EVOLUTION OF WOMEN'S HIGH JUMP PERFORMANCE BETWEEN 2011-2020

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DOI: https://doi.org/10.51267/icehhm2022bp02

Abstract. *The study aims to highlight the evolution of the Junior II Women's high jumpers in the last 10 years at the National Indoor and Outdoor Championships. This study is based on the analysis of the results recorded at the final competitions specific to the Juniors II Women. The final competitions were held in the Lia Manoliu Athletics Hall, Bucharest during the indoor season and at the Lia Manoliu National Stadium in Bucharest and the Trivale Stadium in Pitesti during the outdoor season. The participants of this research were represented by women's high jumpers from different clubs in the country who joined in the National Championships. All results from the last 10 years were recorded. In conducting the investigation and the research we used: literature study method, pedagogical observation, comparative method, document analysis method, statistical-mathematical method, graphical method. The research hypothesis according to which the results of the junior high jumpers in the last 10 years were progressive was not confirmed. Following this study, we found that the performance of these jumpers was regressive, hence the problem of redesigning the strategy of attracting children to practise athletics events and sustaining them in the training process.*

Keywords: *high jumpers, evolution, results, junior.*

Introduction

Although it is easy to learn it roughly, the flop is an extremely difficult technique and its subtle elements can only be taught and learnt once the mechanical and anatomical (biomechanical) correlations are known with great accuracy.

The high jump, the flop, is currently encountered and practised by athletes in our country and throughout the world. The high spinal strain is particular to this style, which allows the spine to cross the bar. This is why this style of jumping, compared to others, requires a thorough and extended training process in order to build the skill of mastering the techniques of backward vaulting (Fataha et al., 2021). The high jump is an extremely meticulous event, in which courage and technical training, ensuring a particular orientation in the space covered, are the key points in its practice (Zhao, 2019). Throughout the high jump, including in the approach run, take-off and flight (the sensation of passing the bar in the air), there is a complex psychological demand for jumpers must have a positive and optimistic mental state (Zhao, 2019). The lack of courage and complexity of this event is one reason why the number of high jumpers is low. In high jump competitions, especially in recent years, the jump execution technique has not essentially changed, there has been no specific improvement in the athletes' impulse/momentum, landing surface and equipment or jumping shoes, but at the national level a decrease in the number of participants and therefore a decrease in the values of the athletic results has been observed. The achievement of sports performance is influenced by a number of factors, on the one hand by individual possibilities, represented by biological, psychological and functional factors, and on the other hand by the coach's ability, the financial possibilities of the club, of the federation, etc.

The traditional training approach in performance sport has become limited and ineffective for increasing sports performance. Achieving sport performance is a challenge for any coach.

High jump performance is influenced by the level of strength development, the effects of overcompensation produced by the training of the practical intervention, the state of fatigue (Philpott et al., 2021), all of which determining the outcome of the training process. The latter influences the performance potential, but performance in its turn depends on "the conditions in which the training is carried out, the infrastructure, the sports policy promoted by the management in different countries. Lack of conditions can affect the national development possibilities of athletes" (Brenzikofer et al., 2021), but can be removed or at least diminished.

The knowledge of the evolution of the achievement of sports performance in an athletic event is a point of view that can teach coaches in guiding the planning of training programmes, in coding the content in order to identify and apply the variables that have an effective impact on the training process, raising the athlete's abilities (Rahi & Sagheer, 2020), to their maximum possibilities. To a large extent, athletic results of high jump are determined by the rational bio-mechanical characteristics, which an athlete is able to achieve, namely: running speed, take-off speed, take-off angle (Adashevskiy et al., 2013). It is very important in order to achieve maximum results in high jump to observe all biomechanical parameters and based on them, it is possible to design a model of jumping technique. In addition, the data also identify possible differences between gender jumpers (Pavlović et al., 2020), as well as a prognosis of a high jumper's performance and a predictive probability distribution over future quantities or relevant events (Gneiting & Katzfuss, 2014), which allows the training process to be designed according to the potential for future developments.

Methodology

Participants

Our paper is a longitudinal study and was conducted on 120 sportswomen participating in the National Athletics Championship finals, with 60 participants in the National Indoor Athletics Championship and 60 participants in the National Outdoor Athletics Championship. The results of the top 6 ranked jumpers in the two competitions were taken into account for each year from 2011 to 2020. As we encountered situations where the participants in the finals of the national championships exceeded 6, we settled on this number as a criterion for accepting participants. Since the analysis was performed at the level of Junior II, being related to the age of 16-17 years, in the period 2011-2020, the participants were different from one edition to another.

Performance assessment tools

In order to know the dynamics of the level of performance in the high jump event in the period 2011-2020, we used as study material the results recorded at the National Athletics Championships obtained in the high jump event, which we found on the website of the Romanian Athletics Federation. We considered it necessary to carry out this research in order to give a warning signal about the true status of athletics training in terms of the evolution of performances in the Junior female high jump category, determined by an almost non-existent material base and a decreasing number of young people who are choosing to engage in athletics.

Proceedings

The research aim was to carry out a longitudinal study of an observational type, highlighting the evolution of the results recorded in the high jump over a period of 10 years, and to collect and analyse the results recorded between 2011 and 2020. As research methods used for this

study, we have applied the following: literature study related to the subject, pedagogical observation, statistical-mathematical method, graphical method.

Results

In order to achieve our goal, we set out to provide an answer to the following question: "*What was the evolution of the women's high jump results at the National Indoor and Outdoor Athletics Championships in the period 2011-2020?"* and to verify the hypothesis according to which "*in the women's high jump event (Junior II) the average of the finals and the average of the best performances at the National Outdoor Athletics Championship 2011-2020 are better than in the finals of the National Indoor Athletics Championship over the same years"*. The research was conducted from October 2020 to February 2021.

The results obtained after having consulted the documents of the Romanian Athletics Federation are presented in Table 1 for the National Indoor Athletics Championships and in Table 2 for the National Outdoor Athletics Championships. We hereby made a descriptive analysis of the average values of the results recorded for each competitive year (Table 1 and Table 2), as well as of the performances obtained by the first-place winners (Table 3), an analysis that allows us to answer the above-mentioned question: *"What was the evolution of the women's high jump results at the National Indoor and Outdoor Championships in the period 2011-2020?"*

National Indoor Championships results

The results for the 2011-2020 National Indoor Athletics Championships for the top 6 ranked athletes in the second year of the National Indoor Athletics Championships are shown in Table 1. As it can be seen (Table 1), the average values, as well as the best and the worst values are almost completely different from year to year.

The analysis of the results recorded in the jumping event graphically represented (Figure 1) highlights the following aspect: the average sports performance recorded the following values: 1.65 m in 2011; 1.63 m in 2012; 1.58 m in 2013; 1.62 m in 2014; 1.55 m in 2015; 1.58 m in 2016; 1.58 m in 2017; 1.62 m in 2018; 1.61 m in 2019; 1.64 m in 2020, as shown in Figure 1.

Table 1 *Results recorded in the high jump event between 2011 and 2020, indoor season*

Crt.no.	**Performances recorded *between 2011 and 2020* - indoor**										**Mean**
/ years	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
1	1.75	1.70	1.72	1.68	1.64	1.70	1.59	1.72	1.73	1.76	1.699
2	1.70	1.70	1.65	1.68	1.60	1.60	1.59	1.68	1.70	1.70	1.660
3	1.65	1.65	1.65	1.68	1.55	1.55	1.59	1.64	1.58	1.63	1.617
4	1.65	1.60	1.50	1.64	1.55	1.55	1.59	1.60	1.54	1.59	1.581
5	1.60	1.60	1.50	1.60	1.50	1.55	1.55	1.60	1.54	1.59	1.563
6	1.55	1.55	1.45	1.45	1.45	1.55	1.55	1.50	1.54	1.59	1.518
V. average	1.65	1.63	1.58	1.62	1.55	1.58	1.58	1.62	1.61	1.64	1.606
V. maximum	1.75	1.70	1.72	1.68	1.64	1.70	1.59	1.72	1.73	1.76	1.699
V. minimum	1.55	1.55	1.45	1.45	1.45	1.55	1.55	1.50	1.54	1.59	1.518
D. standard	0.07	0.06	0.11	0.09	0.07	0.06	0.02	0.08	0.09	0.07	0.07
Coeff. of variation	0.04	0.04	0.07	0.06	0.05	0.04	0.01	0.05	0.06	0.04	0.04

It is interesting that in 9 of the 10 years of reported results, the arithmetic means as well as the first-place performance values are lower than in the first and last analysed years, which make us hope that the results will further improve (Figure 1).

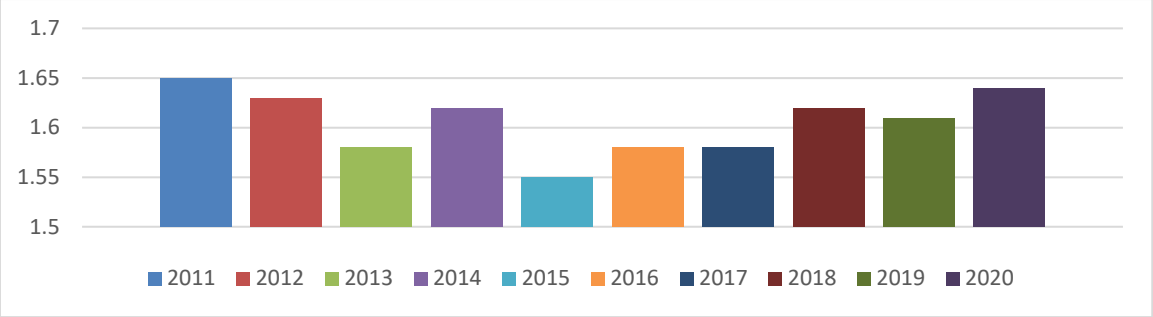

Figure 1. Representation of the average performance of high jumpers between 2011-2020

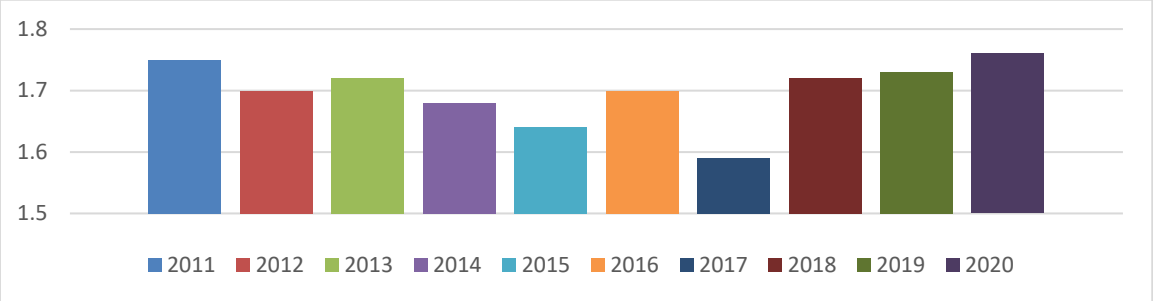

Figure 2. Representation of the maximum performance of high jumpers between 2011-2020

The maximum value of sports performance (Table 1, Figure 2) recorded the following values: 1.75 m in 2011; 1.70 m, in 2012; 1.72 m in 2013; 1.68 m in 2014; 1.64 m in 2015; 1.70 m in 2016; 1.59 m in 2017; 1.72 m in 2018; 1.73 m in 2019; 1.76 m in 2020, as shown in Figure 2. The most valuable results are observed in the first year (2011) of 1.75 m and in the last year (2020) of 1.76 m, which is a small difference, and we appreciate that it is increasing, but also the fact that 2017 recorded the lowest value of the performance to win the championship title in this event.

The minimum sport performance value recorded the following values: 1.55 m in 2011; 1.55 m in 2012; 1.45 m in 2013; 1.45 m in 2014; 1.45 m in 2015; 1.55 m in 2016; 1.55 m in 2017; 1.50 m in 2018; 1.54 m in 2019; 1.59 m in 2020, as shown in Fig. 3. The worst results are observed in 2013 of 1.45 m, but also in 2014 and 2015. What is interesting is that the lowest performance value is not found in 2017 when the poorest performance was recorded.

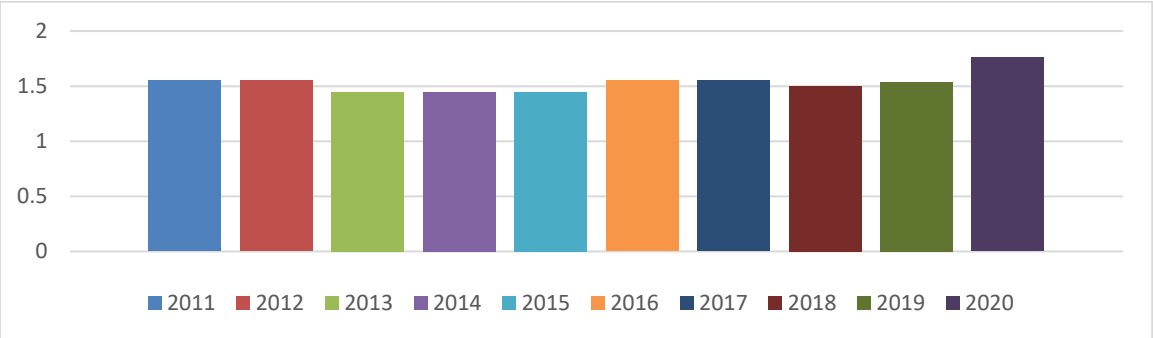

Figure 3. Representation of the minimum value obtained by high jumpers between 2011-2020

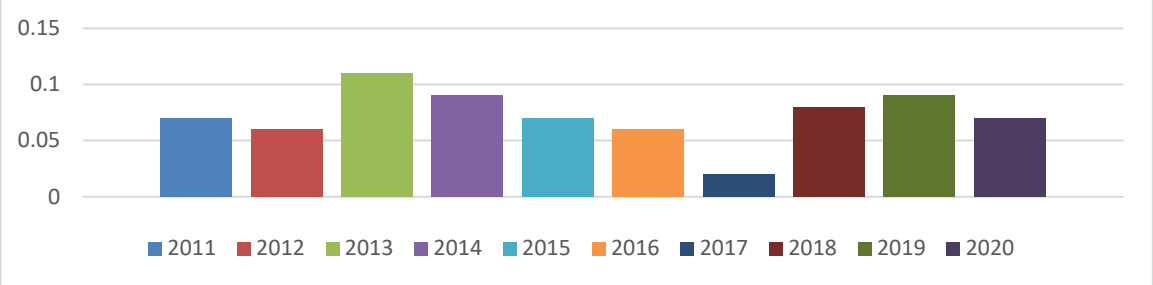

Figure 4. Representation of the standard deviation of high jumpers between 2011-2020

The results at the National Indoor Athletics Championships, for the women's high jump event obtained in the period 2011-20020, showed low values for the coefficient of variation between 0.01 and 0.07, which indicates a good grouping around the average values and therefore group homogeneity. The standard deviation values also show a reasonable uniformity, given by the small number of participants.

National Outdoor Athletics Championships results

The results of the National Outdoor Athletics Championships in the period 2011-2020 for the top 6 ranked athletes in the second year of the National Outdoor Athletics Championships are shown in Table 2. As shown (Table 2), the average values as well as the best and worst values are completely different from year to year.

Table 2 *Outdoor high jump results over the last 10 years*

Crt.no.	**Performances recorded *between 2011 and 2020* - indoor**										**Mean**
/year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
1	1.80	1.65	1.68	1.70	1.65	1.70	1.66	1.68	1.69	1.76	1.697
2	1.60	1.65	1.65	1.65	1.60	1.55	1.63	1.60	1.69	1.76	1.638
3	1.60	1.60	1.60	1.65	1.55	1.55	1.59	1.60	1.60	1.73	1.607
4	1.60	1.60	1.60	1.65	1.50	1.50	1.55	1.60	1.55	1.59	1.574
5	1.55	1.60	1.60	1.60	1.50	1.45	1.55	1.55	1.45	1.59	1.544
6	1.55	1.60	1.60	1.55	1.40	1.45	1.55	1.50	1.40	1.55	1.515
V. average	1.62	1.62	1.62	1.63	1.53	1.53	1.59	1.59	1.56	1.66	1.596
V. maximum	1.80	1.65	1.68	1.70	1.65	1.70	1.66	1.68	1.69	1.76	1.697
V. minimum	1.55	1.60	1.60	1.55	1.40	1.45	1.55	1.50	1.40	1.55	1.47
D. standard	0.09	0.03	0.03	0.05	0.09	0.09	0.05	0.06	0.12	0.10	0.07
Coeff. of variation	0.06	0.02	0.02	0.03	0.06	0.06	0.03	0.04	0.08	0.06	0.04

The analysis of the results recorded in the high jump event at the National Outdoor Athletics Championships, as presented in Table 2 and found in the figure, shows that:

- in all 10 years, all 6 participants managed to pass the initial height, there were few participants and the value of the results was low, for the final stage of the National Championship, a fact that highlights the decline in performance evolution in this event;
- the average value of the sports performance recorded the following values: 1.62 m in 2011; 1.62 m in 2012; 1.62 m in 2013; 1.63 m in 2014; 1.53 m in 2015; 1.53 m in 2016; 1.59 m in 2017; 1.59 m in 2018; 1.56 m in 2019; 1.66 m in 2020, as shown in Figure 5.

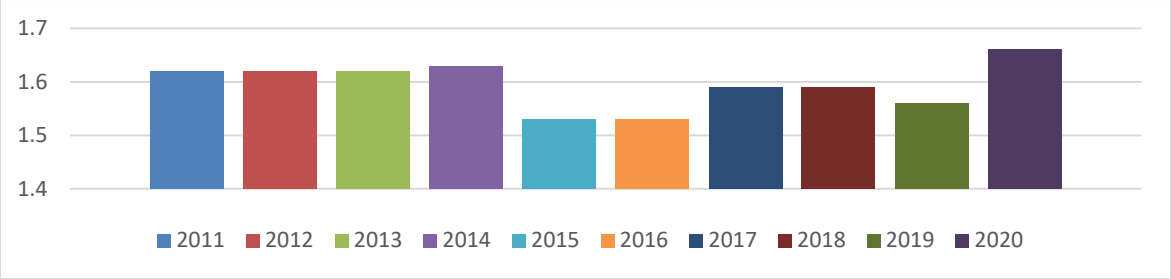

Figure 5. Graphic representation of the average value of the performances obtained by the participants in the finals of the National Outdoor Championship between 2011-2020.

It is notable that in 8 of the 10 reported years, the arithmetic averages as well as the first-place performance values are lower than in 2020, which make us expect that the results will resume an upward dynamics.

The maximum sport performance value (i.e. 1st place) (Table 2 and Figure 6) recorded the following values: 1.80 m in 2011; 1.65 m in 2012; 1.68 m in 2013; 1.70 m in 2014; 1.65 m in 2015; 1.70 m in 2016; 1.66 m in 2017; 1.68 m in 2018; 1.69 m in 2019; 1.76 m in 2020, as shown in Fig. 7. The most valuable results are observed in the first year 2011 of 1.80 m and in the last year 2020 of 1.76 m, thus a small difference, and we appreciate that it is increasing, but also the fact that the lowest value of the performance for winning a title of champion in this event was recorded in 2012 and 2015.

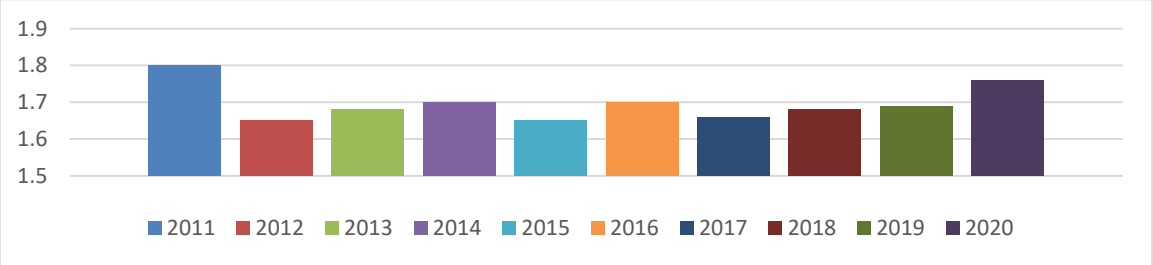

Figure 6. Graphical representation of the maximum performance value in the high jumps participating in the National Outdoor Championship finals between 2011-2020

The minimum sport performance value (Table 2 and Figure 7) was 1.55 m in 2011; 1.60 m in 2012; 1.60 m in 2013; 1.55 m in 2014; 1.40 m in 2015; 1.45 m in 2016; 1.55 m in 2017; 1.50 m in 2018; 1.40 m in 2019; 1.55 m in 2020.

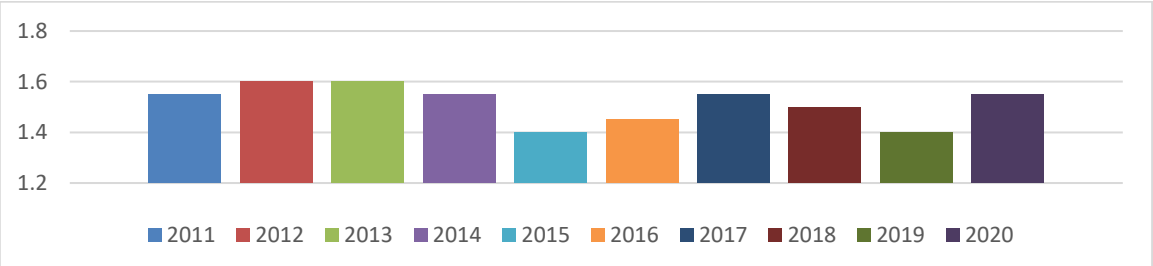

Figure 7. Graphical representation of the minimum performance in the high jumps participating in the finals of the National Outdoor Championship between 2011-2020

The value of the standard deviation (Table 2) obtained by the participants in the high jump event at the National Outdoor Athletics Championship, in the period 2011-2021 shows a good homogeneity, as well as the small values of the coefficient of variation between 0.01 and 0.07

which highlights a good clustering around the mean values and a good homogeneity of the group. Both the small values of the standard deviation and the coefficient of variation were determined by the small number of participants.

Comparison of the first-place results at the National Indoor and Outdoor Athletics Championships

The best performances recorded from 2011-2020 in the High Jump at the National Indoor and Outdoor Championships are presented in Table 3 and Figure 8. As shown, there are differences in the performance values recorded by the first-place winners from one year to the next and from one competition season to the next. Only in 2016 and 2020 the title of Romanian champion was won with the same value in the two seasons and in 2020 the best result was obtained in the indoor, whereas in 2011 in the outdoor competition.

Table 3 *Comparative results recorded in high jump in the period 2011-2020 for the last 10 years in the indoor and outdoor seasons*

Crt. no.	**First place performance 2011-2020**										**Mean**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Indoor	1.75	1.70	1.72	1.68	1.64	1.70	1.59	1.72	1.73	1.76	1.699
Outdoor	1.80	1.65	1.68	1.70	1.65	1.70	1.66	1.68	1.69	1.76	1.697
Differences	+0.05	-0.05	-0.04	+0.02	+0.01	0.00	+0.07	-0.04	-0.04	0.00	-0.002

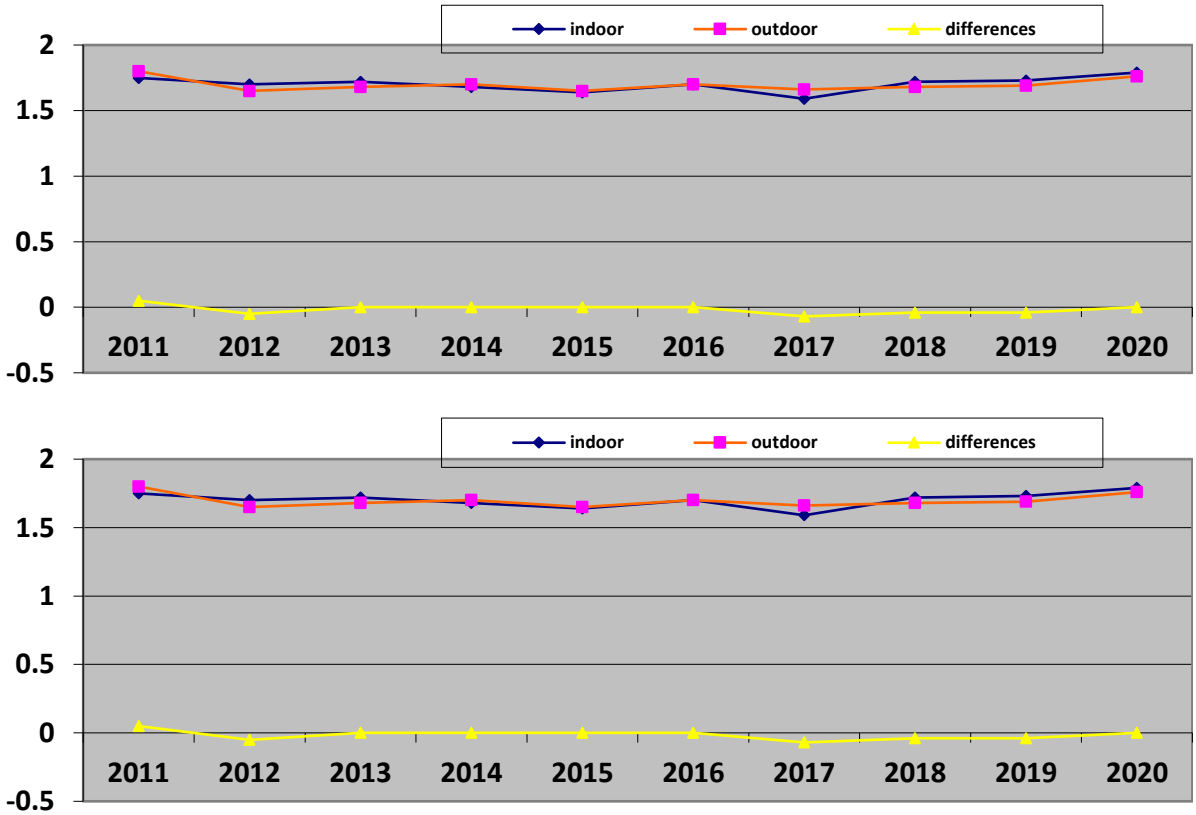

Figure 8. Graphical representation of the first place performances in the 2011-2021 indoor and outdoor high jump competition seasons.

Inferential analysis of T-Student test values and the Cohen's D coefficient

In order to validate or invalidate the hypotheses, we also considered it necessary to perform an inferential statistical analysis of the results obtained, for which we calculated the T-Student test and Cohen's D coefficient.

From the results presented in Table 4, we can highlight the following aspects:

- the evolution of the indoor (M= 1.596. SD= 0.07) and outdoor (M= 1.606. SD= 0.07) results of the average results obtained by the athletes in the last 10 years indicates the statistical significance of the results t= (3.09), $p < 0.027$;
- the Cohen's coefficient values (D= 0.15) suggest a small difference between the athletes' results in the indoor events compared to the athletes' results in the outdoor events and therefore a small effect size.

Table 4. T-Student test results and Cohen's coefficient D

Indicators	10-year value mean	
	Indoor	Outdoor
Number of subjects	6	6
Mean	1.596	1.606
Standard deviation	0.07	0.07
Student's test	3.09	
P* value	< 0.027	
Cohen's D	0.15	

Results between indoor and outdoor testing by applying the Student's t-test. A significant difference between the two tests if $p < 0.05$.

Discussion and Conclusion

A comparison of the results recorded by the first-place winners in the indoor and outdoor National Athletics Championship competitions shows that performances are sometimes higher and other times lower in the two competition seasons. In general, the results in the indoor competition season are better than in the outdoor competition season in the following years: 2012 (1.70 m), 2013 (1.72 m), 2018 (1.72 m), 2019 (1.73 m), the results in 2016 (1.70 m) and 2020 (1.76 m) were equal, and the results from the 2011 and 2015 competitive season were weaker in the indoor than in the outdoor seasons. As shown in Table 3, the difference between the results obtained at the indoor and outdoor competitions is not very significant.

The outdoor results are higher only in 2011, 2014, 2015 and 2017. From these records, it appears that the outdoor results are weaker than the indoor results, a negative aspect, since in reality in the big competitions (European and World Championships) results from outdoor seasons are better compared to indoor ones. It is also noted that the lowest performance was in 2017 in the indoor season of 1.59 m and the highest in 2011 of 1.80 m and the difference between the average of the indoor and outdoor seasons is 0.002.

The poor long-term sports results underline the disinterest of the responsible organisations at the national level. The sports results depend on the physical, motor and mental predispositions of the athletes, on the large number of athletes involved in the training process, on the financial and material resources invested in young people and on the evolution of society in each country. Brenzikofer et al., (2021), point out that national and world-class developmental characteristics in top athletes emerge as early as age 14, and the potential, local training conditions, infrastructure and sports policies offered to young athletes in different countries can affect their developmental trajectories and not in the least leaving the training and competition system. Sports performance in the 11-18 age group fluctuates between 5% and 10-18% (Tønnessen et al., 2015), which cannot be stated about our participants as they represented different generations. There is an increasing interest in achieving sports performance at an early age; coaches are more focused on achieving results in children, rather than preparing performers to excel in youth and seniors.

In forecasting the progress of performance in athletics, practitioners must take into account in setting their goals the following: the strategies for achieving success (Haugen et al., 2018), the predispositions of the athletes and the material and financial conditions of the clubs, as "models created according to seasons" since the sports results obtained in the "first season provide an early assessment for the coach" (Örs and Bayraktar 2020), which can be a starting point in planning the future training process.

In order to answer the question *"What was the evolution of the results in the women's high jump event at the National Indoor and Outdoor Championships in the period 2011-2020?",* we performed a descriptive analysis of the results of the average values recorded each year in the two competitive seasons as well as of the performances obtained by the first-place winners. According to the data analysed in this study, the following ideas stand out:

- over the 10 editions of the National Indoor Athletics Championship and 10 editions of the National Outdoor Athletics Championship, held in the period 2011-2020, between 6 and 8 competitors participated in the high jump event, an extremely small number for a National Championship final, and we included only six in the research;

- the average performance values, for each year, do not have an increasing trend, ranging in the competitive indoor season between 1.65 m in 2011 and 1.64 m in 2020 and in the competitive outdoor season between 1.64 m in 2011 and 1.66 m in 2020;

- from the two findings, it appears that the participation in the women's high jump event is not increasing either in performance or in number, which should concern specialists and take certain measures. In conclusion, the evolution of the women's high jump results at the National Indoor and Outdoor Athletics Championships in the period 2011-2020 was an oscillatory one, with a very small increase of 2 cm in the outdoor season;

- the most valuable indoor performances were achieved in the first year, 2011 with 1.75 m and in the last year, 2020 with 1.76 m. The difference is lower by 1 cm, and we appreciate the fact that it is growing, but also the fact that the lowest value of the performance for winning a title of champion in this event was recorded in 2017.

These results entitle us to consider that the answer to the question *"What was the evolution of the results of the women's high jump event at the National Indoor and Outdoor Athletics Championships in the period 2011-2020?"*, is a warning for the management of Athletics in Romania and requires to approach new strategies.

In order to verify the hypothesis, we carried out a descriptive and an inferential analysis, with the help of which we derived the following ideas:

- from the comparison of the average values of the first-place performances recorded in the period 2011-2020, namely for indoors of 1.699 m and outdoors of 1.697 m, it is observed that there is a very small difference of 0.002, thus the average of the results is slightly better for the indoor season than for the outdoor season;

- the average results calculated for the 2011-2020 competitions recorded an indoor value of 1.606 m and an outdoor value of 1.596 m, so it is observed that there is a small difference of 0.010, thus the average of the results is 0.010 m better in the indoor season compared to the outdoor season;

- in the indoor season, the most valuable results were achieved in the first year, namely 2011, with 1.75 m and in the last year, namely 2020 with 1.76 m. The difference is small, but we appreciate the fact that it is increasing,

- in the outdoor season, the best performance was recorded in the first year, i.e. 2011, with a value of 1.80, but later the performances were lower. Therefore, it appears that the results of the high jumpers were not evolutionary;

- the hypothesis according to which "in the women's high jump (Junior II) the average of the results in the 2011-2020 National Outdoor Athletics Championships finals is better than in the National Indoor Athletics Championship finals of the same years" is refuted. This statement

is also supported by the fact that the value of t = (3.09) and p < 0.027, underlining that the results did not have a continuous ascendancy, and the values of the Cohen's coefficient (D= 0.15) show a small difference between the results obtained by the athletes in the indoor events compared to the results obtained by the athletes in the outdoor events.

In conclusion, the answer to the above-mentioned question points out a decline in sports performances and the hypothesis was not validated, since the results of the Junior II high jumpers, obtained both in the indoor season and in the outdoor season, were not evolutionary from one season to another and not from one year to another. The denial of the hypothesis suggests the reorganisation of the training process, but also the reorientation of the selection process. However, our longitudinal study has several limitations Although the results of the 120 high jumpers were presented in the research, with 60 in the indoor season and 60 in the outdoor season, in each edition, the results obtained by only 6 participants were analysed, thus a small number.

Following discussions with athletics coaches in the country, we identified various issues which led to the decline of this event, such as: few coaches specialising in this event, the change in social dominance at the age of 16-17, the complexity of the event, the loss of motivation of young athletes and interest, the difficulty of coping with the monotony and routine so essential in performance sport, early selection, the coach's temptation to work at certain early sustained volumes at a training level well above the age level, nervousness, fear of heights and bar, many injuries during the training period, lack of certain qualities specific to the high jump, stagnation of growth in terms of height and uncontrolled weight gain.

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