ANALYSIS OF THE BEST WOMEN'S HIGH JUMP RESULTS IN THE OLYMPIC GAMES HISTORY

Dario Škegro and Zrinko Čustonja

Faculty of Kinesiology, University of Zagreb, Croatia

Original scientific paper

Abstract

The aim of the investigation was to analyse women's high jump performances in the Olympic Games' history. Analysis covers results of the gold, silver and bronze women medallists in Olympic high jumping. The possibilities of forecasting performances on the polynomial linear regression basis were commented. The dynamics of results progression was explained. Analysis was based on the results of 60 women athletes, winners of the gold, silver or bronze medal at the Olympic Games since 1928 in Amsterdam until 2012 in London.

***Key words**: high jump, history of Olympic Games, regression analysis, best results*

Introduction

Monitoring the results achieved at the Olympic Games or at other main sports competitions can offer numerous answers to the issues of the structure and effects of sport training process, efficiency of learning technical and tactical elements in certain sporting discipline, new technologies influence, quality of new diagnostic procedures application and development of sports results themselves through history. Historically, the development of sports results is important for tracking progression in and determination of developmental characteristics of athletes pertaining to certain sports through observing great sport competitions like the Olympic Games, World and European Championships and other main competitions. Analysis of result development is especially suitable in athletics' disciplines since sport achievements have been measured exactly. Competitions in athletics are held worldwide under standardized conditions, determined by the IAAF rules (IAAF, 2011). The results/achievements are obtained highly objective, with no impact from referees. Therefore, ranking of competitors in athletics' disciplines is based on highly precise measurements. Numerous recent research studies give coaches and athletes valuable feedback on the previously mentioned issues. Scientifically based analyses and forecasting in certain sporting disciplines is founded on the already existing insights into stable regularities of the sport in question (Harasin, 2002; Lepers, 2008; Milinović, Milanović and Harasin, 2008; Chiu and Salem, 2010). By analysing sports results it is possible to determine general principles of achievement development of individuals. These general principles enable sport practitioners to determine probable achievements of individual athletes and also of sport discipline in general (Wazny, 1978). Also, development of the results and records in sport is a reliable way to get an insight into potentials of human body (modified to Lippi et al., 2008).

Women's high jump competition is a part of the official Olympic program since the 1928 Olympic Games in Amsterdam, Holland. Number of competitors on these Games was 3014 from 46 countries of the world, and only 290 of them were women (Platonov and Guskov, 1997). The first woman gold medallist in this discipline was a Canadian athlete Ethel Catherwood. Her winning result was 159 centimetres (Wallechinsky, 2000). Since then till the London Olympic Games in 2012 this athletics' discipline has become very popular, as can be seen in the Games and other great sport competitions. The main goal of this investigation was to establish trend of result development in women's high jump at the Olympic Games tournament. Also, the authors wanted to discuss possibilities of predicting results for the competitions to come.

Methods

In this investigation sample of participants is comprised of the winners in woman's high jump competitions at Olympic Games since 1928 in Amsterdam, Holland until 2012 in London, United Kingdom. In 20 Games that were held until today, there were 60 gold, silver and bronze medallists. Consequently, the sample of participants is 60 athletes' winners of Olympic medal in woman's high jump competitions at the Olympics. The data used in this investigation were collected from "The Complete Book of the Olympics" (Wallechinsky, 2000). Since all the results from the Olympic Games were not contained in this book, the rest of the data was collected from the official web site of the Olympic Movement, www.olympic.org. The collected data was analysed and processed using statistical program STATISTICA 9.0 at the Faculty of Kinesiology, University of Zagreb. The trend of result development was analysed to determine whether a successive change of the results had a linear or curvilinear flow.

The linear and polynomial regression analysis was used to process trends of the development of the best results in women's high jump at the Olympics.

Results

Table 1 contains original results of the gold, silver and bronze medallists at the Olympic Games since 1928 in Amsterdam until 2012 in London. Also, in the Table are mean values for every year based on the result of medallists for each year. The results are expressed in centimetres.

Table 1. Original results of women's high jump medallists at the Olympic Games

City and year	Gold	Silver	Bronze	Average
Amsterdam 1928	159	156	156	157
Los Angeles 1932	166	166	160	164
Berlin 1936	160	160	160	160
London 1948	168	168	161	165.66
Helsinki 1952	167	165	163	165
Melbourne 1956	176	167	167	170
Rome 1960	185	171	171	175.66
Tokyo 1964	190	180	178	182.66
Mexico City 1968	182	180	180	180.66
Munich 1972	192	188	188	189.33
Montreal 1976	193	191	191	191.66
Moscow 1980	197	194	194	195
Los Angeles 1984	202	200	197	199.66
Seoul 1988	203	201	199	201
Barcelona 1992	202	200	197	199.66
Atlanta 1996	205	203	201	203
Sydney 2000	201	201	199	200.33
Athens 2004	206	202	202	203.33
Beijing 2008	205	205	203	204.33
London 2012	205	203	203	203.66

Based on the results shown in Table 1 we can depict an image about the progression of results in women's high jump at the modern Olympics. The best result values progressed by 47 centimetres. First time when women's high jump became a part of the official Olympic program in 1928, the winning result was 159 centimetres. This result developed and grew up to 206 centimetres in Athens 2004 and 205 centimetres in Beijing 2008 and London 2012. Accordingly, average of the three best results at the Olympics also progressed from 157 centimetres in 1928 to 203.66 centimetres in 2012. These results are graphically presented in Figure 1.

Development of women's high jump gold medal winner's results

Progression of women's high jump gold medallists' performances is shown in Figure 2. Table 2 contains results of the linear regression analysis computed according to the results of the gold medallists in women's high jump at the Olympic Games since 1928 till 2012. Original results and predicted values based on the computed linear regression are shown in Table 3. Based on the obtained results it can be concluded that the linear regression analysis is not a good tool for assessing performance in the women's high jump at the Olympic Games.

Namely, large differences in the values of the original and the estimated results, or residuals were obtained.

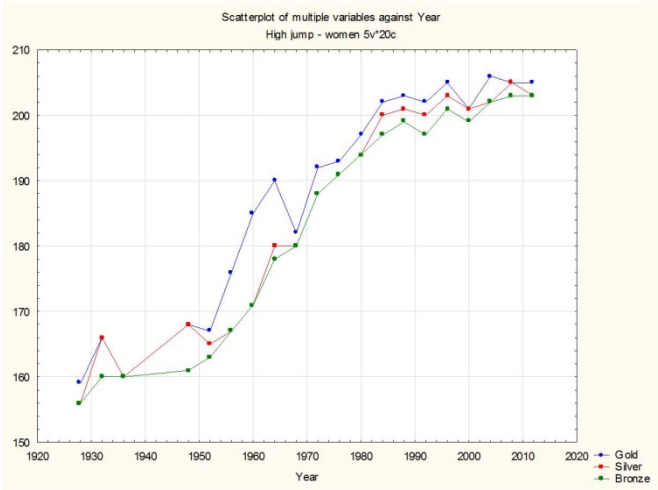

Figure 1. Development of the gold, silver and bronze medallists' results at the women's high jump competitions of the modern Olympic Games since 1928 till 2012.

Figure 2. Development of the best result at women's high jump competitions of the modern Olympic Games since 1928 till 2012.

Table 2. Results of linear regression analysis for the best results at women's high jump competitions at the Olympics

Model is: v2=b0+b1*v1 (High jump - women) Dep. Var.: Gold Level of confidence: 95.0% (alpha=0.050)						
	Estimate	Standard error	t-value df = 18	p-value	Lo. Conf Limit	Up. Conf Limit
b0	-1036.04	887.04	-116.80	0.0000	-1222.40	-849.68
b1	0.62	0.04	138.03	0.0000	0.53	0.72

Figures 3, 4 and 5 show dispersion of the results in a coordinate system using the linear, quadratic and cubic regression equations based on the best performances in women's high jump at the Olympic Games since 1928 till 2012. Also, the results of the original and estimated performance values, along with the residuals, are shown in Tables 4 and 5. The best way to describe progression of the results is to use the quadratic regression equation as shown in Figure 4 and Table 4.

Table 3. Original results, estimated results and residual values for the best results at women's high jump competitions on the Olympics based on the linear regression analysis

Model is: v2=b0+b1*v1 (high jump - women)			
Olympic Games	Original results	Estimated results	Residuals
Amsterdam 1928	159	160.40	-1.40
Los Angeles 1932	166	162.88	3.12
Berlin 1936	160	165.36	-5.36
London 1948	168	172.81	-4.81
Helsinki 1952	167	175.29	-8.29
Melbourne 1956	176	177.77	-1.77
Rome 1960	185	180.26	4.74
Tokyo 1964	190	182.74	7.26
Mexico City 1968	182	185.22	-3.22
Munich 1972	192	187.70	4.30
Montreal 1976	193	190.19	2.81
Moscow 1980	197	192.67	4.33
Los Angeles 1984	202	195.15	6.85
Seoul 1988	203	197.63	5.37
Barcelona 1992	202	200.11	1.89
Atlanta 1996	205	202.60	2.40
Sydney 2000	201	205.08	-4.08
Athens 2004	206	207.56	-1.56
Beijing 2008	205	210.04	-5.04
London 2012	205	212.53	-7.53

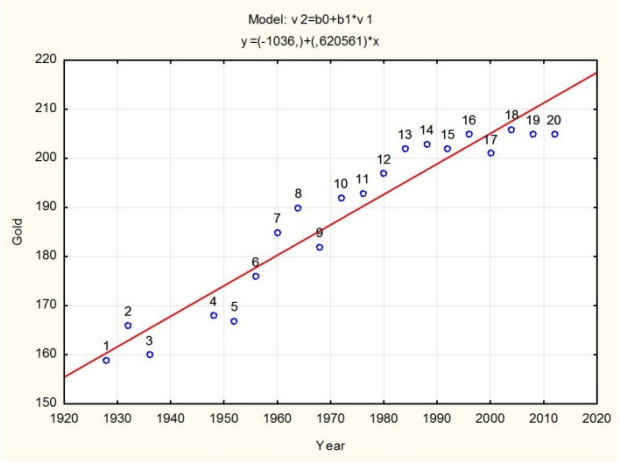

Figure 3. The best results and linear function in a coordinate system computed by the linear regression equation.

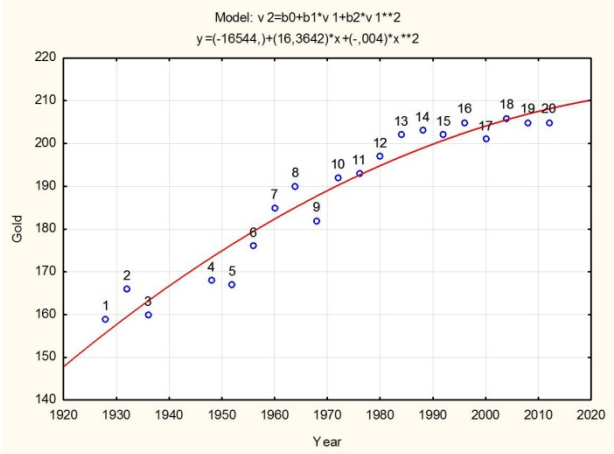

Figure 4. The best results and linear function in a coordinate system computed by the square regression equation.

Just minimal deviations of the estimated results in high jump for women at the Olympic Games from the actual competition results were obtained in calculations using quadratic regression analysis. This is the reason why it is feasible to conclude that the quadratic linear equation is the best way to describe and estimate performance of female high jumpers at the Olympics. This is the way to get best indicators in trend analysis of performances.

Table 4. The original results, estimated results and residual values for the best results in women's high jump competitions of the Olympics based on the quadratic regression analysis

Model is: v2=b0+b1*v1+b2*v1**2 (high jump - women)			
Olympic Games	Original results	Estimated results	Residuals
Amsterdam 1928	159	155.73	3.27
Los Angeles 1932	166	159.51	6.49
Berlin 1936	160	163.15	-3.15
London 1948	168	173.32	-5.32
Helsinki 1952	167	176.45	-9.45
Melbourne 1956	176	179.46	-3.46
Rome 1960	185	182.33	2.67
Tokyo 1964	190	185.08	4.92
Mexico city 1968	182	187.71	-5.71
Munich 1972	192	190.20	1.80
Montreal 1976	193	192.57	0.43
Moscow 1980	197	194.81	2.19
Los Angeles 1984	202	196.92	5.08
Seoul 1988	203	198.90	4.10
Barcelona 1992	202	200.75	1.25
Atlanta 1996	205	202.48	2.52
Sydney 2000	201	204.08	-3.08
Athens 2004	206	205.55	0.45
Beijing 2008	205	206.90	-1.90
London 2012	205	208.11	-3.11

Conclusion

In this paper we brought up a few possible ways to analyse the performance trend in women's high jump top-level competitions. This investigation is based on the best results of 60 female high jumpers at the Olympic Games since 1928 in Amsterdam, Holland, till 2012 in London, United Kingdom.

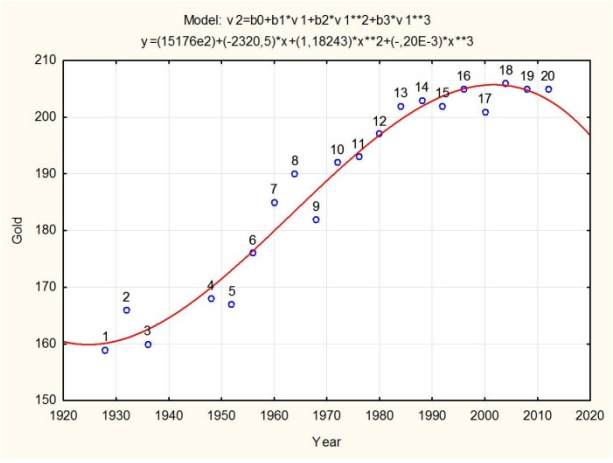

Figure 5. The best results and linear function in a coordinate system computed by the cubic regression equation.

From the plots, which were presented in the study, it can be concluded that the result development of women high jumpers through the Olympic Games' history has a form of progressive regression function. It would be best to use the quadratic regression analysis to describe the performance trend in this discipline. It is important to emphasize that along with the statistical analysis of the results it is crucial to consider other parameters as well. These parameters should include level of athletes' preparedness, their health status, psychological state and level of the development of training technologies in historical contexts of sport results achieved in a certain sport discipline. Namely, estimation and forecasting of the future results based just on the information about performance and computations is not appropriate. To support the afore-mentioned, we wish to highlight that total deviations of the estimated from the original results equalled zero. This shows that forecasting and estimation based just on regression models is meaningless. Of course, all useful information from this system of monitoring sports performance trends must be recognised. That is why it is important to continue with investigations using this or similar models in order to improve sport and sports science.

Table 5. The original results, estimated results and residual values for the best results at women's high jump competitions of the Olympics based on the cubic regression analysis

Model is: v2=b0+b1*v1+b2*v1**2+b3*v1**3 (high jump -			
Olympic Games	Original	Estimated	Residuals
Amsterdam 1928	159	160.11	-1.11
Los Angeles 1932	166	161.02	4.98
Berlin 1936	160	162.54	-2.54
London 1948	168	169.91	-1.91
Helsinki 1952	167	173.06	-6.06
Melbourne 1956	176	176.43	-0.43
Rome 1960	185	179.93	5.07
Tokyo 1964	190	183.50	6.50
Mexico city 1968	182	187.05	-5.05
Munich 1972	192	190.51	1.49
Montreal 1976	193	193.80	-0.80
Moscow 1980	197	196.84	0.16
Los Angeles 1984	202	199.56	2.44
Seoul 1988	203	201.88	1.12
Barcelona 1992	202	203.72	-1.72
Atlanta 1996	205	205.01	-0.01
Sydney 2000	201	205.67	-4.67
Athens 2004	206	205.61	0.39
Beijing 2008	205	204.77	0.23
London 2012	205	203.07	1.93

References

Chiu, L.Z.F., & Salem, G.J. (2010). Time series analysis: Evaluating performance trends within resistance exercise sessions. *Journal of Strength and Conditioning Research*, *24*(1), 230-234.

Harasin, D. (2002). *Analiza trendova u razvoju rezultata u atletskim bacačkim disciplinama na Olimpijskim igrama*. [Performance trend analysis in athletics' throwing disciplines at the Olympic Games. In Croatian.] (Master of Science thesis, University of Zagreb) Zagreb: Kineziološki fakultet Sveučilišta u Zagrebu.

IAAF (2011). Competition rules 2012-2013. Accessed on 15th February, 2013, at the internet address: http://www.iaaf.org/about-iaaf/documents/rules-regulations.

Lepers, R. (2008). Analysis of Hawaii Ironman performances in elite triathletes from 1981 to 2007. *Medicine and Science in Sports and Exercise*, *40*(10), 1828-1834.

Milinović, D., Milanović, D., & Harasin, D. (2008). Analiza razvoja trenda olimpijskih rezultata pobjednica u bacanju koplja. [Performance trend analysis of the champions in women's javelin throwing at the Olympic Games. In Croatian.] In B. Neljak (Ed.), Proceedings of 17. ljetne škole kineziologa, Poreč, 2008 (pp. 141-146). Zagreb: Hrvatski kineziološki savez.

Olympic.org (2013). Official web site of the Olympic Movement: http://www.olympic.org/athletics-high-jump-women.

Platonov, V., & Guskov, S. (1997). *Olympic Sports*. Kyiv: Olympic Literature.

Važni, Z. (1978). *Sistem sportskog treninga*. [Sports training system. In Serbian.]. Beograd: Savez za fizičku kulturu.

Wallechinsky, D. (2000). *The Complete Book of the Olympics*. London: Aurum.

ANALIZA NAJBOLJIH REZULTATA ŽENSKOG SKOKA U VIS U OLIMPIJSKOJ POVIJESTI

Sažetak

Cilj ovog rada jest utvrđivanje trenda razvoja nizova rezultata u ženskom skoku u vis na Olimpijskim igrama kroz povijest. Analiza obuhvaća rezultate osvajačica pojedinih odličja na Olimpijskim igrama od 1928. do 2012. godine te osvrt na prognoziranje rezultata temeljem linearnoga, kvadratnoga i kubnoga regresijskog modela. Na temelju prikupljenih i obrađenih rezultata izražena je dinamika razvoja sportskih rezultata u skoku uvis u navedenom razdoblju. Analiza je provedena na temelju rezultata 60 ispitanica koje su na Olimpijskim igrama od 1928. do 2016. godine bile osvajačice jednoga od odličja.

***Ključne riječi**: skok uvis, povijest Olimpijskih igara, regresijska analiza, najbolji rezultati*

Received: March, 21, 2013
Accepted: June 10, 2013
Correspondence to:
Dario Škegro, PhD
University of Zagreb
Faculty of Kinesiology
10000 Zagreb, Horvaćanski zavoj 15, Croatia
Phone: +385 (0)98 910 1537
E – mail: dskegro@kif.hr