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A COMPARATIVE LOOK AT THE MORFO--FUNCTIONAL PROFILES OF THE POLISH JUNIOR AND SENIOR BADMINTON REPRESENTATIVES

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Authors' contribution:

A. Study design/planning
B. Data collection/entry
C. Data analysis/statistics
D. Data interpretation
E. Preparation of manuscript
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Abstract:

Study aim: The aim of the study was to compare the morpho-functional profiles of Polish badminton players in junior and senior age categories and to check the stability of variables determining the sports level of Polish representatives in the junior category compared with the results achieved in this respect by the players of the Polish senior team.

Materials and methods: Research was conducted in 2017 on a group of 12 badminton players appointed to the Polish team. The comparative data were taken from a study of 16 juniors, representing the Polish team of badminton players in this age category. The scope of research included those variables that - using multidimensional statistical analyses - were identified as determinants of the sports level in the so-called morpho-functional profile, prepared for a group of juniors. These were the following variables: body height, shoulder width, arm reach with a racket, amplitude of movements in the radial-wrist joint, power of upper and lower limbs, running speed, strength of abdominal muscles, response time with selection, spatial orientation, coupling of movements and kinaesthetic differentiation. Basic volatility measures and morpho-functional profiles in the adopted groups were calculated for all the variables included, using the mean results and standard deviations of both badminton representations. The T scale was used in this respect.

Results: In most of the studied variables, relatively small individual differences were found, smaller in the senior group than in the junior set. In the junior group, the difference between individual variables reached the limit of 0.52 standard deviation, with a slight dominance of energy-related abilities. A slightly larger variation (0.62 SD) was observed in the group of seniors with a clear dominance of coordination abilities. A large advantage of seniors over juniors was also seen (in addition to coordination abilities) in the scope of wrist mobility, MPA (maximal anaerobic power) of lower limbs and strength of the abdominal muscles.

Conclusions: The obtained results confirmed the appropriateness of applying progressive training in youth groups of badminton players. The analyses also suggest the need to verify training programmes for young badminton students, with clear emphasis on the need for early shaping of the level of coordination abilities and comprehensive development of motor skills.

Introduction

Trainers often ask themselves the question: why do promising juniors in many sports disciplines not prove themselves in the reality of senior competitions? Of course, it happens that a well-trained junior also achieves excellent results in the senior category. However, these are incidental cases, excluding such sports disciplines as: artistic gymnastics, swimming, etc., in which these situations are related to the specificity of these competitions.

Badminton, as it seems, requires progressive training, consisting in a gradual increase in results, with apogee at the stage of adulthood [1, 2]. The nature of the game determines this. When locating all activities associated with playing badminton within motor structure, it should be stated that on the efficacy side, acyclic movements dominate here, with a specific duration and high variability of forms. It is worth underlining, that this sport requires and, at the same time, develops comprehensive physical fitness. Each movement sequence observed in the game proper usually requires a complex of predispositions, and therefore, the use of a certain quantum of strength, speed, endurance and coordination. However, already superficial observation of the game allows to determine the nature of the badminton player's effort as speed-endurance. Therefore, these loads are, on the one hand, anaerobic (maximal use of force in the shortest possible time) - take-offs, changes in the direction of movement, fast and strong birdie hits, jumps, etc., and aerobic (resulting from the duration of the game and the number of repeated various movement sequences) [3-5] .The dynamics of the game require work muscle causing a change in muscle length and tension. During the match, a player engages 80% of total muscle mass (general effort), mainly of the lower limbs, shoulder girdle and forearm. High importance during rebounding ailerons is also placed on the chest, abdominal and dorsal muscles. Trying to determine the type and nature of efforts in relation to the work performed by a badminton player in the game proper, this game is considered a sport discipline with a high intensity of aerobic and anaerobic exercise loads [3]. During the game, a very important function is also fulfilled by all components of speed.

This game optics allows to believe that it is also important to respect, in the course of long-term sports training, the individual properties of a player, related to the current level of his/her biological maturity. There are no two identical units, and developmental processes have different courses. Thus, the effects of the performed exercises do not uniformly reflect individual adaptation affiliations to the utilised stimuli. This maxim must be applied in each of the phases of the long-term training process and be consistent with the training procedures used, in its methodological and technological aspects. Only such a procedure allows the postulate to achieve attributes characteristic of the master's model in adulthood [6, 7].

Early specialisation and the associated intensification of training processes - admittedly - lead to permanent stabilisation of sporting achievements already at the age of 19-20, but on the other hand, they are not conducive to using the optimal sporting potential of an adult. Failure to comply with the stage-based principle and the stage-related training objectives associated with it, may be the cause of many teaching and training failures [6]. At the youth stages of sports training, participation and results in sports competitions should not be determinants of the training process, but direct consequences of the level of training. At this stage of sports preparation, the main goals of the training should be focused around training improving motor skills and motor abilities. Participation in sporting competitions is determined by training and qualified goals of already formed players [8].

Within the context of these comments, the issue of identifying and forecasting the development of stable features is particularly important. A very significant procedure is to select individuals, who have the appropriate genetic potential for success in a selected sport [9, 10]. This is a greatly important problem, because these properties in combination with other environmental factors (motor skills with high eco-sensitivity, training base, living conditions, etc.) make up the system enabling control and synergy of actions accelerating a player's development, with the perspective of calculating final achievements at the senior age [9, 11].

Bearing the above in mind, the main purpose of this study was to evaluate the stability of variables determining sports level in the morpho-functional model of the Polish junior badminton team, in parallel with the results achieved in this regard by badminton players of the Polish senior team. The purpose of the work can be reduced to answering the following research questions:

- at what level are the morpho-functional predispositions of Polish senior and junior badminton players developed?
- do morpho-functional predispositions included in the profile calculated for the Polish junior badminton team show stability in the players appointed to the senior team?
- which of the variables examined in the senior players can be described as leading, in parallel with the results achieved by the badminton players of the junior team?
- how great is the diversity of the studied variables in junior and senior staff groups?

Research materials and methods

The research material was a group of 12 players from the Polish senior badminton team. The study was conducted in October 2017, at the final stage of preparation for the most important competitions and sporting events. Comparative data were taken from a study of 16 juniors, who constitute the Polish team of badminton players in this age category [12]. Alike the Polish senior national team, the junior group was in the last phase of preparations for the Polish championship. The average age of representatives in the senior category was 22.7

years, with 12.7 years of professional experience, while in the junior team, this totalled 17.7 and 8.7 years, respectively. All procedures were carried out with the consent of the appropriate sports authorities. Competitors, after receiving information about the study purpose and method, agreed to participation (consent of the Bioethical Committee No. 159/KBL/OIL/2017).

Scope of research:

The scope of research included variables, which - using multidimensional statistical analyses - emerged as determinants of the sports level in the so-called morpho-functional profile, prepared for a group of juniors - representatives of Poland [12].

The measurements of somatic features were taken using the Martin technique [13] and included the following variables:

- body height (b - v),
- shoulder width (a - a),
- arm reach with forehand grip of racket at in standing position with arm maximally extended,
- amplitude of movements in the radial-carpal joint, measured in 4 basic directions in the frontal and sagittal planes, using an electronic goniometer.

Energy-based motor skills tests were carried out using tests, such as:

- power tests of upper and lower limbs according to Spieszny's tests [14],
- running speed with changing the direction of movement (running on the "envelope") - the total time of three repetitions without an interval [15],
- strength of abdominal muscles (sed - leg) according to the guidelines proposed in the International Physical Fitness Test [16].

In terms of coordination abilities, computer tests were applied, taking the following variables into account [17]:

- average response time with selection,
- spatial orientation,
- coupling of movements,
- kinaesthetic differentiation.

Methods of statistical analysis:

- MPA (of the lower limbs) was calculated according to the formulas [14];
  from the results of the 10 x 3 m shuttle run.

$$MPA = \frac{36000 \times m}{t^3}$$

where:
m - body mass [kg]
t - duration of the test in [sec]

- and from the results of "tapping" with an MPA medicine ball (upper limbs)

$$MPA = \frac{20 \times (2 + 0,1\ m) \times g \times h_s}{t}$$

where:
m - body mass [kg]
g - acceleration of gravity [9.81 m/s²]
hs - height when seated [m]
t - time of trial performance [sec]

- arithmetic means and basic measures of variation were calculated for all examined traits and abilities,
- morpho-functional profiles were calculated in the adopted groups using normalised results for the mean and standard deviation of both representations of badminton players in total (T scale).

Results

According to the adopted method, morpho-functional profiles were calculated on the basis of previously selected variables, determining the sports level of badminton players in the "junior" age category. Therefore, their stability in the group of seniors (Polish National Team), possible differences between the described sets of players and the structure of these models created using the T scale, were examined.

The numerical characteristics on the basis of which the morpho-functional profiles were outlined, in the training groups adopted for analysis are presented in Tables 1-2, and their graphical representation is illustrated in Figure 1. A parallel approach to the averaged modules allows to determine their variability at the level of 0.53 standard deviation, with predominance of the senior team over the group of juniors. It should be noted, however, that the included variables are characterised by a diverse range of variability in the entire studied population of badminton players, larger in the junior team (Table 1). A similar, small differentiation in results of both observed groups can be seen in such variables as: body height, shoulder width, range of the arm with the racket and speed measured by running the 'envelope' test (juniors 2.6 - 3.7%, seniors 2.8 - 3.3 %). On the other hand, the greatest variability is seen in the MPA range of the lower limbs and kinaesthetic differentiation, in juniors: 42.0% and 60.5%, and in seniors: 24.8% and 54.0%, respectively. The diversity of other variables oscillates between 8.3% - 17.4% in juniors and within the range of 6.9% - 18.9% in the senior fraction.

In the junior group, interspecific differentiation is marked within 0.52 of standard deviation (Fig. 1). Above the module are the MPA variables for the arms, speed measured using the "envelope" run test, shoulder width, range of the arm with the racket and kinaesthetic differentiation. It should be noted, however, that all these instructions, considered to be parallel with the morpho-

Table 1. Descriptive statistics of morpho-functional variables for the junior and senior representations

variables / group	Measures of variability	Wrist mobility	Body height	Shoulder width	Arm range with racket	Average reaction time with selection	Spatial orientations	Movement coupling	Kinaesthetic differentiation	MPA of upper limbs	Running speed	MPA of lower limbs	Abdominal muscle strength
Juniors N=16	$\bar{x}$	57.32	179.12	40.48	298.12	392.81	56.75	48.50	32.75	279.58	22.78	2398.57	34.12
	SD	6.35	4.79	1.05	9.40	60.10	7.79	8.44	19.83	40.06	0.85	1008.32	2.85
	V	10.4	2.7	2.6	3.1	15.3	13.7	17.4	60.5	14.3	3.7	42.04	8.35
Seniors N=12	$\bar{x}$	61.25	182.02	40.62	300.25	319.92	48.75	40.58	28.75	278.63	22.69	2925.82	36.58
	SD	3.98	6.09	1.14	8.35	33.53	4.69	5.66	15.53	52.61	0.72	725.26	3.53
	V	6.9	3.3	2.8	2.8	10.5	9.6	13.9	54.0	18.9	3.2	24.8	9.6
Total N=28	$\bar{x}$	59.57	180.36	40.54	299.03	361.57	53.32	45.11	31.04	279.17	22.74	2624.53	35.18
	SD	5.72	5.48	1.07	8.87	61.76	7.67	8.28	17.91	44.94	0.78	921.81	3.33
	v	9.6	3.0	2.6	3.0	17.1	14.4	18.3	57.7	16.1	3.4	35.1	9.5

Table 2. Value of morpho-functional variables for the senior and junior representations expressed in T scale points

Variables	Senior representation	Junior representation	*d*
Wrist mobility	52.9	46.1	6.8
Body height	53.0	47.7	5.3
Shoulder width	50.7	49.4	1.3
Arm range with racket	51.4	49.0	2.4
Average reaction time with selection	56.7	44.9	11.8
Spatial orientation	55.9	45.5	10.4
Movement coupling	55.5	45.9	9.6
Kinaesthetic differentiation	51.3	49.0	2.3
MPA of upper limbs	49.9	50.1	-0.2
Running speed	50.6	49.5	1.1
MPA of lower limbs	53.3	47.5	5.8
Abdominal muscle strength	54.2	46.8	7.4
	52.9	47.6	5.3

functional profile prepared for the group of seniors, are located at a relatively short distance from the module (from 0.14 to 0.25 standard deviation). A similar arrangement is adopted by instructions located below the module. These are: response time with selection, spatial orientation, coupling of movements and, to some extent, wrist mobility (variation from the mean of 0.15 - 0.27 standard deviation). In this case, therefore, one can speak of a relatively little varied morpho-functional profile (the motor features and abilities creating it, with a slight dominance of energy-based abilities).

In the senior fraction, slightly greater diversity in the arrangement of individual variables shaping the level of the entire module is observed. This difference reaches the limit of 0.62 standard deviation. The dominating abilities comprise reaction speed with selection, spatial orientation and coupling of movements, distant from the module by 0.38, 0.30 and 0.26 standard deviation, respectively. Variables determining shoulder width, arm reach with the racket, kinaesthetic differentiation, MPA of the arms and speed measured via the "envelope" run below the module. Their distance from the mean is defined

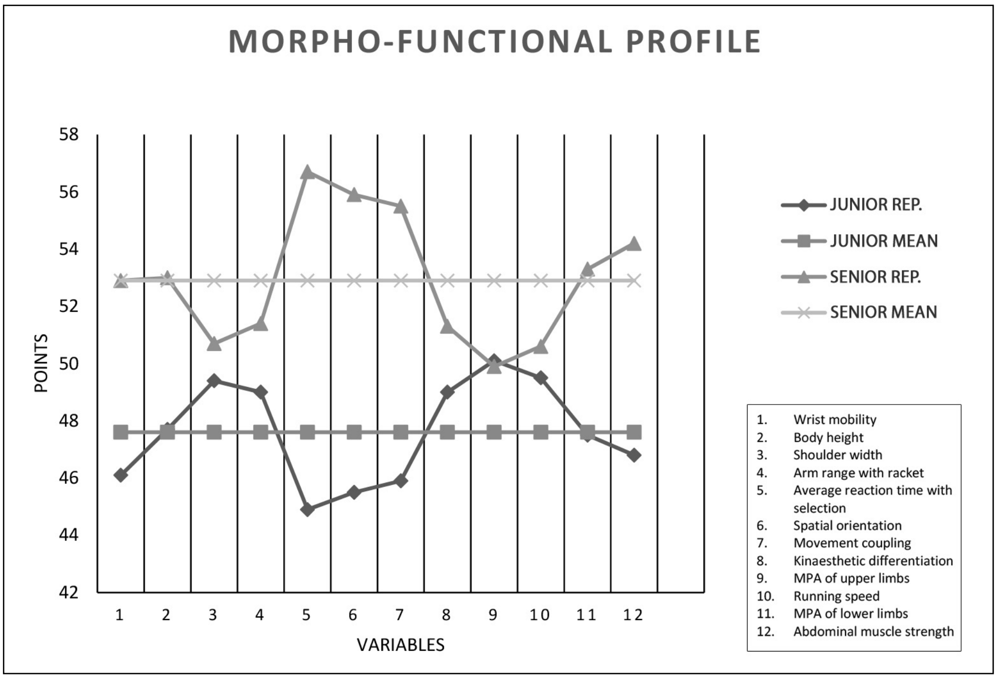

Fig. 1. Profile variables of the morpho-functional model for the senior representation in parallel to the morpho-functional dispositions identified in the junior group

by the limits of 0.15 - 0.30 standard deviation. Other variables of the senior module are very close to the arithmetic mean of all compared traits and abilities. Similar as in the case of the junior representatives, the seniors exhibit a fairly diverse morpho-functional profile, but with the dominance of coordination skills, which is also reflected in the clear advantage of seniors over juniors in the area of these variables. In the case of response time with selection, this value equals 1.18 SD, with respect to spatial orientation, this is at a maximum of 1.04 SD, and in the range of coupling of movements, this reaches the value of 0.96 standard deviation. It should also be noted that there were significant differences, which concerned such variables as: wrist mobility (0.68 SD), body height (0.53 SD), MPA of the lower limbs (0.58 SD) and abdominal muscle strength (0.74 SD). Other variables were also superior to the junior performance, but came very close.

Discussion

The starting point for research on the Polish senior representation in badminton were previous explorations carried out, among others, on a selected group of juniors (Polish National Team) [12]. These earlier observations aimed to bridge the gap in the area of complex analyses of the multi-faceted determinants of sports level among young badminton players. They particularly concerned the impact of structural, energy and coordination dispositions on the development of competitors' competences. An attempt was made to solve this priority problem in a pragmatic and holistic manner. For these reasons, research on the senior representation was conducted from a heuristic approach to the research questions posed at the beginning, ensuring that the considered issues constitute a logical whole, finding an explanation in the essence of the game and sports training. Before discussing key issues, it is worth paying attention to the relatively small variability of most of the examined traits and abilities, both in the group of juniors and seniors. As shown, it was slightly smaller among mature players than in the junior group. This fact can be explained by the permanent selection, which promoted badminton players to the Polish team, with relatively maximum parameters of desired somatic features and motor skills. However, there is a great differences within the following variables, kinaesthetic differentiation, as well as MPA of the lower limbs, in both of the compared groups. With the generally perceived advantage of the senior group over the junior fraction, reaching 0.53 standard deviation, we may indicate compensation of the observed variables in the master's pattern [18]. Certain negligence in progressive training cannot be ruled out, which is known to consist of gradually increasing the volume of applied exercises, paying attention to their versatility applied in youth groups, and gradually increasing the volume of targeted and specialised training, when approaching sports championship at the age of maturity

[1, 2]. This is an important issue if non-compliance with this rule is the cause of many failures in the pursuit of a sports career.

However, the key issue seems to be the shape of morpho-functional profiles in the compared badminton players. The dominance of coordination abilities over other variables in the senior group deserves special attention. In this respect, there is also a symptomatic advantage of players in this group over those from the junior team (0.96 - 1.18 SD). However, these phenomena seem obvious and understandable. They are, nevertheless, very interesting, because information obtained in this manner, may contribute to improving the movement skills of trained players. In badminton, these issues are not yet sufficiently recognised or clarified, because researchers dealt with - in the vast majority of cases- the technique of the elements of the game rather than its cognitive, mnemonic and sensory conditions. Nonetheless, as a result of observations, the view that badminton is included in the group of sport disciplines with non-standard properties and requires a high level of coordination, is validated [3]. As it is known, in the structure of motor skills, they fill the information gap and generally refer to coordination abilities determining coupling, differentiation, orientation, rhythmising, reaction speed and adjustment [19]. It seems that each of them plays an important role in playing badminton, in terms of quality and effectiveness of the implemented movement tasks, in various spatial and temporal conditions. This optics of perception regarding phenomena related to the role of motor coordination in shaping the level of the game, seems to be reinforced by the authors' observations and analyses.

As already noted earlier, the observed phenomenon is manifested with great force (compared to the group of juniors) in the team of seniors. Interpreting this situation, one should remember about the important role of coordination skills in shaping game technique, which, when combined with rational training of coordination skills, provides positive effects in the game proper. Great emphasis on improving special fitness in the group of seniors causes a feedback reaction phenomenon known from literature [20]. Improving the technique of individual game elements, especially those spectacular and non-standard, increases the level of coordination skills, while these have considerable impact on further modelling sports technique.

The great importance of eye-hand coordination and reaction time for the game was also confirmed in the research by Yuan et al. [21], while the role of these abilities in improving the game technique was emphasized, among others, by Chin et al. [22], Starosta et al. [23], Sakurai et al. [24] and Mooney et al. [25]. The explorations undertaken by Poliszczuk and Mosakowska [26] also seem very interesting in terms of efficiency of perceiving and processing visual information during movement and determining the mutual relationship between these phenomena in high-class badminton players aged 19-26. In other analyses based on a scientific experiment, the relationship between the reaction skills of badminton players and their perceptive performance was determined in terms of motor-related activities [27, 28]. The conducted analyses confirmed the great importance of perception in the area of recognition ability and efficiency of motor training as part of shaping game skills.

The lower level and much smaller inter-group differentiation within the kinaesthetic differentiation capacity may be associated with the high variability of this coordination ability found in both of the compared groups. However, the relatively low level of coordination skills in the junior team seems disturbing. In parallel with the results of seniors, they may indicate some negligence in their formation. This may also be related to the dominance of energy-based abilities in this badminton player fraction, i.e. training focused mainly on the development of fitness abilities.

Finally, it is worth focusing on the relatively large advantage of seniors over juniors in terms of variables such as MPA of the lower limbs, abdominal muscle strength, wrist mobility and body height (differences depending on the variable within the range 0.53 - 0.74 SD). Effective playing requires fast movement around the court in order to assume the right position in time and space. This is due to the high level of MPA in the lower limbs. This has huge impact on the correctness and technique of performing almost all elements of the game. All motor acts typical for the relationship of this motor ability are immanent to successful game play. The facts found correspond to the general opinion of other authors, qualifying badminton as an endurance discipline, but above all, requiring a high level of energy-based (speed-strength) abilities [3, 4]. Considering that power (as an energy predisposition) plays a very important role in badminton considering the implementation of most technical elements; it is also worth paying attention to the design of systematics of exercises shaping body balance during various hits of a racket in the attack - requiring the use of muscle strength in the shortest possible time [29]. Simultaneously, Sakurai and Odtsuki [24] have proven beyond a doubt that muscle performance is a significant factor in the accuracy, power and speed of striking: smash during a jump. In the research by Amus et al. [30], the great importance of power, arm range and amplitude of lower limb movements in achieving positive effects in the game proper was also suggested. However, in the research by Ślawska and Jagodziński [31], based on selected badminton players for observation, the dominant role of anaerobic work during the meetings was confirmed. Many other authors also wrote about efforts, among others - those anaerobic, characteristic of the game of badminton[32, 33, 34]. The research concerned elite players and affirmed the earlier quoted observations.

Issues in the field of power shaping mainly for improving elements related to the technique of racket impact, were developed on the basis of biomechanical analyses conducted by Waddell et al. [35], Wołkow [36] and Laffaye et al. [37]. They dealt with the competences and motor skills of sports students in terms of recruitment and selection in badminton.

The set of variables in the somatic model of seniors was also strongly associated with body height (advantage over juniors by 0.53 SD), a feature which can often compensate for deficiencies in the smooth and fast movement of a player on the court [18]. There are many reports in the area of this issue, but only concerning the somatic conditions of special fitness of badminton players [38, 39, 40].

An even greater advantage of seniors over juniors was recorded in the scope of wrist mobility (0.68 SD). This is logical insofar as this property helps a player to give the birdie strength and initial speed. In the study on badminton players - so far - the importance of wrist flexibility in shaping the technique of the game has not been addressed. The amplitude of movement in this area turned out to be a very significant anatomical and functional feature in the authors' research, affecting the sports level of senior players. From the experience of the authors of this work, as well as other coaches and superior players, it can be stated that high mobility of the wrist is important when performing hand movements during unconventional plays - most often surprising rivals. It is also of great importance when performing short serves, as well as all combination shots, shortening the distance of the birdie's flight. Other birdie strikes - their assortment being quite significant - also require intensive wrist work during the initial phase of movement, and only then, significant arm (strength) work. In this sense, the dominance of this factor, in comparison with the junior group, is completely logical and understandable.

The large variation (0.74 SD) between the compared groups in favour of seniors in terms of abdominal muscle strength should also be considered logical. It is related to the improvement of smash and clear strikes, as well as all elements of the game performed in extremely difficult situations on the court, above all, including during a jump [3].

In summary of the discussion, it is worth emphasizing that the system of variables conditioning the level of sport that changes with age of badminton players marks a certain trend in shaping the master model. This specific classification is consistent with the views of other authors, who, determining the stage nature of sports improvement models, recommend the use of procedures consisting in setting appropriate norms for morpho-functional variables and sports results at subsequent stages of training - progressive training [1, 2, 9]. Stelter's publication [40] is one of its kind in the field of planning badminton training, which addresses the problem quite comprehensively. He contained a thought related to the issues of effective planning of sports training in badminton. He based his thoughts and opinions on extensive professional experience and coaching practice. The value of this study is undoubtedly demonstrating the differences between training 12-year-old children, 16-year-old girls and boys or 20-year-old women and men. The author's praxeological approach to training processes deserves attention. In his concept, the author rightly used the thesis that a child is not a reduced model of an adult. For these reasons, the purpose of the proposed training programme is to train young badminton players using progressive loads, adapted to the age of exercising children and adolescents. This long-lasting and patient work should guarantee their proper development, as well as prepare young athletes for basic sports activities, including sports championships. Therefore, it is justified to systematically control and evaluate the somatic features and motor skills of both young and mature badminton players, which, in combination with diagnosis of developmental age, may protect trainers and coaches from making too hasty and often wrong decisions in recruitment and selection and in programming training processes.

Conclusions and practical implications

1. Morpho-functional predispositions included in the profile calculated for the Polish junior badminton team do not show stability in players appointed to the senior team.
2. The junior group is dominated by energy-based abilities (MPA of the upper limbs, running speed) and some somatic features (shoulder width, shoulder range), as well as kinaesthetic differentiation abilities. In the morpho-functional profile of seniors, however, some coordination abilities stand out, such as: response time with selection, spatial orientation and coupling of movements.
3. The diversity of the studied variables in the groups of junior and senior representatives can be defined as moderate (larger in the group of seniors).
4. In training young badminton players, a progressive training system is recommended, consisting in shaping motor skills in accordance with the participants' biological development possibilities and sensitive periods guaranteeing maximum development of specific dispositions at the right time.

5. The training programme for young badminton players, contenders for the Polish National Team, requires verification, which means paying more attention to the development of coordination abilities.
6. Too early striving to maximise results and sports championship in badminton games can be the cause of many failures among already mature players.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Ethics Committee

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