the average percentage of medals won in the most recent games in which they competed prior to hosting the games and the earliest games in which they competed after they host the games, allows for any increase or decrease in performance over time. The results are given in Table 5. Again the ratios are generally greater than one with a median of about two. Clearly the home advantage is not due to some ancient performances or the results of boycotts, and is still present in recent performances.

Table 5
Comparison of percentage of available medals won by host countries at home and in the Olympics before and after home games.

Year	Country	Average of performance in games before and after being host	Home performance	Ratio
1896	Greece	11.4	38.5	3.4
1900	France	13.4	37.0	2.8
1904	U.S.A.	14.7	84.4	5.7
1906	Greece	19.9	15.0	0.8
1908	Great Britain	12.2	44.9	3.7
1912	Sweden	11.1	21.0	1.9
1920	Belgium	1.4	8.1	5.6
1924	France	7.9	10.4	1.3
1928	Netherlands	2.4	5.8	2.4
1932	U.S.A.	15.8	29.9	1.9
1936	Germany	5.6	22.9	4.1
1948	Great Britain	3.0	5.6	1.9
1952	Finland	4.0	4.8	1.2
1956	Australia	3.6	7.5	2.1
1960	Italy	5.4	7.8	1.4
1964	Japan	4.3	5.8	1.3
1968	Mexico	0.2	1.7	9.3
1972	Germany	5.7	6.7	1.2
1976	Canada	3.6	1.8	0.5
1980	U.S.S.R.	19.1	30.9	1.6
1984	U.S.A.	14.0	25.3	1.8
1988	Korea	3.6	4.5	1.3
1992	Spain	1.3	2.7	2.1
1996	U.S.A.	13.3	12.0	0.9

Proportion of gold medals

There is evidence in the literature that in many sports different teams enjoy different levels of home advantage [12-14]. This would probably be true in the Olympics, where teams may or may not travel across several time zones and even seasons, and to possibly different cultures. The question arises whether home advantage is greater for the better athletes. It seems reasonable that crowd involvement may be greater when a home athlete is a chance for gold than when they are possibly vying for a medal. This should produce a greater proportion of gold medals for home teams than normally. A higher proportion of gold medals is also obtained under a model where a country that normally wins the same proportion of gold silver, bronze and fourth places enjoys a home advantage that lifts the same proportion of placegetters up one level. Both these effects would result in a 'richer' mixture of winning medals. The actual numbers of medals available alters both in number and proportion at various games. In the early days, the number of gold exceeded the number of silver and

bronze, but this is reversed in later games, with more bronze medals than gold being awarded. In total, 7376 gold, 7280 silver and 7642 bronze have been awarded for an overall percentage of gold medals of 33% gold. Table 6 gives the proportion of gold medals won by the host country at each Olympics, and compares it with both their average away proportion and the actual proportion of gold medals available at their home games. Certainly in the second half of the century, almost all teams have won a richer mixture of medals than both their away games average and the average available at their home games. From the time of the last games in Australia, Canada with no gold is the only country to have a worse winning mixture than was available. The median home performance has a 10% richer mix than is available and than their historical performance. Apart from the early games, most teams win both a greater percentage of gold medals at home, and better than expected at home. Clearly a home country is likely to have a richer mix than their own average in away games and the overall average at their own games.

Table 6
Percentage of gold medals won by host countries

Country	YEAR	Gold medals won as Percentage of total won	Percentage of gold medals available	Average away percentage of gold medals
Greece	1896	21.3	36.1	27.8
France	1900	28.4	34.8	31.1
U.S.A.	1904	33.6	35.1	43.1
Greece	1906	23.5	34.1	27.8
Great Britain	1908	38.6	34.1	23.5
Sweden	1912	36.9	32.7	29.3
Belgium	1920	40.0	35.9	23.2
France	1924	34.2	33.9	31.1
Netherlands	1928	31.6	33.6	20.8
U.S.A.	1932	39.4	33.6	43.1
Germany	1936	37.1	33.5	27.9
Great Britain	1948	13.0	33.7	23.5
Finland	1952	27.3	32.5	35.1
Australia	1956	37.1	32.6	29.9
Italy	1960	36.1	33.0	38.8
Japan	1964	55.2	32.7	26.4
Mexico	1968	33.3	33.1	12.4
Germany	1972	32.5	32.7	27.9
Canada	1976	0.0	32.3	24.7
U.S.S.R.	1980	41.0	32.3	39.0
U.S.A.	1984	47.7	32.9	43.1
Korea	1988	36.4	32.6	11.6
Spain	1992	59.1	31.8	14.7
U.S.A.	1996	43.6	32.2	43.1

3. Conclusion

There is a large random element in the performance of countries in the Olympic games. The total number of medals and gold medals are highly correlated, and the number of medals awarded has steadily increased over the years. The percentage of all available medals would be a better measure of a country's performance than the number of gold, which is the measure usually trumpeted by the media. Australia's performance has steadily increased over the years, with a more dramatic increase since Montreal. In 2000 Australia has the bonus of what is clearly a large home advantage. Historically the home team wins over three times their usual percentage of medals, but this may be difficult to achieve given the large base level of performance Australia has recently attained. At its last home Olympics, Australia gained 7.6% of available medals, twice the percentage they achieved in the games

immediately before and after Melbourne. However the isolation of Melbourne in 1956 resulted in a low number of athletes attending, and the games were also weakened by two boycotts. This time Australia is also coming off a strong performance in Atlanta of nearly 5% so to expect a repeat performance of their last games effort might be optimistic. However there is also strong evidence that the mix of medals is richer for the home teams, so Australia can expect to win a proportion of the gold medals greater than both their long term average of 30% and the actual percentage available at Sydney.

In making predictions there is always the effect of randomness. Most of the above applies equally well to Canada, a country usually about the same level as Australia on the medal tally. Let's hope that after Sydney, Canada remains the only country in the Modern Olympics not to win a gold medal at the games they host.

4. References.

1. Clarke, S.R. and D.S. Dyte, Using official ratings to simulate major tennis tournaments. Submitted
2. Dyte, D. and S.R. Clarke, A ratings based model for World Cup soccer. Submitted.
3. Blest, D.C., Lower bounds for athletic performance. *The Statistician*, 1996. **45**(2): p. 243-253.
4. Grubb, H.J., Models for comparing athletic performances. *The Statistician*, 1998. **47**(3): p. 509-521.
5. Heazlewood, I.T. and G. Lackey, The use of mathematical models to predict elite athletic performance at the Olympic games, in *Mathematics and Computers in Sport*, N. de Mestre, Editor. 1996, Bond University: Gold Coast, Qld. p. 185-205.
6. Stefani, R.T. Applying least squares to team sports and Olympic winning performances. in *Mathematics and Computers in Sport*. 1992. Gold Coast, Qld: Bond University.
7. Stefani, R., Predicting Outcomes, in *Statistics in Sport*, J. Bennett, Editor. 1998, Nicki Dennis. p. 249-273.
8. Condon, E.M., B.L. Golden, and E.A. Wasil, Predicting the success of nations at the Summer Olympics using neural networks. *Computers and Operations Research*, 1999. **26**: p. 1243-1265.
9. Sommers, P.M., Meddling with 1996 Olympic results. *Chance*, 1996. **9**(4): p. 28-30.
10. Wallechinsky, D., *The Complete Book of the Olympics*. 1984, New York: Penguin.
11. Stefani, R.T., Observed betting tendencies and suggested betting strategies for European football pools. *The Statistician*, 1983. **32**: p. 319-329.
12. Stefani, R.T. and S.R. Clarke, Predictions and home advantage for Australian rules football. *Journal of Applied Statistics*, 1992. **19**(2): p. 251-261.
13. Harville, D.A. and M.H. Smith, The home-court advantage: How large is it, and does it vary from team to team? *The American Statistician*, 1994. **48**(1): p. 22-28.
14. Clarke, S.R. and J.M. Norman, Home ground advantage of individual clubs in English soccer. *The Statistician*, 1995. **44**(4): p. 509-521.

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