

ASSESSMENT OF EXPLOSIVE STRENGTH SKILLS OF LOWER EXTREMITIES IN ICE HOCKEY PLAYERS FROM KOMETA GROUP BRNO

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Abstract: *The aim of the study was to determine the growth of explosive strength in both lower extremities in ice hockey players in the course of several years training cycles (later as RTC). Measurement was carried out at the beginning of the competitive season, and at the end of competitive and training season in years 2015-2017. To compare findings among age categories in each particular year. The level of explosive skills has been diagnosed by force plate Bertec in the laboratory of the Faculty of Sport Studies in Brno. The survey was carried out in groups of ice hockey players born in years 2000, 2001, 2002, 2003. In total 48 boys, aged 13 – 18 who play ice hockey on competitive level. All of them regularly train in Kometa Group Brno, divided according to age categories. Findings of the research indicate that statistically significant growth of an explosive strength of both lower extremities can be observed in players born in 2002 and 2003, or in other words on the verge of 14th and 15th year of age.*

Keywords: *vertical jump, ice-hockey, strength skills.*

1. Introduction

Authors of “Krafttraining” publication deal with an issue of body building in adolescent age. They focus on biological specific features in respect of sexual maturation, particularly secondary sexual characteristics, and they define age limits for strength training initiation [6]. Speed

of skating correlates with running speed and also with tests explosiveness and maximal anaerobic performance (vertical jump, spring, two-footed jump, Wingate max.). Farlinger, Fowles stated, that when correlation analysis between explosive strength, acceleration and speed of skating is applied, a significant dependence is proved. On the base of this

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finding, it is convenient to enrich ice hockey trainings with fitness programmes that can determine factors of skating performance. Dále Jesenský, Kokinda (2017) and [1], [7] report that upper limit of older school age is specific for growth of hormones in the body, particularly testosterone, which leads to accelerated physical maturation, development of muscular power and mass. Players perform a lot of starts, stops, changes for directions and physical fights. Maximal intensity of skating represents merely 4.6% of total time spent on the ice, but being faster than the rival increases the chances to get a puck and score a goal.

Thus, velocity, strength and explosiveness represent the crucial physical skills for ice hockey players (Burr et al., 2008). Šimonek, Doležajová, Lednický (2007) in their publication „Rozvoj výbušné síly dolních končetin ve sportě“ deal with explosive strength of lower extremities. The aim is to provide coaches with a resource of training tools focusing on development of explosive strength in lower extremities, as well as fundamental knowledge on methodology and development. [10] introduces the publication designed not only for wider audience of trainers, but also for trainers on various qualification levels, students of sport studying programmes and last but not least for laypersons and public. Intended publication introduces basics of sport training, theoretical and practical aspects based on his-own experience. Strength of players' legs is pronounced during a game both in dynamic and static regimen. Legs with strong, explosive and fast skills are vital tool for skating. Maximization of the explosiveness is the result of an immediate total intake of both fast and slow motor units [3]. Being aware

of explosive skills of players in various age is in direct relation with training results and it facilitates the process of method selection, planning and training programme. Explosive strength is defined as a skill of a sportsperson to produce the highest possible strength in the shortest possible time (Zatsiorsky and Kraemer, 2014). Plyometric method represents a specific kind of a muscular workout which results in an increase of explosive strength skills.

Explosive strength, namely explosive performance (P) is related with strength, and also with velocity, because it is the product of strength (F) and velocity (v): $P=F \times v$ [9]. Maximal pace of progressive changes (sensitive period) in strength skills is related with the period of maximum vigour between 13th and 14th year and 16th and 17th year of age. As long as static-strength skills in boys are concerned, it is between 14th and 17th year. Dynamic-strength skills in boys prove an optimal development at the age of 11-12 years. Bukač (2007) states, that optimal development of muscular power in boys occurs in 12-18 months after growing spurt. Muscular power weakens gradually; it disappears after 6-10 weeks. (Villarreal et al., 2009) in their metaanalysis aroused from 56 studies, deal with the plyometric training and its enhancing effect to vertical jump.

However, it is necessary to bear in mind that youth categories have been restructured since 2018/2019, when the older adolescent category was cancelled. Instead, there were established two categories – adolescents and juniors. For purposes of our research, we assessed the original categorization system, according to which we tested each category.

2. Material and Methods

All GRF parameters were registered by Bertec walkway (Bertec force plate FP6012-15, USA, length: 120 cm, width: 60 cm). Overall, the walkway is 4.8 m long (4 force plates consecutive). As the subject walks over the platform, the sensors enable collection of GRF parameters. Data is sampled at frequencies for three directions: Fz (vertical direction) 360 Hz; Fx (mediolateral direction) and Fy (anteroposterior direction) 400 Hz, but for our purpose we have used only vertical direction. The walkway is connected to a PC by a serial interface cable. The force and temporal characteristics of gait are displayed by Simi Motion (version 9.0.5) as force-time curve Fx (t) for both lower limbs. Data were collected at the Laboratory of Kinanthropological Research on the campus of Masaryk University of Brno, Czech Republic.

2.1. Statistic analysis

Quantitative method of processing. Data are evaluated after each measurement, processed by statistic sorting of the first and second degree (1 degree per cent, mean value, tables), - statistic data processing, mean value, modus, median, determinative deviation, boxplot chart-median, 2nd and 3rd quartile, minimum and maximum. For assessment of statistic processing we used (non-parametric) t-test. To establish a statistic significance of difference during the development we used a paired t-test. Parameters are described with mean value and a determinative deviation. Level of statistic significance $p < 0.05$.

2.2. Research participants

Participants of the research were ice hockey players, members of Kometa

Group Brno. Testing battery consisted of players born in 2000, 2001, 2002, 2003. Age of the testing group was between 13 and 18 years. In total 48 boys took part in the research. Measurement was carried out at the beginning of the competitive season (September), at the end of competitive season (March, April), and at the end of preparatory (training) season (June). In total 7 measurements were carried out. Testing process itself took part in seasons 2015/16, 2016/17, 2017/18.

3. Results

Results are introduced in part A in absolute values of explosive strength for both lower extremities (Tables 1 and 2.), according to years (2000, 2001, 2002, 2003) in multi-year RTC. Next part of results represents the view of explosive strength in part B in relative values (Tables 3 and 4). Each measurement was taken three times per RTC in years 2015-2018. After every single jump we compared level of explosive strength within the year category. Data were sorted out according to year of birth. Based on the obtained values, we calculated basic statistic data: mean value, determinative deviation, minimum, maximum, 1st quartile, median and 3rd quartile. Further, we processed tables and charts in absolute values (charts 1 and 2) and charts in relative values (charts 3 and 4).

Next part presents results of statistic analysis of explosive strength, changes during time, processed for both lower extremities according to year of birth (2000, 2001, 2002, 2003), in part C in absolute values (Table 5) and D in relative values (Table 6).

Legend for tables and charts – see below:

Legend 1 (legend for tables and charts descriptive statistics in results).

It contains players born in 2000, 2001, 2002, 2003. Number in headline shows age, letters show the period when the measurement was taken.

a: beginning of ZO (competitive season, beginning of September);

b: end of ZO (competitive season, end of March);

c: end of PO (training season, end of June)

ZO– competitive season,

PO– training season;

N– Newton

13, 14, 15, 16, 17, 18 – age of players;

-det. dev. – determinative deviation

-Vertical values in chart no. 1. and 3 –

-results – in N and N/kg.

-Horizontal values in chart no.1 and 3 – age of players and individual measurements in N and N/kg.

-Vertical values in chart no.2. and 4 - results - in N and N/kg.

-Horizontal values in chart no.2. and 4 – all individual measurements

according to year of birth in N and N/kg.

Legend 2 (legend for statistic tables assessment of T-test in discussion).

It contains players born in 2000, 2001, 2002, 2003. Number in headline shows measurement 1-7, n=8, 10, 15 number of players in each year category, $p < 0.05$ level of statistic significance).

Both lower extremities in N 1-7 measurements of explosive strength in both legs in absolute values (Newton).

N=8 (2000) number of players born in 2000.

N=10 (2001) number of players born in 2001.

N=15 (2002) number of players born in 2002.

N=15 (2003) number of players born in 2003.

A. Results of the research of explosive strength in both lower extremities in absolute values (N) across years (2000, 2001, 2002, 2003) in tables (Tables 1 and 2) and charts (chart 1 and 2)

Table 1

Results of explosive strength measurement in both lower extremities in N in all players born in 2000, 2001, 2002, 2003 across (first part)

Years across	13 a	13 b	13 c	14 a	14 b	14 c	15 a	15 b
Mean value	1068.6	1067.4	1164.8	1307.0	1287.4	1510.4	1568.1	1609.7
Det.dev.	283.8	290.0	306.8	285.0	299.9	296.7	316.3	221.7
median	1059.5	954.5	1041.3	1236.8	1246.4	1500.1	1504.7	1568.4
minimum	661.2	688.0	867.3	877.6	762.3	1062.4	1087.2	1195.3
maximum	1553.1	1667.9	1785.8	1900.9	1896.7	2000.4	2344.6	1992.3
1 st quartile	820.0	869.6	904.1	1075.4	1010.3	1235.1	1299.1	1440.1
3 rd quartile	1374.5	1387.5	1385.3	1567.9	1468.8	1830.2	1829.1	1810.8

Tables 1 and 2 show the development of explosive strength level in lower extremities in N (absolute values) for all players during their transmission to higher

year, among all years. We can observe continual growth of explosive strength in both lower extremities between 14th and 15th and 16th and 17th year of age.

Table 2

Results of explosive strength measurement in both lower extremities in N in all players born in 2000, 2001, 2002, 2003 across (second part)

Years across	15 c	16 a	16 b	16 c	17 a	17 b	17 c	18 a
Mean value	1722.4	1702.1	1721.7	1762.8	1929.7	1825.3	1855.0	1969.9
Det.dev.	219.7	294.1	185.1	218.7	253.6	136.0	1.2	130.1
median	1740.1	1726.4	1780.4	1854.1	1907.0	1883.3	1854.7	1989.0
minimum	1287.3	1222.4	1368.3	1166.6	1562.6	1516.0	1853.7	1763.4
maximum	2000.1	2564.0	1991.7	1998.1	2635.6	1992.4	1857.3	2157.6
1 st quartile	1576.7	1450.1	1565.4	1660.8	1737.5	1760.5	1854.0	1828.3
3 rd quartile	1879.7	1938.5	1894.6	1859.7	2063.9	1896.9	1856.0	2089.0

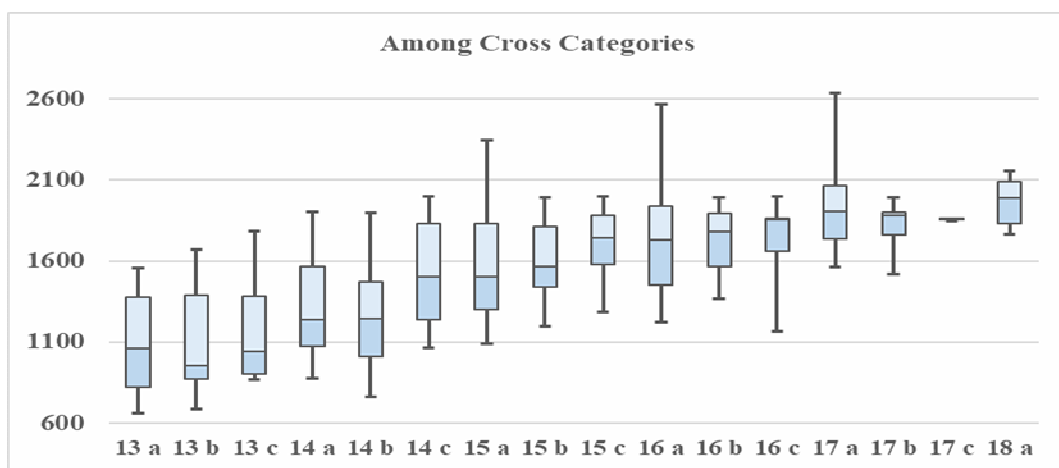


Chart 1. Results of explosive strength measurement in both lower extremities in N (years 2000, 2001, 2002, 2003) - box plot charts

In order to assess the evenness of the group, we depicted the results by the means of box plot chart for each year across. As apparent from this chart, obtained values have growing tendency, regularly after the third attempt, which stands for the end of training season. Chart 1 also shows a significant growth of explosive strength in lower extremities at the end of 14th 15th and 18th year, where

the growth of explosive strength is the most distinctive.

Development of explosive strength in both lower extremities is rather continual when entering higher years, see chart 2.

We can further observe a drop in strength of both lower extremities at the end of a competitive season (regularly after second measurement of RTC).

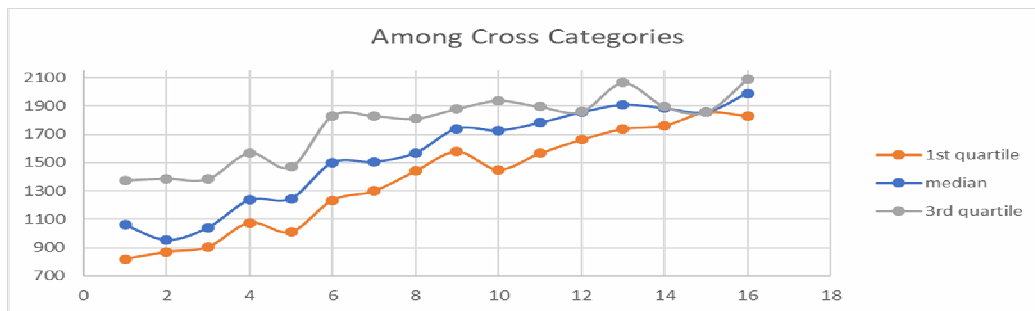


Chart 2. Results of explosive strength measurement in both lower extremities in N (years 2000, 2001, 2002, 2003) across years (1st and 3rd quartile, median)

Next, there is a progressive strength growing in 6th measurement in both lower extremities (end of 14th year of the age).

B. Results of the research of explosive strength in both lower extremities in relative values (N/kg) across years (2000, 2001, 2002, 2003) in tables (Tables 3 and 4

and charts (Charts 3 and 4). We obtained fundamental findings also by using relativizing approach, when we related obtained results with body weight of players. Here, faster maturing and weight growth was significantly manifested.

Table 3

Results of explosive strength measurement in both lower extremities in N/kg in all players born in 2000, 2001, 2002, 2003 across (first part)

Years across	13 a	13 b	13 c	14 a	14 b	14 c	15 a	15 b
Mean value	22.4	21.6	23.0	22.7	21.3	24.2	24.8	23.3
Det.dev.	3.8	4.2	4.1	4.1	4.4	3.6	3.9	3.1
median	20.9	22.8	21.2	21.9	20.9	23.7	24.4	23.2
minimum	15.1	13.7	17.9	15.6	12.6	19.4	19.6	19.5
maximum	27.6	27.6	31.1	32.9	29.8	31.8	34.5	32.4
1 st quartile	19.5	17.8	19.4	19.6	18.7	21.1	21.4	20.8
3 rd quartile	26.3	24.9	26.9	25.5	24.5	26.2	27.7	24.9

Table 4

Results of explosive strength measurement in both lower extremities in N/kg in all players born in 2000, 2001, 2002, 2003 across (second part)

Years across	15 c	16 a	16 b	16 c	17 a	17 b	17 c	18 a
Mean value	24.5	24.5	24.3	24.2	25.9	25.2	25.6	27.6
Det.dev.	2.9	3.0	3.3	2.8	3.0	2.7	2.8	4.2
median	24.4	23.3	24.2	23.8	26.3	25.3	24.5	26.1
minimum	19.8	21.0	20.3	19.3	20.4	20.4	22.5	21.6
maximum	31.4	30.7	34.1	29.5	32.1	29.6	30.1	34.8
1 st quartile	22.1	22.3	21.6	22.3	23.2	23.0	23.1	25.3
3 rd quartile	26.6	27.0	25.6	26.1	28.6	27.5	28.8	32.6

Tables 3 and 4 show the development of explosive strength in lower extremities in relative values (N/kg) for all players during their advancement to higher year category, among all years. From results given in tables 3 and 4 is obvious that probands achieved the highest levels at the end of their 14th and 15th year, where is the greatest progress. Further, we can

see strength development between 17th and 18th year. In the same time, we have to state that in the course of subsequent measurements, particularly in the second season, we observed body maturation, gaining weight and therefore the growing of explosive strength in relative values was not as considerable as in absolute values, see tables 1 and 2.

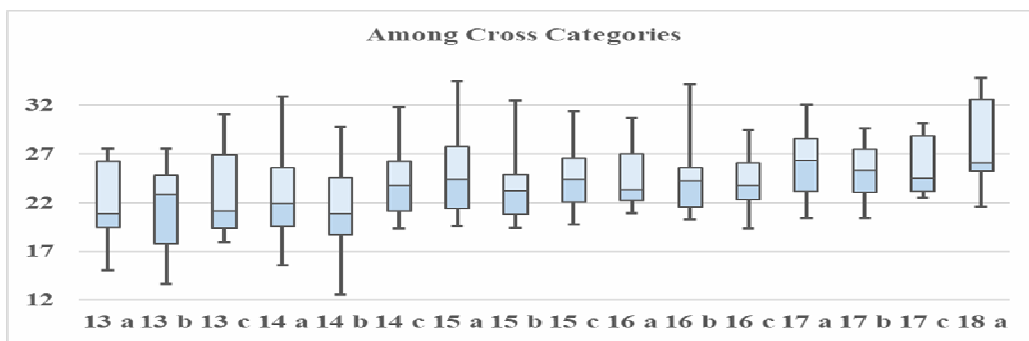


Chart 3. Results of explosive strength measurement in both lower extremities in N/kg (years 2000, 2001, 2002, 2003) – box plot charts

In order to assess homogeneity or evenness of the group, we depicted the results by the means of box plot chart for each year across. In chart 3, we can observe wave like character of explosive

strength in both lower extremities all over the measuring time. Obtained levels have increasing tendency, particularly at the end of 14th and 15th year.

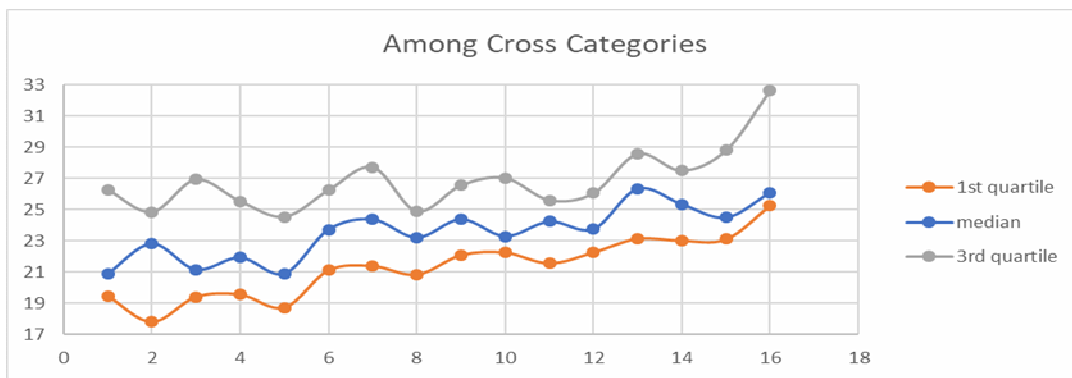


Chart 4. Results of explosive strength measurement in both lower extremities in N/kg (years 2000, 2001, 2002, 2003) across years (1st and 3rd quartile, median)

Development of explosive strength during transmission after each measurement is of wavy like character till the end of all measurements in all years – this is expressed by median in chart 4. The most significant growth of explosive strength in both lower extremities is apparent in 6th and 13th measurement

(end of 14th and beginning of 17th year) in each year.

C. Results of statistic analysis of explosive strength in both lower extremities simultaneously according to years of birth in absolute values are given in table 5:

Table 5

Results of statistic analysis of changes explosive strength in both lower extremities in absolute values

	2000		2001		2002		2003	
Measurement of both lower extremities in N 1-7	n = 8	p ¹	n = 10	p ¹	n = 15	p ¹	n = 15	p ¹
Both legs in N 1	1 609 (198)		1 636 (286)		1 338 (295)		1 069 (294)	
Both lower extremities in N 2	1 661 (166)	0.601	1 580 (248)	0.487	1 231 (284)	0.164	1 067 (300)	0.975
Both lower extremities in N 3	1 779 (144)	0.212	1 644 (230)	0.461	1 558 (256)	<0.001	1 165 (318)	0.110
Both lower extremities in N 4	1 844 (171)	0.348	1 761 (292)	0.006	1 617 (306)	0.049	1 276 (292)	0.014
Both lower extremities in N 5	1 825 (145)	0.723	1 776 (204)	0.731	1 629 (217)	0.819	1 344 (325)	0.137
Both lower extremities in N 6	1 855 (1)	0.831	1 748 (288)	0.642	1 774 (212)	0.008	1 463 (344)	0.012
Both lower extremities in N 7	1 970 (139)	0.065	2 015 (318)	0.464	1 720 (386)	0.648	1 451 (358)	0.415

¹Statistic significance of the difference in comparison with the preceding value calculated by paired t-test.

Parameters are described by the mean values and determinative deviation

Table 5 shows statistically significant difference in explosive strength skills in both lower extremities in absolute values in boys born in 2001, as the significant difference between 3rd and 4th measurement in boys born in 2002, significant difference between 2nd and

3rd measurement, between 3rd and 4th measurement, and between 5th and 6th measurement.

D. Results of analysis of explosive strength in both lower extremities simultaneously according to years of birth in relative values are given in table 6:

Table 6

Results of statistic analysis of changes explosive strength in both lower extremities in relative values

	2000		2001		2002		2003	
Measurement of both lower extremities in N/kg 1-7	n = 8	p ¹	n = 10	p ¹	n = 15	p ¹	n = 15	p ¹
both in N/kg 1	24.3 (1.9)		26.0 (3.6)		20.9 (3.5)		22.4 (3.9)	
both in N/kg 2	24.4 (4.5)	0.910	23.9 (4.2)	0.085	19.0 (4.0)	0.106	21.6 (4.4)	0.352
both in N/kg 3	25.2 (2.5)	0.595	23.9 (3.2)	0.982	23.3 (2.4)	<0.001	23.0 (4.3)	0.270
both in N/kg 4	26.1 (3.4)	0.360	25.0 (3.4)	0.058	23.7 (2.7)	0.370	24.4 (4.1)	0.119
both in N/kg 5	25.2 (2.9)	0.290	24.1 (2.2)	0.728	23.0 (2.3)	0.312	23.6 (3.7)	0.259
both in N/kg 6	25.6 (3.0)	0.283	23.3 (3.0)	0.355	24.9 (2.9)	0.013	25.2 (4.4)	0.067
both in N/kg 7	27.6 (4.6)	0.039	25.7 (3.1)	0.455	24.0 (3.6)	0.317	25.3 (5.2)	0.828

¹Statistic significance of the difference in comparison with the preceding value calculated by paired t-test. Parameters are described by the mean values and determinative deviation.

As obvious from table 6, there exists statistically significant difference in explosive strength skills in both lower extremities in relative values in boys born in 2000 between 6th and 7th measurement, in boys born in 2002 the difference between 2nd and 3rd measurement a 5th and 6th measurement.

4. Discussion

Based on statistic analyses, using t-test we revealed significant growth in absolute values of explosive strength skills in lower extremities between the last measurement provided at the age of 13 and the first measurement of 14 years old (p¹ 0.014), nevertheless far more significant difference was recorded on the verge of 14th and 15th year of age (p¹ 0.001 for last measurement at the age of 14 and p¹ 0.049 for the first measurement at the age of 15), see Table 1. This tendency of development is related to absolute values, while in relative values connected with players body weight, the statistically significant growth was recorded even later – at the end of 15th year p¹ 0.013, see

Table 1. This tendency, however, is not unconditional for relative strength. When the body weight is manifested in explosive strength, the process of strength growing in this period is mitigated. Since growing of the body weight is typical for this period, it is convenient to follow the strength development in a relativising way. Despite the fact, that absolute strength is growing, when contextualized with the current body weight of the player, the progress can be reduced. Nevertheless, in our group we concluded that significant growth of relative level of explosive strength (considered for 1kg of body weight) was found at the end of 14th (p¹ 0.001) as well as at the end of 15th year of age (p¹ 0.013).

5. Conclusion

Findings of our research proved significant growth of explosive strength in lower extremities between 14th and 15th year. When body weight was manifested in explosive strength level, we recorded lowering of the growing process in this period.

It is necessary to take into account, that progress in explosive strength skills in ice hockey players is not of the highest intensity for our tested group in sensitive period (just as common population or any other sport category), but it rather culminates between 14th and 15th year. This might be caused by the fact, that systematic training of ice hockey (skating particularly) initiates the progress of explosive strength skills at early age and therefore a significant growth of its level occurs later, and is connected with the peak period of puberty (physical development of an individual).

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