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Original research article

CANONICAL RELATIONS BETWEEN SPORT-SPECIFIC AND MORPHOLOGICAL STATUS AMONG FIRST LEAGUE FEMALE SOCCER PLAYERS

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Abstract. *The aim of this study was to identify and explain the morphological conditionality of specific soccer motor variables among first league soccer players. According to the aim of the research, a sample of 70 Croatian first league female soccer players was measured in 18 morphological tests, and 7 suitably selected soccer specific motor tests. A canonical correlation analysis was applied. Contrary to our expectations, the results indicate that the morphological status cannot be treated as a reliable predictor (p=0.11) of the actual players' quality manifested trough precisely selected soccer-specific motor variables. Consequently, the selection of female soccer players cannot be carried out only through determining the morphological status of female soccer players, but exclusively through an analysis of their functional status and soccer-specific variables. Due to the selected representative sample, it is assumed that the results can be generalized to the population of elite female soccer players.*

Key words: *morphological features, soccer-specific motor features, first league female soccer players, canonical correlation analysis*.

INTRODUCTION

In terms of participation and support in general, soccer is considered primarily a male sport. On the other hand, female soccer is one of the sports with a constantly growing number of players, amateur or professional. Also, in the area of female soccer, research on morphological features (Can, Yilmaz & Erden, 2004; Jukić, Sporiš & Mihačić, 2007; Mandić Jelaska, Lovrić & Bjelanović, 2013), physiological features (Tumilty & Darby, 1992; Davis & Brewer, 1993; Andersson, 2010), situational fatigue (Mohr, Krustrup & Bangsbo, 2003, Mohr, Krustrup & Bangsbo, 2005; Krustrup, Mohr, Ellingsgaard &

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Bangsbo, 2005; Andersson, Randers, Heiner-Møller, Krustrup & Mohr, 2010), optimal loading during training (Jensen & Larsson, 1992; Greska, Cortes & Onate, 2010), knowledge about doping and nutrition (Mandić Jelaska, Fiorentini & Bašić, 2010), conditioning (Rhodes & Mosher, 1992; Yap & Brown, 2000; Polman, Walsh, Bloomfield & Nesti, 2004; Mujika et al., 2009) and work rate profiles (Rienzi, Drust, Reilly, Carter & Martin, 2000) are topics of recent scientific interest. The fact that the training structure of female soccer players is significantly different from that of male players (Kirkendall, 2007) clearly indicates the need for the intensification of scientific research in the area of women's soccer.

Modern male and female top soccer requires a strong and durable athlete with exceptional motor and functional abilities, and with a sense of improvisation, but also for cooperation during the game (Todd, Scott & Chisnall, 2002; Yap & Brown, 2000; Reilly, Bangsbo & Franks, 2000; Russel & Tooley, 2011). Additionally, it is certain that different variables and their various interaction levels are responsible for the situational efficiency of female soccer players (Krustrup et al., 2005). Furthermore, it is certain that high quality female soccer players possess an adequate level of soccer-specific motor knowledge which is manifested trough skills needed for the optimal realization of soccer-specific tasks (Schmidt & Wrisberg, 2008). Also, it is relatively obvious that the interaction between motor knowledge manifested through the realization of soccer-specific motor tasks and various dimensions of morphological status is reciprocal. Research that indicates that professional female soccer players run approximately 28% longer in high intensity than their colleagues at lower competition levels (Mohr, Krustrup, Kirkendall & Bangsbo, 2007; Mohr, Krustrup, Andersson, Kirkendal & Bangsbo, 2008) additionally points to the fact that conditionality of biomotor dimensions of elite female soccer players needs to be observed as a separate scientific problem than those of their male colleagues.

Some authors (Mandić Jelaska, Katić & Jelaska, 2013) provided deep insight into the structure of relations between the morphological, motor and specific motor variables. They have determined the factor structure of morphological and motor characteristics of Croatian first league female soccer players and their impact on the estimated player quality. Furthermore, two factors were isolated in the space of soccer-specific motor abilities: soccer-specific efficiency (53%) and situational soccer coordination (27%). By using a factor analysis on the extracted latent dimensions, two higher order factors (morphological-motor factor and soccer-specific motor abilities factor) that explain 87% of the common variability were extracted. It is assumed that two extracted higher-order factors fully describe the morphological and motor status of first league female soccer players. Same authors applied a multiple regression analysis to show that the identified factors are very good predictors of female soccer player quality ($R^2 = 0.959$).

It is important to emphasize that research into the relations of morphological and sport-specific status in female soccer is very rare. Accordingly, the primary goal of this study is to identify and explain relations between sport-specific and morphological status among quality female soccer players.

THE METHOD

Participants

The sample of participants consisted of 70 Croatian first league female soccer players of an average age of 21.7 ± 1.3. All of the participants were examined using the same measuring procedure, by the same previously precisely informed officials. Athletes who had recently suffered a serious injury were not included in this study.

Measures and procedures

The sample of morphological variables consisted of 18 tests for assessing the complete morphological status and their selection was made under the assumption of the existence of four latent dimensions: the longitudinal dimensionality of the skeleton, transversal dimensionality of the skeleton, body mass and volume and subcutaneous fatty tissue. All of the variables were measured according to standard and reliable procedures. The measures were as follows: body height, arm length, leg length, hand length, knee diameter, elbow diameter, wrist diameter and hand diameter, body weight, flexed upper arm circumference, relaxed upper arm circumference, thorax circumference, forearm circumference and calf circumference, triceps skinfold, abdominal skinfold, back skinfold and calf skinfold. All of the anthropometric measures used in this study were carried out according to the guidelines outlined by the International Society for the Advancement of Kinanthropometry - ISAK (Stewart, Marfell-Jones, Olds & De Ridder, 2011).

Soccer-specific motor abilities were defined by a set of seven tests that have previously been shown to fully describe a soccer game in the context of five existing latent dimensions: precision shots to the target, ball handling, speed of ball handling, kick force, and speed of curvilinear running (Gabrijelić, Jerković, Aubrecht & Elsner, 1982; Mandić Jelaska et. al., 2013). The tests were selected due to the greatest correlation with the extracted latent dimensions: precision shots to the target with a leg ball kick, precision shots to the target with a leg/head kick, distance achieved by a leg kick, distance achieved by a head kick, running with a ball at right angles, hitting the wall with the ball and a 20m sprint with the ball. A detailed description of the performed tests can be found in Mandić Jelaska et al. (2013). All of the measurements were performed 3 times by previously instructed individuals.

Data analysis

The data analysis methods involved calculating descriptive statistical parameters: the mean (M), standard deviation (SD), minimal (Min) and maximal (Max) result and significance of the Kolmogorov-Smirnov test. Due to the verification of data reliability, the inter-observer relative technical error of measurement for three measurements (TEM) was calculated (Onyango et al., 2006) for all anthropometric data while for soccer-specific motor abilities, the standard error of measurement (SEM) was calculated (Hopkins, 2000). In order to determine the structure of the relations between morphological status and soccer specific motor status, a canonical correlation analysis was applied. Type I error was set at α=5%. All of the calculations were done by using the Statistica 12.0 software (StatSoft, USA) at the Faculty of Kinesiology, University of Split.

RESULTS

For all the morphological variables, TEM was <4.4%, while for all the soccer-specific variables, SEM was <7.9%, therefore indicating high reliability of all the data. Table 1 and table 2 present the descriptive statistics of morphological variables for all 70 Croatian female first league soccer players. Due to the calculated significance of the Kolmogorov-Smirnov test, it can be seen that two variables have mild deviations from normal distribution ($p<0.05$), which does indicate that all the variables are suitable for further multivariate parametric analyses.

Table 1 Descriptive statistics of morphological characteristics

Variable	$\overline{X}$	SD	Min	Max	KS
Body height (cm)	166.78	6.27	152.00	188.00	p>0.20
Arm length (cm)	72.78	4.23	58.00	81.60	p>0.20
Leg length (cm)	99.85	6.22	89.20	121.00	p>0.20
Hand length (cm)	17.81	1.05	14.50	20.80	p>0.20
Knee diameter (cm)	9.97	0.94	6.90	11.80	p>0.20
Elbow diameter (cm)	6.34	0.45	4.90	7.20	p<0.15
Wrist diameter (cm)	5.19	0.35	3.90	5.90	p<0.05
Hand diameter (cm)	7.46	0.39	5.90	8.30	p<0.20
Body mass (kg)	60.32	8.07	42.00	82.00	p<0.20
Upper arm circumference flexed (cm)	27.68	2.49	20.50	34.00	p>0.20
Upper arm circumference relaxed (cm)	26.26	2.45	19.50	33.00	p>0.20
Thorax circumference (cm)	88.21	6.86	68.50	105.00	p>0.20
Calf circumference (cm)	36.20	2.85	26.50	41.80	p>0.20
Forearm circumference (cm)	24.04	2.46	18.00	36.80	p>0.20
Triceps skinfold (mm)	16.89	3.40	9.33	24.20	p>0.20
Back skinfold (mm)	11.31	2.76	7.00	19.60	p<0.15
Abdominal skinfold (mm)	20.53	9.50	8.53	76.00	p<0.05
Calf skinfold (mm)	13.14	3.58	6.13	25.13	p>0.20

Legend: $\overline{X}$ – mean, SD – standard deviation, Min – minimal result, Max – maximal result, KS significance of Kolmogorov-Smirnov test)

Table 2 Descriptive statistics of soccer-specific abilities

Variable	$\overline{X}$	SD	Min	Max	KS
Precision shot to the target with a leg kick (score)	8.53	3.95	1.00	15.00	p<0.10
Precision shot to the target with a head kick (score)	8.24	3.88	2.00	15.00	p<0.15
Distance achieved by a leg kick (m)	39.39	11.38	22.00	58.00	p>0.20
Distance achieved by a head kick (m)	6.88	1.42	4.15	10.55	p>0.20
Running with a ball at right angles (s)[#]	10.09	1.40	8.00	12.90	p>0.20
Hitting the wall with the ball (freq)	19.47	5.42	8.00	35.00	p<0.05
20m sprint with the ball (s) [#]	4.11	0.54	3.10	5.60	p>0.20

Legend: $\overline{X}$ – mean, SD – standard deviation, Min – minimal result, Max – maximal result, KS – significance of Kolmogorov-Smirnov test)
[#]variable with opposite metric orientation

Form table 2 it can be seen that soccer-specific motor variables have satisfactory mean values and relatively small standard deviations, which additionally points to the fact that a relatively homogenous sample of participants was used in this study.

In table 3, the results of the canonical correlation analysis for two sets of observed variables is presented.

Table 3 The results of the canonical correlation significance testing with 0 successive roots removed

Morphological characteristics	Root1	Soccer specific abilities		Root1
Body height	0.03	Precision shot to the target with a leg kick		0.13
Arm length	0.31	Precision shot to the target with a head kick		0.18
Leg length	0.01	Distance achieved by a leg kick		0.04
Hand length	-0.23	Distance achieved by a head kick		0.62
Knee diameter	0.32	Running with a ball at right angles		-0.25
Elbow diameter	0.35	Hitting the wall with the ball		0.67
Wrist diameter	0.61	20m sprint with the ball		-0.70
Hand diameter	0.21			
Body mass	0.15		Can R	0.74
Upper arm circumference flexed	0.16		Can R^2	0.54
Upper arm circumference relaxed	0.36		Chi-Sqr	145.67
Thorax circumference	0.52		p	0.11
Calf circumference	0.50			
Forearm circumference	0.25			
Triceps skinfold	-0.17			
Back skinfold	0.04			
Abdominal skinfold	-0.31			
Calf skinfold	0.07			

Legend: CanR –canonical correlation coefficient, $CanR^2$ - canonical coefficient determinant, Chi-Sqr – value of χ^2 test, df –degrees of freedom, p – level of significance, Root1 – factor structure coefficients

From table 3 it can be seen that the canonical correlation analysis did not identify significant canonical pairs.

DISCUSSION

It is important to say that scientific explorations of biomotor status of elite female soccer players which have been using this set of soccer-specific motor variables are rare (Svensson & Drust, 2005). Various studies clearly indicate the relevance of anthropometric characteristics on the selection processes among soccer players (Gil, Gil, Ruiz, Irazusta & Irazusta, 2007; Russel, & Tooley, 2011). Based on a comparison of the obtained results (Table 1) with the results of similar scientific studies among female soccer players (Dowson, Cronin & Presland, 1999; Can et al., 2004; Jukić, Sporiš & Mihačić, 2007; Ingebrigtsen, Dillern & Shalfawi, 2011; Dillern, Ingebrigtsen & Shalfawi, 2012), it can be concluded that Croatian female soccer players' morphological characteristics do not deviate from standard values.

From table 3 it can clearly be seen that the canonical correlation between two sets of the studied variables is not significant (p=0,11). Furthermore, it has to be pointed that the significance level of the second canonical pair is high (p=0,49). Due to the fact that

variables used in this study represent four hypothetical latent dimensions of morphological status, these results clearly indicate that the conditionality of specific motor variables based on the dimensions of morphological status is weak, which is in accordance with previous studies (Polman et al., 2004). Additionally, the obtained results are similar to those of Mujika et al. (2008), who state that training and talent identification among post-adolescent soccer players of both sexes should focus on soccer-specific endurance and agility as fitness traits. Probably, late selection in female soccer is also one of the reasons for such results (Kirkendall, 2007). More precisely, fundamental movement skills obtained through different sports early on in sport careers or during childhood sport activities have a long term influence on motor abilities and their correlation with morphological status (Schmidt & Wrisberg, 2008). Also, as previous research shows, the lack of control in the players' nutrition and lifestyle habits are the probable reasons of such weak connections. More precisely, the first female league is semi-professional and players do not have strict rules regarding nutrition and behaviour. If we assume the existence of relations between effective conditioning and basic and soccer-specific motor status, maybe a lack of specialized and focused training principles are the reasons for such a weak connection (Polman et al., 2004). Same authors state that more research is required to establish the relationship between physical fitness and soccer performance, as well as the principles underlying the improvements seen through the implementation of focused training programs, for example the SAQ. Furthermore, research points to the fact that SAQ training principles appear to be effective in the physical conditioning of female soccer players, and that these principles can be implemented during whole team training sessions without the need for specialized SAQ equipment (Polman et al., 2004).

Consequently, the selection of female soccer players cannot be done through morphological status of female soccer players, but exclusively through the analysis of functional status and soccer-specific variables (Mujika et al., 2009).

CONCLUSION

The fact that scientific research on the relations between morphological and soccer-specific motor dimensions among first league female soccer players is relatively rare gives this research additional importance. Also, the obtained results provide clear insight into the fact that variables of morphological status cannot be used as predictors of the actual players' quality manifested through carefully selected soccer-specific variables. Additionally, the results are implicitly indicating the necessity of the early and systematic development of specific motor skills, independently for all age categories. Future research of this type should include a difference analysis in morphological characteristics, selected psychological variables, and basic and extended set of soccer-specific abilities according to carefully and precisely defined grouping variables.

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KANONIČKE RELACIJE IZMEĐU MORFOLOŠKOG STATUSA I SPORTSKO SPECIFIČNIH VARIJABLI KOD PRVOLIGAŠKIH FUDBALERKI

Cilj ovog rada bio je da se utvrdi i objasni morfološka uvetovanost specifične nogometne motorike prvoligaških seniorskih fudbalerki. U skladu s ciljem istraživanja, korišten je uzorak od 70 hrvatskih prvoligaških fudbalerki koje su merene u 18 morfoloških varijabli, te 7 prikladno odabranih testova specifične fudbalske motorike. Primenjena je kanonička korelaciona analiza. Suprotno očekivanom, rezultati ukazuju na činjenicu da varijable morfološkog statusa ne možemo sa sigurnošću uzeti kao prediktore (p=0.11) stvarne igračke kvalitete manifestirane putem precizno odabranih varijabli specifične fudbalske motorike. Posledično, selekcija fudbalerki se ne bi smela raditi temeljem morfološkog statusa već isključivo korištenjem funkcionalnog statusa te fudbalsko specifičnih varijabli. Obzirom na odabrani reprezentativni uzorak, pretpostavlja se da se rezultati mogu generalizovati na populaciju elitnih ženskih fudbalerki.

Ključne reči: *morfološke značajke, fudbalsko specifična motorika, prvoligaške fudbalerke, kanonička korelaciona analiza.*