SPIROMETRIC AND MORPHOLOGICAL INDICATORS OF TOP LEVEL HANDBALL PLAYERS

Nenad Rogulj[1], Mladen Marinović[1], Nikola Foretić[1], Vatromir Srhoj[1] and Zvonko Herceg[2]

[1] *University of Split, Faculty of Kinesiology*
[2] *Faculty of Sciences, University of Mostar, Bosnia & Herzegovina*

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Abstract

The aim of this study was to determine the differences and relations of the morphological and spirometry characteristics between elite and the first league quality handball players. The study was conducted on the sample of 35 handball players playing in two clubs of 1st Croatian handball league divided in two groups: national team players (n=15) and the first league quality players (n=20). A total of 18 variables were analysed, 12 out of which to evaluate morphological characteristics and 6 to assess spirometry and ventilation parametres. Generally, by applying variance and discriminant analysis, no statistically significant differences between elite and high-quality players were established in the analysed areas. Individually, statistically significant differences are present only in the shoulder girth and hand length, and spirometry indicators show no statistically significant differences. Relation analysis between morphological and spirometry indicators detected positive statistically significant connections between most of the variables in the spirometry domain and in most of the longitudinal dimensionality skeleton variables as well as shoulder girth.

Key words: *handball, parameters, spirometry, morphology*

Introduction

Handball, as a complex sport game, belongs to polystructural complex kinesiological activities. Its basic characteristics are the abundance of natural ways of movement, but also specific cyclic and acyclic moving structures (Rogulj, 2003). Kinesiological variety reflects on the anthropological status of handball players since there are no anthropological features that cannot be influenced by handball (Srhoj, 2002). However, different anthropological features do not equally contribute to the playing quality. Numerous researches revealed that motor and functional abilities and morphological features are important efficiency indicators in handball players (Srhoj et al. 2006, Galal El-Din et al. 2011) and that these features should be given special significance in the selection process. Morphological characteristics of handball players are one of the most reliable indicators of playing quality and a good selection criterion in choosing players for certain playing positions (Šibila, 2009). Aerobic endurance, being an important guideline of situation efficiency in handball players (Buchheita et al. 2008), may be efficiently developed since early childhood (Malina et al. 2004). Ventilation parameters, being an important component of pulmonary system efficiency, determine aerobic endurance to a great extent, and at the same time, the efficiency in a certain kinesiological activity, likewise in handball (Prakash et al. 2007, Schoene et al. 1997). A great number of sport scientists studied the relations of morphological and respiratory features in athletes, which is also the topic of this research. Sancho-Chust et al. (2010) concluded that body height, in addition to anthropometrical variables connected to height, may be properly used to predict pulmonary function.

In accordance with this, Radovanović et al. (2007) determined above-average values of spirometry parameters in elite female water polo players and connected this to the above-average body height and weight of the respondents. Gabrilo et al. (2011) have been continuously following the pulmonary function of female synchronised swimmers over a one-year cycle. The research showed a significance increase in body height and weight, and consequently the increase of spirometry values in the respondents.

The research done by Ronga et al. (2008) set the aim of studying the influence of 10 different sports on pulmonary function. Among other, they established a significant positive connection between spirometry parameters and body height and weight. Starting with the importance of morphological and respiratory features for efficiency in handball, the intension of this research was to establish the differences, but also relations of these two anthropological features in elite national team and quality first league players.

Methods

The sample of respondents

The research was conducted on the sample of 35 handball players of the two Croatian first handball league clubs. The clubs were ranked among the top three clubs at the end of the championship. One of the clubs won the European Cup that year, while the other played in the quarter-finals of the European Champions league. Top Croatian and world handball players played in these clubs, the members of five national teams of some European countries.

The respondents have won the total of 23 medals with their national teams in major competitions (Olympics, World Championship, European Championship), and one of them was officially the best world handball player. The players' average age was 24,6 and the average competition experience in sport was 137,2 months. The respondents were categorised in two quality groups as elite players (n=15), including national team players from national selections. These were all elite national team players of international values including numerous medal winners in major international competitions. The other sub-sample (n=20) involved players with a generally weaker handball status, not belonging to the previously mentioned category, but to quality first league club players.

The sample of variables

We analysed the total of 18 variables, 12 out of which were used for the assessment of morphological characteristics and 6 to assess spirometry and ventilation parameters. Morphological characteristics were measured according to IBP, and the measures selected, according to the previous scientific knowledge, were the best indicators of the morphological model of handball players (Srhoj et al. 2002), and at the same time best distinguish male and female handball players regarding their playing quality (Cikatić and Foretić 2005, Čavala 2012). To assess longitudinal dimensionality of the skeleton, we measured: body height (AVIST), sitting height (AVISSJ) and hand length (ADUŠAK). To assess transversal dimensionality of the skeleton, we measured: shoulder girth (AŠRAM), pelvis girth (AŠZDJ) and hand girth (AŠŠAKE). Voluminosity and body mass were assessed by the following variables: upper arm volume (AONADL), forearm volume (AOPOT) and body weight (ATT).

To assess sub-skin adipose tissue, we measured: skin folds of the upper arm (AKNTRI), back (AKNLEĐ) and stomach (ANKTRB). To assess spirometry and ventilation functions, we used the following indicators: forced vital capacity (FVC), forced expiration capacity in the first second (FEV_1), middle expiration flow with 75% of vital capacity on the flow-volume curve (MEF_{75}), middle expiration flow with 50% of vital capacity (MEF_{50}), middle expiration flow with 25% of vital capacity (MEF_{25}), peak expiration flow (PEF). The measuring of morphological characteristics was done in the morning in a clinical hospital by an educated kinesiologist according to IBP, and ventilation parameters were measured during the same morning in the Spirometry laboratory at the Pulmonary ward of the clinical hospital on *Pneumoscope Erich Jaeger* instrument. The room and the measuring conditions satisfied the recommendations given by the manufacturer. The calibration of the instrument was done by an original calibration syringe before the measuring, according to the manufacturer's instructions, in order to avoid mistakes in measuring by the instrument itself.

Data processing methods

We analysed basic descriptive and distribution parameters of prediction variables as it follows: arithmetic means (AS), standard deviation (SD), the lowest (MIN) and the highest (MAX) results, asymmetry coefficient (Skewness), distribution curve coefficient (Curtosis) and, with the purpose of testing distribution normality by Kolmogorov-Smirnova procedure, maximum differences between actual and theoretical cumulative frequencies (MaxD). The differences between the two quality groups of players were established by multivariant (ANOVA) and univariant variance analysis (MANOVA), and by dicriminant analysis. The relations between the two sets of variables (morphological and spirometriy) were established by Pearson correlation coefficients. The data were processed by Statistica for Windows ver. 7.0 statistical-graphic package.

Results and discussion

Table 1. Basic descriptive and distribution parametres of prediction variables

Variable	Mean	Min	Max	Std.Dev.	Skewness	Kurtosis	Max d
AVIST	190,58	178,00	205,00	6,69	,04	-,47	,06
AVISSJ	98,90	92,10	105,10	3,54	-,04	-,76	,10
ATT	90,99	72,00	104,00	7,94	-,57	-,38	,12
AONADL	33,60	30,00	39,30	2,11	,63	,39	,13
AOPOT	40,08	35,20	44,90	2,35	,00	-,56	,09
AŠRAM	41,90	36,00	45,30	2,20	-,61	,12	,10
AŠZDJ	30,29	27,00	33,50	1,51	-,20	-,31	,11
AŠŠAKE	8,84	8,10	9,40	,36	-,16	-,84	,13
ADUŠAK	21,93	19,60	23,80	1,01	-,15	-,16	,09
AKNTRI	8,31	5,30	15,50	2,32	1,15	1,76	,12
AKNLEĐ	11,54	7,30	17,40	2,53	,75	-,08	,12
ANKTRB	15,49	5,80	25,90	5,85	,12	-1,19	,10
FVC	6,31	4,23	9,55	1,17	,88	1,02	,15
FEV1	5,47	3,44	7,32	,88	,00	-,24	,08
MEF75	6,91	1,94	15,80	3,59	,34	-,76	,17
MEF50	6,96	3,88	11,90	1,70	,82	,74	,13
MEF25	6,63	2,36	11,09	2,88	-,18	-1,56	,15
PEF	11,56	7,36	17,80	2,77	,47	-,32	,09

Test value of the KS test for Max D on the level p<,01 = ,23

Table 1 displays the analysis results of the basic descriptive and distribution parameters of prediction variables. Kolmogorov-Smirnova test confirmed all the variables were normally distributed, i.e. there is no irregular data dispersion or distribution deviations, thus the variables are suitable for the further processing by multivariant parameter statistical procedures. We can observe a minor negative asymmetry, i.e. a tendency towards higher values of most of the variables in the morphological area, except for the variables to assess sub-skin adipose tissue which incline towards lower values. This shows the sample involved top level athletes who are more dimensioned in longitudinal and transversal dimensionality of the skeleton and voluminosity, than in sub-skin adipose tissue as a negative factor of sport efficiency, which was determined by a large number of researches (Chinn et al. 1996, Lazarus et al. 1997, Harik-Khan et al. 2001). Variables related to ventilation parameters are in the same way mostly insignificantly positively asymmetrical, except for the variable MEF25, meaning that, unlike most morphological variables, has a minor tendency towards lower values.

Table 2. The results of multivariant variance analysis and the discriminant analysis between top level and quality players

Multivariant variance analysis parametres			Disciminant analysis parametres			
Wilks' Lambda	Rao's R	p-level	Eigen-value	Canonicl R	Chi-Sqr.	p-level
,40	1,32	,29	1,49	,77	21,88	,24

Table 3. The results of the univariant variance analysis and discriminant fuction structures between top level and quality handball players

Variable	AS Top level	AS quality	F	p-level	STRUC
AVIST	191,09	190,21	,15	,71	,05
AVISSJ	99,77	98,25	1,61	,21	,18
ATT	93,43	89,15	2,61	,12	,23
AONADL	33,97	33,32	,82	,37	,13
AOPOT	40,78	39,56	2,41	,13	,22
AŠRAM	42,89	41,16	6,05	,02*	,35
AŠZDJ	30,47	30,16	,37	,55	,09
AŠŠAKE	8,99	8,73	5,13	,03*	,32
ADUŠAK	22,25	21,69	2,74	,11	,24
AKNTRI	7,91	8,60	,77	,39	-,13
AKNLEĐ	11,46	11,60	,03	,87	-,02
ANKTRB	15,53	15,47	,00	,98	,00
FVC	6,36	6,27	,05	,83	,03
FEV1	5,50	5,45	,03	,87	,02
MEF75	6,24	7,42	,92	,34	-,14
MEF50	6,58	7,25	1,32	,26	-,16
MEF25	6,67	6,61	,00	,95	,01
PEF	11,61	11,52	,01	,93	,01

By comparing the obtained results to the results of certain previous researches conducted on elite male handball players, we may observe their accordance, particularly in morphological area (Srhoj, 2002), but even the expected difference regarding the results obtained from female handball players (Cikatić and Foretić 2005, Foretić et al. 2007) or the female handball players from younger age categories (Foretić et al. 2005). Similar differences were stressed by Ronga et al. (2008) in the study conducted on male and female athletes in 10 different sports. The authors revealed significantly more spirometry parameter values in male athletes compared to female athletes. The same research showed swimmers have significantly more developed pulmonary function compared to volleyball players, football players, fencers, judo fighters and track-and-field athletes. Table 2, which includes the results of multivariant, i.e. discriminant analysis, displays there are generally no statistically significant differences between elite and quality players in the analysed variables of morphological and spirometry area. By discriminant analysis, we isolated one discriminant function not statistically significant. A detailed insight into to differences regarding certain areas and variables may be obtained from the results of the univariant analysis variance and discriminant function structure, i.e. from the correlation of variables and the discriminant function presented in table 3. By analysing table 3, we may observe only two statistically significant differences found in the morphological area in shoulder girth (AŠRAM) and hand girth (AŠŠAKE) variables.

Although elite handball players expectedly dominate in all variables, it is evident that two mentioned indicators, out of all the morphological characteristics, mostly distinguish elite from quality handball players. We may assume that shoulder girth in particular and to the greatest extent presents morphological characteristics determining playing quality since it enables the player powerful shooting and the increase of the shooting angle, in addition to higher efficiency in performing technical-tactic tasks in defence, particularly in the zone defence systems. Hand girth enables an efficient ball handling and to a large extent increases power and shooting preciseness which is a characteristic of elite players (Van Den Tillaar 2004, Gorostiaga et al. 2005, Srhoj et al. 2012). There are no statistically significant differences in ventilation parameters. Elite players were insignificantly dominant in FVC, FEV1, MEF25 and PEF, and quality players in the last two indicators: MEF75 and MEF50. It is logical to assume that spirometry indicators distinguish playing quality less clearly in sports such as handball which is characterised by mixed aerobic-anaerobic energy processes (Chelly et al. 2011), which makes the elite and the quality players more equal in these indicators than in e.g. motor or morphological indicators (Gorostiaga et al. 2005). Further on, it is not illogical to assume that the absence of statistically significant differences is a consequence of insufficient motivation in elite players during testing. With the purpose of better understanding interactive relations between the morphological and ventilation area, we calculated the cross-correlations coefficients (table 4).

Table 4. Cross correlations between the variables of the morphological and the ventilation area

Variables	FVCA	FEV1	MEF75	MEF50	MEF25	PEF
AVIST	,44	,45	,17	,40	,29	,17
AVISSJ	,49	,46	,18	,30	,15	,18
ATT	,24	,20	-,04	,06	,17	,06
AONADL	-,24	-,14	-,42	-,11	,34	-,22
AOPOT	-,19	-,10	-,31	-,11	,27	-,15
AŠRAM	,33	,39	,03	-,04	,07	,22
AŠZDJ	,05	,17	-,22	,16	,47	-,09
AŠŠAKE	,06	,04	-,01	,13	,20	,21
ADUŠAK	,41	,33	,19	,19	,15	,27
AKNTRI	-,24	-,05	-,07	,03	-,02	-,18
AKNLEĐ	-,02	,03	-,01	-,08	-,18	-,12
ANKTRB	-,14	-,12	-,01	-,09	-,20	-,05

By inspecting table 4, we may observe that all the longitudinal skeleton dimensionality variables have positive and mostly statistically significant correlations with all the ventilation parameters. This means there is a significant positive connection between body measurements lengthwise and ventilation efficiency, i.e. the respondents who are taller, achieve better results in spirometry parameters. Undoubtedly, this was expected since longitudinal dimensionality directly determines larger voluminosity, i.e. lung capacity, and immediately a bigger active mass of the respiratory muscles. Naturally, the nature of this connection involves reversed cause-and-effect causality, i.e. the total bigger active muscle mass characteristic for respondents with stressed longitudinal skeleton dimensionality, necessarily influences development and demands the increase of spirometry-ventilation potentials which enable adequate energy support. All the variables of sub-skin adipose tissue have minor and mostly negative correlations with ventilation variables. It may be assumed that sub-skin adipose tissue, negatively, but not to a large extent, affects the ventilation efficiency. Handball is a sport in which, in addition to anaerobic, there are also aerobic energy processes influencing the burning of adipose tissue and its reduction, both in quality and elite handball players. It is likely that the absence of a higher degree of the negative connection of these two variables primarily lies in the fact that handball abounds in anaerobic energy processes (Rannou et al. 2001, Sporiš et al. 2010) which can affect the reduction of adipose tissue to a significantly lesser degree (Carey 2009). Transversal skeleton dimensionality variables achieve mostly positive, and in some variables statistically significant connections with ventilation variables. The largest correlation is between the shoulder girth and FEV1. It is evident that transversal dimensionality of the upper trunk, involving the proportional dimensionality of the chest, is more important in the starting than in the later phase of exhaling. We may easily conclude that shoulder girth in particular, followed by the proportional voluminosity of lung tissue, but also by the respiratory muscles tissue, is the most reliable morphological indicator of the lung capacity. A strong correlation of the pelvis girth and MEF25 is most interesting. We may assume that the air flow efficiency in the final phases of exhaling positively affects the diaphragm efficiency and the efficiency of stomach muscles in the lower part of the stomach, which are likely more dimensioned in handball players with stressed transversal dimensionality of the pelvis. Variables referring to volume have less significant, but negative correlations with ventilation indicators apart from MEF25 where there is a positive connection. Volumes are body voluminosity measurements affected by muscle mass as well. We may assume that larger voluminosity in particular, and at the same time the muscle mass of the upper trunk, improves the power of exhaling in the starting phase. This assumption is corroborated by the total body mass which expectedly has positive, although relatively low correlations with the ventilation indicators.

Conclusion

Situation and result efficiency in handball players undoubtedly depend on all the anthropological features, including morphological characteristics as well, in addition to spirometry and ventilation parameters. This research established that the differences between elite national team players and quality first league handball players are generated more by morphological than by spirometry and ventilation parameters.

The differences are more evident in longitudinal and transversal skeleton dimensionality variables than in adipose tissue. Regarding the fact these morphological characteristics are greatly genetically determined and not subjected to almost any of the changes under the influence of kinesiological treatments, we may consider them reliable indicators in the selection process in handball.

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SPIROMETRIJSKI I MORFOLOŠKI POKAZATELJI VRHUNSKIH RUKOMETAŠA

Sažetak

Cilj istraživanja je bio utvrditi razlike, ali i odnose morfoloških i respiracijskih obilježja vrhunskih reprezentativnih i kvalitetnih prvoligaških rukometaša. Istraživanje je provedeno na uzorku od 35 rukometaša dvaju rukometnih klubova I hrvatske rukometne lige, podijeljenih u dva subuzorka kao vrhunski reprezentativni (n=15) i kvalitetni prvoligaški igrači (n=20). Analizirano je ukupno 18 varijabli od kojih 12 za procjenu morfoloških karakteristika i 6 za procjenu respiracijskih i ventilacijskih parametara. Primjenom analize varijance i diskriminacijske analize nisu utvrđene statistički značajne razlike između vrhunskih i kvalitetnih rukometaša u analiziranim prostorima u cjelini. Pojedinačno, statistički značajne razlike prisutne su samo u varijablama širina ramena i dužine šake, a kod respiracijskih indikatora nije zabilježena niti jedna statistički značajna razlika. Analiza relacija između morfoloških i respiracijskih indikatora detektirala je pozitivne statistički značajne veze između većine varijabli respiracijskog prostora s većinom varijabli longitudinalne dimenzionalnosti skeleta te širinom ramena.

Ključne riječi: *rukomet, parametri, spirometrija, morfologija*

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Correspondence to:
Assoc.Prof. Nenad Rogulj, PhD
Faculty of Kinesiology
University of Split
21000 Split, Teslina 6, Croatia
Phone: +385 95 835 3195
E-mail: nrogulj@kifst.hr