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Sport Skill Level and Gender with Relation to Age, Physical Development and Special Fitness of the Participants of Olympic Volleyball Tournament Beijing 2008

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A B S T R A C T

The aim of this study was to provide an answer to the question whether and how age, body height, body mass, body mass index and results from fitness tests are related to sport skill level and gender of the participants of the Olympic volleyball tournament. Two-Way ANOVA was used to find the dependency of the variables on the factor of sport skill level (A – teams which took places 1 to 4, B – places from 5 to 8; C – places from 9 to 12) and gender (F – female; M – male). Statistical significance was set at $p<0.05$. The Bonferroni's adjustment was carried out for three $p=0.017$ and fifteen $p=0.003$ pairs of comparisons). The M and F athletes included in A–C groups (N=48 in each group) were than compared to the classification in the neural network of Probabilistic Neural Network (PNN). A combined effect of the factors of sports level and gender on the height of attack jump ($F=4.13$; $p=0.02$) and block jump ($F=9.22$; $p<0.001$) was identified. The level of achievement was modified by the differences between the men and women. A significant advantage over the groups B and C was found for attack height and block height. In the group A, the differences between the results obtained for women and men in the ranges of attack and block with respect to the net height were not significant. Mean range of block jump did not match up to attack jump, particularly in women. The application of PNN network showed that age, BMI, relative attack jump and block jump are good predictors of sport results. The percentage of properly classified players in the group of men was lower than in women (42.4 vs. 56.3%). In this regard, big differences were found at the lower level of sport results: A (77.1 vs. 79.2%), B (25.0 vs. 25.0%) and C (25.0 vs. 64.6%). In conclusion, selection for national teams should take into consideration the players with long competitive experience with adequate weight/height ratios, who exhibit good training adaptations to jumping exercise.

Key words: *volleyball athletes, biometry, physical fitness, sport results*

Introduction

Identification, selection and accurate characterization of the variables that determine good sport results in volleyball are very difficult. Similar to other team games, the structure of an elite player is determined by mental values[1], special motor skills[2–4], complex and coordination motor abilities[4,5] and specific somatic characteristics[6,7]. According to the conventional Farfiel's typology[4], volleyball can be regarded as a sport with non-standard features. This is caused by the limitations of internal and environmental origins. They allow for classification of this sport as the third (the highest) level. Besides the structure of stimuli (internal and external), it is distinguished by the use of energy, coordination and somatic potential and the high level of motion structure (kine-

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matic and dynamic) stabilization and, most importantly, the degree of complexity of the game. At the champion level, a particularly important function is performed by open movement structures[8]. At the high level of training, the way a task is performed should be adequate to the stimuli in the game and be followed by adequate movement reactions. Therefore, the high level of a volleyball player can be achieved through learning to use a great number of variants to solve a particular movement task. Fast choice of an optimal technique depends on tactical preparation of the players. It is also necessary to utilize heuristics. As emphasized by Diaczkow[9], the goal of the game overrides the action plan. The dynamics of the game forces volleyball players to perform work that involves over 80% of muscle mass, with particular focus on lower limbs, shoulder girdle, forearm and fingers. When hitting the ball, muscles of chest, abdomen and back are also engaged.

High level of coordination abilities, combined with the energy-related abilities, affect the quality and effectiveness of all the movement activities because they are performed under changing spatial and temporal conditions. The effective aspect of motor activity[9,10] is dominated by acyclic movements with short duration and high variability of the used forms. The character of repeated movement sequences necessitates development of not only anaerobic and aerobic capacity or movement skills used by a volleyball player in different game positions, but also specific psychomotor[11] and somatic[6,12] characteristics. The great number of variables that determine the sports level in volleyball necessitates multi-dimensional analyses which should be aimed at optimization of the choice of players and optimization of their training process. Reduction of the analysis to a few variables which were the most important to sport excellence gives a clearer picture of cause-and-effect relationships. In practice, the choice of the necessary information is made by coaches.

The goal of the present study was to provide answers to the following research questions:

(1) Are age, height, mass, body mass index and results obtained from specific fitness tests related to the sport skill level and gender of volleyball players?

(2) What is the degree to which sports level of male and female volleyball players can be predicted based on the above characteristics?

Materials and Methods

Based on the results from the Olympic Volleyball Tournament Beijing 2008, a team ranking for men and women was determined for women and men who had taken places 1 to 12. The investigations covered the analysis of individual characteristics of 144 women and 144 men who took part in this tournament[13]. The available information concerning dates of birth, body height, body mass and players' position was analysed. Furthermore, the volleyball athletes' (Olympians') age was calculated through subtraction of the date of birth from the data of the tournament. Body mass index was calculated from the formula of BMI = body mass in kg/body height in square metres. Based on the results from special tests that had measured the range of arms in attack and in block[13]. According to recommendations of International Volleyball Federation the height of spike is measured by the highest reach of athlete with a jump approach. For block the same applies with the jump approach. Each team is responsible (officials) for collecting these data. The authors of the present study calculated the relative values (with respect to the net's height) for women (range/224 cm) and men (range/243 cm). Jumping tests are reliable for both male and female volleyball players. The intraclass correlation coefficient between three sessions ranged from 0.89 to 0.93 for males and from 0.90 to 0.95 for females[14].

The arithmetical means and standard deviations (±SD) were compared to the following dependent variables: age, body height/mass, BMI, range during attack jump and block jump. Although a previous study[12] compared the mean values for men and women, it was necessary to take these values into consideration again in order to find possible interactions in the analysis of variance. A two-way analysis of variance (ANOVA) design with interaction was employed to measure the relationships between the above variables and the factor of sport level (A: teams that had taken places 1 to 4; B: places from 5 to 8; C: places from 9 to 12) and gender (M – male, F – female). The Bonferroni's adjustment was carried out for three comparisons at $p=0.017$ and fifteen comparisons at $p=0.003$). Furthermore, the effect size (partial η^2) and power were calculated. A Tukey's HSD multiple comparison test with 95% confidence interval was used to find significant differences between the pairs of means ($p<0.05$). Actual designation of male and female players for groups A to C was also compared with the classification predicted by means of Probabilistic Neural Network (PNN) software. Jackknife techniques to indicate the likelihood of replication was used. This technique employed split samples to empirically compare results across the sample splits. Statistical calculations were made using Statgraphics Centurion v. XVI.I software.

Results

Mean results with regard to the sport level of men and women are presented in Table 1. The statistical results of comparison of means for age, body height, body mass and body mass index and volleyball-specific fitness tests are also presented in Table 1. The analysis of the effect of the factor of the level of achievement demonstrated that team members differed in their body mass and BMI. The teams in the groups A dominated significantly over the teams of the group C in terms of their body mass and BMI, whereas no significant differences were found between the groups A, B and C with regard to age and body height. Similarly, teams with level A showed significantly higher body mass and body mass index compared to the group B. The volleyball-specific fitness tests demonstra-

TABLE 1
AGE, BODY HEIGHT, MASS, BMI AND SPECIFIC FITNESS IN MALE AND FEMALE VOLLEYBALL PLAYERS WITH DIFFERENT LEVEL OF ACHIEVEMENT (A,B,C) IN OLYMPIC TOURNAMENT (±SD)

Group (N)	Age (years)	Body Height (m)	Body Mass (kg)	BMI (kg/m^2)	Attack (cm)	Block (cm)	Attack relative to net's height	Block relative to net's height
Male (144)	28.2±14.61	1.97±0.07	89.1±7.68	22.9±1.58	343.7±14.6	327.1±10.96	1.41±0.06	1.35±0.05
A (48)	29.6±11.67	1.98±0.07	90.4±7.13	23.0±1.42	344.6±11.7	325.1±10.60	1.42±0.05	1.34±0.04
B (48)	27.1±11.41	1.97±0.07	87.0±7.62	22.3±1.42	345.9±11.4	328.1±10.13	1.42±0.05	1.35±0.04
C (48)	27.9±19.15	1.97±0.07	90.0±7.97	23.4±1.72	340.4±19.1	328.1±12.01	1.40±0.08	1.35±0.05
Female (144)	26.0±4.25	1.83±0.08	70.2±6.76	21.1±1.53	304.4±12.98	290.9±13.73	1.36±0.06	1.30±0.06
A (48)	26.4±4.26	1.85±0.07	72.8±6.84	21.4±1.90	310.8±12.87	297.4±12.97	1.39±0.06	1.33±0.06
B (48)	26.3±4.10	1.82±0.10	69.0±7.00	20.8±1.25	301.5±13.74	288.0±15.01	1.35±0.06	1.29±0.07
C (48)	25.3±4.38	1.81±0.06	68.7±5.69	21.0±1.31	300.8±9.71	287.4±10.76	1.34±0.04	1.28±0.05
1.Ac F	18.69	2.97	6.26	5.69	6.76	2.48	7.10	2.83
p	0.0414	0.0530	0.0022	0.0038	0.0014	0.0858	0.0010	0.0606
Part η^2	0.02	0.02	0.04	0.04	0.05	0.02	0.05	0.02
Power	0.61	0.57	0.89	0.86	0.92	0.49	0.93	0.55
2.Ge F	3.22	279.73	515.17	100.92	617.0	650.37	67.66	59.43
p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Part η^2	0.06	0.50	0.64	0.26	0.69	0.70	0.19	0.17
Power	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1*2 F	2.06	0.48	2.11	2.40	3.81	8.98	4.13	9.22
p	0.1293	0.6171	0.1226	0.0922	0.0232	0.0002	0.0171	0.0001
Part η^2	0.01	0.003	0.01	0.02	0.03	0.06	0.03	0.06
Power	0.42	0.13	0.43	0.48	0.69	0.97	0.72	0.97

1. Ac – Achievement group factor, 2. Ge – Gender factor, 1*2 – Interaction

ted a significant effect of sport level on mean results of range in attack jump, but not in block jump. The effect of this factor was expressed in significant differences between the groups A>B and A>C (multiple comparison test), which confirms a paramount importance of special fitness (attack jump) for the level of achievements during tournaments. This relationship was also confirmed by the analysis of the results of jumping tests with respect to the net's height in attack. It was also found that the men were older than women, with a natural advantage of men over women in physical development indexes and the results obtained from specific fitness tests. A combined effect of both factors on the results of jump with respect to the net's height was observed in block and in block relative to net's height.

Different profile of the lines connecting the mean attack jump and block jump results points to an interaction of the factors of sports level and gender. This interaction suggests that the level of achievements during the Olympic Games was modified by the differences in characteristics of men and women. In the group A, mean results obtained for attack jump (Figure 1) and block jump in relation to net's height (Figure 2) were significantly higher than the groups B and C, which are similar with this regard. Furthermore, group A did not show significant differences in the range of attack and defence with respect to the net's height (multiple comparison test). Data analysis shows that the mean range of block jump does not match up to attack jump level, which is more noticeable with respect to the groups of women with different level of achievement during the tournament.

The application of the Probabilistic Neural Networks (PNN) confirmed the importance of the analysed variables (age, BMI, relative range in attack jump, relative range in block jump) for prediction of sport result (Group A, B and C). The percentage of properly classified players in total in the group of men was lower than in women (42.4% vs. 56.3%). At the lowest level of sports result (Group C), the significant differences in these terms were observed in: A (77.1% vs. 79.2%), B (25.0% vs. 25.0%) and C (25.0 vs.64.6%).

Discussion

Analysis of the course of action and their effectiveness in the 2009 Europe Championships[15] showed that »…attacking is the highest point-scoring game action, but as

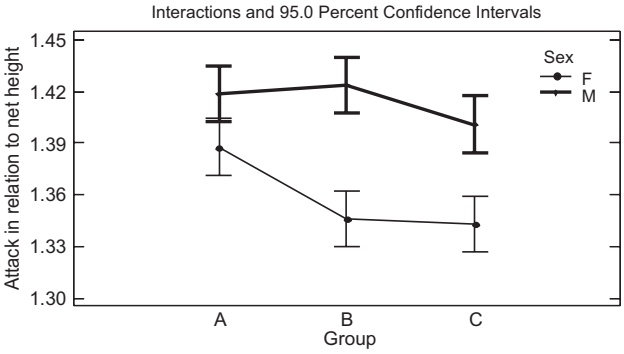

Fig. 1. Mean results for attack jump vs. net's height.

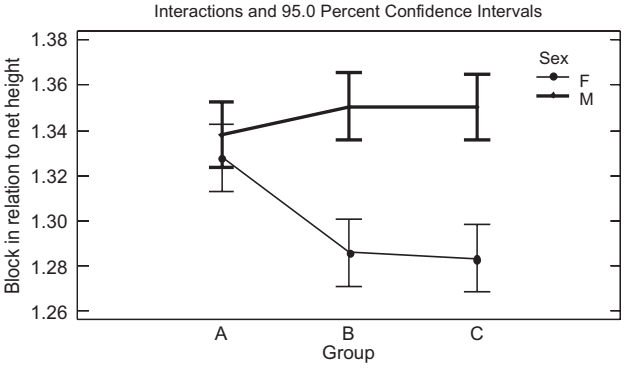

Fig. 2. Mean results for block jump vs. net's height.

matches become more even (sets with more than 25 points or fifth and tie break sets), points scored by blocking become decisive for attaining victory in elite-level competition, where teams make considerably fewer errors and the number of points achieved by serving tends to be even«. Discriminant analysis was used to identify the game-related statistics which better discriminated performances by sex. Analysis yielded an emphasis on fault serves, shot spikes and reception digs. The considerable variability was evident in the game-related statistics profile, as men's volleyball games were better associated with terminal actions (errors of service), and women's volleyball games were characterized by continuous actions (in defence and attack). These differences may be related to the anthropometric and physiological differences between women and men and their influence on performance profiles[15]. However, they did not take into consideration[15,16] the characteristics discussed in the present study. The determination of the importance of individual variables for a success in such a complex sport as volleyball remains disputable as compensation capacity and temporary indisposition of a player might affect the outcome of the player's individual actions and the whole synergy. The coach might then choose a reserve player with the potential adequate for actual game demands. The analysis presented in this study was based on the data obtained from the whole team, including the reserves. The study demonstrated how the small differences in some variables might affect the level of achievement in volleyball. The discussion of the authors' results will be limited to the presentation of a brief description of the observed phenomena. The first problem concerned the effect of body height on sports level in the analysed teams. This relationship was found neither in men nor women. Undoubtedly, this is connected with the fact of low variability of this characteristic among volleyball elite players. However, typical differences were found within the teams. They are related to the tactical player's position during the game, which results from selection and specialization[7,11,12]. In the Olympic Volleyball Tournament[12] women and men (intergroup comparison) who played in the position of libero, opposite, outside hitter, seter, middle blocker did not differ in their age and BMI. Body height in both groups depended on player's position. Middle blockers were significantly higher than other players. Opposite players and outside hitters were higher than setters and liberos in the group of women. The opposite and outside hitters had similar height. The liberos (having 171 cm on average in both female and male groups) were significantly lower than the representatives of other player positions. The results obtained in both women and men for relative attack and block height of the middle blockers, outside hitters and opposite formed homogeneous groups. The specialized players exhibited significant advantage over the setters and liberos. The characteristics of body build are undoubtedly important for the choice of a sport[17,18]. Moreover, in team games, they determine player's position[12,19–21]. Body build also determines the choice of the weapon in fencing[22], technical preferences in karate fighting[23,24] and the choice of fighting techniques in wrestling[25] and ju-jitsu[26].

The most significant variable in this study was body height and BMI whose optimal value determines the sport level in volleyball. Stronger body build contributes to releasing more energy in explosive actions near the net. The special fitness tests showed evident contribution of the range of arms in jump to both defensive and offensive actions. This skill was the most remarkable for the teams with the highest sports level (group A), which obviously contributed to their effectiveness. The range relative to the net's height used during a jump performed at the right moment facilitates recognition and the change in technique. The optimal choice of technique and tactics of sports fight depends on motor abilities and determines highest sports achievements[15,22–27]. This seems to have been a result of a great experience of the players in this study, represented by optimal age of men and women who participate in the Olympic volleyball tournament. The first part of the results did not show the sexual dimorphism with respect to the analysed variables. Classification is one of the most frequently encountered decision making tasks of human activity. A classification problem occurs when an object needs to be assigned into a predefined group or class based on a number of observed attributes related to that object. Many problems in business, science, industry, and medicine can be treated as classification problems[28]. The distinctiveness in variables characterising humans might lead to competitive advantage within an elite group athletes and can be demonstrated by: homogeneity of physical structure

among elite competitors, unique physical characteristics which are not commonly observed in normal population and significant differences between the best athletes and lower level competitors. Some studies have stressed low standard deviation of body mass in elite volleyball athletes in comparison to combat sports[29]. This study used a PNN method which allows for classification of the elite of athletes who play volleyball based on the individual characteristics in different groups of sports level. Based on 4 variables (age, BMI, relative jump in attack and in block), the method revealed the differences between the groups separated according to a level of playing, allowing for a synthesis of the results obtained for women and men. Higher predictive ability for the classification for a group according to the sport level was achieved in women compared to men (in groups A and C).

A few characteristics of volleyball athletes at early stages of development have been presented recently[30–32]. These studies have demonstrated greater body height in 10–12 years old schoolgirls selected for volleyball training compared to untrained subjects. Volleyball training affected muscle mass and, consequently, improved explosive strength of jumping[30]. In another study of 13 years old female volleyball players, factors of longitudinal dimensionality of the skeleton and explosive power of legs and agility mostly affected the situational efficiency[31]. 13–15 years old female volleyball players were well described by volleyball-specific jumping, e.g. high standing vertical jump reach and spike approach vertical jump[32]. Regularities were observed in cumulative effects of training and selection processes in young volleyball players. In Olympians, body mass, BMI, height of attack and block jumping determined their level of achievement.

One limitation of this study was the lack of consideration of a variety of variables which were impossible to be measured. The investigations focused on these variable might further the understanding of the preconditions for sport results obtained by the athletes who play volleyball. The authors of the present study realize that the sports level in the participant of Olympic tournaments is similar. It concerns the most of the parameters connected with motor coordination, technique of the game, precision and speed. The victory is often determined by such variables as the effectiveness of attack, block and the quality of performing these elements of the game. The phenomenon of the decline in effectiveness might also be observed as a result of elevated fatigue. This phenomenon is observed in particular in the fifth set which is decisive for the match. It seems that this is more evident in women compared to men. The very important components of fitness at this stage of the tournament (fatigue) are psychomotor traits such as concentration, divisible and alternating attention, selectivity, aptness and speed of perception and processing of the stimuli[11].

Conclusions

This study found that, regardless of gender, higher experience and mass with similar body height are conducive to achievements during Olympic volleyball tournaments. The range of attack and block with respect to the net's height determines the competitive value of a participant of volleyball tournaments. The following conclusion can be drawn from these observations: the selection for national teams should take into consideration the players with long competitive experience, with specific mass/height ratio, who demonstrate improved capacity of training adaptations to jumping exercise.

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RAZINA SPORTSKE VJEŠTINE I SPOL U ODNOSU NA GODINE, FIZIČKU RAZVIJENOST I SPECIAL FITNESS-A KOD SUDIONIKA OLIMPIJSKOG TURNIRA U ODBOJCI U PEKINGU 2008. GODINE

S A Ž E T A K

Cilj ovog istraživanja bio je dati odgovor na pitanje da li su, i u kojoj su mjeri dob, visina, tjelesna masa, indeks tjelesne mase i rezultati testova fitnessa u odnosu na razinu sportskih vještina i spol sudionika olimpijskog turnira odbojke. Dvosmjerna analiza varijance korištena je pri pronalaženju ovisnosti varijabli na faktor razine sportske vještine (A – timovi koji su se o mjestima 1–4, B – mjesta 5–8, C – mjestima 9–12) i spola (F – ženski; M – muški). Statistička značajnost postavljena je na $p < 0,05$. Bonferoni podešavanje provedeno je za tri $p=0,017$ i petnaest $p=0,003$ parova usporedbe. M i F sportaši uključene u A–C skupina ($N=48$ u svakoj skupini) su uspoređeni sa klasifikacijom u neuronskoj mreži Probabilističke neuronske mreže (PNN). Kombinirani učinak faktora sportskoj razini i spola na visini skoka u napadu ($F=4,13$, $p=0,02$) i blok skoka ($F=9,22$, $p<0,001$) je identificiran. Razina postignuća dopunjavala se razlikama između muškaraca i žena. Značajna prednost nad skupinama B i C je nađena pri visine skoka u napadu i blok skoka. U skupini A, razlike između rezultata dobivenih za žene i muškarce u rasponima od visine skoka u napadu i bloku u odnosu na visine mreže nisu bili značajni. Primjena PNN mreže pokazala je kako dob, BMI, relativni skok u napadu i blok skok su dobri prediktori sportskih rezultata. Postotak ispravno klasificiranih igrača u skupini muškaraca bio je niža nego kod žena (42,4 *vs.* 56,3 %). U tom pogledu, značajne razlike pronađene su na nižoj razini od sportskih rezultata: A (77,1 *vs*. 79,2 %), B (25,0 *vs.* 25,0%) i C (25,0 *vs.* 64,6%). U zaključku, selekcija za nacionalne timove treba uzeti u obzir igrače s dugim natjecateljskim iskustvom s adekvatnim omjerima težine i visine, koji pokazuju dobre prilagodbe u treningu pri vježbama skakanja.