Original Article

A longitudinal study on the sports results' dynamics in the hammer throw event

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Abstract:
This longitudinal study had the purpose to highlight the dynamics of the results recorded during the hammer throw event for one of the country's top sportswomen and to provide some conclusions regarding the evolution of those results together with the training programs. In order to highlight the evolution of the results in the hammer throw event, we have used the following research methods: bibliographic study, observation, results' recording, statistical-mathematical methods and numerical methods of interpolation and approximation. The sports results' collection and recording were taken from the official documents of the Romanian Athletics Federation and of the National Sports Agency. The verified hypotheses have proven that the results recorded from 2003 to 2011 had an increasing dynamics, progress was different from one year to another, and sports competition was better in a certain part of the competition season.
Key words: hammer throw, results, evolution, mathematical interpolation, statistical methods..

Introduction

Sport is a field that has competition as a dominant component, and motivation for obtaining sports results has led to an increase in the number of hours of intense effort. In addition, training has become more sophisticated, partly due to the professionals' and researchers' help in the field of sport. There is currently a wide database on athletes, which is reflected in the methodology of sports training.

Designing a training plan for the performance sportwomen should be based on a well scientifically argumented methodology in order to obtain the expected sports results according to Rață E., 2007.

Hypothesis

In order to highlight the ascending path followed by Bianca Perie, we have accomplished a longitudinal study which covers the period between years 2003 and 2011.

This study started from the hypothesis that the results recorded for a period of 9 years, by a talented sportswoman, have a continuous and balanced progression.

Method

Research was carried out on a single subject, represented by a hammer throw female athlete, who over the years, has managed to become a well-known person in the world of athletics, a person with possibilities to reach top positions in the great international competitions. The sportswoman had been training for 11 years, with a 9-year national experience and a 6-year international one. The conduct of the study implied a collection of results, from the documents of the Romanian Athletics Federation, obtained over a period of 9 years of participation in official competitions. Because over the 9 years, our sportswoman added in her personal record the results collected from one competition to the other, the results have also been recorded and analysed on a yearly basis. As methods of research we used: bibliographic study, observation, case study, statistical-mathematical method, graphical method.

Results

The interpretation of the data recorded in competitions has been carried out on the basis of an analysis of results recorded from a competition season to another, from one year to the other, for the entire competitional period between 2002? and 2011.

Analysis of the 2003 hammer throw results

In 2003, the sportswoman falls within the Juniors III category. At this category, the hammer ball weighs 3 kg (RAF , 2003 - 2011). As it is observed in table no. 1, she threw both a 3-kg hammer and a 4-kg one. The

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results are different in value, a fact that underlines the difference in the effort involved. The values of the results show a significant increase of 4.67 m for the 3-kg hammer throw and 4.93 m for the 4-kg hammer throw.

Table 1. 2003 Results

2003 competition season	Data	Result [m]
Summer (3 kg.)	22.03	52.45
	19.07	56.12
Summer (4 kg.)	22.03	41.75
	31.05	42.20
	21.06	46.68

Analysis of the 2004 hammer throw results

The sportswoman, Bianca Perie, participated in 2004 in one competition during the winter season and in four competitions during the summer season (results archived by RAF , 2003 - 2011).

Table 2. 2004 Results

2004 competition season	Data	Result [m]
Winter	20.03	54.65
Summer	22.05	55.42
	29.05	55.15
	2.06	57.74
	24.07	57.51

As shown in table no. 2, Bianca Perie participated in five official competitions. In the winter competition season, she obtained a result of 54.66 m, a result which is a personal record, and in the summer season competitions she also reached two personal records, with a progress in the competition of 2.08m. The results obtained in 2004 show a good orientation in training and possibilities of evolution.

Analysis of the 2005 hammer throw results

As in the previous year, the sportswoman, Bianca Perie, participated in 2005 in one competition in the winter season and in four competitions in the summer season (results archived by RAF., 2003 - 2011).

Table 3. 2005 Results

2005 competition season	Data	Result [m]
Winter	18.03	65.13
Summer	4.06	63.35
	11.06	64.86
	2.07	61.86
	23.07	53.74

In the winter competition season, she obtained the result of 65.13 m - a special personal record; performance which was not reached in the summer competition season, where she recorded a performance of 64.86 m. Although the 2005 results are special, they do not excel in the summer season, she recorded in the end a result (53.74 m) below the maximum level of the previous year. As shown in table no. 3, Bianca Perie participated in five official competitions. The results obtained underline a decrease in her performances with 11.39 m, starting from the indoor competitions to the outdoor ones, which may be justified by an accident or an inappropriate training program (less likely).

Analysis of the 2006 hammer throw results

As in the previous year, the sportswoman, Bianca Perie, participated in 2006 in a competition in the winter season and in ten competitions in the summer season (results archived by R.A.F., 2003 - 2011).

Table 4. 2006 Results

2006 competition season	Data	Result [m]
Winter	3.03	63.81
Summer	20.05	65.98
	27.05	63.41
	3.06	64.71
	10.06	64.91
	17.06	66.11
	1.07	62.92
	2.07	63.93
	8.07	63.29
	15.07	66.65
	23.07	65.60

In the winter competition season, the result of 63.81 m represented a result weaker than the one in the previous year (obviously, if we look at the results obtained during the summer season of the previous year). Although the 2006 results are good, they do not excel in the summer season, she also recorded an average result below the level of the previous year. As shown in table no. 4, Bianca Perie participated in eleven official competitions.

Analysis of the 2007 hammer throw results

As in the previous year, the sportswoman, Bianca Perie, participated in 2007 in a competition in the winter season and in 11 competitions in the summer season (results archived by RAF., 2003 - 2011).

Table 5. 2007 Results

2006 competition season	Data	Result [m]
Winter	9.03	67.24
Summer	5.05	63.40
	20.05	65.24
	26.05	63.88
	2.06	62.19
	10.06	64.30
	16.06	64.50
	23.05	64.45
	30.06	63.29
	27.07	62.10
	11.08	63.29
	23.07	66.10

In the winter competition season, the result of 67.24 m represented a new personal record, but as in 2005, this performance was no longer reached in the summer competition season, where the best performance was 66.10 m. The results of the summer of 2007 were slightly below the level of 2006; they do not excel and were below the maximum level of the previous year.

As shown in table no. 5, Bianca Perie participated in 12 official competitions. The results obtained in the summer of 2007 recorded for the second time a decrease in performance from the indoor competitions. We can also underline the high fluctuation from one competition to another.

Analysis of the 2008 hammer throw results

In 2008, as in the previous year, the sportswoman, Bianca Perie, participated in a competition in the winter season and in 4 competitions in the summer season (results archived by RAF. 2003 - 2011).

Table 6. 2008 Results

2008 competition season	Data	Result [m]
Winter	7.03	69.59
Summer	1.06	64.32
	6.06	67.20
	5.07	66.13
	12.07	66.91

In the winter competition season, the result of 69.59 m represented a special new personal record (close to the barrier of 70 m), performance which was no longer reached during the summer competition season, where the best performance was 66.91 m. The results in the summer of 2008 are better than those in 2007. As shown in table no. 6, Bianca Perie participated in 5 official competitions. The results obtained in the summer season of 2008 show a steady increase in performance and certain stability in throwing.

Analysis of the 2009 hammer throw results

The sportswoman, Bianca Perie, participated in 2009, as in the previous year, in a competition in the winter season and in 7 competitions in the summer season (results archived by RAF. 2003 - 2011).

Table 7. 2009 Results

2008 competition season	Data	Result [m]
Winter	6.03	67.97
Summer	9.05	65.77
	22.05	65.55
	30.05	69.00
	5.06	68.35
	18.07	68.53
	1.08	69.40
	14.08	69.63

In the winter competition season, the result of 67.97 m represented the athlete's personal indoor record. This performance was repeatedly overcome in the summer competition season, the sportswoman reaching a new personal record of 69.63 m. The results of the summer of 2009 were better than in 2008, and the dynamics of performance anticipated the results of the following year.

As shown in table no. 7, Bianca Perie participated in 8 official competitions.

Analysis of the 2010 hammer throw results

The sportswoman, Bianca Perie, participated in 2010, as in the previous year, in a competition in the winter season and in 3 competitions in the summer season (results archived by RAF . 2003 - 2011).

Table 8. 2010 Results

2010 competition season	Data	Result [m]
Winter	9.03	66.68
Summer	8.05	64.60
	21.05	65.58
	16.07	73.52

In the winter competition season results of 66.68 m represents a reasonable performance. This performance is improved in the summer competition season with a new personal record of 73.52 m. The results in the summer of 2010 underline large variations of the results obtained, but also a special quality increase. As shown in table no. 8, Bianca Perie took part in only 4 official competitions. The results obtained in 2010 demonstrate the possibility of increasing performance in a period of maturity of activity.

Analysis of the 2011 hammer throw results

The sportswoman, Bianca Perie, participated in 2011, as in the previous year, in a competition in the winter season and in 4 competitions in the summer season (results archived by RAF . 2003 - 2011).

Table 9 - 2011 Results

2011 competitional season	Data	Result [m]
Winter	8.03	67.32
Summer	14.05	67.82
	20.05	67.72
	29.06	70.23
	16,07	71.56
	18.08	71.21

In the winter competition season, the athlete carried out a reasonable performance of 67.32 m. This performance was constantly improving during the summer competition season. The results in the summer of 2011 reveal a slight regression of results, with a particular qualitative leap of 3.84m in the first half of the season. As shown in table no. 9, Bianca Perie participated in 6 official competitions.

Dynamics of results recorded from 2002? to 2011

The evolution of results recorded by Bianca Perie over the 9 years of training and competition participation is shown in table no. 10 and in the following figures. In order to highlight progress and explain certain aspects, we have chosen, for analysis, the best performance recorded in the indoor competition season and the summer season of each year.

Table no.10 Synthesis of results according to the competitional years (in m)

YEAR	2003(4kg)	2004	2005	2006	2007	2008	2009	2010	2011
WINTER	40	54.65	65.13	63.81	67.24	69.59	67.97	66.68	67.32
SUMMER min	41.75	55.15	53.74	62.92	62.19	64.32	65.55	64.60	67.72
SUMMER max	46.68	57.74	64.86	66.65	66.10	66.91	69.63	73.52	71.56
SUMMER med	43.543	56.455	60.953	64.751	63.885	66.14	68.0329	67.9	69.708
YEARLY MEAN	41.772	55.553	63.041	64.281	65.563	67.865	68.0014	67.29	68.514
ΔM	0	1.805	-4.177	0.941	-3.355	-3.45	0.06286	1.22	2.388
ΔF	0	2.86	-11.39	1.79	-1.14	-2.68	1.66	6.84	3.89
ΔV	4.93	2.59	11.12	3.73	3.91	2.59	4.08	8.92	3.84

In table no. 10, three statistical parameters were calculated according to Raţă, Rîşneac & Milici, 2007 and labelled as follows:
• ΔM – difference between average performance in outdoor and indoor competitions;
• ΔF – difference between performance at the end of summer and winter performance;
• ΔV – variation within which the summer season performance oscillated.

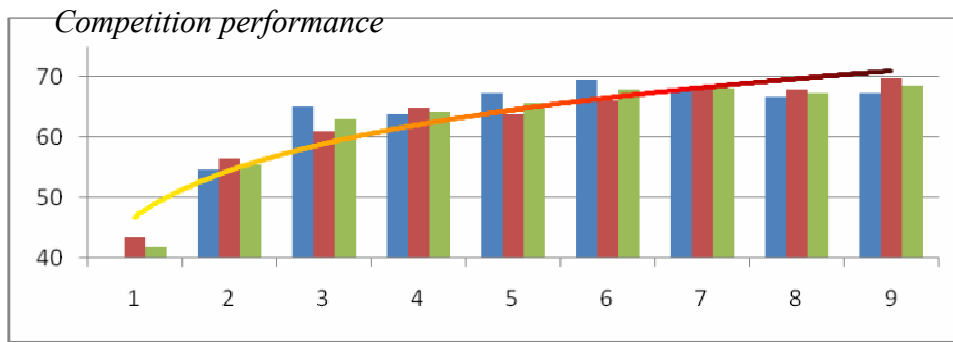

Fig 1. Evolution of: winter performance (blue), summer season mean (red) and yearly mean (green), together with the function of interpolation which indicates their trends, in the analysed period

From the analysis of the data presented in table no. 10, we can observe an exponential evolution according to Milici, Milici, 2013) of the sportswoman's performance during the 9 analysed competition years, as provided in literature (figure 1 - representation of winter performance, summer season mean and yearly mean, together with the function of interpolation which indicates their trends). The same figure shows the three competition years (2005, 2007, 2008) in which winter season performance was better than the summer season performance. The analysis of the three statistical parameters compiled in table no. 10 reveals the fault recorded in the results obtained in the summer of 2005, which is probably due to an accident. Her future evolutions are oscillating and oriented towards a year with very good results (2010). The polynomial interpolation functions of these coefficients show an oscillating production with a period of about 4 years (fig. 2). Although the extreme points for the two features record simultaneity in time, the discrepancy of the results obtained in the summer of 2005 is clearly highlighted through their opposition in the third year of the period analysed according to Calitoiu, Milici, 2011. Thus, there results an easy way for the analysis of sports performance in the long run and a clear outline of the potential defaults and malfunctions that may occur as a result of an accident or inadequacy of the training and coaching program according to Rață, Rîșneac & Milici, 2007.
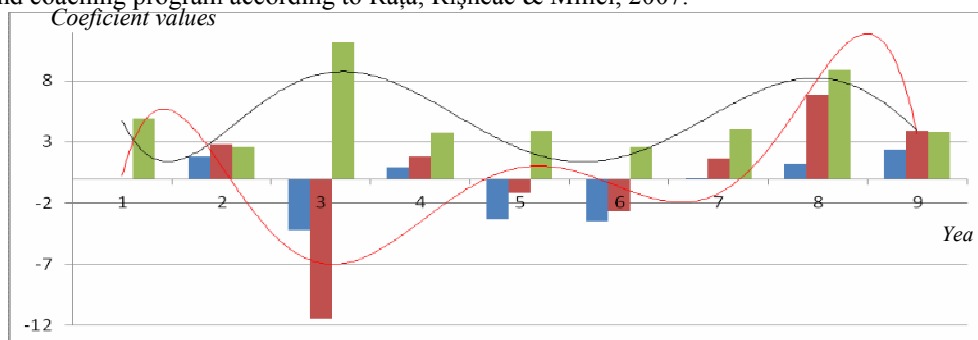

Figure 2. Evolution of the three statistical parameters compiled in table no. 10, within the analysed period

Another suggestive representation of the coefficients in table no. 10 allows a comparison of the results obtained every competitional year of the analysed period according to Rață, Milici, 2009. Therefore, by means of the representation in Cartesian coordinates of the ΔM / ΔF yearly coefficients (fig. 3), we can observe the points' distribution into two opposite frames and the positioning on the left-hand side of the three years in which the results of the competitions in the winter season have been superior to the results in the summer season competitions (highlighting once again the fault in 2005). The representation in figure 4 is based on the values of the ΔM / ΔV yearly coefficients, so it assesses the period during which performance oscillated in the summer season in comparison with all the results of that year. The representation highlights two years: 2005 with a great decrease in sports performance (in the upper left-hand side) and the year with the best competition results, and thus, the best evolution (in the top right-hand side).
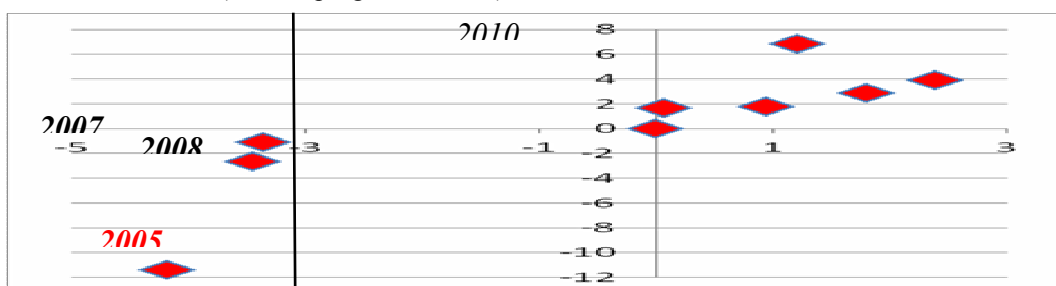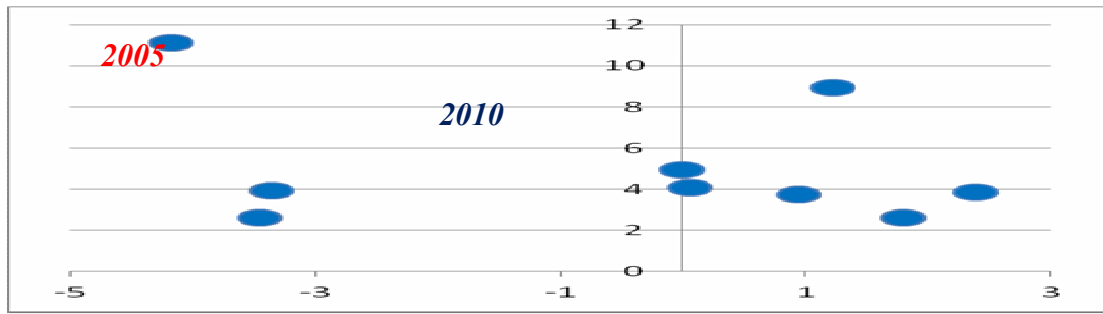

Fig. 3. ΔM / ΔF Representation

Fig. 4. ΔM / ΔV Representation

A separate analysis refers to the calculation of the correlation coefficients according to Milici, Milici, 2013 between the coefficients in table no. 10. This was made as follows: The coefficient of correlation between ΔM and ΔF, representing the evolution of the competition results between the winter and summer seasons of each analysed year, 0.836 - a good dependence which is also marked by the correlation coefficient between the average results of the winter and summer seasons (0.959). This value indicates the consistency of accumulations from one season to another during the training periods; The correlation coefficient between ΔM and ΔV equalling 0.286 and resulting in a very poor connection between the results obtained during the same season and a high range in which competition performance evolved over the duration of a season; The correlation coefficient between ΔF and ΔV of 0.414 which highlights a poor connection between the results recorded between the winter and the summer seasons, which supports the idea that there is no favourite season for our sportswoman and the significant results were divided between the indoor and outdoor competitions. Progress made by the sportswoman, Bianca Perie, over the 9 years of sports activity is different from one year to the other and has oscillating values. As it is observed in table no. 10, the great progress during the summer competition season was recorded in 2004 (the year when she started her training for that competition event) and constantly in the years that followed the 2005 fault with a qualitative leap obviously in 2010, and small drawbacks were recorded in 2011.

Conclusions

The study progress has allowed us to draw the following conclusions:

The hypothesis according to which the results must be recorded over a period of 10 years by a talented sportswoman have an exponential progression, but with oscillating parameters, has been confirmed, if we do not take into account 2005; Each category of age was marked by an obvious increase in sports performance;

The results recorded, processed and analysed emphasize the dynamics of the evolution trends on a yearly basis and according to age group. They prove an uneven, progressive and predictable evolution. The findings have revealed that genuine talents have the ability to make progress in time, a fact which has confirmed the hypothesis, but also, the fact that performance implies shifting values; The calculation of some well-selected statistical coefficients has highlighted, by an easy graphical representation, the main characteristics and syncopes occurred during the evolution of competition results of a performance sportsman and allows the improvement of results by means of a rapid change in the training program; There is a possibility to exploit talents in Romania, when there are found solutions related to the training concept and financial resources.

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