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**Oleksandr KRASILSHCHIKOV** ©

Ph.D. (Pedagogy), Professor  
(School of Health Sciences,  
Universiti Sains Malaysia),  
Malaysia

## **TALENT DEVELOPMENT: HISTORY AND PHILOSOPHY OF THE MODELS RELEVANT TO HIGH-PERFORMANCE SPORT**

**Abstract.** The article deals with the actual issues of talent development in high-performance sport. Talent development is a complex process that involves a combination of genetics and environment. Long-Term Athlete Development Models have contributed to talent development research and generalizations, while Bloom et al.'s study of advanced talent development has laid the foundation for talent development philosophy. Ericsson's Notion of Deliberate Practice emphasizes the importance of the amount of deliberate practice as a significant determinant of expertise attained. Experts invest more hours of practice per week compared to novices and start engaging in deliberate practice at younger ages.

However, it is impossible for individuals with less accumulated practice at a given age to catch up with those who started deliberate practice earlier and maintained optimal levels of practice. Overall, talent development remains a topic of discussion for centuries and requires a combination of genetic predisposition and environmental factors to attain excellence.

Implementing Pre-Detection and Post-Detection procedures in talent development can lead to critical outcomes. Providing quality physical education and regular practice opportunities in schools can increase the number of physically advanced children, leading to more potential talent to be identified and developed by coaches.

**Keywords:** *talent development, high-performance sport, athlete development models, pre-detection and post-detection procedures.*

**Introduction.** Talent Development has been an issue of discussions, debates, and numerous options of managing for decades if not for centuries.

It has often been used interchangeably with the term Attaining Excellence, particularly when emphasising the notion that excellence must be theoretically achievable by anyone, not necessarily by someone possessing talent. Hence, philosophically speaking here comes the first controversy: agreeing with the opinion that excellence in any human activity can be achieved by anyone, statement that excellence in sports (performance in which is often measurable and always comparable) can be achieved by anyone is questionable.

Excellence in sport (particularly the international level one) requires talent and international level of excellence is typically achieved due to complex interactions between advances in both genotype and phenotype with first being determined by genetic predisposition, whereas the second depending a lot on environmental factors including coaching, facilities, nutrition, scientific support, and many more.

Sports and talent development in sports may not the primary objective of research and implementation attempts while developing Generalized Talent

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© Krasilshchikov O., 2023

ORCID iD: <https://orcid.org/0000-0001-7575-1026>

olek@usm.my

Development Models. Sports and Excellence in Sports research, however, gave way to the development of Long-Term Athlete Development Models, which in turn contributed back to other fields of human activities and immensely supported the efforts of scientists and practitioners in talent development research and generalizations.

The issues of talent development in sport and in pre-sport activities as well obviously have own history and philosophy, both of which are attempted to be discussed in this paper.

**Analysis of recent research and publications.** *Generalized talent development models and attaining excellence.* One of the most often cited and referred to as foundational to the talent development philosophy and further advances of talent development models is a study of Bloom and colleagues (1985) which was aimed at understanding of how advanced talent is developed. Researchers interviewed 120 subjects who had achieved international level success in various fields such as art, music, academics, and sports.

The study outcomes indicated that individuals who achieved excellence in various fields, had kind of similar learning and development pathways. To put it simple, author divided the entire development process into phases, such as initiation, development, and perfection.

One of the features was that the model embraced the holistic approach and described stages of development not by chronological age, but by the completion of certain tasks (Wolstencroft, 2002).

Importantly, the contents of the model described the features and actions from the roles played point of view and included the roles of performer, mentor, and parents. It also included general features, and more importantly the transitions between the phases (Figure 1).

Stage 1 Initiation	Stage 2 Development	Stage 3 Perfection
<b>Performer</b>	<b>Performer</b>	<b>Performer</b>
<ul style="list-style-type: none"> <li>Joyful</li> <li>Playful</li> <li>Excited</li> <li>'Special'</li> <li>Fun/social oriented</li> </ul>	<ul style="list-style-type: none"> <li>Hooked/committed</li> <li>Potential identified</li> <li>More serious</li> <li>Task/achievement oriented</li> </ul>	<ul style="list-style-type: none"> <li>Obsessed/dominates life</li> <li>Personally responsible</li> <li>Independent</li> <li>Willingness to dedicate time and effort required for highest standards</li> </ul>
<b>Mentor</b>	<b>Mentor</b>	<b>Mentor</b>
<ul style="list-style-type: none"> <li>Process centred</li> <li>Kind/cheerful/caring</li> <li>Notice child's 'giftedness'</li> </ul>	<ul style="list-style-type: none"> <li>Superior technical knowledge</li> <li>Strong personal interest</li> <li>Respected</li> <li>Strong guidance and discipline</li> <li>Expected quality results</li> </ul>	<ul style="list-style-type: none"> <li>Master coach</li> <li>Feared/respected</li> <li>Love/hate relationship</li> <li>Successful/demanding</li> </ul>
<b>Parents</b>	<b>Parents</b>	<b>Parents</b>
<ul style="list-style-type: none"> <li>Positive</li> <li>Shared excitement</li> <li>Supportive</li> <li>Notice child's 'giftedness'</li> <li>Sought mentors</li> </ul>	<ul style="list-style-type: none"> <li>More moral and financial support (to maintain mentor relationship)</li> <li>Restrict other activities</li> <li>Concerned for holistic development</li> </ul>	<ul style="list-style-type: none"> <li>Lesser role</li> </ul>
<b>General</b>	<b>General</b>	<b>General</b>
<ul style="list-style-type: none"> <li>Little or no emphasis on competition</li> </ul>	<ul style="list-style-type: none"> <li>Competition used as a yardstick for progress</li> </ul>	<ul style="list-style-type: none"> <li>Fine tuning</li> </ul>
<b>Transition 1</b>		<b>Transition 2</b>
<ul style="list-style-type: none"> <li>Development of an athletic identity</li> <li>Accelerated development</li> <li>Introduction to a more technical coach</li> <li>Becoming more achievement oriented</li> <li>Talent identification</li> <li>Competition becomes yardstick of success</li> <li>Increased commitment</li> </ul>		<ul style="list-style-type: none"> <li>Prioritisation of sport in life</li> <li>Psychological rebellion</li> <li>Transition characterised by turning points perhaps stimulated by a successful performance/key event</li> <li>Introduction of a master coach</li> </ul>

**Fig. 1** – Features of Bloom’s model of attaining excellence  
*Source: (Bloom, 1985)*

Another important step in the development of excellence advancements became the Ericsson's Notion of Deliberate Practice (Ericsson & Charness, 1994), which eventually put the quantity/amount of deliberate practice on top of the factors listed as influencing (or contributing to) the degree of excellence (expertise).

The study concluded that the number of hours of deliberate practice accumulated in a domain is a significant determinant of the level of expertise attained.

Researchers have also found that experts invest more hours of practice per week compared to novices and start engaging in deliberate practice at younger ages.

It was revealed that it is impossible for individuals with less accumulated practice at a given age to catch up with the best individuals who started deliberate practice earlier and maintained optimal levels of practice that did not lead to either exhaustion or burnout (Ericsson & Charness, 1994).

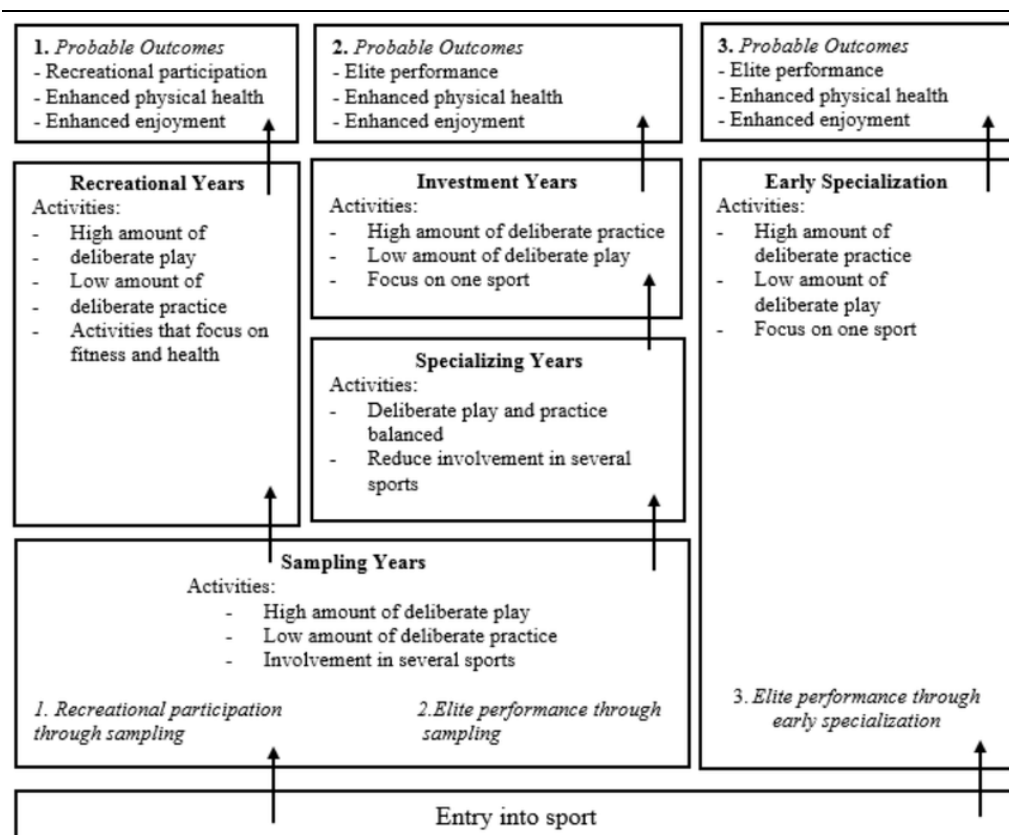
Not all the conclusions of the study were applicable to the sport and sport related careers. Fully supporting the conclusions that amount of accumulated practice is one of the most important factors in attainment of excellence, and that experts typically spent more time practicing than the novices, but impossibility to catch up with best even though they started practicing earlier is not that obvious in sports.

Such situation can be relevant to rhythmic gymnastics, where an eleven-year-old beginner girl has practically no chance on catching up with an advanced athlete who was recruited at the age of 7 and spent 4 years in training already. Main reason being the proximity of the age of possible top performance in gymnastics, which is about 17 to 19 and the fact that the advanced girl has already covered about 40 % of that excellence pathway, whereas the novice girl is at zero level.

In other sports, like boxing or rowing, it does not matter much. Many of the current professional boxing champions (e.g., Antony Joshua and Oleksandr Usyk) have started their careers in boxing after the age of fifteen and had comfortably achieved international amateur levels within a span of 5-7 years, catching up and often surpassing their opponents who started their careers way earlier than them in the amateur boxing. And they still reign in the professional division.

Rowing has known a number of occasions when international levels of performance have been reached within 5 to 6 years, hence talented and effectively trained novices were surpassing their much more experienced opponents in quite a short period of time.

Another popular model which brought talent development pathway to the context of sports participation (Earle, 1997) is known as Cote & Hay (2002) children involvement in sports pathway (Fig. 2).



**Fig. 2** – Children involvement in sports pathway  
 Source: (Cote & Hay, 2002)

In their structure, the sampling years consisted of a period during which children were encouraged to get engaged with different sports and games for recreational participation, rather than for attaining specific goals. Pathway towards elite performance through sampling, though is also possible.

During the specializing years, the athletes were encouraged to narrow their involvement in several sport or disciplines. The investment years were characterized by the pursuit of an elite level of performance usually in one specific sport.

With these three phases being obviously observed, participation still got a recreational pathway with no shot at high performance and also an early specialization pathway, with sort of moving ahead without sampling and investment years. That, perhaps, can be applicable to the early age specialized sports such as gymnastics (both rhythmic and artistic), diving, acrobatics and figure skating.

**The purpose of the article is** to investigate the features of talent development models, relevant to high-performance sport.

**Formulation of the main material.**

*Long-term athlete development models.* Interestingly, there is no chronological sequences observed in the emergence of Generalized Talent Development (GTD) models and emergence of the well-known both theoretically and practically Long-Term Athlete Development (LTAD) models. Both were emerging in their own pace and in a way were mutually contributing to both model groups advancements.

Since it is not possible to discuss every practical LTAD model designed by numerous International and National Sports Governing bodies in multiplicity of sports for their longitudinal improvement, we will focus on the basic LTAD models, offered by the known sports scientists in the recent decades.

One of the first scientifically based LTAD models was suggested by East German sports scientist Dietrich Harre (Xappe, 1971). In his views, the long-term athlete development should include phases of *Basic Training* (Foundation Training) with two sub-phases, which depending on the group of sports, were defined as:

- Technical (Artistic) Sports: Phase I: 5 to 7-9; Phase II – 10 to 15-18;
- Power Sports: Phase I: 9-12; Phase II – 13-18;
- Endurance Sports: Phase I: 11-13; Phase II – 14-18.

And the phase of *Advanced Training* (Masters' Training), which depending on the group of sports were defined as:

- Technical (Artistic) Sports: 15 to 18-20;
- Power Sports: 18 to 22-23;
- Endurance Sports: 19 to 23-24.

The obvious advantage of the model is its specific orientation on various groups of sports, depending on the traditional age for the recruitment and the average age of top performance in those groups, which for obvious reasons is different.

Another model of LTAD was suggested in the earth while USSR, where Vladimir Platonov (Platonov, 1984) worked out the 5-stage model of long-term athlete development, which included the following stages:

*Initial Training*: about a year or two duration for more of the introductory type of training.

*Preliminary Basic Training*: two to three years of training with overall physical development in mind.

*Specialized Basic Training*: three to four years to master highly specialized skills and obtain specific fitness of the selected sport, discipline and event.

*Maximal Realization of Individual Potential*: four to five years of training to reach peak fitness, skills and performance levels.

*Maintenance of Acquired Performance*: unspecified duration for an athlete to try maintaining peak conditions to perform at the top level for as long as it is possible.

The model didn't suggest any particular age brackets for various groups of sports, progressive development, however, was introduction of the stage of Maintenance of Acquired Performance. It proved critical, especially with increased longevity of the professional athletes and their successful participation in numerous consecutive Olympic Games and world championships.

Another interpretation of LTAD model was suggested in India by Hardayal Singh (1991). His developed sequence included the following phases:

- Basic Training (3-4 years);
- Advanced Training (4 years).

High Performance Training, which for various groups of sports was specified as follows:

- Technical (Artistic) Sports: 15 years onwards;
- Power Sports: 19/20 years onwards;
- Endurance Sports: 20 years onwards;

- Combats: 19 years onwards;
- Team Games: 19 years onwards.

That in a way was an extension of East German developed model catering for various sports depending on their age-specific recruitment and optimal age for top performance.

Canadian sport scientist T. Bompa (1994) suggested dividing the athlete long term training into generalised and specialized phases. Generalized, in turn was subdivided into two sub-phases. *Initiation* was meant for athletes of six to ten years of age with focus on overall athletic development and not sport-specific performance. *Foundation* was suggested for athletes of 11 to 14 years of age where the emphasis was still supposed to be on developing skills and motor abilities, not on performance and winning.

Specialized phase was also subdivided into the sub-phase of *Specialization*: for athletes of 15 to 18 years of age with proper foundation, performing more exercises and drills aimed specifically at high-performance development. *High performance* sub-phase was meant for athletes of 19 and above years of age to achieve high performance.

With undoubtful logic of the suggested sequence, a lot of doubts are however existing regarding the umbrella age suggested for the phases and sub-phases. In neither of the phases one can comfortably place a gymnast and a rower, for example, for the obvious reason of completely different age of recruitment and age of attaining excellence in these two sports.

Eventually, in 2005, another LTAD model was suggested by Canadian scientist I. Balyi (Canadian Sport Centres, 2005). In its modified version it is currently the most popular around the world LTAD model so far developed. Original model (2005) consisted of seven phases, five of which were directly belonging to training in sports, whereas the first and the last ones were one – pre-sport activities related, and another one – post-sport activities related. Remaining five phases by and large resembled the 5-stage Platonov's USSR model of long-term athlete development.

The consecutive phase of the suggested LTAD model were marked and successfully marketed as:

- Active Start (for children from 1 to 6 years of age);
- FUNdamentals (Boys: 6-9; Girls: 6-8);
- Learning to Train (Boys: 9-12; Girls: 8-11);
- Training to Train (Boys: 12-16; Girls: 11-15);
- Training to Compete (Males: 16-23; Females: 15-21);
- Training to Win (Males: 19 +; Females: 18 +);
- Active Life All ages.

Obvious positive attempt was made in this model to cater for gender differences in growth and development, umbrella age for various sports, however, obviously isn't a positive development.

As earlier mentioned, this original model was further developed and the latest edition (Balyi, 2006, Athletics Canada) contains a couple of extra phases, which obviously demonstrate an attempt to fit the model to the needs of the professional sport, in addition to the needs of the amateur sport as it was originally developed for.

Those nine current stages of the latest model include the following as in Table 1.

**Table 1**

**Structure of the Long-Term Athlete Development**

No.	Stage name	Chronological Age	Stage objectives
1	Active Start Stage	Males 0-6, and Females 0-6	To make play and physical activity fun and exciting and an essential component of daily routine throughout life.
2	Fundamental Stage (Fundamentals 1)	Males 6-9, and Females 6-8	To begin teaching agility, balance, Coordination, and speed (ABC's). To continue to instil the importance of daily play and physical activity.
3	Learning to Train Stage (Fundamentals 2)	Males 9-12 and Females 8-11	To continue to enhance ABC's to develop overall sports skills. To begin to integrate physical, mental, cognitive, and emotional components within a well-structured program. To develop physical literacy.
4	Training to Train Stage ("Building the Engine")	Males 12-16, and Females 11-15	To develop endurance, strength, and speed. To develop athletics-specific skills and fitness.
5	Learning to Compete ("Challenge of Competition")	Males 16-18 plus, and Females 15-17 plus	To develop event specific area physical preparation. To introduce event specific protocols to identify strengths and weaknesses. To implement event area specialization. To integrate physical, mental, cognitive and emotional development.
6	Training to Compete ("Heat of the Battle")	Males 18-21 +/-, and Females 17-21 +/-	To optimize event specific preparation for competition. To refine event area specialization. To continue with integration of physical, mental, cognitive and emotional development. To conduct event-specific testing and monitoring.
7	Learning to Win ("Consistent Performance")	Males 20-23 +/-, and Females 20-23 +/-	To maximize event specific preparation for high performance results. To introduce a formal Performance Enhancement Team. To continue with integration of physical, mental, cognitive and emotional development. To learn to compete when it counts.
8	Winning for a Living ("Performing when it Counts")	Males 23+/-; and Females 23 +/-	To maximize event specific preparation for results at the Olympic and World level. To maximize of training, competition, and recovery activities in support of a professional athletics career. To attain competitive repeatability when it counts. To work with a professional support team. To plan for retirement from athletics competition.
9	Active for Life ("Dealing with Adversity")	Males any age Females any age	To make preparations for their integration into society.

Source: based on (Balyi, 2006)

Undoubtedly, the most comprehensive model developed so far, it still has numerous questions unanswered, particularly on the age groups depending on the group of sports and on sensitive periods of various motor qualities best developed.

And, as previously mentioned, this model touches upon one of the most important issues of talent development which precedes actual talent development in and importantly through sports.

*Pre-sport talent development considerations.* Talent Development is traditionally (and basically by default) linked to the development of talent through sports related activities, after promising individuals get involved in regular training, the field is narrowed, and talented children are retained in sports specific environment. Such statement, however, philosophically is far from being correct.

The simple reason is that the question than remains unanswered: does talent exist and is it being developed before being identified through sport specific tests and measurements as such, during the process of Talent Identification? If it does, then how talent evolves, progresses, in what environment it does happen, and through which structures such developments are supported?

It sounds fair to say, both philosophically and logically, that Talent Development begins much earlier than talented child is detected by a scout or a coach as a potential subject for future sport-related endeavours. Hence, it is worth focusing on *Pre-Detection Talent Development* which ideally occurs within school environments through means and methods of physical education (Krasilshchikov, 2011; 2013).

Such development should be treated as Talent Activation and target to increase the number of children with unfolded movement potential through properly adjusted physical activities before they actually get exposed to Talent Detection process typically run by coaches.

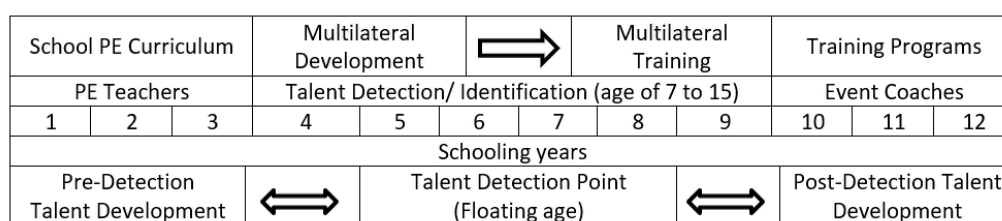
Most of the Talent Identification in Sport specialists traditionally consider the term 'Talent Development' as grooming the ones Detected and further Identified as talent, mostly by means and methods of training in sport chosen for further specialization.

Such approach, however, doesn't help answering the question: When in fact Talent Development begins? The answer to this question sounds simple and complicated at the same time: Talent Development perhaps begins with the conception of the new life. And if this is agreeable, then we also have to admit the fact that Talent Development from that very moment and until talent Detection as such and Talent Identification in sport in this time continuum is least researched and examined.

And yes, talent development is factually ongoing long before we try or even think of identifying talent through methodologies available with sports. And another yes – way before Talent Detection occurs.

That gives us a completely different outlook of what was suggested to term as *Pre-Detection Talent Development* (Krasilshchikov, 2011), which should and in fact has completely different objectives from the traditionally known Talent Development, which under the circumstances seems fare to term as *Post-Detection Talent Development* (Figure 3).





**Fig. 3** – The logic and sequence of Pre- to Post-Detection Talent Development

Source: modified from (Krasilshchikov, 2013)

Visualizing such scenario applicable to pre-sport association of children, we need to investigate the role of the community and family, which both form the environment for the effective talent development before schooling comes into picture with its physical education system hence becoming the prime contributor to Pre-Detection Talent Development.

The model, which has brought to light the crucial role of Physical Education in Talent Development is known as Bailey and Morley’s Model of Talent Development in Physical Education (Bailey, Tan & Morley, 2004; Bailey, Morley & Dismore, 2009).

It focused on three hypotheses, out of which two are critically important to the present discussion. Those hypotheses are:

The differentiation between potential and performance, with consequent rejection of performance as a talent selection (identification) criterion in children. The hypothesis of practice being of vital importance in the realization of talent. First hypothesis reiterates the importance of potential over the current performance (particularly in children), whereas the second one actually brings us back to the philosophy of deliberate practice (Ericsson & Charness, 1994).

Bringing your attention back to the Detection Point, which becomes the starting point to Talent Development in sport and more importantly through sport. What happens at the ‘Detection point’? When the talent is detected, starts Post-Detection Talent Development But another pathway emerges if the talent isn’t detected. What happens then?

Children who were not detected/identified by coaches as talented are back to schooling physical education pool and stick with Pre-Detection Talent Development program (Multilateral in its nature) which normally is school based and ideally has to be focused at unfolding a talent (if any) through the well-balanced school physical education with quality teaching and regular opportunities to practice. Children keep enjoying their physical education classes, improve their physique and fitness while waiting for the upcoming opportunities to be talent identified through other sports, in which recruitment starts later.

**Conclusions.** With suggested Pre-Detection and Post-Detection procedures in place and supported theoretically and practically, we can expect certain critical for Talent Development outcomes.

If quality physical education teaching and regular opportunities to practice are provided in full to the children through school physical education, we might expect significant increase the number of ‘movementally’ gifted and physically advanced children at any given school age.

If that goal is achieved, the number of children with ‘activated’ potential which are ready to be exposed to thorough Talent Detection and Talent Identification procedures may increase many folds, hence:

- a) increasing the probability of a child to be identified as talent;
- b) simplifying the coaches' job to recognize and identify the talent among hundreds of screened potentially talented children to further develop their talent for sport and through sport.

*Conflict of Interest and other Ethics Statements*

The author declares no conflict of interest.

**References**

- Bailey, R., Morley, D. & Dismore, H. (2009). Talent development in physical education: a national survey of policy and practice in England. *Physical Education and Sport Pedagogy*, 14 (1), pp. 59-72.
- Bailey, R.P., B. Tan, and D. Morley. (2004). Secondary school teachers' perceptions of identifying talented pupils in physical education. *Physical Education and Sport Pedagogy*, 9 (3), pp. 133-48.
- Balyi, I. (2005). Canadian Sport Centres. Long-Term Athlete Development – Canadian Sport for Life. Vancouver, 2005.
- Balyi, I. (2006). Athletics Canada. Long Term Athlete Development, 2006.
- Bloom, B. S. (1985). Developing talent in young people. Ballantine.
- Bompa, T. O. (1994). Theory and Methodology of Training (3<sup>rd</sup> ed.). Iowa: Kendall/Hunt.
- Cote, J., & Hay, J. (2002). Children's involvement in sport: A developmental perspective. In Psychological Foundations of Sport (Edited by J.M. Silva and D. Stevens), Boston: Merrill, pp. 484-502.
- Earle, C. A. (1997). Framework for the Development of Gifted and Talented Sportspeople in Schools. FHS, 1997.
- Ericsson, K.A., & Charness, N. (1994). Expert performance: Its structure and acquisition. *American Psychologist*, 49, pp. 725-47.
- Harre, D., (1971). The Doctrine of Training. M., Physical Culture & Sport Publishers, 1971. [in russ.].
- Krasilshchikov, O. (2011). Talent Recognition and Development: Elaborating on a Principle Model. *International Journal of Developmental Sport Management*, 1 (1), pp. 1-11.
- Krasilshchikov, O. (2013). Talent Identification and Development: Reassessing the Principle Model. *Acta Facultatis Educationis. Physicae Universitatis Comenianae*, 51 (1), pp. 25-32.
- Platonov, V., (1984). Theory and Methodology of Sport Training. Kiev, Higher Education Publishers, 1984. [in russ.].
- Singh, Hardayal, (1991). Science of Sports Training, DVS Publ., New Delhi, 1991.
- Wolstencroft, E., (Ed.), (2002). Talent Identification and Development: An Academic Review. A report for *Sport Scotland* by The University of Edinburgh.

**Олександр КРАСІЛЬЩІКОВ**

**РОЗВИТОК ТАЛАНТІВ: ІСТОРІЯ ТА ФІЛОСОФІЯ  
МОДЕЛЕЙ ЩОДО СПОРТУ ВИСОКИХ РЕЗУЛЬТАТІВ**

**Анотація.** У статті розглядаються актуальні питання розвитку таланту у спорті високих досягнень. Розвиток таланту – це складний процес, який включає поєднання генетики та середовища. Довгострокові моделі розвитку спортсменів сприяли дослідженням та узагальненням розвитку талантів, тоді як дослідження Блума та ін. про прогресивний розвиток талантів заклали основу для філософії розвитку талантів. Поняття продуманого тренування від Еріксона наголошує на важливості обсягу навмисної тренування як важливого визначального фактора отриманого досвіду. Фахівці витрачають більше годин практики на тиждень порівняно з новачками та починають свідому практику в молодшому віці.

Однак людям із меншою кількістю досвіду в певному віці неможливо наздогнати тих, хто почав свідому практику раніше та підтримував оптимальний рівень практики. Загалом розвиток талантів залишається темою дискусій протягом століть і вимагає поєднання генетичної схильності та факторів навколишнього середовища для досягнення досконалості.

Впровадження процедур пре-детекції та пост-детекції в розвитку талантів може призвести до критичних результатів. Забезпечення якісної фізичної освіти та можливості для регулярних тренувань у школах може збільшити кількість фізично розвинених дітей, що призведе до того, що тренери виявлятимуть і розвиватимуть більше потенційних талантів.

**Ключові слова:** розвиток таланту, спорт високих досягнень, моделі розвитку спортсмена, процедури пре-детекції та пост-детекції.

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