Charles University

Faculty of Physical Education and Sport

Dissertation summary

The relationship between multilateral development
and specific sport skill acquisition in middle childhood

Autoreferát disertační práce

Vztah mezi úrovní všestrannosti a osvojením specifických sportovních dovedností
u dětí v mladším školním věku

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Content of the dissertation summary

1 Introduction

Nowadays, sport and physical education is a significant source of physical activity for children and youth (Baker, 2003). Children practically do not engage in spontaneous physical activities. They exercise mainly in physical education or sports clubs.

For example, in the United States, nearly 72 percent of school-aged youth are active participants in at least one organized sports team or club. It corresponds to almost 29 million young people engaging in organized sports. Similar growth in sports participation is apparent throughout the world in children of all ages (Brenner, 2007; Eiðsdóttir, Kristjánsson et al., 2008; Mostafavifar, Best et al., 2013).

Additionally, for most children, physical education is the only guaranteed opportunity to enhance their physical literacy and experience various sports with appropriate instruction and assessment (Myer, Jayanthi et al., 2016).

It follows that most of the physical activity of children and youth is organized by teachers or coaches. Therefore, the theory of coaching children in sport is becoming more and more important.

All sports are beneficial if performed under proper direction and supervision. Each sport has aspects that can contribute to an enjoyable experience and positive physical and mental development (Caslow, 2015). However, teachers or coaches must decide whether to advocate early sport specialization or developmentally appropriate training in children's sports training.

Early sport specialization versus developmentally appropriate training has been debated since the 1970s. It is a long-standing discussion about the relative merits of early versus late specialization in a sport (Williams, Ford, 2008). Most studies highlight the negative aspects of early sport specialization. Therefore, it might seem that the negative consequences of early sport specialization are well known.

However, there are still children who started to specialize in one sport too early. There are sports programs, coaches, and parents who encourage or sometimes even force children to choose one sport at an early age and to begin intensive training at the chosen activity with the ultimate goal of achieving an elite level (Horn, 2015).

Additionally, some coaches or parents still believe that the best way to develop elite athletes is to participate in only one sport from an early age and perform it year-round (Myer, Jayanthi et al., 2016).

Historical trends indicate that team sports athletes appear more likely to diversify their sports, but even this trend has started to change. Certain positions in team sports, such as baseball pitchers, can be trained as if they were specialized individual sports (Myer, Jayanthi et al., 2015). Therefore, early sport specialization from early to middle childhood has become increasingly common (Jayanthi, Pinkham et al., 2013). Additionally, early specialization in youth sports is growing because some believe that children who specialize early develop advanced skills more quickly (Caslow, 2015).

Despite the large number of available studies dealing with the topic of long-term athlete development, researchers claim that we still do not know much about early sport specialization and more research on this topic is needed (e.g. Baker, Cobley, Fraser-Thomas, 2009; Horn, 2015).

Researchers present developmentally appropriate training as an alternative approach to early sport specialization. Developmentally appropriate training can also be found under these synonymous terms: late sport specialization, early diversification or early sport sampling.

One of the basic principles of developmentally appropriate training is the so-called multilateral development. Multilateral development in children's sports training is associated with many benefits, such as respecting the children's biological age, preventing injuries, or helping the transfer of motor skills.

In this dissertation, we focus on the last-mentioned potential benefit of multilateral development. We investigate the relationship between multilateral development and specific sport skill acquisition in middle childhood.

2 Literature review

2. 1 Multilateral development

Notably, a high volume of the so-called multilateral development is characteristic of developmentally appropriate training. Multilateral development is one of the essential training principles of children's sports training (Perič, 2008).

Multilateral development is the ability to do a wide range of physical activities (Perič, 2008). Simultaneously, the physical activity level is influenced by physical abilities, movement skills, and psychological conditions (see Figure 1 below).

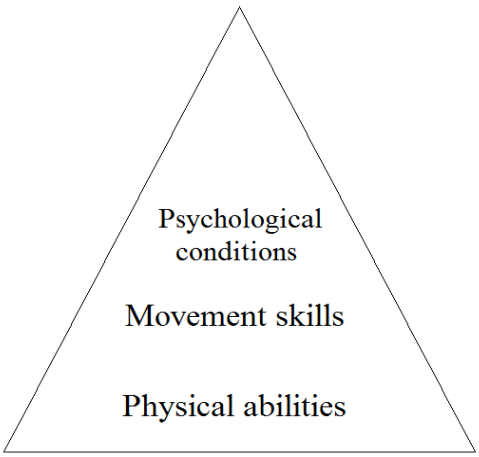

Figure 1: Structure of physical activity (Perič, 2008)

Also, Perič (2008) distinguishes three different levels of multilateral development:

- general level of multilateral development,
- specialized level of multilateral development,
- special level of multilateral development.

The general multilateral development level includes all physical activities (e.g. athletics, swimming, skiing, etc.). The specialized multilateral development level includes physical activities with similar movement patterns (e.g. track cycling, road cycling, cyclocross, etc.). A special multilateral development level includes physical activities within one sport (e.g. ice hockey player can play as a forward and also as a defenceman).

According to this multilateral development classification by Perič (2008), we deal with the general multilateral development level in this dissertation.

„The purpose of multilateral development is to improve overall adaptation. Children and youth who develop a variety of skills and motor abilities are more likely to adapt to

demanding training loads without experiencing stresses associated with early specialization." (Bompa, Carrera, 2015, p. 6)

The position of multilateral development in long-term athlete development is illustrated in Figure 2 below. *„Although the ages will vary from sport to sport and from individual to individual, the model demonstrates the importance of progressive development. The base of the pyramid, which may consider the foundation of any training program, consists of multilateral development. When the development reaches an acceptable level, athletes specialize in one sport and enter the second phase of development. The result will be a high level of performance."* (Bompa, Carrera, 2015, p. 5-6)

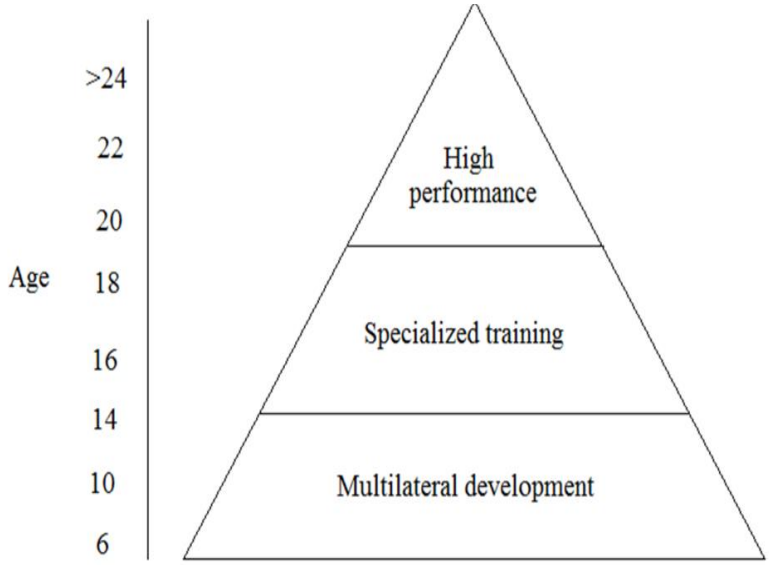

Figure 2: The suggested long-term approach to specificity of training includes a base of multilateral development (Bompa, Carrera, 2015)

According to Perič and Pecha (2014), the multilateral development approach to sports training uses a broad spectrum of adaptation stimuli (largely non-specific stimuli).

It has to be noted that different authors use different terms for this concept of "multilateral development" in the early stages of long-term athlete development. For example:

- versatility (e.g. Drabik, 1996),
- all-round development (e.g. Drabik, 1996),
- multisite development (e.g. Perič, Pecha, 2014),
- overall development (e.g. Balyi, 2002),
- multiskill development (e.g. Bompa, Carrera, 2015).

Furthermore, terms such as multisport athlete or multisport participation are also used (e.g. Roetert, Woods, Jayanthi, 2018).

2. 2 Multilateral development in the long-term athlete development

First publications about long-term athlete development were published in Russia (e.g. Vajcechovskij, 1971; Valik, 1975; Matvejev, Novikov, 1976). Nowadays, sports organizations worldwide adopt various theoretical concepts about long-term athlete development (Mckeown, Ball, 2013). The most popular is Balyi's LTAD model (Balyi, 2001; Balyi, Hamilton, 2004), Côte's Developmental Model of Sports Participation (DMSP) (Côté, Lidor, Hackfort, 2009), and Lloyd's Youth Physical Development Model (YPS) (Lloyd, Oliver, 2012).

In the Czech literature, Choutková, Fejtek (1989) or Štilec (1989) dealt with long-term athlete development. The latest and well-known publications on this topic are by these authors: Dovalil, Choutka et al. (2002), Dovalil, Perič (2010), Perič (2008).

All these models mentioned above emphasize the importance of playing multiple sports or doing various physical activities during the early stages of long-term athlete development.

For example, in the LTAD model, the first stage of athlete development recommended an emphasis on the overall development of the athlete's physical capacities and fundamental movement skills and is encouraged participation in as many sports as possible (Balyi, 2002; Balyi, Hamilton, 2004). According to (Balyi, 2001), fundamental movement skills should be practised and mastered before sport-specific skills are introduced. There is a high probability that this emphasis on motor development will produce athletes with better trainability for long-term sport-specific development. Suppose the fundamental motor skill training is not developed between the ages of nine to twelve. In that case, skills cannot be recaptured later.

Similarly, the Côte's Developmental Model of Sports Participation (DMSP) (Côté, Lidor, Hackfort, 2009) says that early diversification in childhood is linked to a longer sports career and has positive implications for long-term sports involvement. As we mentioned in the previous text, early diversification refers to engaging in various sports during the formative youth sports years.

Also, Lloyd's Youth Physical Development Model (YPS) (Lloyd, Oliver, 2012) suggests that the most suitable period for acquiring fundamental movement skills is early and middle childhood in boys and girls. According to Lloyd, Oliver (2012), fundamental movement skills are building blocks for sport-specific movement patterns and should be typically the focus of physical development programs for children from early childhood to develop gross motor skills.

3 Research problem

Some research supports the concept of multilateral development in the early stages of athlete development. Several studies have found that elite performance is usually preceded by sampling various sports. Also, it has been demonstrated that some athletes who had diversified sport backgrounds and engaged in deliberate play during childhood still reached an elite level in sport (Baker, Côté, Abernethy, 2003; Baker, Côté, Deakin, 2005; Soberlak, Côté, 2003). Moreover, in long-term athlete development models, multilateral development (i.e. sampling various sports and physical activities) in childhood is recommended.

However, some experts argue that these models were developed based on the use of a combination of methods (e.g. literature reviews, collection of retrospective or case study data, information obtained from practitioners in the sports talent development field, comparison of children as measured across several levels, observational/anecdotal data) (Horn, 2015). Furthermore, many studies have been conducted with a retrospective design based on the seminal work of Bloom (1985), which could face methodological problems, because athletes cannot recall their past experiences or the recall of their past experiences could be distorted (Moesch, Elbe et al., 2013). Additionally, other authors (e. g. Bailey, Collins et al. 2010; Ford, Croix et al. 2011; Oliver, Lloyd, 2012) also criticize that the long-term athlete development model by Balyi (2002) is mainly theoretical and lacks supporting longitudinal empirical evidence.

At present, prospective longitudinal studies proving or disproving the importance of multilateral development for specific sport skill acquisition are not commonly available. Goodway and Robinson (2015) claim that we have much to learn about developmental pathways into the elite sport, and therefore prospective, rather than retrospective, studies are needed. Correspondingly, Myer, Jayanthi et al. (2016) argue that there have been few, if any, long-term prospective surveillance studies comparing the potential benefits and risks of young athletes who are specialized versus those who are diversified.

Also, Horn (2015) asserts that it would be of particular value to conduct longitudinal studies following a large sample of children as they progress through the tracks illustrated in the various talent development frameworks. According to Horn (2015), it would be particularly beneficial to conduct a longitudinally based investigation of a sample of children to obtain richer detail regarding the how and why of children's and adolescents' movement through the stages.

4 METHODOLOGY

4. 1 Aim of the study

This dissertation aims to investigate the relationship between multilateral development and specific sport skill acquisition, specifically in ice hockey and athletics.

4. 2 Objectives

We assigned the following objectives:

1. make an overview of long-term athlete development,
2. define the concept of multilateral development in long-term athlete development,
3. select and define multilateral development indicators,
4. select sports and specific sport skills within these sports that children acquire in middle childhood,
5. determine the evaluation of specific sport skill acquisition in selected sports,
6. organize and execute testing sessions,
7. analyze the collected data,
8. write up and summarize the results.

4. 3 Research questions

Our main research question was:

1. What is the relationship between multilateral development and specific sport skill acquisition in middle childhood? In other words, does a higher level of multilateral development leads to a higher level of specific sport skill acquisition at a later age?

From this main research question above arose these other sub-questions:

2. How much of the variance in ice hockey/athletic skill acquisition is explained by multilateral development indicators? In other words, how well do multilateral development indicators predict the level of ice hockey/athletic skill acquisition at a later age?
3. Which multilateral development indicators are the best predictors of better ice hockey/athletic skill acquisition?
4. Can statistical approaches such as confirmatory factor analyses provide evidence to support the general motor ability concept?

4. 4 Hypothesis

H1: There is a strong positive and statistically significant relationship between multilateral development and specific sport skill acquisition in both selected sports.

In other words, there is a strong positive relationship between selected nine non-specific motor tests (multilateral development indicators) and three specific motor tests (specific sport skills) within selected sports.

H2: Multilateral development indicators explain more than 60 percent of the variance in the level of athletic/ice hockey skill acquisition.

H3: The best predictors of better athletic/ice hockey skill acquisition are multilateral development indicators that evaluate coordination predispositions.

H4: Our „model“ for multilateral development evaluation provides evidence to support the general motor ability concept.

4. 5 Proband and sport selection

Regarding the selection of sports, we chose one collective and one individual sport, whereas both are characterized as "late specialization sports". It is ice hockey and athletics.

For the proband selection, we used a purposive non-probability sampling method. We selected 6-7-year-old children from two athletic clubs and two ice hockey clubs in Prague (Czech Republic). Thanks to my internship abroad, we also included children from an ice hockey club in Herentals (Belgium) in our sample.

Sports clubs were selected based on their availability and concerning their sports facilities. The main requirement was a gym or playground with a minimum length of 25 meters.

The condition of choosing a child from a sports club was his/her age and health status. The child had to be 6-7 years old and had no health problems that would limit him/her in sports performance.

The research did not include children whose parents disagreed with the investigation and children who did not come to the test due to illness or other personal reasons.

4. 6 Procedures

Firstly, we asked coaches to cooperate in the research. Secondly, coaches familiarized parents with the possibility of their children's participation in the study. After that, there was a meeting with the parents of the children. Parents were acquainted with their children's involvement in the research, realizing testing sessions, schedule, and personal data protection. Before participating, parents of children read and signed an institutional review board-approved informed consent document.

In the first phase (Figure 3 below), we assessed children's multilateral development. We conducted the testing sessions only indoors. All participants wore suitable sports clothing (gym tracksuit, tee-shirt, gym shoes, or rubber-soled shoes).

We organize each testing session as follows. After the anthropometric measurements and warm-up, we separated the group of children into two groups. One group started the first test (Flag tag game); the second group had a rest. Then we changed the groups.

Subsequently, we performed the following tests (Routine with a stick, Flexed-arm hang, Rolling three balls, Sit and reach, Agility Illinois test, Standing long jump, and Sit-ups) as a "circuit training". It means that we separated the group of children into smaller groups (the number of groups depended on the number of children), and each group went to one station (test). After each child from the group completed the test, the whole group moved to the next station (test). In the end, all participants together performed the last test, which was the Shuttle run.

In the second phase (one year later), we evaluated selected ice hockey skills or athletic skills in these same children.

We used non-standardized questionnaires completed by the children's parents or close relatives for a more detailed description of children's sports background.

4. 7 Research design

This dissertation is based on non-experimental longitudinal research and uses the tools of correlation analysis. We searched for the relationship between multilateral development and specific sport skill acquisition in children in middle childhood.

In the first phase, we evaluated multilateral development in children who were 6-7 years old. One year later, we assessed the level of specific sport skill acquisition in these children, specifically in ice hockey and athletics (see phases of the research in Figure 3 and the testing sessions schedule in Table 6 below).

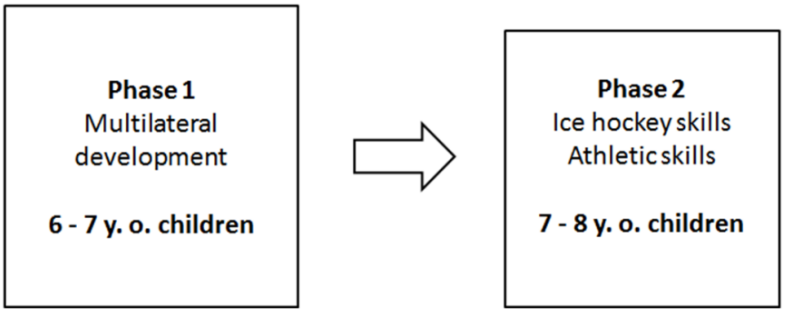

Figure 3: Phases of the research

Table 6: Schedule of testing sessions

Year	Group A	Group B
2018	Evaluation of multilateral development (6-7 years old children)	
2019	Evaluation of specific sport skill acquisition (7-8 years old children)	Evaluation of multilateral development (6-7 years old children)
2020		Evaluation of specific sport skill acquisition (7-8 years old children)

4. 8 Multilateral development evaluation

4. 8. 1 Selection of multilateral development indicators – the first phase

We selected the so-called multilateral development indicators according to the study by Perič, Ružbarský (2019). These authors set up an expert committee that consisted of university teachers (n=5) (at least associate professors and experts in the field of sports training and talent identification). Under the head of the expert group's supervision, the authors did individual and group interviews with these experts to propose multilateral development indicators.

Group interviews with experts were used to define primary domains of multilateral development based on the general theory of sports performance structure. This theory describes five fundamental factors underlying the structure of individual sport performance (Dovalil, 2012) (see Figure 4):

1) conditioning factors
2) technical factors
3) tactical factors
4) somatic factors
5) personality factors (psychological factors)

However, the expert commission concluded that only four of these five factors could be evaluated in training or physical education conditions: conditioning factors, technical factors, tactical factors and somatic factors.

Experts excluded psychological factors (personality factors) due to difficult indications of personality traits in 6 and 7-year-old children due to a low degree of stability of these personality traits caused by ontogenetic development (Perič, Ružbarský, 2019).

When evaluating the options for the evaluation of multilateral development, which are based on the factors mentioned above, the expert commission decided to choose the following domains:

a) chronological age
b) somatic predispositions (body height and body weight)
c) conditioning factors (motor abilities)
d) predispositions for manipulation of objects (for the domain of non-specific predispositions for technique)

e) predispositions for decision-making processes (for the domain of non-specific predispositions for tactics)

4. 8. 2 Selection of multilateral development indicators – the second phase

In the second phase, the expert commission determined indicators for evaluating individual domains mentioned in the previous Chapter 4. 8. 1. The main requirement was to select indicators with high validity and reliability to the assessed criterion. The second requirement was that it should be possible to realize these indicators (tests) in training conditions or physical education.

However, the most relevant requirement was that the indicators could not be affected by children's previous movement experience. It means that selected indicators can not be specific for ice hockey or athletics. In other words, selected indicators (motor tests) should not be commonly used in ice hockey or athletics. This requirement ensured that children would have minimal motor experience with these indicators (motor tests).

In terms of somatic factors, it was included evaluation of body height and body weight.

Regarding conditioning factors, the expert commission decided to evaluate the level of individual motor abilities (coordination, speed, strength, endurance and flexibility) and the "blending" some of these motor abilities (coordination-speed, speed-strength and strength-endurance). Therefore, it was designed this basic structure:

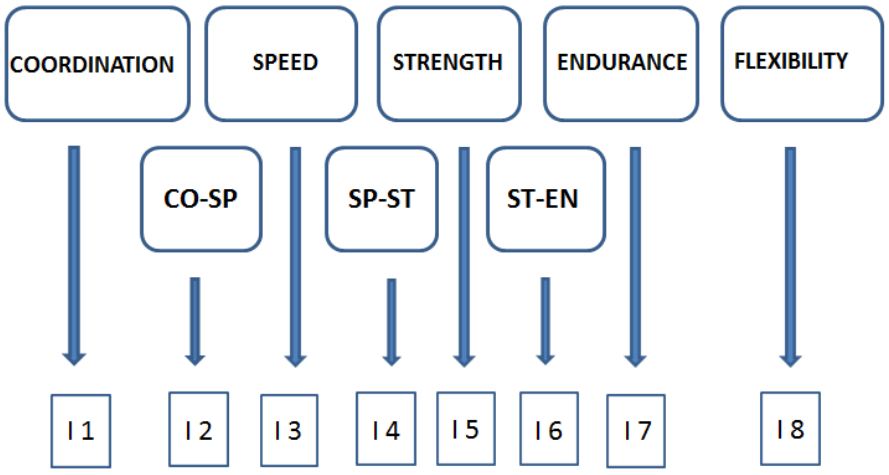

Figure 5: Indicators for the evaluation of motor abilities (addapted from Perič, Ružbarský, 2019)

Depending on the validity, reliability, and simplicity of administration, the following indicators (motor tests) for evaluating motor abilities were selected (see Table 7 below). For some of these selected tests were established standards for middle childhood children (see Kovář, 1985).

However, there is no specific indicator for assessing speed. The pilot study revealed that a high percentage of schools do not have a gym larger than 50 m and transition from the gymnasium to the playground caused organization-related severe problems. Therefore, the expert commission excluded a 50-meter sprint from the test battery. Hence, the expert commission proposed an option of predicting levels of speed abilities by administering the Standing long jump test and the Shuttle run test, respectively (see Table 42) (Perič, Ružbarský, 2019).

As written in Table 7, we exchanged the 4*10 m shuttle run for the Agility Illinois test. We made this change due to the higher validity of the Agility Illinois test.

Table 7: Selected motor tests for the evaluation of motor abilities

Motor ability	**Indicator (test)**	**Reliability (r_{stab})**
Coordination	Routine with gym stick	0,95*
Speed-coordination	Agility Illinios test	0,94-0,99***
Speed- strength (explosive strength)	Standing long jump	0,93*
Strength	Flexed arm hang	0,80*
Strength-endurance	Sit-ups in 30 seconds	0,80*
Endurance	Endurance shuttle run	0,93**
Flexibility	Sit and reach test	0,97*

Reliability coefficient cited by:

** Měkota, Blahuš, 1983*

*** Liu, Plowman, Looney, 1992*

**** Raya, Gailey et al., 2013*

Table 42: Predictive validity values for the 50-meter sprint (n=407) $p_{0,001}$=0,13 (adapted from Perič, Ružbarský, 2019)

Predictive validity coefficient	Prediction 50 m - Total	Prediction 50 m boys (n=220)	Prediction 50 m girls (n=187)
50-meter sprint	0,680	0,754	0,601

In non-specific indicators for tactical predispositions, experts formulated a requirement that the motor test should be simple, easy to understand, and easy to administer. The group interviews yielded a proposal for children playing games that children know, making the games simple to organize. As determined by the expert commission, several games were proposed, and three games with the highest degree of logical validity were chosen. The game chosen was the Flag tag game, during which children had to steal colour flags from each other (Perič, Ružbarský, 2019) (see Table 8 below).

In the area of non-specific indicators for technical predispositions (manipulation of objects) expert committee chose three tests that, from the perspective of validity, assess predispositions of manipulation of objects and are not dependent on previous movement experience. As the domain of decision-making indicators, the commission chose the test that required children to roll three balls over a specific course (test named Rolling three balls) (Perič, Ružbarský, 2019) (see Table 8 below).

Table 8: Selected motor tests for evaluation of technical and tactical predispositions

Non-specific technical predispositions	**Test (indicator)**	**Reliability**
Predispositions for manipulation of objects	Rolling three balls	0,84*
Non-specific tactical predispositions	**Test (indicator)**	**Reliability**
Predispositions for decision-making processes	Flag tag game	being determined ****

Reliability coefficient cited by:

* *Měkota, Blahuš, 1983*

**** *Perič, 2018a (unpublished)*

4. 9 Selection and evaluation of specific sport skills

In athletics, children under 11 years are classified into these age categories:

- athletic kindergarten (5-7 year old children),
- mini athletic preparation (8-9 year old children),
- athletic preparation (10-11 year old children).

The content of practices during these periods are mainly games and fun exercises for speed and coordination development. Children learn fundamental movement skills and acquire the basic technique of athletic disciplines, primarily running, jumping, and throwing. Therefore, we chose these athletic skills for evaluation: Long jump, Overarm throw and 50 m sprint.

We are aware that 50 m sprint is strongly influenced by the level of physical abilities, especially by speed development. In children, however, the running speed is significantly affected by the running technique. Additionally, in Kids' athletics, the great emphasis is usually placed on improving children's running technique. Therefore, we assume that children with a better running technique are faster than children who do not master the technique of running so well. Therefore, we consider 50 meters sprint as a skill in this work.

We evaluated athletic skills quantitatively according to the rules of athletics. However, some rules have been adjusted according to the children's age (e.g. the long jump was measured from the point of take-off).

When we were selecting ice hockey skills, we were also based on the age of children and united training system according to Belmonte, Emahiser et al. (2010). We chose ice hockey skills that children should acquire in middle childhood. It is passing, shooting, and stickhandling. We evaluated selected ice hockey skills also quantitatively according to Perič (2018b).

4. 10 Inferential statistics

Pearson correlation analysis and Partial correlation analysis were used to find correlations between individual indicators of multilateral development in athletes and ice hockey players in particular and also together.

Independent samples t-test was used to assess whether young ice hockey players and athletes differ in multilateral development indicators. Also, this test was used to determine whether boys and girls differ in multilateral development indicators.

Exploratory factor analysis (EFA) was applied to determine the underlying factor structure in a set of variables that evaluate multilateral development in the sport.

To answer research question number two and three (see Chapter 4. 2), a standard multiple regression was performed between multilateral development indicators as independent variables and the level of ice hockey skill acquisition as a dependent variable.

To answer research question 4, whether our multilateral development assessment model provides evidence to support the general motor ability concept, we used the one-factor confirmatory factor analysis (CFA).

To determine the relationship between multilateral development and specific sports skill acquisition, we performed a canonical correlation analysis between a set of multilateral development indicators and a set of ice hockey (or athletic) skills.

5 Results

5. 1 Variance in the level of ice hockey skill acquisition explained by multilateral development indicators

To answer research questions 2 and 3, we performed a standard multiple regression between the set of multilateral development indicators as independent variables and the level of ice hockey skill acquisition as a dependent variable. We used SPSS REGRESSION, and SPSS EXPLORE for evaluation of assumptions.

Table 32: ANOVA[a] (Ice hockey)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	96,950	9	10,772	5,714	,000[b]
	Residual	79,173	42	1,885		
	Total	176,123	51			
a. Dependent Variable: the level of ice hockey skill acquisition						
b. Predictors: (Constant), Routine with a stick, Flexed arm hang, Sit and Reach, Illinois Agility test, Standing long jump, Sit-ups, Shuttle run, Flag tag game						

Our model reaches statistical significance (Sig = 0,000, this means p<0,0005).

Table 33: Model Summary[b] (Ice hockey)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0,742[a]	0,550	0,454	1,37298
a. Predictors: (Constant), Routine with gym stick, Rolling three balls, Long jump from a spot, Stamina in pull-up, Illinois Agility test, Sit-ups, Sit and Reach, Shuttle run, Flag tag game				
b. Dependent Variable: the level of ice hockey skill acquisition				

The adjusted R square value of 0,454 indicates that multilateral development indicators predict almost half of the variability in the level of ice hockey skill acquisition. In other words, our model which includes nine multilateral development indicators explains 45,4 per cent of the variance in the level of ice hockey skill acquisition.

Table 34: Coefficients[a] (Ice hockey)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	0,419	4,976		0,084	0,933			
	Routine with stick	-0,026	0,022	-0,142	-1,187	0,242	-0,370	-0,180	-0,123
	Flexed arm hang	0,045	0,060	0,097	0,747	0,459	0,470	0,115	0,077
	Rolling 3 balls	-0,050	0,025	**-0,254**	-1,970	**0,055**	-0,505	-0,291	-0,204
	Sit and Reach	-0,036	0,059	-0,074	-0,609	0,546	-0,149	-0,094	-0,063
	Illinois Agility test	-0,058	0,091	-0,077	-0,639	0,526	-0,289	-0,098	-0,066
	Standing long jump	0,034	0,016	**0,294**	2,082	**0,043**	0,589	0,306	0,215
	Situps	0,002	0,059	0,004	0,033	0,974	0,413	0,005	0,003
	Shuttle run	0,001	0,004	0,024	0,156	0,877	0,470	0,024	0,016
	Flag tag game	0,117	0,060	**0,242**	1,945	**0,058**	0,434	0,287	0,201

a. Dependent Variable: the level of ice hockey skill acquisition

Suppose we want to know which of multilateral development indicators contributed to predicting the dependent variable (the level of ice hockey skill acquisition). In that case, we have to look in the output box labelled Coefficients in Table 34 above.

Of these nine multilateral development indicators, Standing long jump (Beta value = 0,294), Rolling three balls (Beta value = -0,254) and Flag tag game (Beta value = 0,2042) make the most considerable unique contribution to explaining the dependent variable (the level of ice hockey skill acquisition). The Beta value for the other indicators is slightly lower, indicating that they made less of a contribution. However, only the indicator Standing long jump makes a statistically significant contribution to the equation.

We can summarize that the standard multiple regression results presented above allow us to answer two questions posed in the methodology. Our model, which includes nine multilateral development indicators, explains 45,4 per cent of the variance in ice hockey skill acquisition. Of these nine indicators, indicator Standing long jump, indicator Flag tag game, and indicator Rolling three balls make the most considerable unique contribution. In other words, these indicators are the best predictors of better ice hockey skill acquisition.

5. 2 Variance in the level of athletic skill acquisition explained by multilateral development indicators

Also, in athletics, we performed a standard multiple regression between multilateral development indicators as independent variables and the level of athletic skill acquisition as a dependent variable.

Table 35: ANOVA[a] (Athletics)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	149,648	9	16,628	6,303	,000[b]
	Residual	50,120	19	2,638		
	Total	199,768	28			
a. Dependent Variable: the level of athletic skill acquisition						
b. Predictors: (Constant), Routine with gym stick, Flexed arm hang, Sit and Reach, Illinois Agility test, Standing long jump, Sit-ups, Shuttle run, Flag tag game						

Like in ice hockey, our model reaches statistical significance (Sig = 0,000, this means p<0,0005).

Table 36: Model Summary[b] (Athletics)

Model	R	R square	Adjusted R square	Std. Error of the Estimate
1	0,866[a]	0,749	0,630	1,62416
a. Predictors: (Constant), Routine with gym stick, Flexed arm hang, Sit and Reach, Illinois Agility test, Standing long jump, Sit-ups, Shuttle run, Flag tag game				
b. Dependent Variable: the level of athletic skill acquisition				

The adjusted R square value of 0,630 indicates that more than half of the variability in the level of specific sport skill acquisition score is predicted by multilateral development indicators. In other words, our model explains 63 per cent of the variance in athletic skill acquisition.

Of these nine multilateral development indicators, indicator Standing long jump (Beta value = 0,424) and indicator Routine with a stick (Beta value = -0,387) and Rolling three balls (Beta value = -0,294) make the largest unique and statistically significant contribution.

In summary, our model, which includes nine multilateral development indicators, explains 63 per cent of the variance in the level of athletic skill acquisition. Of these nine indicators, indicator Standing long jump, indicator Routine with a stick and indicator Rolling three balls are the best predictors of better athletic skill acquisition (see Table 37 below).

Table 37: Coefficients (Athletics)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	-0,191	6,025		-0,032	0,975			
	Routine with a stick	-0,123	0,050	**-0,387**	-2,468	**0,023**	-0,531	-0,493	-0,284
	Flexed arm hang	0,094	0,077	0,194	1,222	0,237	0,571	0,270	0,140
	Rolling three balls	-0,155	0,072	**-0,294**	-2,156	**0,044**	-0,357	-0,443	-0,248
	Sit and Reach	0,051	0,073	0,097	0,706	0,489	0,480	0,160	0,081
	Illinois Agility test	-0,178	0,208	-0,121	-0,855	0,403	-0,450	-0,193	-0,098
	Standing long jump	0,056	0,023	**0,424**	2,415	**0,026**	0,698	0,485	0,278
	Situps	-0,006	0,107	-0,010	-0,056	0,956	0,349	-0,013	-0,006
	Shuttle run	0,007	0,004	0,261	1,464	0,159	-0,055	0,318	0,168
	Flag tag game	-0,110	0,095	-0,174	-1,149	0,265	0,295	-0,255	-0,132

a. Dependent Variable: the level of athletic skill acquisition

5. 3 The relationship between multilateral development indicators and specific sport skills

To determine the relationship between multilateral development and the level of specific sport skill acquisition we performed a canonical correlation analysis between a set of multilateral development indicators and a set of ice hockey (or athletic) skills.

Canonical correlation analysis aims to find pairs of linear combinations of each set of highly correlated variables. These linear combinations are called canonical variates.

We utilized an alpha level of 0,05. According to Tabachnick, Fidel (2001), we used the cutoff correlations of 0,30 to interpret the canonical variates. Assumptions for normality, linearity, and homoscedasticity were evaluated through scatterplot distributions; assumptions were met, and no multivariate outliers were detected. However, one child from the athletic sample was eliminated due to extreme points in five multilateral development indicators.

In both sports, we found a statistically significant relationship between the set of multilateral development indicators and the set of specific sport skills.

Generally, results of canonical correlation indicate that our hypothesis is correct. The multilateral development indicators and specific sport skills in ice hockey and athletics are positively correlated.

Table 38: Canonical correlations (Ice hockey)

Root No.	Canon Cor.	Sq. Cor	Eigenvalue	Wilks Statistic	F	Num D.F	Denom D.F.	Sig. of F
1	**0,726**	**0,527**	**1,113**	**0,302**	**2,311**	**27**	**123,304**	**0,001**
2	0,479	0,230	0,298	0,639	1,349	16	86	0,187
3	0,413	0,170	0,206	0,830	1,292	7	44	0,277
H0 for Wilks test is that the correlations in the current and following rows are zero								

In ice hockey, the first canonical root is significant, $\lambda = 0.302$, $F(27, 123) = 2.311$, $p = 0.001$, accounting for 53 % ($r_c = 0.726$) of the overlapping variance. The second canonical root is not significant, $\lambda = 0.639$, $F(16, 86) = 1.349$, $p = 0.187$, $r_c = 0.479$. Also, the third canonical root is not significant, $\lambda = 0.830$, $F(7, 44) = 1.292$, $p = 0.277$, $r_c = 0.413$. Therefore, we interpret only the first canonical variant.

Canonical correlation of the first pair of the canonical variant in ice hockey is 0,726. The square of this canonical correlation represents the proportion of the variance in one group's variate explained by the other group's variate. In this case, the squared correlation is 0,527. It means that the variables that we included in the analysis explain about 53% of the relationship between the multilateral development indicators and ice hockey skills.

Table 39: Canonical correlations (Athletics)

Root No.	Canon Cor.	Sq. Cor	Eigenvalue	Wilks Statistic	F	Num D.F	Denom D.F.	Sig. of F
1	**0,901**	**0,812**	**4,311**	**0,113**	**2,190**	**27,000**	**53,212**	**0,007**
2	0,503	0,253	0,338	0,599	0,694	16,000	38,000	0,781
3	0,446	0,199	0,248	0,801	0,708	7,000	20,000	0,665
H0 for Wilks test is that the correlations in the current and following rows are zero								

Similarly, in athletics only the first canonical root is significant, $\lambda = 0.113$, $F(27,53) = 2.190$, $p = 0.007$, accounting for 82% ($r_c = 0.901$) of the overlaping variance. Therefore, we interpret only the first canonical variant also in athletics.

The set of multilateral development indicators and the set of athletic skills are positively correlated (Canon Cor. = 0,901). The squared correlation is even higher (Sq. Cor = 0,812) than in ice hockey. Variables that we included in the analysis explained 82% of the relationship between the multilateral development indicators and athletic skills.

6 Conclusion

This work aimed to investigate the relationship between multilateral development and specific sport skill acquisition in middle childhood. For these purposes, we chose two sports characterized as late specialization sports because peak performance is usually achieved after full maturation. It is ice hockey and athletics.

Firstly, in the theoretical background, we defined two basic approaches to children's sports training and presented an overview of the most frequently mentioned pros and cons of these two approaches. Secondly, we defined multilateral development in children's sports training and emphasized its potential benefits. Also, we devoted one chapter to the characteristics of middle childhood. Besides, we included a chapter about the theory of general motor ability, which we verified in the results of our research.

Based on a study by Perič and Ružbarský (2019), we selected nine indicators for assessing multilateral development. Then, we selected three ice hockey skills and three athletic skills that children acquire in middle childhood in these sports. We chose these specific sport skills mainly with regard to the age of the children participating in our research.

During the four years of research, we managed to measure the multilateral development of 172 children, specifically children from two athletic clubs and three ice hockey clubs. One year later, we evaluated the level of ice hockey skill acquisition or athletic skill acquisition in these same children.

The dropout rate in both sports was relatively high. Almost 60 percent of children from the athletic sample did not come to participate in the second phase of the research. In ice hockey, 51 percent of children did not participate in the second phase of the research.

Pearson correlation analysis confirms the independence of multilateral development indicators. The strength of the relationship between most selected indicators was small (up to 0.3), and there was no large correlation between indicators. Additionally, partial correlation analysis showed that the observed relationship between multilateral development indicators is not due merely to the influence of body height and body weight. This analysis confirms the expert commission's intention to select such multilateral development indicators that evaluate a wide range of physical activities (i.e. movement abilities and skills).

In ice hockey, almost a half of the variability in specific sport skill acquisition scores is predicted by multilateral development indicators. In athletics, even more than a half of the variability in the level of athletic sport skill acquisition score is predicted by multilateral development indicators. In both selected sports, the best predictor of a higher level of specific

skill acquisition at a later age is the standing long jump indicator and also the rolling three balls indicator. Therefore, we can claim that explosive power of the lower limbs and coordination, specifically hand–eye coordination, are essential motor abilities for skill acquisition in these two sports.

Using canonical correlation analysis, we found a positive relationship between multilateral development and specific sport skill acquisition in ice hockey and athletics. In ice hockey, the variables that we included in the analysis explained about 53 percent of the relationship between multilateral development and ice hockey skill acquisition. In athletics, the canonical correlation was even higher. Variables that we included in the analysis explained about 82 percent of the relationship between multilateral development and athletic skill acquisition.

The results of this research indicate that our initial hypothesis was correct. There is a strong positive relationship between multilateral development and specific sport skill acquisition in both selected sports. This dissertation confirms the importance of multilateral development in children's sports training for specific sport skill acquisition later. Specifically, there is a high probability that six- to seven-year-old children with a higher level of multilateral development will acquire specific sports skills easily or faster than children with a lower level of multilateral development.

We partially confirm our second hypothesis. Multilateral development indicators explain more than 60 per cent of the variance in the level of athletic skill acquisition. However in ice hockey is this percentage lower.

Also, the third hypothesis is partially correct. In both sports, the second best predictor of better skill acquisition was indicator that assessed coordination. Specifically, in ice hockey it was the indicator Rolling three balls and in athletics it was the indicator Routine with a stick. However, in both sports the best predictor of better specific sport skill acquisition was the indicator Standing long jump that evaluates explosive power of lower limbs.

Unfortunately we did not confirm hypothesis number four. Our „model" for multilateral development evaluation does not provide evidence to support the general motor ability concept.

In conclusion, we should emphasize that although we selected two sports that are both characterized as late specialization sports, it follows that multilateral development in these sports is significant. We must realize that developmentally appropriate training is applicable in sports for which it is typical to achieve elite sports performance after maturation (that is, in late specialization sports). Still, this approach can also be suitable in sports where peak performance is achieved typically before maturation (in early specialization sports).

References used in dissertation summary

Bailey, R., Collins, D., Ford, P., MacNamara, Á., Toms, M., & Pearce, G. (2010). Participant development in sport: An academic review. *Sports Coach UK*, *4*, 1-134.

Baker, J. (2003). Early specialization in youth sport: a requirement for adult expertise?. *High ability studies*, *14*(1), 85-94.

Baker, J., Cobley, S., & Fraser-Thomas, J. (2009). What do we know about early sport specialization? Not much!. *High ability studies*, *20*(1), 77-89.

Baker, J., Côté, J., & Abernethy, B. (2003a). Learning from the experts: Practice activities of expert decision makers in sport. *Research quarterly for exercise and sport*, *74*(3), 342-347.

Baker, J., Côté, J., & Abernethy, B. (2003b). Sport-specific practice and the development of expert decision-making in team ball sports. *Journal of applied sport psychology*, *15*(1), 12-25.

Baker, J., Côté, J., & Deakin, J. (2005). Expertise in ultra-endurance triathletes early sport involvement, training structure, and the theory of deliberate practice. *Journal of applied sport psychology*, *17*(1), 64-78.

Balyi, I. (2001). Sport system building and long-term athlete development in British Columbia. *Coaches Report*, *8*(1), 22-28.

Balyi, I. (2002). Long-term Athlete Development-the system and solutions. *FHS-LEEDS-*, 6-10.

Balyi, I., & Hamilton, A. (2004). Long-term athlete development: Trainability in childhood and adolescence. *Olympic Coach*, *16*(1), 4-9.

Bloom, B. (1985). *Developing talent in young people*. BoD–Books on Demand.

Bompa, T. O., & Carrera, M. (2015). *Conditioning young athletes*. Human Kinetics.

Brenner, J. S. (2007). Overuse injuries, overtraining, and burnout in child and adolescent athletes. *Pediatrics*, *119*(6), 1242-1245.

Caslow, D. (2015). Youth Specialization in Sports: Good or Bad?. *Amateur Wrestling News*, 60(8), 16-17.

Côté, J., Lidor, R., & Hackfort, D. (2009). ISSP position stand: To sample or to specialize? Seven postulates about youth sport activities that lead to continued participation and elite performance. *International journal of sport and exercise psychology*, *7*(1), 7-17.

Dovalil, J., & Choutka, M. (2012). *Výkon a trénink ve sportu*. Praha: Olympia.

Dovalil, J., & Perič, T. (2010). *Sportovní trénink*. Praha: Grada.

Dovalil, J., Choutka, M., Svoboda, B., Hošek, V., Perič, T., Potměšil, J., & Bunc, V. (2002). *Výkon a trénink ve sportu*. Praha: Olympia.

Drabik, J. (1996). *Children and sports training.* Island Point, VT: Stadion Publishing Company.

Eiðsdóttir, S. Þ., Kristjánsson, Á. L., Sigfúsdóttir, I. D., & Allegrante, J. P. (2008). Trends in physical activity and participation in sports clubs among Icelandic adolescents. *European Journal of Public Health*, *18*(3), 289-293.

Ford, P., De Ste Croix, M., Lloyd, R., Meyers, R., Moosavi, M., Oliver, J., ... & Williams, C. (2011). The long-term athlete development model: Physiological evidence and application. *Journal of sports sciences*, *29*(4), 389-402.

Goodway, J. D., & Robinson, L. E. (2015). Developmental trajectories in early sport specialization: a case for early sampling from a physical growth and motor development perspective. *Kinesiology review*, *4*(3), 267-278.

Horn, T. S. (2015). Social psychological and developmental perspectives on early sport specialization. *Kinesiology Review*, *4*(3), 248-266.

Choutková, B., & Fejtek, M. (1989). *Malá škola atletiky*. Praha: Olympia.

Jayanthi, N., Pinkham, C., Dugas, L., Patrick, B., & LaBella, C. (2013). Sports specialization in young athletes: evidence-based recommendations. *Sports health*, *5*(3), 251-257.

Liu, N. Y. S., Plowman, S. A., & Looney, M. A. (1992). The reliability and validity of the 20-meter shuttle test in American students 12 to 15 years old. *Research quarterly for exercise and sport*, *63*(4), 360-365.

Lloyd, R. S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. *Strength & Conditioning Journal*, *34*(3), 61-72.

Matvejev, L. P., Novikov, A. D. (1976). *Teorie a didaktika tělesné výchovy a sportu*. Praha: Olympia.

McKeown, I., & Ball, N. (2013). Current practices of long term athlete development of junior athletes in high performance sport environments. *J Aust Strength Cond*, *21*(1), 16-25.

Měkota, K., & Blahuš, P. (1983). *Motorické testy v tělesné v*ýchově. Praha: Státní pedagogické nakladatelství.

Moesch, K., Elbe, A. M., Hauge, M. L., & Wikman, J. M. (2011). Late specialization: the key to success in centimeters, grams, or seconds (cgs) sports. *Scandinavian journal of medicine & science in sports*, *21*(6), e282-e290.

Mostafavifar AM, Best TM, Myer GD. Early sport specialisation, does it lead to long-term problems? *Br J Sports Med*. 2013;47:1060-1061.

Myer, G. D., Jayanthi, N., DiFiori, J. P., Faigenbaum, A. D., Kiefer, A. W., Logerstedt, D., & Micheli, L. J. (2016). Sports specialization, part II: alternative solutions to early sport specialization in youth athletes. *Sports health*, *8*(1), 65-73.

Myer, G. D., Jayanthi, N., Difiori, J. P., Faigenbaum, A. D., Kiefer, A. W., Logerstedt, D., & Micheli, L. J. (2015). Sport specialization, part I: does early sports specialization increase negative outcomes and reduce the opportunity for success in young athletes?. *Sports health*, *7*(5), 437-442.

Myer, G. D., Jayanthi, N., DiFiori, J. P., Faigenbaum, A. D., Kiefer, A. W., Logerstedt, D., & Micheli, L. J. (2016). Sports specialization, part II: alternative solutions to early sport specialization in youth athletes. *Sports health*, *8*(1), 65-73.

Perič, T (2018a). *Evaluation of decision-making processes in middle childhood children.* [Unpublished manuscript]. Faculty of Physical Education and Sport, Charles University.

Perič, T (2018b). *Evaluation of ice hockey skills in children in middle childhood.* [Unpublished manuscript]. Faculty of Physical Education and Sport, Charles University.

Perič, T. (2008). *Sportovní příprava dětí*. 2. doplněné vyd. Praha: Grada.

Perič, T., & Ružbarský, P. (2019). Talent Selection and the Present? The Way Sports Preconditions Are Determined in Slovakia. *Gymnasium*, *19*(1), 52-62.

Perič, T., & Pecha, J. (2014). Sportovní příprava dětí – co ovlivňuje kvalitu tréninkového procesu. In: Flemr, L., Němec, J., Novotný, O. (eds.) (2014). *Pohybové aktivity ve vědě a praxi. Konferenční sborník. U příležitosti*, *60*. *výročí založení fakulty tělesné výchovy a sportu Univerzity Karlovy v Praze.* Praha: Karolinum, 465-475.

Raya, M. A., Gailey, R. S., Gaunaurd, I. A., Jayne, D. M., Campbell, S. M., Gagne, E., ... & Tucker, C. (2013). Comparison of three agility tests with male servicemembers: Edgren Side Step Test, T-Test, and Illinois Agility Test. *Journal of Rehabilitation Research & Development*, *50*(7).

Roetert, E. P., Woods, R. B., & Jayanthi, N. A. (2018). The benefits of multi-sport participation for youth tennis players. *COACHING & SPORT SCIENCE REVIEW*.

Soberlak, P., & Côté, J. (2003). The developmental activities of elite ice hockey players. *Journal of applied sport psychology*, *15*(1), 41-49.

Sport Frameworks. *Spor for Life* [online]. Canada [cit. 2020-03-25]. Available from: https://sportforlife.ca/sport-frameworks

Štilec, M. (1989). *Sportovní příprava dětí a mládeže: pro posl. fak. tělesné výchovy a sportu*. SPN.

Vajcechovskij, S. M. (1971). *Kniha trenéra*. Praha: Olympia.

Valik, B. V. (1975). *Trenérům mladých atletů*. Praha: Olympia. Atletika do kapsy.

Williams, A. M., & Ford, P. R. (2008). Expertise and expert performance in sport. *International Review of Sport and Exercise Psychology*, *1*(1), 4-18.