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Original empirical article

DESCRIPTIVE, FUNCTIONAL AND SEXUAL DIMORPHISM OF EXSPLOSIVE ISOMETRIC HAND GRIP FORCE IN HEALTHY UNIVERSITY STUDENTS IN SERBIA

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Abstract. *The aim of this work is to define basic descriptive model characteristics considering descriptive, functional and sexual dimorphism of basic explosive isometric hand grip force characteristics in healthy and well-trained students of the Academy for Criminalistic and Police studies (ACPS) in the Republic of Serbia. For the purpose of this research, 239 examinees were tested, among whom 143 were men and 96 were women, aged 18 to 24. In order to assess the RFDBASICHG different contractile characteristics we used standardized equipment, i.e., a sliding device that measures isometric finger flexor force, with a tensiometric probe fixed inside the device. Our results showed that the tested male sample had a significantly greater explosive hand grip force in both hands (dominant and non-dominant) than the tested female sample, with regard to both absolute and relative indicators. A statistically significant difference was established for the whole measurement range (the total of variable samples in the function of gender) between men and women, as parameters of sexual dimorphism, at the level of Wilks' Lambda – 0.519, F = 30.567, p = 0.000. In the function of gender, statistically significant functional dimorphism was found in women, i.e., the dominant hand was found to be stronger than the non-dominant one with a statistical significance of t = 2.389, p = 0.019. Considering the defined model parameters for the population of the given age, the results obtained can be used as criterion values for various testing purposes, such as the assessment of explosive hand grip force in athletes and non-athletes of both genders, or the evaluation of gender-related and functional dimorphism of the same.*

Key words: *isometric explosive force, hand grip, dimorphism, student population*

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INTRODUCTION

Hand-grip force characteristics, which can be measured easily and objectively using a dynamometer, is a prediction of multiple outcomes among a variety of subjects. The hand is the basic manipulative organ of the human body, and hand grip force, as a limiting factor, participates in all the manipulative activities realized by the cranial part of the body (Tyldesley et al., 1996). One of the most important pieces of data on contractile capacity is data on the isometric characteristics of the force-time curve model – the values of the force developed in the function of time. The realized force at the level of 100% presents an indicator of the development capacity of the contractile potential at the level of maximal muscle contraction ($F_{max}HG_{iso}$), and in the case of the gradient, it presents an indicator of development capacity of the basic hand grip explosive force. Therefore, the research on contractile characteristics of hand grip muscles is wide-spread, considering the fact that the hand grip force (and the muscles involved in the grip) is positively related to other muscle groups, including the legs; the hand grip force also presents an indicator for valid evaluation of the overall body strength (Bohannon, 2001). Many authors were involved in the research that included maximum isometric muscle force and its dimensions (Hakkinen, 1991; MacDougall et al., 1991; Pryor et al., 1994; Haff et al., 1997; Müller et al., 2000). The aim of these diverse studies was to define basic model characteristics considering descriptive, functional and sexual dimorphism at maximal isometric hand grip force in well-trained athletes for the analytic and diagnostic purposes (Dopsaj et al., 2007; Giles et al., 2006, Guidetti et al., 2002; Leyk et al., 2007; Tan et al., 2001; Ivanović et al., 2009). However, only a few studies have been done in order to define basic descriptive model characteristics considering descriptive, functional and sexual dimorphism at basic explosive isometric hand grip force, especially for the purpose of the sport training (Dopsaj et al., 2009).

The aim of this work is to define basic descriptive model characteristics from the point of view of functional and sexual dimorphism at maximal isometric explosive hand grip force in the healthy and well-trained student population in the Republic of Serbia. The given model will be defined in relation to the absolute and relative values of the explosive force, while the results obtained will be useful for analytic and diagnostic purposes in a wide range of applications: while assessing physical ability; in sport and training with regard to the control and definition of appraising the status, distinct trends or tendencies in changes to physical abilities in diverse populations; in the process of selection; etc.

METHODS

Samples

For the purpose of this research, 239 examinees were tested, comprising 143 men (BH = 181.64 ±5.66 cm, BW = 79.00±9.60kg, BMI = 23.92 ± 2.44), and 96 women (BH = 169.57±4.10 cm, BW = 62.50±7.01kg, BMI = 21.71±2.08). The examinees were the students of the Academy for Police and Criminalistic Studies in Belgrade, who enrolled at their studies between 2003 and 2006. All of the examinees had been accepted after the standard selection procedure of testing health status and physical abilities and they all came from different parts of Serbia. The selection procedure allowed us to treat the examinees as a representative sample of the student population, that is, young and healthy individuals from Serbia, aged 18 to 24. All of the tests were performed in the Laboratory for assessing the basic motor status as part of the subject of Special Physical Education at the Academy for Police and Criminalistic Studies in Belgrade.

TESTING PROCEDURE

Testing procedure

The testing procedure was conducted under the professional and ethical standards and recommendations defined by the American College of Sports Medicine (2006). In order to assess the maximal isometric hand grip explosive force characteristics ($RFD_{BASIC}HG$) we used standardized equipment and testing procedures described and published recently (Demura et al., 2003; Dopsaj et al., 2007; Dopsaj et al., 2009; Ivanović et al., 2009).

Variables

The measurement range was defined by using the following variables:

- $RFD_{BASIC}HG$ - Basic isometric explosive hand grip force (for both hands, the left – $RFD_{BASIC}LHG$ and the right – $RFD_{BASIC}RHG$) representation was done by applying the following procedure (Mirkov et al., 2004; Zatsiorsky at al., 2006):

$$RFD_{BASIC}HG = (F_{max}HG / tF_{max}HG) \cdot 1000$$

Where: $F_{max}HG$ represents the maximal value of isometric hand grip force achieved, and $tF_{max}HG$ represents the time in ms necessary to reach it, expressed in N/s.

- RFDRELHG - relative value of RFDBASICHG (for both hands, the left – RFDRELLHG and the right – RFDRELRHG) classic partialization was done by applying the following procedure (Vanderburgh at al., 1995; Jarić, 2002; Zatsiorsky et al., 2006):

$$RFD_{REL}HG = RFD_{BASIC}HG / BM$$

Where: $RFD_{REL}HG$ are the relative value of basic isometric hand grip force after classic partialization, in index number (N^{-s}/BM); $RFD_{BASIC}HG$ is the Basic isometric explosive hand grip force, in N/s; BM is body mass, in kg.

- RFDALLOMHG - allometric value of RFDBASICHG (for both hands, the left – RFDALLOMLHG and the right – RFDALLOMRHG) allometric partialization was done by applying the following procedure:

$$RFD_{ALLOM}HG = RFD_{BASIC}HG / BM^{0.667}$$

Where: $RFD_{ALLOM}HG$ are the allometric values of the basic isometric hand grip force after allometric partialization, in index numbers ($N^{-s}/BM^{0.667}$); $RFD_{BASIC}HG$ is the basic isometric explosive hand grip force, in N/s; BM is body mass, in kg.

- RFDNd/DoHG - Functional dimorphism as a functional relationship between basic isometric explosive hand grip force of the dominant and non-dominant hand was done by applying the following procedure (Dopsaj et al., 2007; Ivanović et al., 2009):

$$RFDNd/DoHG = RFD_{BASIC}LHG / RFD_{BASIC}RHG$$

Where: $RFD_{BASIC}LHG$ represents the maximal value of the basic isometric explosive left hand grip force achieved, $RFD_{BASIC}RHG$ represents the value of the basic isometric explosive right hand grip force achieved, expressed in index values.

STATISTICAL ANALYSIS

Statistical methods used in this procedure were the descriptive statistical method, Student's statistic, as well as the multivariate statistical method (Hair et al., 1998). All statistic analyses were done by the application of software package SPSS for Windows, Release 11.5.0 (Copyright © SPSS Inc., 1989-2002).

RESULTS

The results of the descriptive statistics are shown in Table 1.

Table 1. Basic descriptive statistics

	RFD_{BASIC} LHG (N/s)	RFD_{ALLOM} LHG ($N^{-s}/BM^{0.667}$)	RFD_{REL} LHG (N^{-s} /BM)	RFDNd/ DoHG (Index values)	RFD_{BASIC} RHG (N/s)	RFD_{ALLOM} RHG ($N^{-s}/BM^{0.667}$)	RFD_{REL} RHG (N^{-s} /BM)
MALEs (N = 143)							
MEAN	694.03	37.88	0.9064	0.9865	726.99	39.67	0.9487
SD	413.81	22.72	0.5478	0.6089	589.96	31.86	0.7600
Cv%	59.62	59.97	60.44	61.72	81.15	80.32	80.11
Min	144.40	7.06	0.1597	0.0967	210.83	9.63	0.2076
Max	2458.71	139.73	3.4042	3.2687	5214.75	273.44	6.3990
FEMALEs (N = 96)							
MEAN	362.85	23.06	0.5950	0.8360	440.90	28.15	0.7281
SD	218.82	14.10	0.3683	0.4963	255.37	16.48	0.4302
Cv%	60.31	61.17	61.90	59.37	57.92	58.53	59.08
Min	45.17	3.12	0.0836	0.0652	83.04	5.73	0.1537
Max	1270.08	82.53	2.1496	2.9851	1424.66	90.82	2.3431

The average values of the basic explosive isometric hand grip force ($RFD_{BASIC}HG$) for the men were 694.03±413.81 and 726.99±589.96 N/s, while the values for the women were 362.85±218.82 and 440.90±255.37 N/s, for the left and the right hand. Functional dimorphism (RFDNd/DoHG) – a functional relationship between basic isometric explosive hand grip force of the dominant and non-dominant hand was at the level of 0.9865±0.6089 for the men and 0.8360±0.4963 for the women. Partialized values of the measured muscle force by the allometric method for the men were 37.88±22.72 and 39.67±31.86 $N^{-s}/BM^{0.667}$, while the values for the women were 23.06±14.10 and 28.15±16.48 $N^{-s}/BM^{0.667}$ for the left and the right hand. The classic method yielded 0.9064±0.5478 and 0.9487±0.7600 N^{-s}/BM for the men, and for the women the values were 0.5950±0.3683 and 0.7281±0.4302 N^{-s}/BM for the left and the right hand (Table 1).

A statistically significant difference was established for the whole measurement range (the total of variable samples in the function of gender) between men and women at the level of Wilks' Lambda 0.519, F=30.567, p=0.000. In relation to the $RFD_{BASIC}HG$, the results did not indicate functional dimorphism in men between the dominant and non-dominant hand at a statistically significant level in each of the observed variables (Table 2). For the sample tested and for the test applied, the functional dimorphism for the men was established at the index level of 0.9865. In other words, the maximal explosive hand grip force of the non-dominant hand was at the level of 98.65 % of the maximal explosive hand grip force of the dominant hand (Table 1).

The parameters that determine the functional dimorphism in women showed a statistically significant difference in the value of $RFD_{BASIC}HG$ were established between the dominant and non-dominant hand at the value of t values – 2.389, p = 0.019. Such a difference was also shown in the partialized values both by the allometric method at the t values – 2.441, p = 0.016, and by the classic method where the t values were – 2.463, p = 0.016, in favor of the dominant hand (Table 2). The results also indicated that for the sample tested and the test applied the functional dimorphism for the women was at the

index level of 0.8360. This means that the maximal explosive hand grip force of the non-dominant hand was at the level of 83.60 % of the maximal explosive hand grip force of the dominant hand (Table 1).

Table 2. Statistically significant level of functional dimorphism

Statistically Significant Level Of Functional Dimorphism			
MALEs (N = 143)			
Variables	Paired Mean Differences	t- values	Sig. (2-tailed)
$RFD_{BASIC}LHG$ - $RFD_{BASIC}RHG$	-32.96027	-.613	.541
$RFD_{ALLOM}LHG$ - $RFD_{ALLOM}RHG$	-1.78144	-.619	.537
$RFD_{REL}LHG$ - $RFD_{REL}RHG$	-.0423558	-.622	.535
FEMALEs (N = 96)			
$RFD_{BASIC}LHG$ - $RFD_{BASIC}RHG$	-68.96452	-2.389	.019*
$RFD_{ALLOM}LHG$ - $RFD_{ALLOM}RHG$	-4.53439	-2.441	.016*
$RFD_{REL}LHG$ - $RFD_{REL}RHG$	-.1189288	-2.463	.016*

As for the parameters that determine the level of sexual dimorphism, the results showed that in the case of the men there was statistical significance in the level of the force applied in all the tested variables, as follows: $RFD_{BASIC}LHG_{Males}$ vs $RFD_{BASIC}LHG_{Females}$ – F values 51.730, p = 0.000; $RFD_{BASIC}RHG_{Males}$ vs $RFD_{BASIC}RHG_{Females}$ – F values 21.514, p = 0.000; $RFD_{ALLOM}LHG_{Males}$ vs $RFD_{ALLOM}LHG_{Females}$ – F values 32.466, p = 0.000; $RFD_{ALLOM}RHG_{Males}$ vs $RFD_{ALLOM}RHG_{Females}$ – F values 11.799, p = 0.001; $RFD_{REL}LHG_{Males}$ vs $RFD_{REL}LHG_{Females}$ – F values 23.778, p = 0.000; $RFD_{REL}RHG_{Males}$ vs $RFD_{REL}RHG_{Females}$ – F values 7.616, p = 0.006; $RFDNd/DoHG_{Males}$ vs $RFDNd/DoHG_{Females}$ – F values 4.054, p = 0.045.

Regarding sexual dimorphism, the coefficient showing the relationship between Female/Male at $RFD_{BASIC}LHG$ was 0.5228, at $RFD_{BASIC}RHG$ was 0.5940, at $RFD_{ALLOM}LHG$ was 0.6086, at $RFD_{ALLOM}RHG$ was 0.6956, at $RFD_{REL}LHG$ was 0.6564, at $RFD_{REL}RHG$ was 0.7525, whereas at RFDNd/DoHG it was 0.8474 (Figure 1).

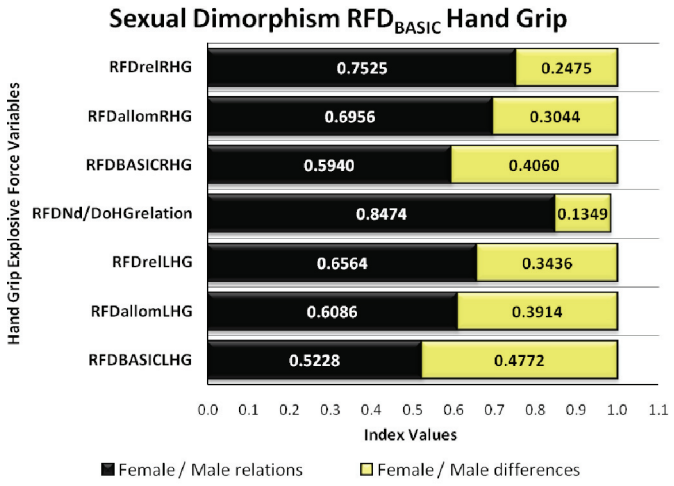

Fig. 1. Sexual dimorphism in $RFD_{BASIC}HG$ contractile characteristics of the hand grip

Table 3 presents the defined population model indicators, where the observed values of explosive hand grip force are shown in the function of percentile distribution indicators for the male population, whereas Table 4 shows the same indicators for the female population. Figures 2 to 8 present the percentile distribution of the obtained variables for the Females/Males.

Table 3. Percentile distribution – descriptive isometric contractile characteristics of hand grip parameters for males

MALEs (N = 143)							
Percentiles ‰	RFD_{BASIC} LHG (N/s)	RFD_{ALLOM} LHG ($N^{-s}/BM^{0.667}$)	RFD_{REL} LHG (N^{-s}/BM^{7})	RFDNd/ DoHG (Index values)	RFD_{BASIC} RHG (N/s)	RFD_{ALLOM} RHG ($N^{-s}/BM^{0.667}$)	RFD_{REL} RHG (N^{-s}/BM)
1	144.93	7.38	0.1703	0.1288	213.46	10.48	0.2384
5	262.83	14.04	0.3304	0.2694	273.77	14.43	0.3422
10	300.41	16.08	0.3830	0.3851	323.27	16.43	0.3949
15	337.18	18.59	0.4370	0.4713	354.63	19.85	0.4698
20	364.58	20.65	0.4833	0.5392	390.48	21.58	0.5066
25	408.41	22.16	0.5275	0.5933	432.95	23.44	0.5509
30	441.58	23.90	0.5758	0.6573	449.60	24.54	0.5924
35	467.58	26.08	0.6229	0.7146	486.56	25.55	0.6240
40	511.63	28.28	0.6800	0.7355	509.39	27.89	0.6597
45	553.94	30.20	0.7232	0.7803	543.04	29.35	0.6997
50	595.32	32.35	0.7604	0.8282	564.72	31.65	0.7747
55	622.85	35.16	0.8225	0.8803	603.94	33.91	0.8131
60	695.07	37.05	0.9070	0.9467	664.21	35.97	0.8696
65	752.25	39.48	0.9306	0.9966	694.04	39.02	0.9531
70	773.48	42.35	1.0043	1.0750	782.63	41.78	1.0036
75	849.49	45.01	1.1141	1.1684	848.49	45.06	1.0571
80	950.08	53.25	1.2847	1.2940	901.72	53.16	1.2332
85	1017.63	56.70	1.3857	1.4884	1033.37	56.07	1.3225
90	1255.40	69.02	1.6265	1.9482	1250.98	64.29	1.5341
95	1536.48	83.23	1.9417	2.4832	1637.87	90.79	2.1045
100	2458.71	139.73	3.4042	3.2687	5214.75	273.44	6.3990

Table 4. Percentile distribution – descriptive isometric contractile characteristics of hand grip parameters for females

FEMALEs (N = 96)							
Percen-tiles ‰	RFD_{BASIC} LHG (N/s)	RFD_{ALLOM} LHG ($N^{-s}/BM^{0.667}$)	RFD_{REL} LHG (N^{-s}/BM)	RFDNd/ DoHG (Index values)	RFD_{BASIC} RHG (N/s)	RFD_{ALLOM} RHG ($N^{-s}/BM^{0.667}$)	RFD_{REL} RHG (N^{-s}/BM)
1	45.17	3.11	0.08359	0.06519	83.0432	5.7274	0.1537
5	97.68	5.82	0.1450	0.2753	151.87	9.60	0.2753
10	150.58	9.81	0.2611	0.3957	181.57	11.87	0.3957
15	169.86	11.70	0.2989	0.4483	216.83	13.78	0.4483
20	184.36	12.68	0.3361	0.4750	244.20	15.68	0.4750
25	215.39	13.41	0.3462	0.5207	260.38	16.68	0.5207
30	239.89	14.96	0.3682	0.5515	276.36	17.49	0.5446
35	252.58	15.85	0.4033	0.6157	309.63	18.29	0.5810
40	258.22	16.63	0.4283	0.6698	312.39	19.40	0.6615
45	284.47	18.11	0.4617	0.7055	317.30	20.39	0.7030
50	312.42	18.90	0.4828	0.7395	345.27	21.97	0.7320
55	326.09	19.70	0.5045	0.7770	403.00	25.60	0.7631
60	346.69	21.40	0.5432	0.8164	425.94	26.85	0.8116
65	386.90	25.11	0.6436	0.8831	473.45	29.29	0.8767
70	428.63	27.97	0.7210	0.9559	503.12	32.72	0.9521
75	458.76	30.12	0.7910	1.0320	568.93	37.37	1.0113
80	532.80	33.83	0.8519	1.1508	638.83	39.45	1.1222
85	591.85	36.56	0.9511	1.2319	692.50	44.77	1.2124
90	635.42	38.67	1.0074	1.6144	745.04	49.01	1.5154
95	810.65	55.28	1.4750	1.9428	893.47	58.88	1.8349
100	1270.08	82.53	2.1496	2.9851	1424.66	90.82	2.3431

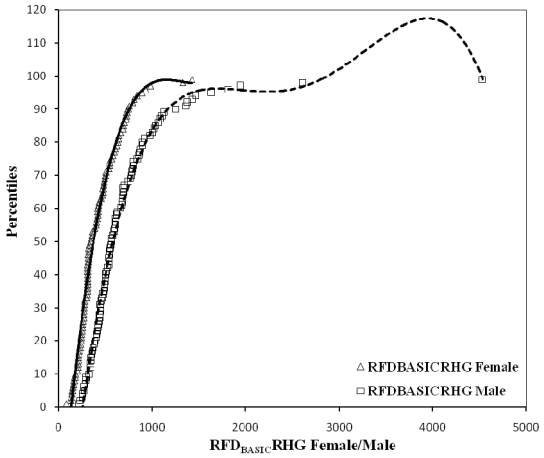

Fig. 2. Percentile distribution of the variable RFDBASICRHG Females/Males.

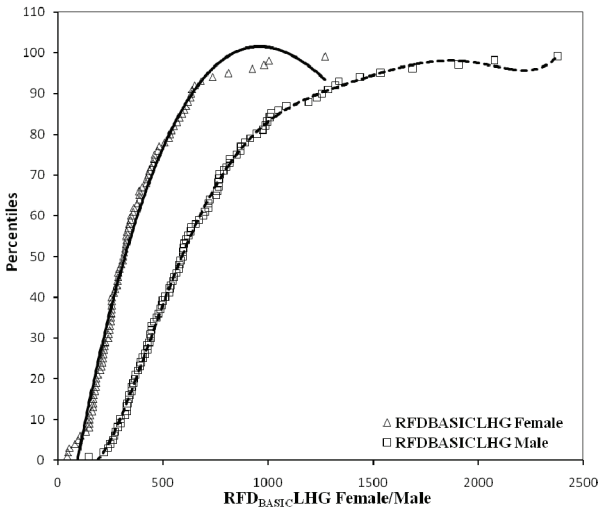

Fig. 3. Percentile distribution of the variable RFDBASICLHG Females/Males.

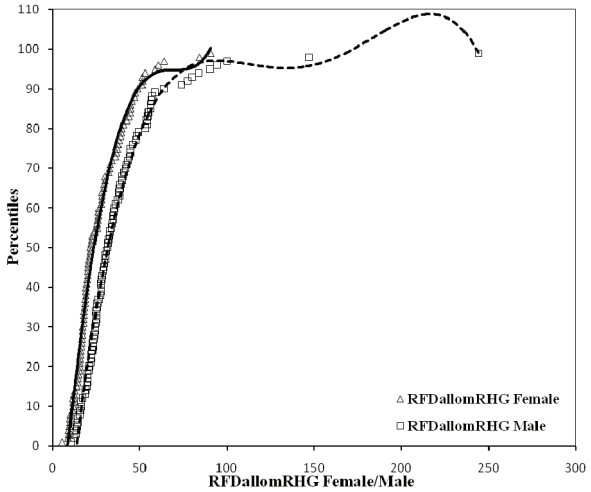

Fig. 4. Percentile distribution of the variable RFDALLOMRHG Females/Males.

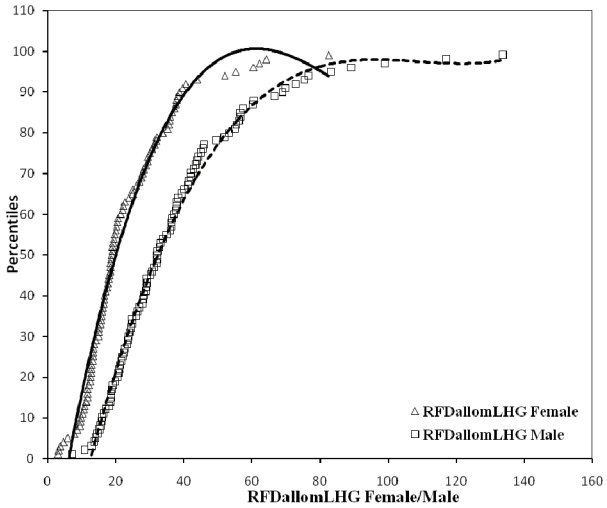

Fig. 5. Percentile distribution of the variable RFDALLOMLHG Females/Males.

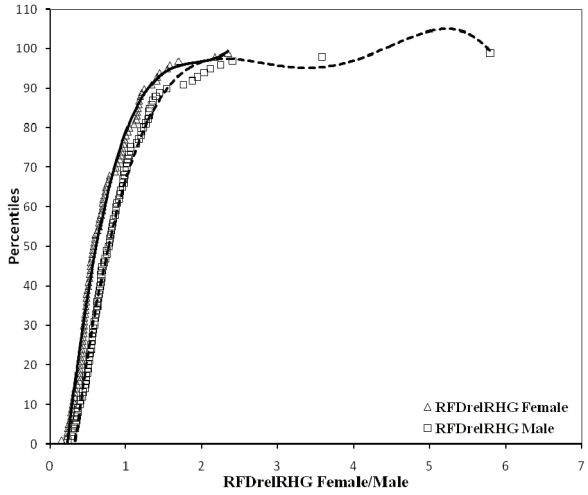

Fig. 6. Percentile distribution of the variable RFDRELRHG Females/Males.

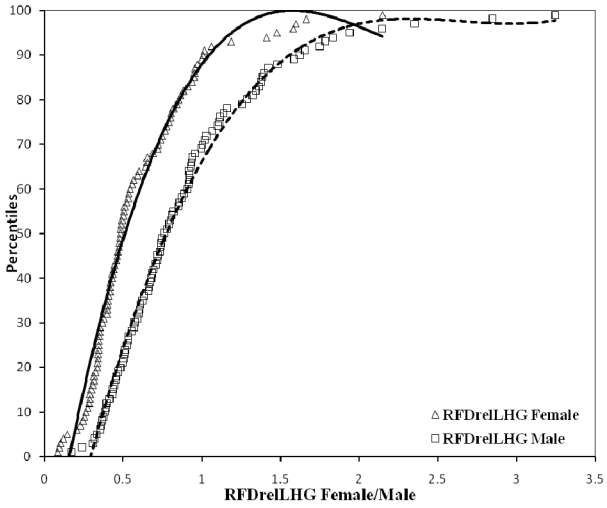

Fig. 7. Percentile distribution of the variable RFDRELLHG Females/Males.

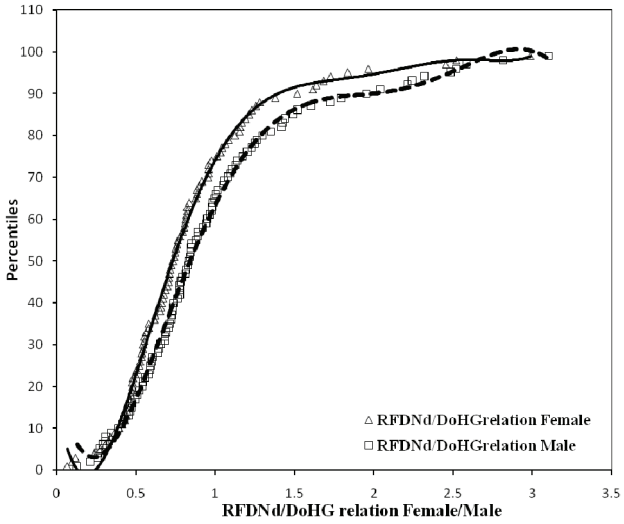

Figure 8. Percentile distribution of the variable RFDNd/DoHG Females/Males.

Tables 5 gives the parameters of polynomial function of the mathematical models defined for the estimate of percentile (distribution) positioning of the parameters tested for the basic explosive hand grip force regarding the tested male and female population.

Table 5. Polynomial parameters of the defined mathematical models for males and females

	Variables	Polynomial parameters	Adj. R^2
MALEs	$RFD_{BASIC}LHG$	$y = -3.0232e\text{-}13x^5 + 9.5371e\text{-}10x^4 - 1.4595e\text{-}06x^3 + 0.0010x^2 - 0.2037x + 9.6652$	0.9987
	$RFD_{ALLOM}LHG$	$y = -6.6870e\text{-}08x^5 + 2.3808e\text{-}05x^4 - 0.0029x^3 + 0.1374x^2 - 0.2350x - 10.3119$	0.9986
	$RFD_{REL}LHG$	$y = -8.0715x^5 + 69.3465x^4 - 207.5072x^3 + 231.3327x^2 - 7.0803x - 10.0453$	0.9986
	RFDNd/DoHG	$y = -12.8021x^5 + 110.4733x^4 - 341.7861x^3 + 433.8244x^2 - 142.9772x + 16.6648$	0.9971
	$RFD_{BASIC}RHG$	$y = -1.2405e\text{-}13x^5 + 4.9594e\text{-}10x^4 - 8.9373e\text{-}07x^3 + 0.0006x^2 - 0.0765x - 9.8369$	0.9960
	$RFD_{ALLOM}RHG$	$y = -8.5209e\text{-}09x^5 + 4.014E\text{-}06x^4 - 0.0005x^3 + 0.0028x^2 + 3.1469x - 41.0106$	0.9973
	$RFD_{REL}RHG$	$y = -1.1875x^5 + 13.6738x^4 - 45.7942x^3 + 21.4044x^2 + 115.6789x - 35.9954$	0.9976
FEMALEs	$RFD_{BASIC}LHG$	$y = -1.0605e\text{-}11x^5 + 1.6416e\text{-}08x^4 - 1.2367e\text{-}05x^3 + 0.0044x^2 - 0.4875x + 17.3576$	0.9977
	$RFD_{ALLOM}LHG$	$y = -1.1956e\text{-}06x^5 + 0.0002x^4 - 0.0186x^3 + 0.5431x^2 - 2.8847x + 3.8566$	0.9942
	$RFD_{REL}LHG$	$y = -107.7117x^5 + 585.2219x^4 - 1113.4436x^3 + 832.4350x^2 - 113.4060x + 3.6169$	0.9929
	RFDNd/DoHG	$y = -18.1952x^5 + 147.1094x^4 - 421.1696x^3 + 481.8122x^2 - 123.6085x + 8.6981$	0.9968
	$RFD_{BASIC}RHG$	$y = -6.0956e\text{-}12x^5 + 1.0989e\text{-}08x^4 - 9.5969e\text{-}06x^3 + 0.0041x^2 - 0.5549x + 23.5721$	0.9938
	$RFD_{ALLOM}RHG$	$y = -3.4181e\text{-}07x^5 + 7.9562e\text{-}05x^4 - 0.0064x^3 + 0.1817x^2 + 1.3344x - 20.5411$	0.9947
	$RFD_{REL}RHG$	$y = -29.4597x^5 + 174.7746x^4 - 356.5129x^3 + 248.3960x^2 + 65.5073x - 22.6464$	0.9952

DISCUSSION

The polynomial functions models we arrived at by applying a mathematical method as the most reliable metrological procedure (Ristanović, 1989) have very high predict-ability in estimating the percentile distribution of contractile parameters from 99.29% for the variable $RFD_{REL}LHG_{Female}$ (Adj. R^2= 0.9929, Figure 7) to 99.87 % for the variable $RFD_{BASIC}LHG_{Male}$ (Adj. R^2= 0.9987, Figure 3); with the error estimation within the range between 0.13 % to 0.71 %, the results can be accepted as exceptionally reliable (Table 5, Figures 2-8).

The reason why there was no significant differences in the functional dimorphism of the men probably lies in fact that men dedicated more time to physical preparation and to improving their motor abilities in the course of their education at the ACPS and their preparation for the execution of professional tasks. Also, it is highly likely that individual

lifting training in the gym significantly influences the results. The improvement of motor abilities in the course of the education at the ACPS and different types of snatches, specific positions and holding the bar with both hands in the gym contributed to the specific adaptation which resulted in the loss of functional domination of one hand or in the equal disability in both hands, for the level of maximal isometric hand grip force as well as for the intensity of gradient of the force increase of the hand grip ($RFD_{BASIC}HG$) in both hands.

A comparison with the results published by Dopsaj et al., 2007, shows a positive correlation with our results. Regarding sexual dimorphism at maximal isometric hand grip force in the healthy and well-trained student population in the Republic of Serbia, the coefficient showing the relationship between Female/Male at $F_{max}LHG$ was 0.5829 (this study yielded the relationship between Female/Male at $RFD_{BASIC}LHG$ was 0.5228), at $F_{max}RHG$ it was 0.5922 (this study yielded the relationship between Female/Male at $RFD_{BASIC}RHG$ it was 0.5940), at $F_{ALLOM}LHG$ it was 0.7019 (this study yielded the relationship between Female/Male at $RFD_{ALLOM}LHG$ it was 0.6086), at $F_{ALLOM}RHG$ it was 0.7144 (this study yielded the relationship between Female/Male at $RFD_{ALLOM}RHG$ it was 0.6956), at $F_{REL}LHG$ it was 0.7701 (this study yielded the relationship between Female/Male at $RFD_{REL}LHG$ it was 0.6564), at $F_{REL}RHG$ it was 0.7839 (this study yielded the relationship between Female/Male at $RFD_{REL}RHG$ it was 0.7525), whereas at $F_{max}L/R$ it was 0.9843 (this study yielded the relationship between Female/Male at RFDNd/DoHG it was 0.8474).

Considering the isometric muscle force in both genders and in various muscle groups, it was established that the $F_{max}ISO$ of back-waist extensor muscles, measured by the Isometric Dead Lift test for the male student population had an average of 1715.77 N, while for the females it was 1020.97 N. The index value used to assess sexual dimorphism for isometric strain at trunk extensor muscles was at the level of 0.5951 (Blagojević et al., 2006). The given index is almost the same as in our research for the hand grip $RFD_{BASIC}HG$ (0.5940 for the right and 0.5228 for the left hand).

Besides, in the research conducted by Komi & Karlsson, 1978, on 31 examinees both male and female, aged 15 – 24, showed that the average value of the maximal isometric leg extension force in women is at the level of 80.3% of the measured average value for the men (171.9±30.0 kp vs 214.2±54.5 kp), while the average value of the time necessary to reach 70% of maximal force for the women is at the level of 198.9%. This fact can lead to the conclusion that the level of sexual dimorphism from the aspect of maximal force, as well as from the aspect of explosive force is approximately the same for a particular muscle group or a majority of them. As a support to this hypothesis, we could consider the data given by Häkkinen, 1991, who used a sample of top male and female basketball players to establish sexual dimorphism for the maximal absolute leg extension force at the level of 0.6955, for the maximal absolute trunk flexion force at the level of 0.5240, and for the maximal absolute trunk extension force at the level of 0.5860.

The results from a study carried out on a sample of the 1st and the 4th year students of the ACPS and trained athletes from the discipline Power Lifting conducted by Dopsaj at al., 2009, showed that the average values of $RFD_{BASIC}LHG$ measured in Power Lifting in comparison with the obtained results from our study are at the level of 66.5‰ (percentile), for the 4th years students 49.5‰ and for the 1st years students 43.5‰. The average values of the $RFD_{BASIC}RHG$ are at the level of 71.5‰ (percentile) in Power Lifting, for the 1st year students 69.5‰ and for the group of the 4th year students 59.5‰. The average

values for the RFD_{ALLOM}LHG are at the level of 49.0‰ in Power Lifting, for the group of the 4th year students 48.5‰ and for the 1st year students 40.2‰. The average values for the RFD_{ALLOM}RHG are at the level of 68.0‰ for the 1st year students, in Power Lifting 65.2‰ and for the group of 4th year students 58.0‰. The average index values of the functional relationship between basic isometric explosive hand grip force of the dominant and non-dominant hand are at the level of 60.8‰ in Power Lifting, for the group of the 4th year students 33.8‰ and for the 1st year students 40.2‰.

On the other hand, the physical characteristics of female volleyball players (Rajić et al., 2004) aged 19 ± 2.19, who have an isometric explosive dominant hand grip force (RFD_{BASIC}HG) at the level of 50.60 ± 25.31 Da/Ns (496.22 ± 248.21 N/s), positioned them at 69.1‰ (percentile) in relation to the value of the RFD_{BASIC}HG of the model defined for good conditioning of young and healthy Serbian females.

CONCLUSION

This study defined the basic descriptive model characteristics considering descriptive, functional and sexual dimorphism at basic explosive isometric hand grip force in healthy and well-trained student of the ACPS in the Republic of Serbia.

Our results showed that the tested male sample had a significantly greater explosive hand grip force in both hands (dominant and non-dominant) than the tested female sample, with regard to both absolute and relative indicators. A statistically significant difference was established for the whole measurement range (the total of variable samples in the function of gender) between the men and women, as parameters of sexual dimorphism, at the level of Wilks' Lambda – 0.519, F=30.567, p=0.000. As for the parameters that determine the level of sexual dimorphism, the results showed that for the men there was a statistically significant higher level of the force applied in all of the tested variables. The fact that these gender differences were established for the basic explosive hand grip force characteristics is not surprising. Various factors such as the cross-sectional area, muscle fiber characteristics, differences in skeletal muscle mass and the distribution of muscle mass in upper limbs contributed in a statistically significant manner to the difference between the men and women.

In the function of gender, statistically significant functional dimorphism was found only in women, i.e., the dominant hand was found to be stronger than the non-dominant one with a statistical significance of t=2.389, p=0.019. It is highly likely that the reason why statistically significant functional dimorphism was not found for the men can be explained by the differences in the overall volume and/or the type of strength and power training outside the course of education, which resulted in the loss of functional domination of one hand or in the equal disability of both hands for the men.

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DESKRIPTIVNI, FUNKCIONALNI I POLNI DIMORFIZAM EKSPLOZIVNE IZOMETRIJSKE SNAGE STISKA ŠAKE KOD ZDRAVIH STUDENATA U SRBIJI

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Cilj rada je definisanje modela karakteristika deskriptivnog, funkcionalnog i polnog dimorfizma eksplozivne izometrijske sile stiska šake obe ruke kod zdravih i dobro treniranih studenata Kriminalističko policijske akademije (KPA) u Republici Srbiji. Testirano je 239 studenata, 143 muškog i 96 ženskog pola, starosti od 18 do 24 godine. Za procenu eksplozivne izometrijske sile stiska šake RFDBASICHG korišćena je standardizovana oprema, klizni instrument za merenje izometrijske sile pregibača prstiju sa tenziometrijskom sondom unutar nje. Rezultatiti dobijeni ovim istraživanjem pokazuju da testirani ispitanici muškog pola imaju značajno veće vrednosti eksplozivne sile stiska šake obe ruke (dominantne i nedominantne) u odnosu na ispitanike ženskog pola, sa aspekta kako apsolutnih tako i relativnih vrednosti. Statistička analiza je utvrdila da između posmatranih sub uzoraka između muškaraca i žena postoji generalna statistički značajna razlika svih ispitivanih kontraktilnih karakteristika na nivou Wilks Lambda 0.519, F = 30.567, p = 0.000. U funkciji pola, statistički značajne razlike funkcionalnog dimorfizma izmerene su kod žena, dominantna ruka je snažnija od nedominantne na nivou statističke značajnosti t = 2.389, p = 0.019. Na osnovu definisanog modela karakteristika, dobijeni rezultati se mogu koristiti kao kritetirijumi u različite svrhe testiranja, za procenu eksplozivne sile stiska šake kod trenirane i netrenirane populacije oba pola ili u svrhu procene polnog i funkcionalnog dimorfizma.

Ključne reči: *eksplozivna izometrijska sila, stisak šake, dimorfizam, studentska populacija*