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ORIGINAL PAPER (ARTIGO ORIGINAL)

BASIC AND SPECIFIC CHARACTERISTICS OF THE HAND GRIP EXPLOSIVE FORCE AND TIME PARAMETERS IN DIFFERENT STRENGTH TRAINED POPULATION

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ABSTRACT
DOPSAJ, M.; IVANOVIĆ, J.; BLAGOJEVIĆ, M.; KOROPANOVSKI, N.; VUČKOVIĆ, G.; JANKOVIĆ, R.; MARINKOVIĆ, B.; ATANASOV, D.; MILJUŠ, D. Basic and specific characteristics of the hand grip explosive force and time parameters in different strength trained population. Brazilian Journal Biomotricity, v. 3, n. 2, p. 177-193, 2009. Background: The aim of this study is to define basic and specific characteristics of explosive force and time parameters of hand grip HG_{iso} in different strength trained population. Testing sample of 189 examinees included: Control group consisted of the 1st year students of the Academy for Criminalistic and Police studies (ACPS), Well trained – the 4th years students of ACPS and trained athletes from the discipline Power Lifting. Methods: In order to assess the $RFDHG_{iso}$ 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. Specific characteristics were measured according to Zatsiorsky et al. (2006) and were showned by the S gradient parametres or F-t relation. Results: Multivariate statistical analysis established that there is a significant difference at all contractile characteristics at the level of Wilks´ Lambda 0.739, F=2.378, p=0.000, among the observed sub-samples. Statistically significant difference was also established at following variables regarding the observed sub-samples: in $tF_{50\%}$LHG F=4.023, p=0.019 and in RFD_{BASIC}LHG F=3.133, p=0.046. Conclusion: The results of almost all obtained general and specific variables and time parameters of hand grip explosive force showed that the maximal values are in Power Lifting. The fact that statisticaly significant diferences was established for variable of basic explosivity of left hand grip force and

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also the smallest average values of RFD_{BASIC}LHG in the Control group isn`t surprising. Different tipes of snatches, specific position and holding the bar with both hands in Power Lifting contributed the specific adaptation witch resulted loss of functional domination of one hand or in equalising diabillity in both hands, for the level of maximal isometric hand grip force as for the rate of force development of hand grip (RFD_{BASIC}HG) in both hand.

Key Words: explosive force, hand grip, different strength trained population.

INTRODUCTION

Hand is the basic manipulative organ in human body, and hand grip force, as a limiting factor, participates in all manipulative activities realized by the cranial part of the body (TYLDESLEY et al., 1996). The researches of contractile characteristics of hand grip muscles are wide-spreaded 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). Additionally, the measurement equipment for assessing maximal isometric hand grip force ($F_{max}HG_{iso}$) is very easy to use, and it is not related to examinees´ age, health condition or training status (TAN at al., 2001; GUIDETTI at al., 2002; WASSMER at al., 2002; DEMURA at al., 2003; GILES at al., 2006; DOPSAJ at al., 2007; LEYK at al., 2007). In the course of education the students on the ACPS and their preparation for execution of professional tasks, great consideration is given to improving their motor abilities. One of the prerequisite for sucessful fulfilling professional tasks is a high level of motor abilities. Many research results (NILSSON et al., 1989; COLLINS et al., 2000; WEYAND et al., 2000; VUČKOVIĆ et al., 2007b) show that the different force mechanical characterictics of primary muscular groups which are involved in solving the comlex motorical tasks, e.g. different types of polygon (back-waist extensor musculature, leg extensors and left and right-hand finger flexors), significaly define success on the basis of time necessery to solve the task. As the results which are solved in real police situations represent complex system of motorical actions, activities whith the extreme tension of the body and the muscular control on the basis of force level, force intensity and whith the permanent regulation of the mechanisms within the muscular control, coordination of movements, it is obvious that the sucess in solving these tasks depends on force characteristics that the policemen show through the whole range of the F-t relation. The research results showed that 31.50% of efficiency of shooting out of hand fire-arms depends on contractiles abilities of the tested muscular groups on the basis of level and intensity to develop force in time unit - explosivity. The research results showed that the eficiency of shooting from the fire weapon depends on F_{max} (COPAY et al., 2001) and also on isometric RFD_{BASIC} of left and right hand grip (VUČKOVIĆ et al., 2007; VUČKOVIĆ et al., 2007b).

One of the most important characteristics which can help to define the realization quality of human locomotion is the mechanical contractile muscle capacity to develop as much force as possible in the function of movement in time. This research was conducted with an objective to determine isometric characteristics of force-time curve model related to basic and specific explosive force and time parametre characteristics of hand grip in diferent trained population from the aspect of strength.

METHODS

Sample

The subjects sample included 189 examinees (male) of different trained population on the basis of force: normal trained - the control group which included the 1st year students of ACPS (N=91), well trained which included the senior year (the 4th years) students of ACPS

(N=84) and trained athletes from the Power Lifting (N=14).

Table 1 - Anthropo-morphological charactaristics of the total sample

Anthropo-morphological characteristics of the total sample (N=189)				
	Control group N=91	**Well trained N=84**	**Power Lifters N=14**	**AVG**
	Mean±SD	Mean±SD	Mean±SD	Mean±SD
BH (cm)	182.05±5.10	181.96±4.90	182.82±7.69	182.11±5.23
BW (kg)	82.69±8.32	80.53±8.17	89.86±17.56	82.30±9.49
BMI	24.92±1.88	24.30±2.09	26.79±4.21	24.78±2.29

The following basic anthropometric data of the tested sample were collected: BH=182.11±5.23cm, BW=82.30±9.49kg, BMI=24.78±2.29 (Table 1). All tests were performed in the Laboratory for assessing the basic motoric status within the study subject of Special Physical Education at Academy for Police and Criminalistic Studies in Belgrade from 2006. till 2007, using the same procedure and the same equipment (DOPSAJ et al., 2007).

Testing procedure

Testing procedure was conducted under the professional and ethical standards and recommendations defined by American College of Sports Medicine (2006). In order to assess the maximal isometric hand grip force ($F_{max}HG_{iso}$) we used standardized equipment, i.e., a sliding device that measures isometric finger flexor force, with a tensiometric probe fixed inside the device (Figure 1a). The tensiometric probe was connected to the force reader with the measurement precision of the probe at the level of ±0.01N, while the force reader showed the precision of ±0.1N (Figure 1b). An earlier study established a high statistical validity of the measuring equipment used at the level of 0.961, while the reliability of the measuring method was at the level of 0.991. Therefore, both the testing procedure applied and the results obtained can be considered as representative (DOPSAJ at al., 2000; DEMURA at al., 2003; DOPSAJ at al., 2007). All examinees were tested after 2–3 minutes of independent warm-up, with the examinee standing in the upright position and holding the measuring device with the probe in the hand tested, with the arm resting in the natural posture alongside the body, while the other arm was resting alongside the body or with the hand on the opposite thigh.

Figure 1 - The device with the tensiometric probe (a) and the force indicator (b)

The hand holding the device with the probe was approximately 10 cm away from the body. The examinees were not allowed to move from the initial position during the test trial, nor could they lean the hand or the device against the thigh or another solid object (Figure 2). We used power grip, where all the fingers are flexed around an object. The power grip is not only the simplest grasping movement, but also the grip where we can produce a higher level of force than with the others, such as the precision grip, the manipulative grip, various tool grips, various types of pinch, etc. (TAN at al., 2001; YAN et al., 2001; McGORRY at al., 2007).

Figure 2 - The examinee's position during the test

The test for evaluation of maximal hand grip force was applied, and each examinee had two attempts for each hand, with one minute rest between trials. The attempt with the greater hand grip force was analysed.

Variables

The measurement range was defined by using the following variables:

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

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

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.

- Specific isometric explosive hand grip force or the S gradient of hand grip (for both hand, left – $RFD_{50\%}LHG$ and right – $RFD_{50\%}RHG$) peaked at 50% of $F_{max}HG$

$$RFD_{50\%}HG = (F_{50\%}HG / tF_{50\%}HG) \square 1000$$

Where: $F_{50\%}HG$ represents the value of isometric force achieved for 50% of $F_{max}HG$, and $tF_{50\%}HG$ represents the time in ms necessary to reach it $F_{50\%}HG$, expressed in N/s.

- Relative value of $RFD_{BASIC}HG$ (for both hand, left – $RFD_{allom}LHG_{100\%}$ and right – $RFD_{allom}RHG_{100\%)}$ allometric partialisation was done by applying the following procedure (VANDERBURGH at al., 1995; JARIC, 2002; ZATSIORSKY et al., 2006):

$$RFD_{allom}HG_{100\%} = RFD_{BASIC}HG / BM^{0.667}$$

Where: $RFD_{allom}HG_{100\%}$ are the relative value of basic isometric hand grip force after allometric partialisation, in index number ($N^{-s}/BM^{0.667}$); $RFD_{BASIC}HG$ is the Basic isometric explosive hand grip force, in N/s; BM is body mass, in kg.

- Relative value of $RFD_{50\%}HG$ (for both hand, left – $RFD_{allom}LHG_{50\%}$ and right – $RFD_{allom}RHG_{50\%)}$ allometric partialisation was done by applying the following procedure:

$$RFD_{allom}HG_{50\%} = RFD_{50\%}HG / BM^{0.667}$$

Where: $RFD_{allom}HG_{50\%}$ are the relative value of S gradient of hand grip after allometric partialisation, in index number ($N^{-s}/BM^{0.667}$); $RFD_{50\%}HG$ is the S gradient, in N/s; BM is body mass, in kg.

Statistical analysis

Statistical methods used in this procedure were the descriptive statistical method, the multivariate statistical method – General Linear Model – multivariate procedure and post – hoc test (Bonferonni's test) (HAIR et al., 1998). Descriptive comparison between different trained population was performed using Z score standard, where the average values of observed variables of the Control group were used as a standard criterion.

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 statistic regarding different trained population are shown in Table II (Mean, SD, Min, Max).

The maximal average value $RFD_{BASIC}LHG$ was measured in Power Lifting and was 762.95±411.07 N/s, then in group of Well trained students 594.19±309.50 N/s and then in Control group 542.89±297.43 N/s. The maximal average value $RFD_{BASIC}RHG$ was measured in Power Lifting and was 794.04±421.89 N/s, then in Control group 772.95±1007.18 N/s and then in group of Well trained students 658.55±297.90 N/s (Table 2).

The maximal average value $RFD_{50\%}LHG$ was measured in power lifting and was 5321.96±3925.60 N/s, then in Control group 4946.64±2684.97 N/s and then in group of well trained students 4665.95±2074.63 N/s. The maximal average value $RFD_{50\%}RHG$ was measured in Control group and was 5308.89±3164.43 N/s, then in group of Well trained students 5276.66±2193.18 N/s and then in Power Lifting 4412.93±1862.47 N/s (Table 2).

The maximal average value $tF_{50\%}LHG$ was measured in Power Lifting and was 105.34±72.87 ms, then in group of Well trained students 76.10±57.82 ms and then in Control group 65.67±36.98 ms. The maximal average value $tF_{50\%}RHG$ was measured in Power Lifting and was 108.07±66.07 ms, then in Control group 75.35±61.55 ms and then in group of Well trained students 74.55±64.10 ms (Table 2).

The maximal average value $tF_{max}LHG$ was measured in examinees from Control group and was 1145.49±494.67 ms, then in Power Lifting 1142.52±390.65 ms and then in group of Well trained students 1103.63±439.85 ms. The maximal average value $tF_{max}RHG$ was measured in Power Lifting and was 1121.81±403.89 ms, then in Control group 1087.09±525.85 ms and then in group of Well trained students 1049.35±390.84 ms (Table 2).

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Table 2 - The results of the descriptive statistics regarding different trained population and statistical significant difference[1]

Descriptive statistics						
	Control group	Well trained	Power Lifters	Control group	Well trained	Power Lifters
Left hand grip	**MEAN±SD**			**Min - Max**		
$RFD_{BASIC}LHG$ (N/s)	542.89±297.43*	594.19±309.50	762.95±411.07*	173.68 - 1815.03	182.20-1741.55	400.78-1711.60
$RFD_{50\%}LHG$ (N/s)	4946.64±2684.97	4665.95±2074.6	5321.96±3925.60	1040.30 - 16723.24	471.58-10702.69	1567.84-17044.42
$tF_{50\%}LHG$ (ms)	65.67±36.98*	76.10±57.82	105.34±72.87*	15.83 - 226.43	21.78-455.42	18.40-248.12
$tF_{max}LHG$ (ms)	1145.49±494.67	1103.63±439.85	1142.52±390.65	303.37 - 2486.92	266.29-2250.31	407.25-1784.26
$RFD_{allom}LHG_{50\%}$ ($N^{-s}/BM^{0.667}$)	261.77±143.31	251.13±113.48	278.87±223.10	51.86-880.43	28.10-573.13	64.84-944.86
$RFD_{allom}LHG_{100\%}$ ($N^{-s}/BM^{0.667}$)	28.54±15.68	32.01±17.25	38.28±20.92	10.33-95.56	9.36-110.31	21.33-85.05
Right hand grip	**MEAN±SD**			**Min - Max**		
$RFD_{BASIC}RHG$ (N/s)	772.95±1007.18	658.55±297.90	794.04±421.89	220.46-7074.08	258.66-1519.62	361.71-1853.38
$RFD_{50\%}RHG$ (N/s)	5308.89±3164.43	5276.66±2193.2	4412.93±1862.47	668.41-17708.00	478.00-12301.79	1732.53-8389.24

[1] ***RFD_{BASIC}LHG statistical significant diference Power Lifters vs Control group 220.06N/s, p=0.045 and *$tF_{50\%}$LHG – statistical significant diference Power Lifters vs Control group 39.67ms, p=0.020***

$tF_{50\%}RHG$ (ms)	75.35±61.55	74.55±64.10	108.07±66.07	12.61-423.57	22.07-446.84	38.26-266.94
$tF_{max}RHG$ (ms)	1087.09±525.85	1049.35±390.84	1121.81±403.89	74.49-2258.79	333.68-2038.23	499.07-1688.71
$RFD_{allom}RHG_{50\%}$ ($N^{-s}/BM^{0.667}$)	281.85±172.99	283.94±118.46	225.83±107.50	34.63-957.17	28.48-658.77	80.29-470.62
$RFD_{allom}RHG_{100\%}$ ($N^{-s}/BM^{0.667}$)	40.57±51.99	35.17±15.38	39.14±19.31	12.12-384.64	14.50-80.81	19.25-85.89

The maximal average value $RFD_{allom}LHG_{50\%}$ was measured in Power Lifting and was 278.87±223.10 $N^{-s}/BM^{0.667}$, then in the Control group 261.77±143.31 $N^{-s}/BM^{0.667}$ and then in the group of Well trained students 251.13±113.48 $N^{-s}/BM^{0.667}$. The maximal average value $RFD_{allom}RHG_{50\%}$ was measured in group of Well trained students and was 283.94±118.46 $N^{-s}/BM^{0.667}$, then in the Control group 281.85±172.99 $N^{-s}/BM^{0.667}$ and then in Power Lifting 225.83±107.50 $N^{-s}/BM^{0.667}$ (Table II).

The maximal average value $RFD_{allom}LHG_{100\%}$ was measured in Power Lifting and was 38.28±20.92 $N^{-s}/BM^{0.667}$, then in the group of Well trained students 32.01±17.25 $N^{-s}/BM^{0.667}$ and then in the Control group 28.54±15.68 $N^{-s}/BM^{0.667}$. The maximal average value $RFD_{allom}RHG_{100\%}$ was measured in examinees from Control group and was 40.57±51.99 $N^{-s}/BM^{0.667}$, then in Power Lifting 39.14±19.31 $N^{-s}/BM^{0.667}$ and then in the group of Well trained students 35.17±15.38 $N^{-s}/BM^{0.667}$ (Table II).

Multivariate statistical analysis showed that there is a general statistically significant difference at the level of Wilks´ Lambda 0.739, F=2.378, p=0.000, among the observed sub-samples. Partial statistically significant difference was established in following variables: $tF_{50\%}LHG$ F=4.023, p=0.019 and $RFD_{BASIC}LHG$ F=3.133, p=0.046.

The results showed that statistically longer time neceserry to reach isometric left hand grip force in variable $tF_{50\%}LHG$ have Power Lifters in comparison with the Control group (105.34±72.87 ms vs 65.67± 36.98 ms, p=0.019) (Table II).

Also, the results showed that the statistical higher rate of force development for the left hand in variable $RFD_{BASIC}LHG$ (basic explosive left hand grip force) have Power Lifters in comparison with the Control group (762.95±411.07 N/s vs 542.89±297.43 N/s, p=0.046) (Table II).

The research Results in relation to Z score

Graphs 1 to 8 presents standardized differences of the observed hand grip force variables $RFD_{allom}LHG_{50\%}$, $RFD_{50\%}LHG$, $RFD_{allom}LHG_{100\%}$, $RFD_{BASIC}LHG$, $RFD_{allom}RHG_{50\%}$, $RFD_{50\%}RHG$, $RFD_{allom}RHG_{100\%}$, $RFD_{BASIC}RHG$ regarding the different strength trained population. The standard criterion represents the average values of criterion population – Control group students.

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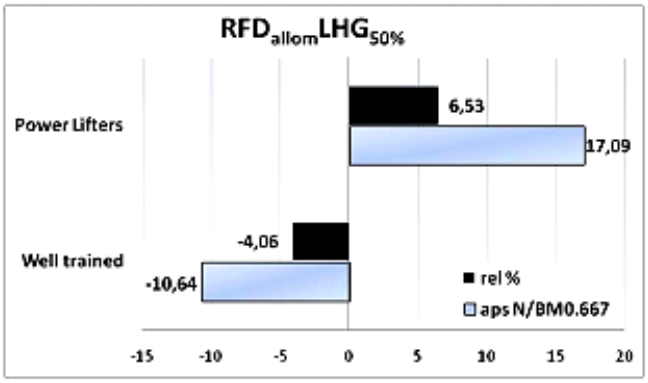
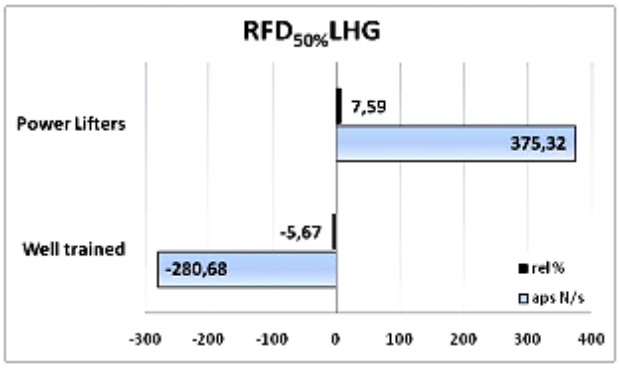
Values of standardized differences (Graph 1) between the criterion population and the examinees of different strength trained population regarding the research variables are in between 10.64 $N^{-s}/BM^{0.667}$ or 4.06% (Well trained students) of deficit to 17.09 $N^{-s}/BM^{0.667}$ or 6.53% (Power Lifters) of sufficiency regarding the average value criterion of the Control group for the relative value S gradient of the left hand grip variable defined by allometric method $RFD_{allom}LHG_{50\%}$.



Graph 1- Standardized differences of the variables $RFD_{allom}LHG_{50\%}$

Values of standardized differences (Graph 2) between the criterion population and the examinees of different trained population regarding the research variables are in between 280.68 N/s or 5.67% (Well trained students) of deficit to 375.32 N/s or 7.59% (Power Lifters) of sufficiency regarding the average value criterion of the Control group for the S gradient of the left hand grip variable $RFD_{50\%}LHG$.



Graph 2- Standardized differences of the variables $RFD_{50\%}LHG$

Values of standardized differences (Graph 3) between the criterion population and examinees of different trained population are in between 3.47 $N^{-s}/BM^{0.667}$ or 12.16% (Well trained students) and 9.74 $N^{-s}/BM^{0.667}$ or 34.13% (Power Lifters) of sufficiency regarding the average value criterion of the Control group for the relative explosive left hand grip variable defined with allometric method $RFD_{allom}LHG_{100\%}$.

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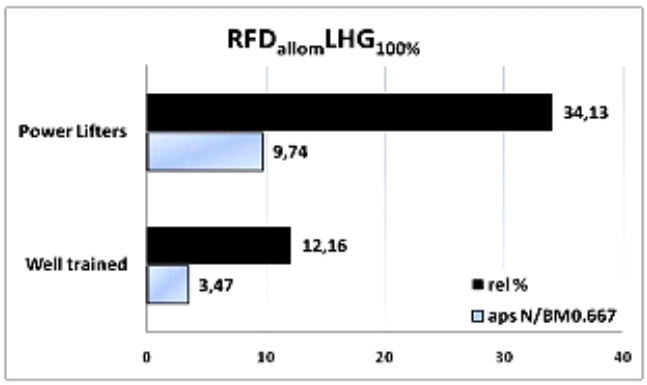
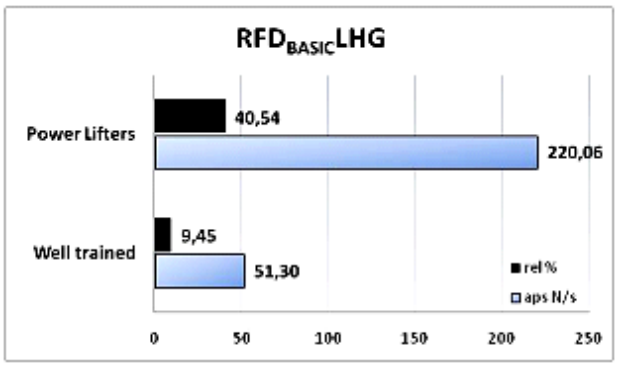


Graph 3- Standardized differences of the variables $RFD_{allom}LHG_{100\%}$

Values of standardized differences (Graph 4) between the criterion population and examinees of different trained population are in between 51.30 N/s or 9.45% (Well trained students) and 220.06 N/s or 40.54% (Power Lifters) of sufficiency regarding the average value criterion of the Control group for the basic explosive left hand grip variable $RFD_{BASIC}LHG$.



Graph 4- Standardized differences of the variables $RFD_{BASIC}LHG$

Values of standardized differences (Graph 5) between the criterion population and examinees of different trained population are in between 2.09 $N^{-s}/BM^{0.667}$ or 0.74% (Well trained students) of sufficiency to 56.02 $N^{-s}/BM^{0.667}$ or 19.88% (Power Lifters) of deficit regarding the average value criterion of the Control group for the relative value S gradient of the right hand grip variable defined by allometric method $RFD_{allom}RHG_{50\%}$.

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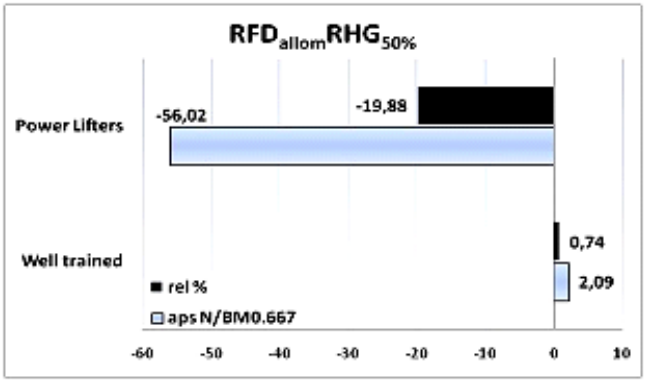
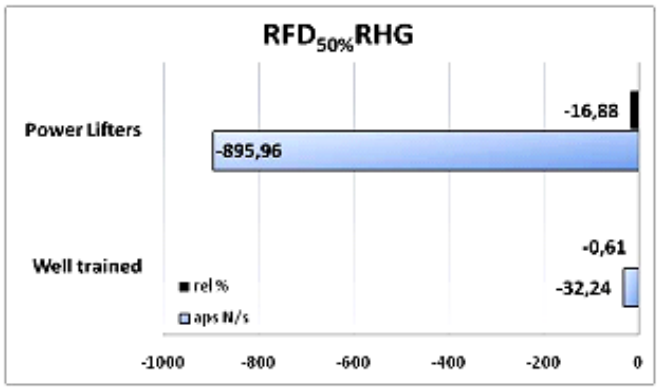


Graph 5- Standardized differences of the variables $RFD_{allom}RHG_{50\%}$

Values of standardized differences (Graph 6) between the criterion population and examinees of different trained population are in between 32.24 N/s or 0.61% (Well trained students) and 895.96 N/s or 16.88% (Power Lifters) of deficit regarding the average value criterion of the Control group for the S gradient of the right hand grip variable $RFD_{50\%}RHG$.



Graph 6- Standardized differences of the variables $RFD_{50\%}RHG$

Values of standardized differences (Graph 7) between the criterion population and examinees of different trained population are in between 5.40 $N^{-s}/BM^{0.667}$ or 13.31% (Well trained students) and 1.43 $N^{-s}/BM^{0.667}$ or 3.52% (Power Lifters) of deficit regarding the average value criterion of the Control group for the relative explosive right hand grip variable defined by the allometric method $RFD_{allom}RHG_{100\%}$.

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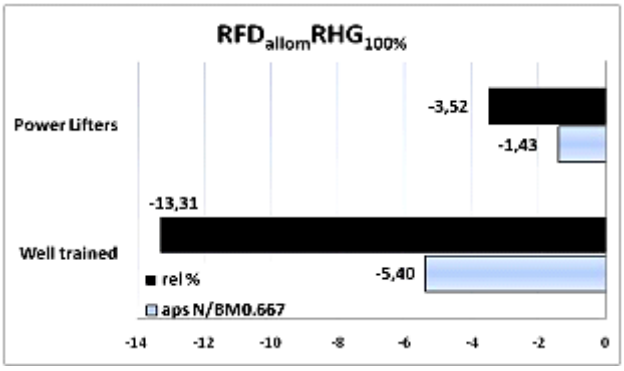
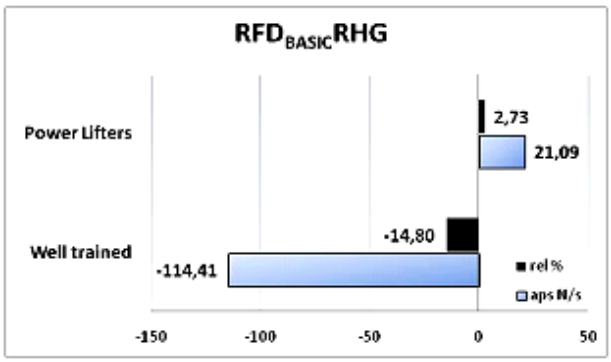


Graph 7- Standardized differences of the variables $RFD_{allom}RHG_{100\%}$

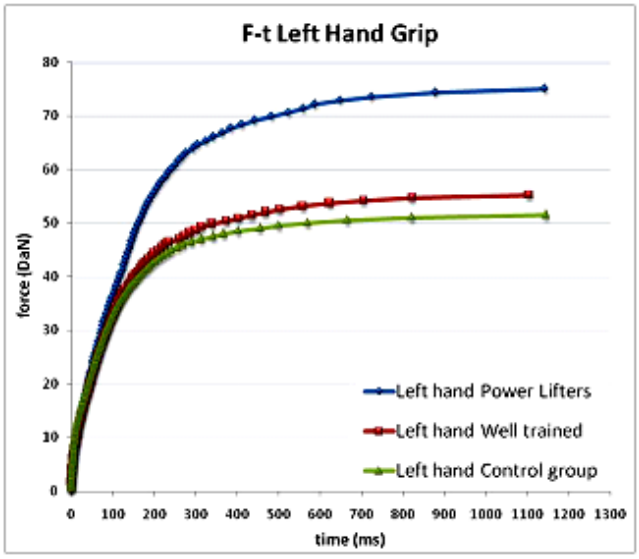
Values of standardized differences (Graph 8) between the criterion population and examinees of different trained population are in between 114.41 N/s or 14.80% (Well trained students) of deficit to 21.09 N/s or 2.73% (Power Lifters) of sufficiency regarding the average value criterion of the Control group for the basic explosive right hand grip variable $RFD_{BASIC}RHG$.



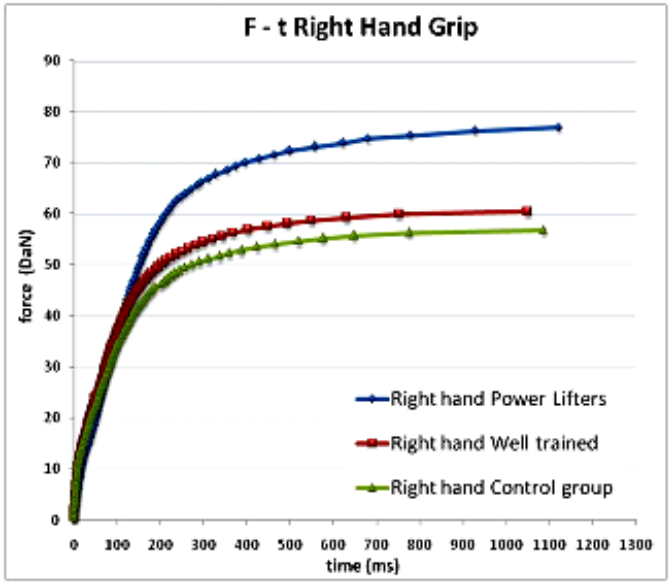
Graph 8- Standardized differences of the variables $RFD_{BASIC}RHG$

DISCUSSION

The graphs 9 and 10 show the curves F-t relation left and right hand grip of the observed examinees.



Graph 9- F-t relation of left hand grip



Graph 10- F-t relation of right hand grip

The maximal average value of Specific explosive hand grip force for Left Hand - $RFD_{50\%}LHG$, Basic explosive hand grip force for both hand - $RFD_{BASIC}HG$, the time necessary to reach it $F_{50\%}HG$ for both hand - $tF_{50\%}HG$, the time necessary to reach it $F_{max}HG$ for right hand $tF_{max}RHG$, relative value of S Gradient for left hand - $RFD_{50\%}LHG$ after allometric partialisation, relative value of Basic explosive hand grip force for left hand $RFD_{allom}LHG_{100\%}$ after defined by allometric partialisation were measured in Power Lifting.

The results of previous research schowed that in the maximal isometric hand grip force values, the highest average values were measured in power lifters athletes, which is understandable considering the nature of this sport (IVANOVIĆ et al., 2009). In elite strength athletes, as a result of adaptation to long-term training load specificity on maximal force, strength and power, the values which were above the average were established in relation to other sports, as well as to the control population students of Police Academy. Especially Power Lifters who usually

perform heavy – resistance training programmes, that is performed over the years may have produced long term training – induced increases in the maximal voluntary neural drive to the muscles associated with increased rapid neural activation of motor units and/or selective hyperthropy or transformation of tipe II muscle fibres into stronger counterparts (HÄKKINEN et al., 1987; RYUSHI et al., 1988; HÄKKINEN 1989; IVANOVIĆ et al., 2009). In Power Lifting, as well as in other disciplines which involves great hand grip force (boxing, handball, rock climbing), where the adaptation is in strength or muscle power it was established that there is a significant correlation between the sport discipline and the differences in strength and/or muscle power output which can be explained by training background as well (IZQUIERDO et al., 2002). The same phenomenon was established in highly trained female athletes from sports which are known to require significantly strong hand grip strength – judo and handball, which are significantly stronger than their untrained female counterparts (LEYK et al., 2007). While researching the physiological factors which have influence on boxing competition performance, it was established that the hand grip force, as an indicator of upper-body muscular strength, is one of two basic factors related to competition efficiency performance (GUIDETI at al., 2002). Because of increased demand placed upon the upper body, for example during climbing of increased difficulty, possessing greater strength and endurance in the arms and shoulders could be advantageous (GILES et al., 2006).

In relation to $F_{max}HG_{iso}$ in previous research (IVANOVIĆ et al., 2009) functional dimorphism ($F_{max}Nd/DoHG_{iso}$) and norm values for assessing the status of functional dimorphism for the sample of exameenis in different sports was established between the dominant and non-dominant hand. If we compare the results of this and previous (IVANOVIĆ et al., 2009) research we can argue with great possibility that trained men from Power Lifting have almost the same values of functional dimorphism. On the other hand there are no differences between the average values of functional dimorphism or functional relationship between maximal hand grip force of dominant and non - dominant hand (in our research the average values of $F_{max}Nd/DoHG_{iso}$ was 0,9747 and in previous research was 0.9579, in index value). According to the categorisation and obtained results in previous research (IVANOVIĆ et al., 2009) we can classify the examinees in this research in folowing categories: Power Lifters (0.9747, in index value) are in the category of dominant symmetry of functional hand grip relations, Well trained groups (0.9133) are in the category of normal/average value of $F_{max}Nd/DoHG_{iso}$, Control group (0.9073) are in the category of asymmetry of the $F_{max}Nd/DoHG_{iso}$.

Regarding the aim of this paper, it is relevant to show the results based on relation of explosive hand grip force between dominant and non - dominant hand ($RFD_{BASIC}Nd/DoHG_{iso}$) (Graph 11).

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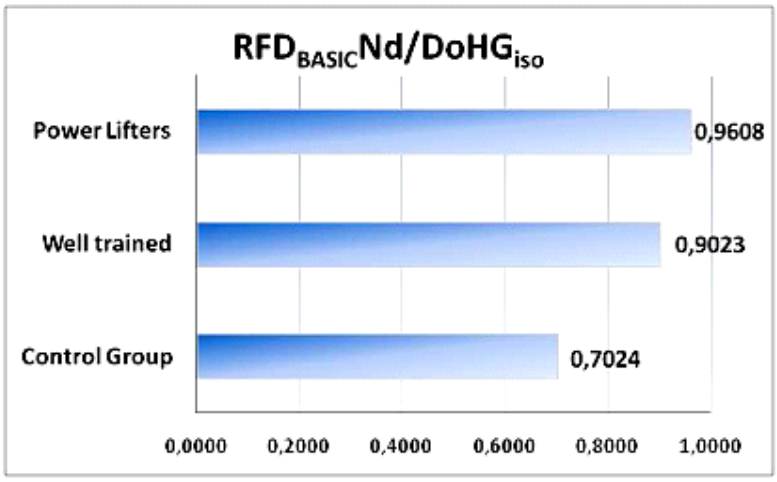

Graph 11- Functional relationship between basic isometric explosive hand grip force of dominant and non-dominant hand

The maximal average index value of functional relationship between basic isometric explosive hand grip force of dominant and non - dominant hand (0.9608, in index value) was established in Power Lifting (in other words, basic explosivity of hand grip force of non - dominant hand is on the level of 96.08 % of basic explosivity of hand grip force of dominant hand), 0.9023 in well trained group and 0.7024 in Control group. The reason for the differencies based on relation of explosive force between dominant and non - dominant hand, especially between Control group and Power Lifters probably lies in fact that in sport in which both hands are equally used, in training sessions and competitive games measured contractile characteristic of hand muscles between dominant and non - dominant are synchronised (Graph 11). Power Lifters used both hands equally while lifting weights. Because of that maximal average values of functional dimorphism and relation of basic explosive force between dominant and non - dominant hand are measured in this sport. The fact that statisticaly significant diferences was established for variable of basic explosivity of left hand grip force and also the smallest average values of RFD_{BASIC}LHG in the Control group isn`t surprising. Different tipes of snatches, specific position and holding the bar with both hands in Power Lifting contributed the specific adaptation witch resulted loss of functional domination of one hand or in equalising diabillity in both hands, for the level of maximal isometric hand grip force as for the intesity of gradient of force increase of hand grip (RFD_{BASIC}HG) in both hand.

CONCLUSION

This study defined basic and specific characteristics of explosive force and time parameter of hand grip in diferent strength trained population.

Multivariate statistical analysis established that there is a general statistically significant difference among the observed sub-samples in different groups at the level of Wilks´ Lambda 0.739, F=2.378, p=0.000. Partial statistically significant difference between Power Lifters and Control group was established in following variables: $tF_{50\%}$LHG F=4.023, p=0.019, (105.34±72.87 ms vs 65.67±36.98 ms) and RFD_{BASIC}LHG F=3.133, p=0.046, (762.95±411.07 N/s vs 542.89±297.43 N/s). The fact that statisticaly significant diferences was established for variable of basic explosivity of left hand grip force and also the smallest average values of RFD_{BASIC}LHG in the Control group isn`t surprising. Different

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tipes of snatches, specific position and holding the bar with both hands in Power Lifting contributed the specific adaptation witch resulted loss of functional domination of one hand or in equalising diabillity in both hands, for the level of maximal isometric hand grip force as for the intesity of gradient of force increase of hand grip ($RFD_{BASIC}HG$) in both hand. The maximal average index value on relation of explosive force between dominant and non - dominant hand ($RFD_{BASIC}Nd/DoHG_{iso}$) was established in Power Lifting – 0.9608 (in other words, basic explosivity of hand grip force of no – dominant hand is on the level of 96.08% of basic explosivity of hand grip force of dominant hand), 0.9023 in well trained group and 0.7024 in Control group.

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