Coll. Antropol. **31** (2007) 1: 267–273
Original scientific paper

Integration of Technical and Situation Efficacy into the Morphological System in Young Female Volleyball Players

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A B S T R A C T

The aim of the study was to identify morphological structures of young female volleyball players according to age, and to assess the impact of these morphological structures on technical and situation efficacy. A set of 13 morphological measures as predictor variables, a set of 6 technique elements, and assessment of performance quality as criterion variables were employed in a sample of 246 female volleyball players. The sample consisted of 32 players aged 12–13, 147 players aged 14–15, 50 players aged 16–17, and 17 players aged 18–19. Analysis of variance showed the female volleyball players of various age groups to differ significantly according to the variables assessing the longitudinal skeleton dimensionality, and body mass and volume, as well as in all tests used on volleyball technique evaluation. Factor analysis of morphological measures applied across all age groups generally yielded two morphological structures: the one determined by skeleton development, i.e. longitudinal and transverse bone growth, and another one determined by soft tissue development, i.e. muscle and adipose tissue growth. Results of regression analysis revealed the longitudinal skeleton dimensionality to significantly determine the block technique performance across all age groups, and to a lesser extent performance of the spike technique in the 14–15 and 16–17 age groups. Regression correlation analysis also showed the developed skeleton based on the predominance of longitudinality to be a significant positive predictor of situation performance in all age groups.

***Key words**: female volleyball players, morphological structures, performance quality*

Introduction

Results of some studies in female and male junior and senior volleyball players[1–16] suggest the longitudinal skeleton dimensionality, coordination (agility) and explosive strength of the vertical-jump type to have greatest positive impact on volleyball performance. Subcutaneous adipose tissue is the only feature with unfavorable effect on volleyball performance.

In a sample of 50 Italian female volleyball players, Viviani and Baldin (1993)[1] found a predominance of the endomorphic and mesomorphic somatotype components. In both samples of male and female volleyball players (members of the first and second Italian division), Gualdi-Russo and Zaccagni (2001)[2] found the mesomorphic somatotype component to prevail in both sexes. Because of the greater amount of adipose tissue and less developed musculature, the endomorphic component was more pronounced in female than in male volleyball players. The ectomorphic component was greater in first- division male and female volleyball players as compared with those from second division. The ectomorphic somatotype component was more pronounced, and the mesomorphic and especially endomorphic component less pronounced in first- and second-division female players than in amateur female players. The authors conclude that the data obtained could prove useful in the selection of female volleyball players as well as on desig- ning plans and programs of training for specific player positions[2–3].

Stamm et al. (2003)[4] investigated the relationship of some anthropologic status dimensions with performance in a sample of female volleyball players aged 13–16. The authors found that, among others, anthropometric characteristics had a significant impact on performing all technical-tactical elements in volleyball, spike and block in particular.

Received for publication November 18, 2006

The main aim of the present study was to identify the morphological structures of female volleyball players aged 12–13, 14–15, 16–17, and 18–19, and to determine the relationship of these structures with technique quality and situation performance.

Subjects and Methods

Subject sample

The total study sample consisted of 246 female volleyball players aged 12–19, members of volleyball teams from the Split-Dalmatia, Istria, and Zagreb Counties. The total of 246 study subjects were divided into four age groups: 32 players aged 12–13, 147 players aged 14–15, 50 players aged 16–17, and 17 players aged 18–19.

Variable sample

Two sets of variables were used: a set of morphological variables as predictors, and performance of basic volleyball technical elements and assessment of situation performance as criterion variables. Thirteen morphological measures were used on morphological status assessment in order to identify longitudinal skeleton dimensionality, transverse skeleton dimensionality, body mass and volume, and subcutaneous adipose tissue. Each variable was measured three times. The following measures were included: standing reach, body height, foot length, body weight, upper arm circumference, abdominal circumference, femoral circumference, elbow diameter, wrist diameter, ankle diameter, subscapular skinfold, triceps skinfold, and suprailiocristal skinfold.

A set of 6 variables were employed for assessment of volleyball technical efficacy. Analysis of video records by six independent assessors (professors of kinesiology specialized in volleyball) evaluated the technique of performance of the six basic technical-tactical elements: service, serve reception, setting, spike, block, court defense[17,18].

One variable based on team quality and on individual player's quality within the team each were established for assessment of situation performance of female volleyball players[17,18].

Data analysis

The basic descriptive parameters of morphological variables, technique variables and performance variables were calculated first (arithmetic mean and standard deviation) for each group of study subjects. In line with the aim of the study, factor analysis of predictor, i.e. morphological variables was used first for each group of subjects as varimax rotation of the significant main components of intercorrelation matrix. Correlation between the set of predictor latent morphological variables and each criterion variable (assessment of particular technical elements) was determined by regression correlation analysis for each group of study subjects. Regression correlation analysis was also employed to determine correlation between the set of isolated morphological factors and the criterion variable of performance. Partial coefficients of regression (β), coefficient of multiple correlation between the set of predictors and the criterion (ρ), and level of significance of regression coefficients and multiple correlation were calculated.

Results and Discussion

Analysis of variance of anthropometric variables (Table 1) indicated the female volleyball players of various age groups to differ significantly in the variables evaluating longitudinal skeleton dimensionality and voluminosity. Changes were more pronounced at the turn from age 14–15 to age 16–17. Body height was by 3.5 cm greater in 16–17 than in 14–15 age group, and by 1.7 cm in 18–19 than in 16–17 age group. This could be explained by the process of selection, which was especially emphasized at the turn from 14–15 to 16–17 age group (corresponding to high school enrollment). Obviously, in this period the players with more pronounced longitudinal skeleton dimensionality were selected as competition team members. Thus, the role of longitudinal skeleton dimensionality in competition success increased in older age groups.

Longitudinal skeleton dimensionality enables ball contacts at a greater height above the net, which is of utmost importance in spiking and blocking. However, due to the complexity of these elements, considerable amount of time is needed to master the technique and to apply it in situation conditions (at competitions).

For these reasons, longitudinal skeleton dimensionality does not entail any significant competition advantage in the players aged 12–13. The more so, in very tall players it may even have an unfavorable effect on situation performance because of accelerated growth and development.

However, it should be borne in mind that, in this sample, most successful players aged 18–19 generally play at the setter and libero positions. At these positions, the pronounced longitudinal skeleton dimensionality is not as important as in other positions. These positions require considerable playing experience.

A player at the libero position should have a very high precision in serve reception. This requires high quality technique as well as emotional stability.

Most successful players aged 16–17 are very tall girls (mostly members of junior team) that generally play middle attacker position. At this position, a pronounced longitudinal skeleton dimensionality is of great importance, and can at the same time be covered by players with shorter playing experience.

As there were no significant differences in the variables for assessment of subcutaneous adipose tissue among volleyball players of various age groups, the significant differences in the variables for assessment of body voluminosity could in part be explained by the impact of training process on the muscle tissue increase.

TABLE 1
BASIC DESCRIPTIVE PARAMETERS OF MORPHOLOGICAL VARIABLES AND VARIABLES ASSESSING VOLLEYBALL TECHNIQUES IN FEMALE VOLLEYBALL PLAYERS OF DIFFERENT AGE GROUPS

Variable	1 (n=32) X±SD	2 (n=147) X±SD	3 (n=50) X±SD	4 (n=17) X±SD
Standing reach	221.59±7.95	223.55±9.00	227.12±9.71	231.00±10.87[b]
Body height	169.33±6.09	170.86±6.45	174.36±6.57	175.99±7.37[c]
Foot length	24.73±1.11	24.88±1.22	25.24±1.20	25.76±1.43[b]
Body mass	55.92±8.62	59.51±7.28	63.98±8.46	66.84±7.37[c]
Upper arm circumf.	25.14±2.39	25.80±2.23	26.72±2.20	26.88±1.78[b]
Abdominal circumf.	72.35±4.60	74.29±5.89	77.85±5.81	80.26±5.44[c]
Femoral circumf.	53.96±4.07	55.23±3.89	57.60±4.15	58.21±2.59[c]
Elbow diameter	6.31±0.36	6.37±0.32	6.49±0.34	6.44±0.27
Wrist diameter	5.23±0.27	5.32±0.27	5.40±0.27	5.33±0.28
Ancle diameter	6.58±0.40	6.60±0.35	6.66±0.33	6.79±0.59
Subscapular skinf.	9.48±3.19	10.08±2.75	10.98±3.01	11.04±2.23
Triceps skinf.	14.79±3.89	14.85±3.93	16.24±4.08	14.76±2.52
Suprailiocristal skinf.	11.74±4.62	11.09±4.09	11.75±4.13	10.70±3.43
Service	2.84±1.07	2.94±0.99	3.45±0.96	3.87±0.87
Serve reception	2.80±0.84	3.19±0.90	3.25±0.83	3.86±0.78
ght Setting	3.12±1.02	3.15±0.87	3.53±0.78	3.52±1.01
Spike	2.77±1.01	2.90±0.94	3.38±0.84	3.78±0.82
Block	2.88±0.78	2.99±0.84	3.27±0.76	3.24±1.26
Court defense	2.41±0.99	2.62±1.01	2.94±0.77	3.87±0.87

Age groups: 1 – 12–13 years, 2 – 14–15 years, 3 – 16–17 years, 4 – 18–19 years
[a]$p<0.05$, [b]$p<0.01$, [c]$p<0.001$

Some authors, e.g., Gualdi Russo and Zaccagni (2001)[2], suggest that excessive subcutaneous adipose tissue exerts an unfavorable effect on situation performance in volleyball players.

The analysis of variance (Table 1) revealed the female volleyball players of various age groups to differ significantly in all variables for assessment of the volleyball element technique quality. It was expected because a high quality technique is a major precondition to achieve supreme competition results.

Volleyball elements are technically very demanding, especially those performed on jump (spike, block, jump service, and jump set). A great number of repeats over years of training are needed for the technique of volleyball elements to improve and become automatic.

In the 12–13 age group, factor analysis of anthropometric variables isolated two factors (Table 2), which explained an almost identical amount of the system variance (40% and 35%).

Longitudinal skeleton measures yielded highest projection onto the first factor, followed by transverse skeleton measures, whereas the measures of body volume and mass showed moderate rates. This factor appears to be responsible for skeleton development, accompanied by the muscle mass development. Such a developmental pattern was observed in 40% of study subjects, representing the basis upon which the specific motor skills and motor abilities will be integrated through volleyball training.

The morphological factor defined by skeleton development accompanying the development of muscle tissue is the basis of the overall morphological development, and has been isolated in previous studies in girls aged 7, 8 and 9 (e.g., Katić et al., 1994[19]; Katić, 2003[20]).

Skinfold variables as well as body circumference and mass variables showed extremely high projections upon the second isolated factor. This factor is responsible for soft tissue development, i.e. for the muscle to adipose tissue ratio. This ratio was not optimal in at least 35% of players aged 14–15, due to the adipose tissue predominance over muscle tissue. This is quite obvious knowing that the circumferences are to a considerable extent saturated with adipose tissue in these girls.

Thus structured morphological factor has already been defined in previous studies (e.g., Katić et al., 1994[19]; Katić, 2003[20]), pointing to the concurrent ectomorphy and mesomorphy development as a favorable, and to an excessive amount of adipose tissue as an unfavorable facet of the body development as a whole.

Accordingly, factor analysis of anthropometric variables in female volleyball players aged 12–13 revealed two mechanisms responsible for their morphological de-

TABLE 2
FACTORIAL STRUCTURE OF MORPHOLOGICAL VARIABLES IN FEMALE VOLLEYBALL PLAYERS OF DIFFERENT AGE GROUPS

Variable	1 (n=32)		2 (n=147)			3 (n=50)		4 (n=17)	
	F1	F2	F1	F2	F3	F1	F2	F1	F2
Standing reach	0.85	0.21	0.03	0.95	0.22	–0.09	0.91	0.95	–0.02
Body height	0.90	0.23	0.05	0.94	0.20	–0.11	0.92	0.95	–0.08
Foot length	0.84	–0.05	0.01	0.64	0.51	0.13	0.89	0.94	0.05
Body mass	0.66	0.69	0.78	0.42	0.35	0.67	0.66	0.63	0.69
Upper arm circumf.	0.46	0.81	0.87	0.01	0.19	0.88	0.22	0.17	0.82
Abdominal circumf.	0.44	0.70	0.76	0.32	0.24	0.76	0.38	0.46	0.76
Femoral circumf.	0.41	0.76	0.81	0.17	0.29	0.84	0.31	0.33	0.70
Elbow diameter	0.79	0.15	0.43	0.10	0.67	0.38	0.54	0.42	0.59
Wrist diameter	0.75	0.15	0.06	0.23	0.78	0.27	0.71	0.70	0.36
Ancle diameter	0.84	0.08	0.04	0.28	0.83	0.21	0.80	0.54	0.25
Subscapular skinf.	–0.03	0.84	0.81	–0.17	0.02	0.77	0.10	–0.16	0.84
Triceps skinfold	0.09	0.85	0.79	–0.11	–0.01	0.86	0.01	–0.02	0.56
Suprailiocristal skin.	–0.16	0.90	0.83	0.03	–0.09	0.78	–0.26	0.04	0.71
Lambda	5.15	4.57	4.75	2.68	2.40	4.75	4.70	4,41	4.29
Var. %	39.6	35.2	36.5	20.6	18.5	36.5	36.1	33.9	33.0

Age groups: 1 – 12–13 years, 2 – 14–15 years, 3 – 16–17 years, 4 – 18–19 years

velopment. The first mechanism, bearing greater load at this developmental age, is responsible for the processes of skeleton development, accompanied by the development of muscle tissue, thus it could be postulated as a mechanism responsible for the general morphological development.

The second mechanism is primarily responsible for the formation (accumulation) of adipose tissue, and only secondarily for the development of muscle tissue. The probably inadequate physical activity in most girls cannot exert a major impact on the development of muscle tissue, thus it cannot be differentiated as a separate feature of their morphological development.

It is concluded that the isolated factors describe two morphological types by their structure, i.e. ectomesomorphic and endomesomorphic type found in players aged 12–13.

In the 14–15 age group, factor analysis isolated three factors in the area of anthropometric variables. The variables for assessment of body mass and volume, and of subcutaneous adipose tissue had highest projections on the first factor providing most information on the morphological characteristics of this study sample (>36%). This factor is responsible for the muscle and adipose tissue regulation. In this age group, this ratio in the total volume was almost equal, with nearly identical amount of muscle and adipose tissue. Relative to the 12–13 age group, where adipose tissue predominated over muscle tissue, in the 14–15 age group muscle tissue was found to have gradually predominated over adipose tissue, probably as the result of two-year volleyball training.

The second and third isolated factors showed a differentiation in skeleton development into longitudinal and transverse development to have occurred in this age group. The second factor is defined by the variables for assessment of longitudinal skeleton dimensionality and is responsible for longitudinal skeleton growth. In such a skeleton, the muscles are long and thin, while adipose tissue is quite negligible. Such features were observed in more than 20% of the subjects.

The third factor is defined by the variables for assessment of transverse skeleton dimensionality and is responsible for transverse skeleton development, associated with thicker but shorter muscles and minimal presence of adipose tissue. These morphological characteristics were recorded in more than 18% of the subjects.

Results of factor analysis in the area of anthropometric variables in female volleyball players aged 14–15 revealed three types of developmental processes of morphological characteristics: processes related to muscle and adipose tissue regulation; processes related to longitudinal skeleton development; and processes related to transverse skeleton development. At this age, the morphological development obviously proceeds according to a varying pattern in particular groups of young female volleyball players, thus it is quite likely that they were undergoing different developmental stages. In the majority of study subjects, the precipitated longitudinal growth in the preceding period was followed by an increase in body mass and volume due to the enhanced muscle tissue development (first isolated factor). In other study subjects, either the developmental stage with intensified longitudinal skeleton development (second isolated factor), or

the developmental stage characterized by intensive transverse bone development (ossification) (third isolated factor) was under way.

In the female volleyball players aged 16–17, factor analysis of anthropometric variables yielded two factors explaining the nearly identical amount of common system variance (>36% each). The first factor was defined by quite high projections of morphological measures for assessment of body mass and volume, and measures for assessment of subcutaneous adipose tissue, and the second factor by high projections of the measures for assessment of longitudinal skeleton dimensionality and by lower yet quite high projections of the morphological measures for assessment of transverse skeleton dimensionality.

Thus structured factors suggest two mechanisms to be equally responsible for the overall morphological development of female volleyball players of this age, i.e. one mechanism for the development and regulation of soft (muscle and adipose) tissue ratio, and the other for the development and regulation of hard tissue (bone) length to thickness ratio. These mechanisms apparently play comparable role in the overall morphological development, and are associated with the biological continuity of developmental functions and volleyball training supporting these functions. The morphological development of female volleyball players is therefore primarily related to the development, i.e. formation of optimal musculature and development of longitudinal skeleton dimensionality.

In comparison with the 14–15 age group, the 16–17 age group showed integration of longitudinal and transverse skeleton dimensionality into a unique factor responsible for overall skeleton development. As the development approaches its definitive state, a stage of concurrent longitudinal and transverse bone development probably follows the varying curves in skeleton development previously observed in particular subject groups.

Factor analysis of anthropometric variables in female volleyball players aged 18–19 isolated two factors explaining the significant amount of common system variance (34% and 33%). The variables assessing longitudinal skeleton dimensionality showed extremely high projections on the first factor, followed by moderate projections of the variables assessing transverse skeleton dimensionality. This morphological factor is primarily responsible for longitudinal skeleton development, thus it can be called the factor of longitudinal skeleton dimensionality.

The variables assessing muscle and subcutaneous adipose tissue had comparably high projections on the second factor, along with moderate projections of the variables of transverse skeleton dimensionality. This factor is primarily responsible for the amount of muscle and adipose, i.e. soft tissues, and the structure of this factor can be defined as mesoendomorphic.

The two morphological structures obtained in the 18–19 age group pointed to the formation of optimal and definitive morphological complexes that determine volleyball performance. The selection of female volleyball players for elite teams also includes the criterion of body height, which is especially important in subsequent selection steps, e.g., on selecting junior (age 18–19) competition team.

The factors obtained describe two types of female volleyball players which are least recognizable in the 18–19 age group: the type of players of above-average body height, long and thin muscles, bones of medium thickness, and free from adipose tissue. The other type are players of under-average body height with pronounced musculature, bones of moderate thickness, yet with rather pronounced adipose tissue, i.e. short and fat, dumpy.

Skeleton development will limit the development of muscle tissue. Therefore, the muscle mass increase can further be influenced upon in the first type of players, as it is facilitated by adequate bone width or thickness. In the other type of players, however, there is less possibility of muscle mass increase but it is possible to influence the adipose tissue reduction. Accordingly, the morphological structures obtained can be further optimized by training to meet the specific volleyball requirements.

Table 3 presents relations between isolated morphological structures and realization of particular techniques in female volleyball players of different age groups. Results of regression analysis indicated significant deter-

TABLE 3
REGRESSION ANALYSIS OF TECHNIQUE VARIABLES IN LATENT MORPHOLOGICAL AREA

Factor	Service β	Reception β	Setting β	Spike β	Block β	Defense β
Age 12–13 yrs						
L/T	0.23	0.18	0.39	0.36	0.47[a]	0.27
A/M	–0.22	–0.17	0.20	–0.10	–0.01	–0.49
ρ	0.28	0.22	0.48	0.35	0.47	0.50
Age 14–15 yrs						
M/A	–0.01	0.05	0.01	–0.17	–0.08	0.12
L	0.15	0.09	0.11	0.31[b]	0.51[c]	0.12
T	0.05	0.00	–0.03	0.01	0.01	–0.02
ρ	0.15	0.11	0.12	0.34[b]	0.51[c]	0.18
Age 16–17 yrs						
M/A	0.07	–0.11	–0.12	–0.35[a]	–0.24[a]	–0.08
L/T	0.14	–0.04	0.25	0.42[b]	0.65[c]	0.12
ρ	0.17	0.11	0.28	0.57[b]	0.71[c]	0.15
Age 18–19 yrs						
L/T	0.41	0.04	0.20	0.44	0.57[a]	0.25
M/A	–0.09	0.04	–0.02	0.11	–0.03	0.13
ρ	0.42	0.05	0.21	0.45	0.57[a]	0.28

Age groups: 1 – 12–13 years, 2 – 14–15 years, 3 – 16–17 years, 4 – 18–19 years, L/T – Longitudinal/Transverse ratio, A/M – Adipose/Muscular tissue ratio, M/A – Muscular/Adipose tissue ratio, L – Longitudinal, T – Transverse, β – regression coefficient, ρ – multiple correlation

[a]$p<0.05$; [b]$p<0.01$; [c]$p<0.001$

TABLE 4
REGRESSION ANALYSIS OF SITUATION PERFORMANCE IN LATENT MORPHOLOGICAL AREA FOR FEMALE VOLLEYBALL PLAYERS OF DIFFERENT AGE GROUPS

Factor	1 (n=32)	β	2 (n=147)	β	3 (n=50)	β	4 (n=17)	β
F1	L/T	0.55 [c]	M/A	–0.12	M/A	–0.21	L/T	0.55[b]
F2	A/M	–0.29 [a]	L	0.53[c]	L/T	0.61[c]	M/A	0.33
F3			T	0.09				
ρ		0.62 [c]		0.56[c]		0.65[c]		0.64[a]

Age groups: 1 – 12–13 years, 2 – 14–15 years, 3 – 16–17 years, 4 – 18–19 years, L/T – Longitudinal/Transverse ratio, A/M – Adipose/Muscular tissue ratio, M/A – Muscular/Adipose tissue ratio, L – Longitudinal, T – Transverse, β – regression coefficient, ρ – multiple correlation

[a]$p<0.05$, [b]$p<0.01$, [c]$p<0.001$

mination of longitudinal skeleton dimensionality with block technique realization across all age groups, and a lower yet significant determination of longitudinal skeleton dimensionality with realization of the spike technique in the 14–15 and 16–17 age groups. The role of longitudinal skeleton dimensionality in predicting the block and spike techniques notably increased with age (groups 1 to 3).

Since muscle and adipose tissue is defined as a single factor, it can only be presumed that muscle tissue will have a favorable impact, and adipose tissue an unfavorable impact on the realization of all volleyball techniques, spike, block and court defense in particular.

Regression correlation analysis yielded substantial information on the effect of the identified morphological structures on volleyball performance in various age groups (Table 4). Multiple correlation showed the set of morphological structures to be a good predictor of situation efficacy in all age groups, with the developed skeleton underlain by predominant longitudinality being a significant positive predictor of situation performance in all age groups.

The other morphological structure integrating muscle and adipose tissue at a varying ratio (from adipose tissue predominating over muscle tissue in 12–13 age group through muscle tissue predominating over adipose tissue in 18–19 age group) showed varying determination of situation performance across the study age groups. So, the impact of soft tissue on situation performance was unfavorable in the youngest age group (age 12–13) and favorable in the oldest age group (age 18–19). Accordingly, the soft tissue composition is modified by training in terms of significant muscle mass increase.

Thus, the morphological structures of female volleyball players are optimized with the playing quality improvement, this in relation to the techniques predominating at a particular playing position.

The set of variables of the six volleyball techniques evaluated is a good predictor of situation efficacy in each age group[17]. Particular techniques play a varying role in the expression of playing quality according to age groups. Thus, serve technique is the best predictor of playing quality in 12–13 age group[17], block and spike techniques in 14–15 age group[17,18], spike and block techniques in 16–17 age group[17,18], and court defense in 18–19 age group[18]. Grgantov et al.[21] found similar effects in beach volleyball.

Conclusion

The present study investigated age related differences in female volleyball players in the following parameters: manifest morphological variables and volleyball technique variables; structures of latent morphological variables; and relations of latent morphological variables with technical and situation efficacy.

The data obtained indicated the development and formation of ideal morphological structures in young female volleyball players to be closely related to the process of selection and body transformation processes induced by volleyball training.

Generally, it is concluded that the performance in female volleyball is predominantly determined by longitudinal skeleton dimensionality or simply by body height, along with quality muscle tissue. Merely based on the main statistical parameters it is apparent that changes in body height and muscle mass, especially of the trunk and thigh, occur concurrently with changes in the variables of technical efficacy of the female volleyball players.

Factor analysis provided an even more complete picture of the players' morphological characteristics. Analysis across age groups has pointed to the formation of two morphological structures that exist in two types of female volleyball players. The two morphological structures are defined by two components each. The first one, depending on skeleton development, is defined by longitudinal and transverse bone growth, whereas the second one, depending on soft tissue development, is defined by muscle and adipose tissue ratio.

The first morphological structure defines the morphological complex, which predominantly determines playing quality and is optimal for solving all play situations, especially those related to the play over the net. These players are of above-average body height, and

above-average wrist and ankle diameters, with moderately developed muscle mass, of the trunk and thigh in particular, and minimal adipose tissue. Their body height allows them ball contacts at a greater height above the net; their ankle diameter ensures greater stability and facilitates their overcoming the load on landing and taking off in spike and block techniques; their wrist diameter contributes to the ball shooting strength on spike and service; their trunk and thigh musculature contributes to their efficacy in all techniques, especially those involving jump, i.e. above the net.

The second morphological structure defines the morphological complex, which is generally optimal for solving situations in field defense. These players are of under-average body height with above-average body mass predominated by muscle tissue over adipose tissue, which is accompanied by moderate transverse skeleton dimensionality. Such a morphological structure favors psychomotor speed and agility-mobility, which is typical for the players in court defense.

Study results indicate that achievement of top results in female volleyball requires the processes of selection and training to be performed in relation to solving both general and specific playing tasks, i.e. these processes should also be directed to a particular playing specialization.

Acknowledgements

This research is a part of a project of the Ministry of Science, Education and Sport of the Republic of Croatia (No: 0177190 head researcher: Prof. R. Katić).

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INTEGRACIJA TEHNIČKE I SITUACIJSKE EFIKASNOSTI U MORFOLOŠKI SUSTAV KOD MLADIH ODBOJKAŠICA

SAŽETAK

Cilj istraživanja je identificirati morfološke strukture mladih odbojkašica u odnosu na starosnu dob i utvrditi utjecaj tih morfoloških struktura na tehničku i situacijsku efikasnost. U tu svrhu na uzorku od 246 odbojkašica i to: 32 mlađe kadetkinje starosne dobi 12–13 godina, 147 mlađih kadetkinja starosne dobi 14–15 godina, 50 kadetkinja starosne dobi 16–17 godina i 17 juniorki starosne dobi 18–19 godina, primijenjen je skup od 13 morfoloških mjera kao varijabli prediktora i skup od 6 elemenata tehnike i procjena igračke kvalitete kao varijabli kriterija. Analizom varijance je utvrđeno da se odbojkašice različitih uzrasnih kategorija značajno razlikuju u varijablama koje procjenjuju longitudinalnu dimenzionalnost skeleta i volumen i masu tijela, kao i u svim testovima za procjenu odbojkaških tehnika. Faktorska analiza morfoloških mjera kod odbojkašica promatrano kroz uzrasne kategorije definirala je uglavnom dvije morfološke strukture i to: prvu za koju je odgovoran razvoj skeleta, tj. rast kostiju u dužinu i širinu i drugu za koju je odgovoran razvoj mekih tkiva, tj. razvoj mišićnog i masnog tkiva. Rezultati regresijskih analiza su pokazali značajnu determiniranost longitudionalne dimenzionalnosti skeleta s realizacijom tehnike bloka preko svih uzrasnih kategorija, te nešto manju i značajnu determiniranost longitudionalne dimenzionalnosti skeleza s realizacijom tehnike smeča kod mlađih kadetkinja i kadetkinja. Regresijska korelacijska analiza je utvrdila da razvijeni skelet u osnovi kojeg je dominantna longitudionalnost, je značajan i pozitivan prediktor situacijske uspješnosti u svim uzrasnim kategorijama.