FITNESS AND SOMATIC CONDITIONING OF A SPORTS LEVEL IN A WOMEN'S VOLLEYBALL TEAM AT THE CHAMPIONSHIP LEVEL

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Abstract. There is a significant complexity of movements and an ability to adapt to changing situations during a match, hence, a factor which decides about sports rank of a player is their motor fitness. The assessment of muscle power output and abilities of coordination in high-rank players can be one of the most essential model indicators either in the process of athlete selection or in the process of sports training. The research question is: How the measured indicators of a somatic body construction and motor fitness condition the sports level of volleyball players who specialize in different tactical functions? The paper demonstrates the test results of 12 volleyball players from MKS Muszynianka – a vice-champion of Poland in 2009. Basic features of a somatic body construction were measured; the indicators of muscle dynamic strength, visual perception and visual-motor coordination were tested. The comparative analysis of the applied somatic and fitness indicators in the study explains both the model of choice of tactical specializations in the game and sports hierarchy of volleyball players at championship level. Lengthwise predispositions of a body construction are prominent in the model; however, fitness skills (muscle dynamic strength and visual-motor coordination) may well compensate for insufficient somatic indicators.

Key words: volleyball, women, physical fitness, visual perception, sports specialization

Introduction

The sports result in team games depends on the system of various factors. The theory of sport distinguishes external factors – connected with the training system, and internal ones – a sportsperson's biological predisposition. Indication parameters which encourage the effectiveness of a player is crucial for the process of training. Accurately chosen training methods will increase sports level of particular athletes which, as a consequence, will enhance performance of a team. The cooperation of players in team games is emphasized and, consequently, the significance of the choice of players to a so-called tactical specialization. For instance, volleyball distinguishes the following specializations: the receiver, the wing-spiker, the middle-blocker, the setter, the libero. So far,

the performed research has demonstrated that volleyball players – either men or women – stand out (against population) having both exceptional height parameters and an above-average level of dynamic strength (Bredeweg 2003; Eider 2004; Żak and Klocek 2008). Less popular publications point to predispositions of motor coordination and psychomotor processes of perception as factors which essentially determine effectiveness or a sports level (for review: Williams et al. 1999). The most common analyses are simple comparisons: test results of young athletes against test results of experienced ones. There are few publications concerning exceptional sportspeople who have reached a championship level. In this case, a relation within one somatic feature i.e. height, body mass index, single physiological parameters e.g. maximum muscle anaerobic power (Kielak 2002; Petroski et al. 2013; Palao et al. 2014) or chosen cognitive functions – cognitive abilities to receive, process and use information; is searched for. However, these publications do not explicitly answer the crucial question for sports:

What features and functions of an organism determine sports level in volleyball players of particular tactical specializations?

Material and methods

The results of the tests conducted in a group of women (N = 12) – volleyball players in MKS Muszynianka Fakro Muszyna – constitute the material of the research. The team played in the highest league in Poland and in 2009 won the vice-championship title. The tests were carried out in a start period, in a deciding phase of matches for medal positions – play-offs (April 2009). On the basis of an objective observation of matches – mathematic qualitative and quantitive game factors – particular volleyball players were assigned main tactical specialization. The factors constituted also a basic criterion of assessment among players in the same specialization. The players who stood out in the case of the most active participation and the highest effectiveness received the highest rank – 1; the rest of them received the following ranks – 2 and 3. Some of the tested women, in the previous years, had been appointed to the national team of Poland (Table 1). Their international successes among others are the title of the champions of Europe won in 2005 and the participation in 2008 Summer Olympics.

Table 1. Material – basic information about volleyball players

Tactical spec. & sports rank	Symbol	Age [years]	Training age [years]	Belonging to national team
Wing–spiker – 1	WS1	30	16	Y
Wing–spiker – 2	WS2	25	11	N
Middle–blocker – 1	MB1	28	14	Y
Middle–blocker – 2	MB2	31	16	N
Middle–blocker – 3	MB3	27	12	N
Receiver – 1	R1	32	18	Y
Receiver – 2	R2	29	15	Y
Receiver – 3	R3	29	15	Y
Setter – 1	S1	29	15	Y
Setter –2	S2	31	16	N
Libero –1	L1	27	13	Y
Libero –1	L2	28	14	N
	N = 12	min = 25 max = 32	min = 11 max = 18	Yes = 7 No = 5

Table 2. Basic measures of descriptive statistics: the results of the whole group, the results of the primary and secondary team and the value and significance (t-Student test) of differences between groups

	All players				Primary team (starting six)				Second team (bench players)				Mean differ.	
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Val.	p
Age [years]	28.8	1.99	25	32	29.4	1.72	27	32	28.0	2.24	25	31	1.4	0.12
Training [years]	14.6	1.93	11	18	15.3	1.60	13	18	13.6	2.07	11	16	1.7	0.12
Height [cm]	183.4	6.95	172	192	184.1	6.01	174	192	182.4	8.73	172	192	1.7	0.34
Reach [cm]	238.7	9.98	223	252	239.4	8.52	223	248	237.6	12.76	224	252	1.8	0.39
Mass [kg]	68.8	4.99	58	76	70.6	3.99	64	76	66.3	5.59	58	72	4.3	0.08
BMI	20.4	0.76	19.3	21.6	20.8	0.63	19.9	21.6	19.9	0.64	19.3	20.9	0.9	**0.02***
Spike [cm]	302.0	8.62	287	312	303.3	7.23	289	310	300.2	10.92	287	312	3.1	0.28
CMJ [cm]	63.3	5.16	52	73	63.9	6.49	52	73	62.6	2.97	58	66	1.3	0.35
MAW [J]	436	48.6	359	511	451	55.4	359	511	414	30.5	365	442	37	0.11
Throw [m]	13.4	0.90	11.5	15	13.8	0.82	12.8	15	12.8	0.77	11.5	13.5	0.9	**0.04***
SR [s*10^{-2}]	22.0	2.13	18	25	22.7	2.14	19	25	21.0	1.87	18	23	–1.7	0.09
ChR [s*10^{-2}]	34.5	2.81	30	40	34.6	2.94	30	40	34.4	2.97	31	39	–0.2	0.46
EHCoor. [s]	68.5	4.41	63.7	76.4	68.5	4.95	64	76.4	68.6	4.08	63.7	72.4	0.0	0.49
PDivers. [%]	75.7	9.21	55	85	79.6	7.00	64	85	70.2	9.78	55	79	9.4	**0.04***
Orient. [%]	63.9	5.46	56.2	71.8	64.3	5.48	57	71.8	63.3	6.01	56.2	69	1.0	0.39
Tapp. [s]	5.42	0.54	4.8	6.5	5.20	0.42	4.8	5.9	5.72	0.58	4.9	6.5	0.52	**0.05***

* $p < 0,05$.

During research, the following measurements and physical fitness tests were performed:

1. Somatic features: height (Height), weight (Weight), body mass index (BMI), maximal reach of arms in a standing position (Reach).
2. Index of muscle dynamic strength:
   - vertical jump [cm] (CMJ – Counter Movement Jump) (raising one's body centre of gravity in the vertical plane on both feet after run),
   - spike height [cm] (Spike – maximum reach point of fingers in a jump off two feet after run),
   - maximum anaerobic work output (MAW) – in a vertical jump [J], as a ratio:

     MAW [J] = body mass [kg] × vertical jump [m] × gravity acceleration [m × s^{-2}],
   - throw distance with both hands with a 1 kg medicine ball (Throw) from a kneel with both feet [m].

3. Psychomotor indices of visual perception and visual-motor coordination are measured with a computer test (Klocek et al. 2002):

- simple reaction (SR) – pressing the key with the thumb of a dominant hand after a visual signal on the screen,
- choice reaction (ChR) pressing keys with fingers of both hands according to the location of a visual signal on the screen,
- eye-hand coordination (EHCoord.) – an action of a dominant arm after a visual signal on the screen,
- perception diversity test (PDivers.) – a reaction to different visual signals with the thumb and index finger of a dominant hand within limited time,
- orientation test (Orient.) – a prediction of the movement of cursor. Four levels of test with increased difficulty, without time limits,
- plate tapping test (Tapp.) (Eurofit 1988) tests speed of limb movement.

The results were analyzed using basic measures of descriptive statistics. Calculation was performed for the whole group of volleyball players and in divided groups basing on their performance level: the primary team and the secondary team. Individual results were recalculated into standardized value – standardization into arithmetic mean and standard deviation of the results of the whole team according to the following formula: $Wu = (Mean - X_i) \times SD^{-1}$ or $Wu = (X_i - Mean) \times SD^{-1}$ if a bigger value means a worse result (e.g. timing).

Indicators calculated in this way are a dimensionless representation of scalars. Due to such a recalculation, a direct comparison of variability and diversity within measured parameters is possible. In the following step – in order to reduce the number of variables – biologic homogeneous factors were created: "Somatic", "Strength", "Perception&Coordination", "Training&Age". Mathematic value which represents a factor is a mean value of components (standardized values) which are assigned to a particular factor (variables which create particular factors – see Table 3).

Results

Chosen indicators of somatic body construction, motor fitness and age of the tested volleyball players were compared to comparative materials – the level of measured features in national teams – of participants of championship tournaments such as World Championships and Olympic Games in the years 2000–2012 (Palao et al. 2014) and in the representatives of Poland from 1997 (Klocek and Żak 2001).

Somatic indicators in the tested group of volleyball players are identical with the ones published in the comparative material. The measures for particular features are within the following ranges: height - 182-183±9 [cm], weight – 70–72 ±8 [kg], BMI – 21–22 ±1.8, arm's reach 237 ±6 [cm]. The muscle power of lower limbs – measured with the use of a vertical jump test (CMJ) and spike reach (Spike) – in the compared groups was also at a similar level: jump – 63–68 ±6 [cm], spike reach (Spike) – 301–305 ±14 [cm], maximum anaerobic work (MAW) – 440–490 ±60 [J]. The sole significant difference between volleyball players from MKS Muszynianka and players from the national team lies in the measures of Simple Reaction test in favour of players from the national team (the difference of 30 [ms], bigger than 1 SD – 20 [ms]). Both compared groups are characterized by the same level of coordination of fast movement of arms (Tapp.) – 5.4–5.5 ±0.5 [s]. Arithmetic means of age, the period of training and variability measures of these parameters in the tested players prove that in the case of experience, they create

a homogeneous group. They are a little bit older than the comparison group (Age) – 25–27 ±4 [years]; however, the difference (2 [years]) is not bigger than the standard deviation (1 SD).

The aforementioned comparison and the success of MKS Muszynianka prove that the tested group of women is a representative sample for the population of volleyball players who reach championship level.

The differences between the primary and secondary team (Table 2) signify that more effective players have higher indicators of somatic body construction and motor fitness. Players from the primary team were a little older than substitute players and had more experience – all of them took part in an extended training and start programme of the national team. Only during the measurement of reaction time (SR), a substitute setter got an exceptional result (Table 3), what significantly influenced the arithmetic mean. The biggest differences between groups – statistically significant ones – were observed in the measurement of BMI, 1kg ball throw (Throw), perception diversity (PDivers.) and plate tapping (Tapp.). In the case of volleyball, somatic and fitness advantage of players who are ranked higher is logical and indisputable. The received results only confirm the appropriate selection to the primary team.

Table 3. Standardized values (Wu): individual results of volleyball players; standardization to a mean value and standard deviation of all the results

Spec. Feature	WS1	WS2	MB1	MB2	MB3	R1	R2	R3	S1	S2	L1	L2
Age[1]	0.59	–1.92	–0.42	**1.09***	–0.92	**1.59***	0.08	0.08	0.08	**1.09***	–0.92	–0.42
Training[1]	0.73	–1.86	–0.30	0.73	–1.34	**1.77***	0.22	0.22	0.22	0.73	–0.82	–0.30
Height[2]	**1.24***	**1.09***	0.80	–0.20	**1.24***	0.37	–0.49	–0.64	0.37	–0.78	–1.36	–1.64
Reach[2]	0.53	**1.14***	0.33	–0.37	**1.34***	0.73	–0.07	–0.47	**0.93***	–1.07	–1.57	–1.47
Mass[1]	**1.24***	0.34	**1.45***	0.24	0.64	0.24	0.24	–0.36	0.04	–0.96	–0.96	–2.16
BMI	0.12	**1.46***	–1.10	–0.91	**1.19***	0.27	–1.53	–0.62	0.65	0.31	–0.92	**1.09***
Spike[3]	0.93	**1.16***	0.70	0.70	**0.93***	0.46	0.00	–0.23	–0.23	–1.16	–1.51	–1.74
CMJ[3]	0.52	–0.26	0.52	**1.87***	–1.03	–0.65	0.13	0.52	–2.20	0.13	0.52	–0.06
MAW[3]	**1.22***	0.03	**1.35***	**1.55***	–0.37	–0.32	0.25	0.13	–1.58	–0.54	–0.27	–1.45
Throw[3]	–0.63	0.15	0.37	–0.63	–2.06	0.15	**1.81***	–0.18	**1.25***	–0.41	0.70	–0.52
SR[4]	–1.41	–0.47	–1.41	0.00	0.47	0.00	–0.94	0.00	0.00	**1.88***	**1.41***	0.47
ChR[4]	–1.96	–1.60	**1.60***	–0.18	–0.18	0.18	–0.18	0.18	0.18	0.53	0.18	**1.24***
EHCoor.[4]	–1.79	–0.56	**1.03***	**1.03***	–0.58	**0.94***	0.39	**1.10***	–0.74	–0.88	–0.83	0.89
PDivers.[4]	0.69	–2.24	0.58	–1.27	0.25	0.58	**1.01***	–0.94	0.69	0.36	0.69	–0.40
Orient.[4]	–1.26	0.17	**1.46***	**1.31***	–1.40	0.21	–0.71	0.89	–0.16	**0.94***	–0.34	–1.11
Tapp.[4]	0.03	–0.34	**1.15***	0.59	–2.02	**0.96***	–0.90	–0.90	–0.16	**0.96***	**1.15***	–0.53

* - the best results, bigger, at least by 0.9 SD than the arithmetic mean.
[1] components of "Training &Age" factor.
[2] components of "Somatic" factor.
[3] components of "Strength" factor.
[4] components of "Perception &Coordination" factor.

Relations which appear between a position (wing-spiker, middle-blocker, receiver, setter, libero) and the level of calculated factors ("Somatic", "Strength", "Percept.&Coord.", "Training&Age") confirm the specificity of the selection in a team (Table 3, Figure 1). Especially the relation between the position in a game and body construction is a norm both in championship and youth teams, in women and in men (Kielak 2002; Nejić et al. 2013; Palao et al. 2014). In the tested team, the highest somatic indicators (body height, weight and the reach of arm) are

characteristic for the positions of the wing-spiker and the middle-blocker. The lowest somatic values may be found in the case of the libero.

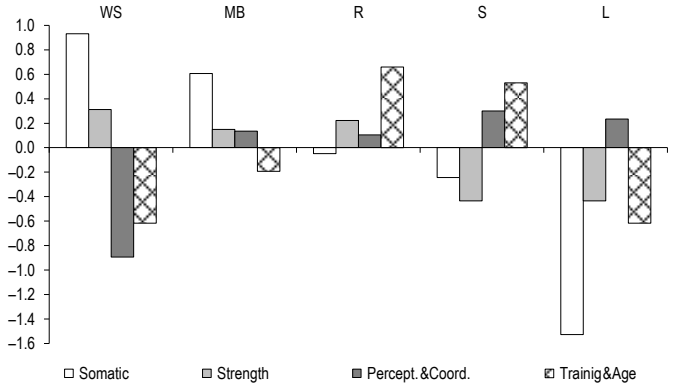

Figure 1. Standardized values of factors for volleyball players with different tactical specialization

Administered in the study, average muscle power output tests, despite some methodological objections (the accuracy of the measurement), are widely used in sports and have satisfactory diagnostic value in order to estimate a significant parameter for the effectiveness of the game – explosive strength (Vandewalle et al. 1987; Harman et al. 1991; Spieszny et al. 2012). The indicators of muscle power represented by "Strength" factor differentiate particular groups of volleyball players to a lesser extent than "Somatic" factor (Table 3, Figure 1). Groups of a wing-spiker, a middle-blocker and a receiver stand out against a setter and a libero. It needs to be emphasized that high value of "Strength" factor in a wing-spiker and a middle-blocker is a consequence of above-average results obtained by the volleyball players from the primary team in spike reach (Spike) and vertical jump (CMJ). In the group of receivers, the second from the primary players stands out in the level of the strength of arms in 1kg ball throw (Throw). Similar relations between the position and the level of strength and power indicator were observed in professional male teams (Klocek et al. 2005; Marques et al. 2009).

Relations of "Percept.&Coord." factor with the position were strongly indicated in both libero players and in a substitute setter (Table 3, Figure 1). The lowest indicators of the tested parameters of visual-motor coordination were noticed in wing-spikers. The best volleyball players with a middle-blocker and receiver specialization reached a remarkable level of the tested predispositions. Either theoretical analyses of special functions in particular positions or empirical tests prove that speed, the quality of reception, processing visual information and controlling the movements determine the sports level in volleyball (Allard & Starkes 1980; Zhang 1990; Kluka 2003; Sibley et al. 2004; Żak & Klocek 2008).

The profile model of a volleyball player considering the criteria of a position and internal factors completes a direct, contrasting comparison of volleyball players of various ranks in the hierarchy of volleyball skills (Table 3, Figure 2). A somatic and fitness profile of both wing-spikers is identical; a significant difference is present in the age and training factor ("Training&Age"). The best middle-blocker in comparison to the substitute player is characterized by a significantly higher level of three factors ("Strenght", "Percept.&Coord.", "Training&Age"). Even greater

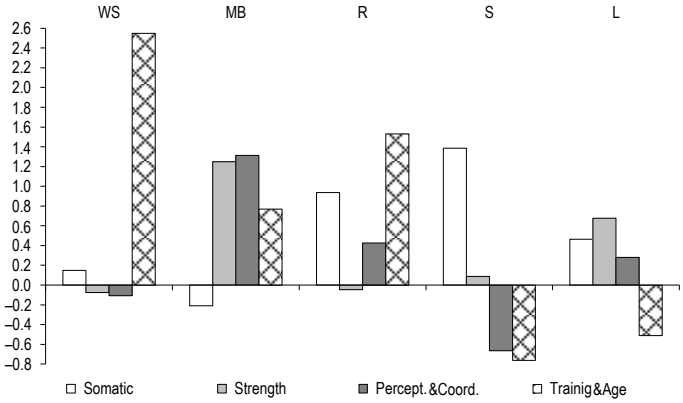

Figure 2. Contrasting comparison – differences between the values of factors for volleyball players at the highest and lowest sports level in the team

difference in the value of motor fitness factors ("Strenght", "Percept.&Coord.") and "Training&Age" factor is between the second blocker from the primary team and a substitute one (Table 3). In this case, even the most favourable somatic body construction of the substitute player could not change the sports rank. Also, the receiver from the first team stands out against her substitute: there is a significant advantage of "Somatic" and "Training&Age" factors and less significant one of "Strength" factor. Two libero players differ in all the factors – bigger values of "Somatic", "Strength" and "Percept.&Coord" factors are characteristic of the player from the primary team. The comparison of setters' results is quite surprising. The player from the primary team has worse results than her substitute in "Percept.&Coord" tests; however, she stands out in her somatic body construction. In this case, it should be assumed that her rank in the team is due to her participation in the national team where she also belongs to a primary team.

Conclusions

All from the tested factors which estimate somatic body construction and motor abilities may be perceived as conditions of special skills in volleyball. The comparative analysis of the applied somatic and fitness indicators in the study explains either the selection model of tactical specializations in the game, or sports hierarchy of volleyball players at an excellent level.

The main, preferred in sports, selection criterion to special positions in the game are lengthwise parameters of body. Nevertheless, the criterion of fitness predispositions should be equally important as the level of dynamic strength, visual perception and visual-motor coordination which may well compensate for "model imperfection" of the somatic body construction.

It is difficult to explicitly state if in the tested group age and training factor influenced the sports level. However, it is indisputable that time and quality of training (being a member of a national team) has a positive influence on the effectiveness of volleyball players.

The applied in the study measurements of somatic body construction, dynamic strength and visual-motor coordination can be used in sports both as a criterion of selection to special functions in the game, and in the course of sports diagnostics as a tool of assessment and control of training effects.

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