MORPHOLOGICAL CHARACTERISTICS OF ELITE U23 SAILORS - FINN EUROPEAN CHAMPIONSHIP, SPLIT 2015

Luka Pezelj, Mladen Marinović and Boris Milavić

Faculty of Kinesiology, University of Split, Croatia

Original scientific paper

Abstract

The aim of this study is to determine morphological characteristics of U23 Finn sailors and to establish relations between their morphological characteristics and situational efficacy at the championship. Therefore, 18 elite U23 Finn sailors (mean age was 20.80±1.27) were measured in 16 morphological variables during the week before the Finn European Championship. It was established that U23 Finn sailors on average had: body height of 188.09±5.80 cm; 92.07±5.66 kg of body mass with 13.01±4.02% of fat mass; and body mass index of 26.06±1.76. Compared to Laser Standard sailors, U23 Finn sailors had higher values in all the aforementioned morphological characteristics. Independent samples T-test between two groups with different levels of situational efficacy (more successful group and less successful group of sailors) yielded statistically significant differences in two variables: body height and sitting height. Sailors from the more successful group were taller than sailors of the less successful group. Multivariate discriminate analysis yielded no statistically significant difference between these two groups. The results obtained indicate that morphological characteristics independently do not cause situational efficacy of U23 Finn sailors and that the reasons for success in Finn class could be partially attributed to better physical fitness of sailors. It is recommended to repeat the same measuring on a larger subject sample with additional monitoring of meteorological conditions in the sailing area.

Key words: *sailing, Finn class, morphological characteristics, U23 sailors, dinghy sailing*

Introduction

Sailing has been one of the Olympic sports since the first Summer Olympic Games in 1896. It has always been the leading sport regarding implementation of technical achievements, which is why it became known as the "sport of the rich". Enormous financial resources are being invested in technological development of sailing even today, with the ultimate goal of achieving the highest speed possible in comparison to the competition. To ensure the same competitive conditions for all competitors, and by doing so, to neutralize the negative effects of investing great material resources, "one-design" classes are being introduced. *International sailing federation (ISAF)* class rules (ISAF, 2013) clearly determine, among other things, the dimensions and materials of boat construction and equipment. Although there are over a 100 sailing classes registered in ISAF, sailing participates in the Olympic program with 8 (5 male), classes which allows athletes to choose a class which is most suitable for their anthropological characteristics. To achieve top results in sailing, the key is tactical intelligence and boat speed (Betrand, 1993), which in turn depends upon the optimal equipment set-up, sail trim, sailing technique and physiological fitness (Walls et al., 1998). Morphological anthropometric measuring represents a method of gathering data on human body structure based on which physical dimensions of functional-diagnostic abilities are determined and assessed (Marinovic and Antunovic, 2008). Knowledge on morphological characteristics of athletes can allow insight into the factors that have an important, and sometimes crucial effect on

characteristics of sports success (Blackburn, 1994). A sailing competition (regatta) takes place out on the open which implies that it is affected by numerous meteorological phenomena. Aside from a number of other meteorological factors, factors that have decisive effect on the structure of each race are sea state and wind speed, which directly determines the energy demand level of the race (Felici, 1999). Sailing competitions of the highest rank (the Olympic Games, world and continental championships) belong to the same competition format and last 6 days. Qualifications last 5 days, during which 9 races are planned, after which the first 10 sailors participate in the Medal race. In ideal circumstances, two races are sailed each day, but it is not uncommon that there are no races at all due to the lack of wind one day, and 3 races are sailed at very high sea the next day. "Non-standardization" of competition is exactly what makes sailing so interesting and unpredictable result-wise, but on the other hand, very thankless for scientific research in competitive conditions. Herein most likely lies the cause of an extremely small number of scientific research conducted on a sample of top sailors in competitive conditions. To the authors' best knowledge, morphological profile of top sailors in any of the Olympic classes has not yet been determined.

Methods

This study included all Finn sailors under the age of 23 years (N=18) who participated in the Finn European Championship (FEC) which took place in

Split, in May 2015. Finn European Championship (FEC) is the second most important competition in the sailing season, right after the World Championship. The format of the competition is open type so it includes sailors from all over the world. Besides the overall placement at the Finn European Championship (FEC), the placement of U23 sailors is determined in parallel, separately. U23 sailors compete within the same sail fleet with all other participants of the European Championship. This European Championship included almost all previously top-ranked U23 sailors, who were all then included in this study. Mean chronological age of the subjects was 20.80±1.27 years. The study was approved by the Ethical Board of the Faculty of Kinesiology in Split and conducted with the support of the Executive Committee of the International Finn Association (IFA). The variable set measuring morphological characteristics included 16 morphological measures which are well known in scientific literature: Body height – HEBOD; Sitting height – HESIT; Leg length – LL; Knee diameter – KDIA; Elbow diameter – EDIA; Total body mass – TBM; Fat mass – FATM; Fat mass percentage – FATM%; Muscle mass – MM; Body Mass Index – BMI; the Sum of 4 skin folds (triceps, back, abdominal and calf) – SUMSF; Mid-upper arm circumference – MUACIR; Forearm circumference – FACIR; Calf circumference – CCIR;

Shoulder width – SWID; Hip width – HWID. Measurements of morphological characteristics were done according to the ISAK protocol (Stewart et al., 2011). Three measures of body mass (FATM, FATM% and MM) represent the algorithm calculation obtained by using the Body Composition Analyzer type MC-980MA, made by TANITA Europe B.V., Amsterdam, Netherlands. The variable of situational efficacy of U23 sailors is represented by their final result placement at the European Championship, expressed in points on the Low Point System (ISAF, 2016). The group of more successful U23 sailors included those sailors who were ranked in the first 35 places, which represents a point marking approximately the half of the total number of competitors at the FEC. The group of less successful U23 sailors included those sailors who were ranked below the 35th place in the overall FEC placement. The measurements of the sailors were taken in the morning time during the week before the FEC, and prior to their first training. Methods of data analysis included calculation of basic and additional descriptive statistical indicators and determination of measures of sensitivity of result distribution (Skewness and Kurtosis coefficients; Kolmogorov-Smirnov test). Differences between more and less successful sailors were determined by Student's t-test for independent samples and discriminate analysis.

Results and discussion

Table 1. Descriptive statistics of morphological characteristics of U23 Finn sailors (N=18)

VARIABLE	M	SD	COEF. VAR.	D * (K-S)	MIN	MAX	SKEW	KURT
HEBOD	188.09	5.80	3.09	0.16	176.10	198.40	-0.05	0.11
HESIT	98.77	3.23	3.27	0.14	91.50	103.40	-0.33	-0.11
LL	89.32	3.71	4.16	0.14	81.70	96.00	-0.17	-0.41
KDIA	10.05	0.64	6.36	0.12	8.75	11.30	0.33	0.58
EDIA	7.20	0.48	6.61	0.11	6.35	8.15	0.01	-0.46
TBM	92.07	5.66	6.14	0.17	76.30	99.00	-1.45	2.38
FATM	12.04	4.01	33.35	0.10	5.70	19.20	0.16	-0.64
FATM%	13.01	4.02	30.87	0.10	6.50	19.80	-0.05	-0.58
BMI	26.06	1.76	6.77	0.13	23.17	30.25	0.70	0.79
MM	76.36	5.16	6.76	0.15	64.10	85.40	-0.41	0.83
SUMSF	56.68	17.08	30.13	0.12	33.70	98.95	0.69	0.56
MUACIR	37.48	2.35	6.27	0.11	32.05	41.25	-0.25	0.36
FACIR	30.63	1.12	3.64	0.16	29.20	32.90	0.49	-0.62
CCIR	40.32	3.46	8.58	0.24	28.20	43.50	-2.68	9.22
SWIT	42.65	1.78	4.18	0.11	39.40	45.20	-0.22	-0.88
HWIT	29.06	2.81	9.67	0.17	20.60	32.60	-1.64	3.90

Legend: M – arithmetic mean; SD – standard deviation; COEF.VAR. – coefficient of variance; D* (K-S) – coefficient of the Kolmogorov-Smirnov test; MIN – minimum result; MAX – maximum result; SKEW – measure of distribution asymmetry; KURT – measure of distribution shape.

The results of descriptive statistics of morphological variables of U23 Finn sailors (N=18) are presented in Table 1. The analysis of distribution parameters shows that all the variables used do not deviate significantly from normal distribution values and are suitable for further parametric statistical analysis. U23 Finn sailors on average had: *body height* of 188.09±5.80 cm; 92.07±5.66 kg of *body mass* with 13.01±4.02% of *fat mass*; and *body mass index* of 26.06±1.76. The features of morphological characteristics of U23 Finn sailors

presented in Table 1 can be compared to the findings of other authors. In comparison, sailors of national ranking in the Olympic Laser Standard class (N=8) and of approximately the same chronological age (22±4 years) have body height of 178±0.06 cm, body mass of 79±3 kg and body fat percentage of 10.5±4.1 (Vangelakoudi et al., 2007). Almost the same results were found in sailors of the same class in the study conducted by De Vito et al. (1996). The sailors were of national ranking (N=8), aged 23.2±3.1 years, with body

height of 181±3 cm, body mass of 78.1±6.1kg, body fat percentage of 13.4±2.0 and Body mass index of 23.8±1.5. Noticeable differences in morphological characteristics of sailors in these two Olympic classes were expected. The Finn class, in relation to the Laser Standard class, among other things, has almost 30% larger sail size, which requires more energy and ballast weight for efficient steerage of the boat (Mackie and Legg, 1999). Higher values in all the aforementioned morphological characteristics that were recorded in

the Finn sailors in comparison to the Laser Standard sailors can be explained exactly by these technical differences between the two classes. By comparing basic morphological characteristics of U23 Finn sailors and their peers who compete in rowing at international level (N=79), aged 23.65±2.82 years, whose body height is 190.84±4.8 cm and body mass is 89.6±6.27 kg (Marinovic, 2011), we can conclude that U23 Finn sailors are morphologically more similar to elite rowers than sailors in the Laser Standard class.

Table 2. Differences in results of morphological characteristics of more successful and less successful groups of sailors

VARIABLE	MORE SUCCESSFUL (N - 7)		LESS SUCCESSFUL (N - 11)		t-value	p=
	M	SD	M	SD		
HEBOD	191.73	5.01	185.77	5.20	2.40*	0.03
HESIT	100.67	2.59	97.55	3.09	2.21*	0.04
LL	91.06	3.79	88.22	3.38	1.66	0.12
KDIA	9.79	0.37	10.21	0.73	-1.38	0.19
EDIA	7.04	0.32	7.30	0.54	-1.18	0.25
TBM	93.87	3.04	90.93	6.72	1.08	0.30
FATM	10.97	4.24	12.72	3.91	-0.89	0.38
FATM%	11.61	4.33	13.90	3.73	-1.19	0.25
BMI	25.57	1.38	26.36	1.97	-0.92	0.37
MM	79.09	3.51	74.63	5.42	1.92	0.07
SUMSF	49.08	15.38	61.52	16.96	-1.57	0.14
MUACIR	37.84	2.45	37.26	2.38	0.50	0.63
FACIR	30.49	0.86	30.72	1.28	-0.43	0.67
CCIR	38.82	4.89	41.27	1.86	-1.52	0.15
SWIT	43.33	1.16	42.22	2.02	1.32	0.21
HWIT	28.77	3.88	29.25	2.07	-0.34	0.74

Legend: M – arithmetic mean; SD – standard deviation; t-value – coefficient of t-test; p= – statistical significance level of t-test; * – statistically significant difference at the level of p<.05.

Means and standard deviations of morphological characteristics of more successful (N=7) and less successful (N=11) U23 sailors, grouped according to the criterion of overall placement at the European Championship, are presented in Table 2.

By analyzing the results, it is clear that more successful U23 sailors have higher mean values in the following variables of longitudinal dimensionality of the skeleton: body height, sitting height, leg length and shoulder width. Moreover, body height and sitting height are the only morphological parameters that significantly differentiate these two groups of sailors.

Body height together with body mass has positive contribution to maintaining the boat in optimal position as it enables the sailor to use greater lever arm in hiking during close-hauled sailing. In spite of their lower values of body height and mass as compared to the more successful sailors, the less successful sailors have somewhat higher mean values in variables of transverse dimensionality of the skeleton: knee diameter, elbow diameter and hip width, but the differences do not reach the level of statistical significance. Moreover, there are no significant differences in parameters of body voluminosity and structure, but certain tendencies of differences between more and less successful

sailors are noticeable. Namely, more successful sailors have averagely 4.5 kg more muscle mass than less successful (p=.07), whereas their mid-upper arm and forearm circumferences are very similar.

Furthermore, by measuring skin folds it was determined that more successful sailors have averagely lower values of subcutaneous fat tissue than less successful sailors, which is also confirmed by lower values of body fat percentage measured by bioimpedance.

Considering that body mass index has high correlation with body fat (Krebs et al., 2007), higher mean results found in less successful sailors in these morphological characteristics variables were expected. It has been known for a long time in scientific literature that certain morphological characteristics of athletes are significantly correlated.

Thus, with the aim of precise multivariate determination of possible differences between more successful and less successful U23 sailors at the Championship, a "reduction" of the morphological characteristics set was done and discriminate analysis of the two groups of U23 sailors was conducted, which is presented in Table 3.

Table 3. Discriminate analysis of groups of U23 Finn sailors with different index of situational efficacy at the Championship

DF 1	λ	Rc	Wilks' lambda	χ^2	SS	p=
	0.90	0.69	0.53	7.72	8	0.46
VARIABLE	**Structure matrix**					
	DF 1					
HEBOD	-0.63					
HESIT	-0.58					
KDIA	0.36					
FATM	0.24					
MM	-0.51					
SUMSF	0.41					
MUACIR	-0.13					
CCIR	0.40					
SITUATIONAL EFFICACY IN EUROPEAN CHAMPIONSHIP	**Group centroids**					
	DF 1					
MORE SUCCESSFUL GROUP	-1.12					
LESS SUCCESSFUL GROUP	0.71					

Legend: λ – eigenvalue of discriminate function; Rc – coefficient of canonical correlation; Wilks' lambda –Wilks' Lambda coefficient (Wλ) of discriminate function; χ^2 – significance test of discriminate function – χ^2 test; *** – level of significance DF at p<.001; SS – degrees of freedom: p= – level of statistical significance DF (of χ^2 -test).

By performing multivariate discriminate analysis on the groups of more and less successful sailors, the existence of statistically significant discriminate function was not determined. These findings are not completely congruent with the findings determined on manifest morphological measures. However, there are noticeable tendencies that the group of more successful sailors is characterized by more prominent characteristics of body height and muscle mass, and the group of less successful sailors is characterized by more prominent characteristics of voluminosity: the sum of skin folds, calf circumference, knee diameter and fat mass. Considering the differences in the findings obtained by univariate and multivariate analysis in this study, with the aim of precise determination of relations between sailors' morphological characteristics and situation-related efficiency, it is recommended to repeat the study with a much larger number of subjects, i.e., U23 sailors. Moreover, it is possible that this arbitrary, artificial classification into two groups of more successful and less successful U23 sailors based on their overall, final placement at the FEC, is not completely suitable for precise determination of the aimed relations. Namely, at this Championship, 9 regattas (races) were sailed in very different meteorological conditions and with different wind speed in the sailing area. Thus, it is recommended for future studies to determine the relations between morphological characteristics of sailors and situation-related efficacy achieved only in regattas in certain meteorological and sailing conditions (e.g., with certain wind speed "power" or in regattas which allow the use of the "free pumping" technique.).

Conclusion

Definition of morphological characteristics of U23 Finn sailors is of great importance for future selection and orientation of young sailors, considering that there have been no scientific studies that used such a sample. The subject sample of this study has very high value because all U23 sailors that were included in the study participated in the U23 Finn World Championship right after the FEC in Split, and among the competition of 30 U23 sailors, won the first 4 places, and 12 of them were ranked among the first 15 in the final placement (TOP 15).

In "only" two morphological parameters (body height and sitting height), univariate significant differences were determined between more successful and less successful U23 sailors, and multivariate discriminate analysis showed no significant difference.

However, noticeable tendencies of differences in the prominence of morphological characteristics exist both in body muscle mass and the sum of skin folds. Considering that by physical exercise and adequate diet one can reduce body fat and increase muscle mass (Hall et al., 2006), the reasons for success in Finn class could be partially attributed to better physical fitness of sailors. Given the importance of determination of morphological characteristics of sailors for selection and orientation, it is recommended to repeat the same measuring on a larger subject sample with additional monitoring and "control" of meteorological conditions in the sailing area.

References

Bertrand, L. (1993). *Australian Yachting Federation elite training program - sports science quadrennial plan 1993-1996*. Australian Yachting Federation, Bloomsbury Publishing: Sydney

Blackburn, M. (1994). Physiological responses to 90 min of simulated dinghy sailing. *Journal of Sports Sciences, 12*(4), 383-390.

De Vito, G., Di Filippo, L., Felici, F., Gallozzi, C., Madaffari, A., Marino, S., & Rodio, A. (1996). Assessment of energetic cost in Laser and Mistral sailors. *International Journal of Sports Cardiology, 5*(2), 55-59.

Felici, F., Rodio, A., Madaffari, A., Ercolani, L., & Marchetti, M. (1999). The cardiovascular work of competitive dinghy sailing. *Journal of Sports Medicine and Physical Fitness, 39*(4), 309-314.

Hall, D.M.B., & Colle, T.J. (2006). What use is the BMI? *Archives of Disease in Childhood, 91*, 286-293.

Krebs, N.F., Himes, H., Jacobson, D., Nicklas, T.A., Guilday, P., & Styne, D. (2007). Assessment of Child and Adolescent Overweight and Obesity. *Pediatrics, 120*(Suppl 4), 193-228.

Mackie, H.W., & Legg, S.J. (1999). Preliminary assessment of force demands in laser racing. *Journal of Science and Medicine in Sport 2*(1), 78-85.

Marinovic, M. (2011*). Korelacija između respiratornih, energetskih i metaboličkih pokazatelja s fizičkom učinkovitošću veslača na ergometru* [Correlation between respiratory, energetic, and metabolical indicators with the physical efficiency of the rowers on a rowing ergometer. In Croatian.]. (Doctoral dissertation), Split, University of Split

Marinovic, M., & Antunovic, T. (2008). Morfološke karakteristike utrke jedriličara [Morphological characteristics of match race sailors. In Croatian.]. In B. Males, D. Miletic, M. Kondric & M. Kvesic (Eds.), *Proceedings of the 3rd International Conference „Contemporary Kinesiology"* (pp. 163-167)*,* Split, Faculty of Science; Mostar, Faculty of Sport; Ljubljana, Faculty of Sport

Stewart, A., Marfell-Jones, M., Olds, T., & De Ridder, H. (2011). *International standards for anthropometric assessment (ISAK),* Moonshine Press, Lower Hutt

International Sailing Federation. (2013). *Racing Rules of Sailing 2013-2016*. Retrieved from http://www.sailing.org/tools/documents/ISAFRRS20132016Final-[13376].pdf

Vangelakoudi, A., Vogiatzis, I., & Geladas, N. (2007). Anaerobic capacity, isometric endurance and Laser sailing performance. *Journal of Sports Sciences, 25*(10), 1095-1100.

Walls, J.T., Bertrand, L., Gale, T.J. & Saunders, N.R. (1998). Assessment of Upwind Dinghy Sailing Performance using a Virtual Reality Dinghy Sailing Simulator. *Journal of Science and Medicine in Sport, 1*(2), 61-71.

MORFOLOŠKE KARAKTERISTIKE ELITNIH U23 JEDRILIČARA - FINN EUROPSKO PRVENSTVO, SPLIT 2015

Sažetak

Cilj ovog istraživanja je odrediti morfološke karakteristike U23 Finn jedriličara i utvrditi odnos između njihovih morfoloških karakteristika i situacijske uspješnosti na prvenstvu. Stoga, 18 elitnih U23 Finn jedriličara (srednji uzrast bio je 20.80+1.27) mjereno je u 16 morfoloških varijabli tijekom tjedna prije Europskog prvenstva u klasi Finn. Utvrđeno je da su U23 Finn jedriličari u prosjeku imali: tjelesnu visinu od 188.09+5.80 cm; 92.07+5.66 kg tjelesne mase sa 13.01+4.02% masnog tkiva i indeks tjelesne mase od 26.06+1.76. U usporedbi sa Laser Standard jedriličarima, U23 Finn jedriličari imali su više vrijednosti u svim prethodno spomenutim morfoloških karakteristikama. Nezavisni uzorci T-testa između dvije grupe s različitim razinama situacijske učinkovitosti (uspješnija skupina i manje uspješnija skupina jedriličara) doprinijeli su statistički značajne razlike kod dviju varijabli: tjelesna visina i sjedeća visina. Multivarijantna diskriminacijska analiza nije doprinijela statistički značajne razlike između ove dvije grupe. Dobiveni rezultati pokazuju da morfološke karakteristike samostalno ne uzrokuju situacijsku učinkovitost U23 Finn jedriličara i to je razlog iz kojeg bi uspjeh u Finn klasi mogao biti djelomično pripisan boljem tjelesnom fitnesu jedriličara. Preporučeno se ponavljati isto mjerenje na većem predmetnom uzorku s dodatnim nadziranjem uvjeta u prostoru za jedrenje.

Ključne riječi: *jedrenje, Finn klasa, morfološke karakteristike, U23 jedriličari, jedrenje malim člancima*