INFLUENCE OF NUMBER OF TRIALS, GRIP BREADTH AND ELBOW POSITION ON THE MAXIMAL GRIP STRENGTH

by

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The aim of this study was to evaluate chosen conditions of global grip strength of people in good health. The study included 70 subjects divided into two groups of 35 people each. Groups were tested in the elbow joint positions of 0° and 90°. A calibrated Jamar dynamometer was used for the study. The arm positions were the same as the standard arm positions recommended by the American Society of Hand Therapists. We analysed the problem how the forearm position, some chosen morphological features and the dynamometer position affected the global grip strength. The authors noted that the highest values of grip strength were most often achieved with the position of resistance beam at the dynamometer level II. The dominant hand was usually stronger and the highest strength value was decidedly registered during the first trial. Results acquired and statistical calculations showed that higher values of strength were noted in such configuration of the upper limb where the elbow joint was straight. The search of dependence between features of body build and grip strength enabled the authors to present a vast matrix of correlation factors.

key words: grip strength, morphological features, elbow joint position, the Jamar dynamometer.

Introduction

The value of grip strength is the fundamental function of a hand [Johanson and others 1998] and is recognised as the measurement of the upper limb energy and functions sum [Beaton and others 1995; Nitschke and others 1999]. The standard functions of a hand are proper activity of internal as well as external muscles and proper complicated stability between hand's extensors and flexors [Jarit 1991]. Hand's injuries usually influence the grip strength temporarily or

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constantly [Beaton and others 1995]. That's why grip strength measurements are often a part of evaluation of people in good health as well as those with various chronic illnesses. Grip strength measurements help to evaluate functional losses hand and carpus's injury after suffered trauma [Marion and Niebuhr 1992], in case of rheumatoid arthritis of carpal tunnel syndrome [Lusardi and Bohannon 1991]. Grip strength is also used as an instrument in evaluating and setting therapeutic and surgical treatment programme [Beaton and others 1995]. Grip strength compared with the non-injured part may give objective proofs of rudimentary hand inefficiency [Josty and others 1997]. It is also a commonly used strength test in most test batteries (YCSPFT, Eurotest, etc).

Various instruments and measurement devices are used to evaluate hand's strength - among them the modified sphygmomanometer mostly used for evaluation of patients with originally progressing rheumatoid arthritis [Lusardi and Bohannon 1991], or a manual dynamometer of Jamar. The Jamar manual dynamometer is one of the main measurement devices used for this aim, the more so as it is recommended by the American Society of Hand Therapists [Nitschke and others 1999] and widespread in the group of hand therapists all over the world. It is used to evaluate the grip degree and strength during the grip in various hand and carpus positions to measure strength of particular grips /palmar, pinch/. It is also widely used to evaluate inefficiency of the upper limb [Joughin and others 1993].

Many authors cite in their studies the measurements with the usage of the Jamar dynamometer, among them: Lusardi and Bohannon [1991], Mathiowetz [1990] or Nitschke and others [1999].

The aim of this study was the evaluation of chosen conditions (such as body height and body mass, chosen morphological features and fatigue) on maximum grip strength values of people in good health. We have also studied influence of elbow joint position straight and bended to 90º and moving resistance beam of the dynamometer on grip values achieved. We cited works of other authors adopting similar study methods and choosing features suggested by the American Society of Hand Therapists.

Material and methods.

The study included 70 subjects, students of physiotherapy at the Academy of Physical Education (39 women and 31 men) aged 20 to 35 years. The mean age in the studied group was 27,5 years.

All subjects were in good physical health with normal functions of both hands and without any neurological defects. Students who had had any hand or forearm injuries which could have some influence on the results, were excluded from the test. Only right-handed subjects took part in the study and they were grouped according to their sex.

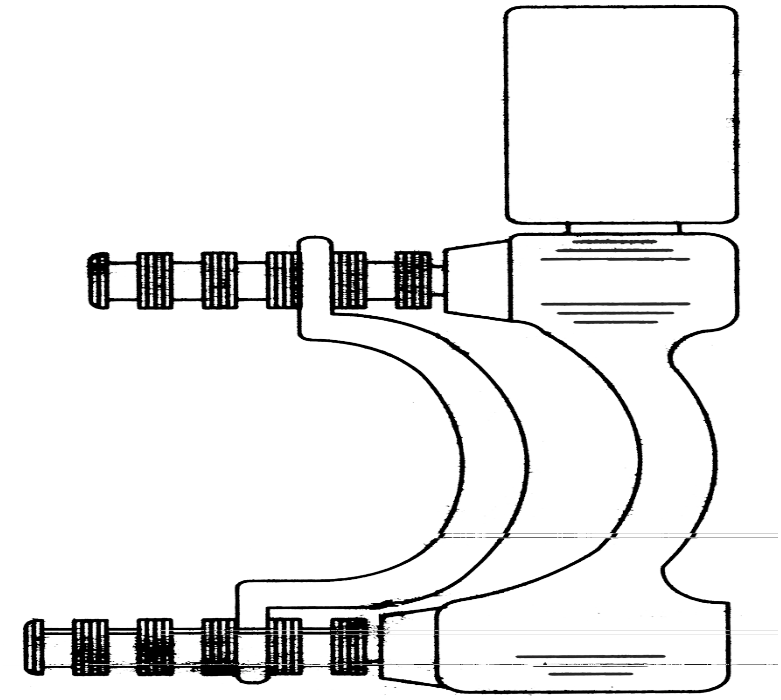

Fig. 1. The Jamar manual dynamometer Deluxe by TEC model 0030J04 [after the instruction of usage of the Therapeutic Equipment Corporation 1990].

A calibrated manual Jamar dynamometer of TEC, model 0030J04 (fig. 1) was used for the study. Regulated positions of the dynamometer - the smallest grip was labelled as level I and the largest as level V - enabled to assess size of grip in each position. The instruction of the Jamar dynamometer usage [Therapeutic Equipment Corporation 1990] shows possibility of increasing the grip breadth from 1.35 inch on the first level to 3.35 inches on the fifth level (1 inch = 2.54 cm). The grip strength was assessed in all of the five dynamometers positions beginning with the smallest grip at the first level, ending with the largest grip at the fifth level. The subjects were divided into 2 groups of 35 people each (I group – 16 women and 19 men, II group – 22 women and 13 men). The first group was tested in the initial elbow joint position of 0° and later in the position of 90°. The second group had the grip strength tested in opposite sequence, i.e. first in the elbow joint position of 90°, then - 0° position.

The tested positions fulfilled the standards of the American Society of Hand Therapists: a comfortable standing position, shoulder adducted and indirectly rotated, forearm in neutral, bended to 90° or straight. According to the studies and suggestions of other authors, wrist position was between 0° and 30° of extension and between 0° and 15° of ulnar deviation [Crosby and Wehbe 1994, Cederlund and others 1999; Marion and Niebuhr 1992; Mathiowetz 1990; Woody and Mathiowetz 1988].

Before the test every subject was instructed how squeeze the gauge (also demonstrated the right grip) and asked to practise the grip once. If necessary the position or method of gripping was corrected. The dominant hand was tested as the first one. The results of measurements were given in kG and values acquired during the test were read only by the examiner.

Data were statistically compared (arithmetical mean, SD and Student-t Test). The relationship between results acquired while testing grip strength and forearm's position and some chosen morphological features (body mass, body weight and others) was evaluated with the help of correlation coefficient. Linear measurements of forearm and hand helped to calculate the coefficient of forearm's shape (WKP) and the coefficient of hand's shape (WKR) according to formulas [Nappier 1980]: $\mathrm{WKP} = \frac{\mathrm{O}}{\mathrm{D}} \times 100\%$, where O = forearm's measurement in 1/3 of its proximal length and D= forearm's length, and $WKR = \frac{S}{D} \times 100\%$, where S= hand's breadth and D = hand's length.

Results

Since the highest values were acquired by the subjects at the first trial and at the dynamometer levels II and III, most of the tables presented below analyse only these results.

Tables 2 and 3 show the results of the differences analysis with the usage of Student-t Test for women and men in both tested groups in the field of grip strength value and influence of forearm position on its value. This analysis was made to find answers to the below questions:

1. Is there any tendency to form statistically essential difference between values of arithmetical means of evaluated grip strength results and elbow joint position?

2. Is there any essential difference between both tested groups, i.e. whether fatigue has any influence on decreasing measurement results?

To answer the above questions we compared results of global grip during the first trial at the second and third dynamometer levels for both studied groups.

Data analysis shows that almost always the values of the first trial at the second dynamometer level are higher than in the first trial at the third level. The same situation is with the second trial at the second level where values are higher than the second trial at the third level. Only results of the men from the second group show a little supremacy of values at the third level (fig. 2,3,4,5).

The highest and the lowest values acquired by males and females at the third level of the dynamometer in both groups, show univocally greater grip strength of men (tab. 1). It is worth mentioning that the lowest values of grip strength of men in both groups are higher than the highest values acquired by women. Proportions of limit values are in the first group 21:3 and in the second group - 15:9. While during trials at the first and second levels of dynamometer all the maximum values acquired by women are higher than the minimum values of men.

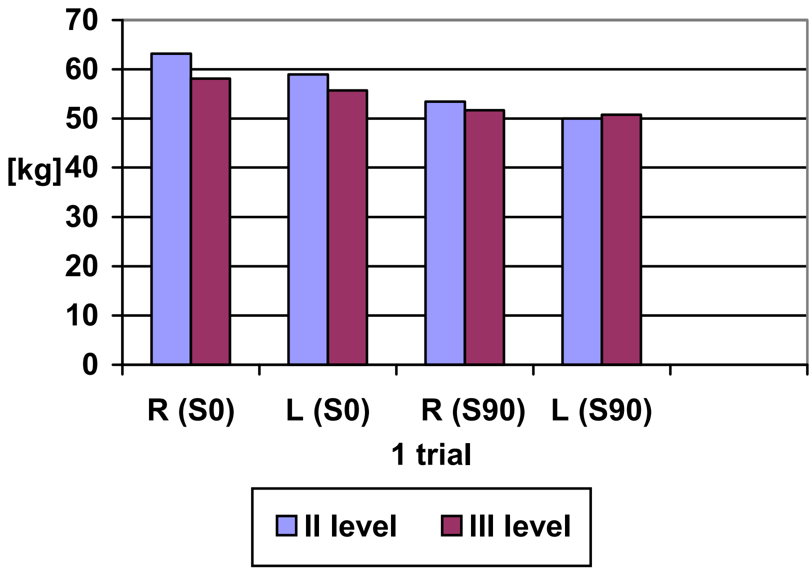

Fig. 2. Mean values of grip strength – male – I group studied

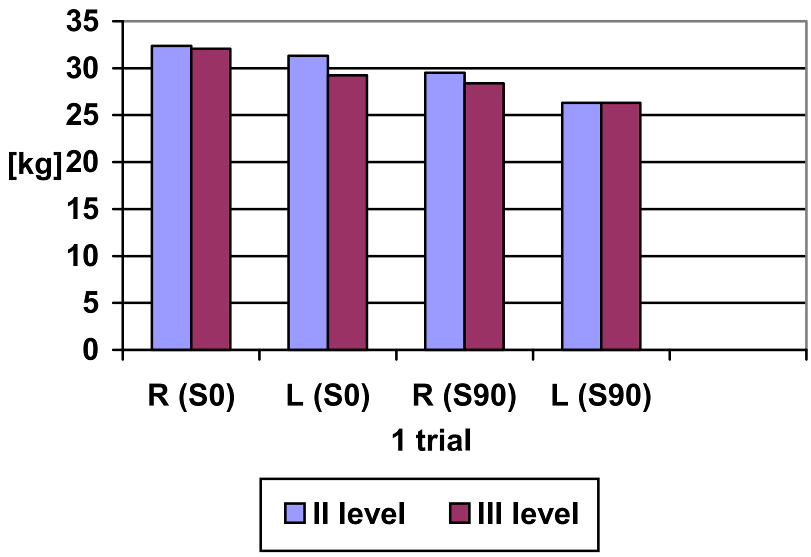

Fig. 3. Mean values of grip strength – female – I group studied

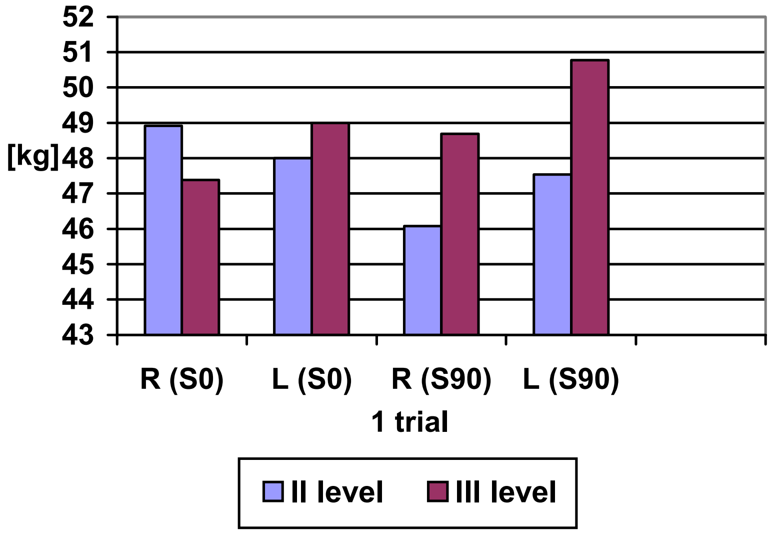

Fig. 4. Mean values of grip strength – male – II group studied

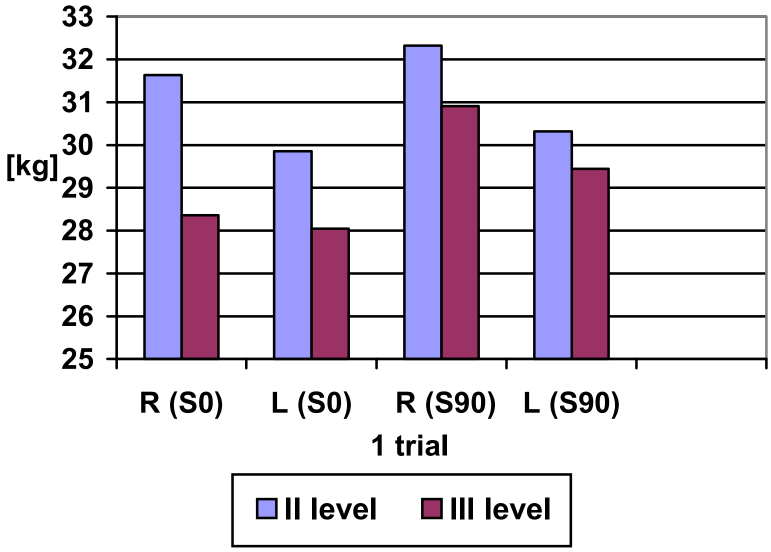

Fig. 5. Mean values of grip strength – female – II group studied

Table 1. Values of grip strength during the first trial for I and II groups studied

Initial position	Dynamometer level	Men – I group				Women – I group			
		values min.	values max.	x	s	values min.	values max.	x	s
R (S 0°)	II	46	81	63,16	9,95	19	47	32,38	6,93
	III	42	75	58,11	8,81	19	43	32,06	6,58
L (S 0°)	II	39	76	59,00	8,98	23	41	31,31	6,51
	III	39	73	55,74	9,36	20	40	29,25	6,48
R (S 90°)	II	36	72	53,47	9,14	20	38	29,50	5,05
	III	37	69	51,68	8,86	17	39	28,38	6,61
L (S 90°)	II	31	68	50,05	8,92	17	37	26,31	6,36
	III	39	64	50,79	7,78	17	32	26,31	4,57

Initial position	Dynamometer level	Men – II group				Women – I group			
		values min.	values max.	x	s	values min.	values max.	x	s
R (S 0°)	II	37	66	48,92	9,31	14	42	31,64	6,25
	III	38	57	47,38	6,96	16	35	28,36	4,73
L (S 0°)	II	36	64	48,00	9,46	20	40	29,86	5,19
	III	40	60	49,00	6,34	16	38	28,05	5,29
R (S 90°)	II	39	63	46,08	6,28	19	44	32,32	7,25
	III	38	60	48,69	6,87	24	41	30,91	4,66
L (S 90°)	II	34	76	47,54	11,56	15	44	30,32	7,30
	III	43	66	50,77	7,87	14	39	29,45	6,12

All the maximum values of grip strength acquired by men are higher than maximum values of grip strength of women. This dependence refers to all the dynamometer measurements for both groups. There is only one exception in the second female group in the S 90° elbow joint position, at the first level of dynamometer.

Analysing the table 2 we can see that the position of elbow joint significantly affects value of grip strength on both sides especially with the first male group tested at the II dynamometer level. Dependence of results achieved on the elbow joint position can be also observed in the male group I at the III dynamometer level for a right hand and in the female group I at the II dynamometer level but for a left hand. No dependence of grip strength values on the elbow joint position was observed only in the male group II. In female group II statistically essential difference at the level of essentiality of p<0.05, was acquired only at the III dynamometer level for a left hand. In case of remaining result we have no reason to reject the hypothesis of medium equality and acquired differences in values are statistically meaningless.

Table 2. Values of Student t Test for I and II groups studied

Initial position	Male - I group (n - 1= 18)		Female - I group (n -1 = 15)	
	Dynamometer level II	Dynamometer level III	Dynamometer level II	Dynamometer level III
	d	d	d	d
R (S 0°) i R (S 90°)	3,04 **	2,18 *	1,30	1,53
L (S 0°) i L (S 90°)	3,00 **	1,72	2,13 *	1,43

Initial position	Male - II group (n - 1 = 12)		Female - II group (n - 1 = 21)	
	Dynamometer level II	Dynamometer level III	Dynamometer level II	Dynamometer level III
	d	d	d	d
R (S 0°) i R (S 90°)	0,88	- 0,46	- 0,47	- 2,37 *
L (S 0°) i L (S 90°)	0,11	- 0,61	- 0,37	- 1,15

* p < 0,05
** p < 0,01
*** p < 0,001

Comparing result for hands on the same side with the help of Student-t Test between groups I and II, we must state that results in the male group are statistically significantly different, above all in the field of values acquired with the elbow joint extended as well at the second level as at the third level. There was no significant difference in the remaining values including results of women which means that the initial position does not affect the value of the grip strength (tab. 3).

Table 3. Values of Student t Test for I and II groups studied

Initial position	Male (n1 + n2 - 2 = 32)		Female (n1 + n2 - 2 = 36)	
	Dynamometer level II	Dynamometer level III	Dynamometer level II	Dynamometer level III
	d	d	d	d
R (S 0°) gr. I i R (S 0°) gr. II	- 3,95 ***	- 3,56 **	- 0,33	2,02 *
L (S 0°) gr. I i L (S 0°) gr. II	- 3,22 **	2,19 *	- 0,74	- 0,61
R (S 90°) gr. I i R (S 90°) gr. II	- 2,45 *	- 0,99	- 0,38	- 1,35
L (S 90°) gr. I i L (S 90°) gr. II	0,67	- 0,01	1,72	1,68

* p < 0,05
** p < 0,01
*** p < 0,001

We observe no essential relationship between the grip strength and body mass and height. Single cases of moderate correlation value refer mainly to the body height of males in the second group tested (tab. 4).

Table 4. Values of correlation coefficient for the mean values of body mass and height and handgrip strength for I and II studied groups

Morphological features	Male - I group							
	R (S 0˚)		L (S 0˚)		R (S 90˚)		L (S 90˚)	
	Dynamometer level				Dynamometer level			
	II	III	II	III	II	III	II	III
Body mass	- 0,50	- 0,06	- 0,30	0,15	- 0,49	- 0,14	- 0,47	- 0,05
Body height	- 0,49	- 0,24	- 0,18	0,10	- 0,20	0,02	- 0,33	0,10

Morphological features	Female - I group							
	R (S 0˚)		L (S 0˚)		R (S 90˚)		L (S 90˚)	
	Dynamometer level				Dynamometer level			
	II	III	II	III	II	III	II	III
Body mass	- 0,38	- 0,18	- 0,34	- 0,13	0,03	- 0,20	0,22	0,28
Body height	0,32	0,44	0,19	0,22	0,36	0,33	0,46	0,52

Table 4

Morphological features	Male - II group							
	R (S 0˚)		L (S 0˚)		R (S 90˚)		L (S 90˚)	
	Dynamometer level				Dynamometer level			
	II	III	II	III	II	III	II	III
Body mass	0,21	0,50	0,12	0,12	- 0,02	0,20	0,40	0,07
Body height	0,500	0,20	0,60	0,40	0,44	0,58	0,59	0,52

Morphological features	Female - II group							
	R (S 0˚)		L (S 0˚)		R (S 90˚)		L (S 90˚)	
	Dynamometer level				Dynamometer level			
	II	III	II	III	II	III	II	III
Body mass	0,08	0,14	0,34	0,15	0,35	0,31	0,59	0,55
Body height	0,05	0,19	0,00	0,34	0,06	0,28	0,18	0,34

From the analysis of table 5 one can see that the greatest dependence of grip strength on morphological features in group I is seen at level III and partly at level II of dynamometer both in the dominant and non-dominant hands. This dependence refers to both women and men at the same time positively influence of analysed features is observed in the female group at the level III of dynamometer with elbow joint bended. From all the analysed morphological features in the group I most often a moderate and significant dependence refers in the group of males to the widest arm and forearm’s measurements, axillary measurement and WKP for both hands and the widest forearm's measurement, hand's breadth and WKP in the group of females.

In the group II (tab. 6) correlation coefficient of grip strength and morphological features positively differ from the results in group I. There are no significant dependences in female groups except the results of grip strength at the second level for the dominant hand in the elbow joint position of S 90° and this dependence refers only to two morphological features: the broadest forearm's measurement and WKP. A little bigger correlation is seen in the second group of males in every elbow joint position and refers mainly to the hand's breadth and partly WKR and absolute length of upper limb.

Table 5. Values of correlation coefficient for mean values of morphological features and handgrip strength for I group tested.

Morphological features	Male							
	R (S 0˚)		L (S 0˚)		R (S 90˚)		L (S 90˚)	
	Dynamometer level				Dynamometer level			
	II	III	II	III	II	III	II	III
Absolute length of upper limb	0,24	0,22	0,07	0,10	- 0,16	- 0,07	- 0,09	0,16
Relative length of upper limb	0,12	0,20	- 0,08	0,08	- 0,24	- 0,08	- 0,24	0,11
Segment length of arm	- 0,03	- 0,28	- 0,13	- 0,41	- 0,28	- 0,41	- 0,29	- 0,34
Segment length of forearm	0,19	0,27	0,21	0,41	- 0,12	0,14	0,10	0,28
Segment length of hand	0,27	0,44	0,26	0,55	- 0,27	0,18	0,22	0,23
Axillary measurement	0,70	0,36	0,44	0,36	0,22	0,19	0,60	0,34
The widest measurement of arm	0,56	0,44	0,56	0,46	0,29	0,36	0,65	0,53
The widest measurement of forearm	0,48	0,47	0,67	0,68	0,52	0,52	0,71	0,71
Hand's breadth	0,16	0,32	0,09	0,34	- 0,10	0,03	- 0,14	0,16
WKP	0,22	0,14	0,46	0,30	0,46	0,27	0,58	0,43
WKR	- 0,05	- 0,01	- 0,11	- 0,11	0,10	- 0,10	- 0,35	- 0,03

Morphological features	Female							
	R (S 0˚)		L (S 0˚)		R (S 90˚)		L (S 90˚)	
	Dynamometer level				Dynamometer level			
	II	III	II	III	II	III	II	III
Absolute length of upper limb	- 0,08	0,22	0,01	0,37	0,29	0,43	0,16	0,43
Relative length of upper limb	0,14	0,41	0,34	0,45	0,35	0,52	0,14	0,36
Segment length of arm	- 0,13	0,10	0,02	0,37	0,38	0,34	0,24	0,38
Segment length of forearm	- 0,03	0,50	- 0,08	0,57	0,03	0,37	- 0,03	0,46
Segment length of hand	0,19	0,40	0,24	0,50	0,30	0,56	0,22	0,53
Axillary measurement	0,27	0,23	0,18	0,23	0,21	0,33	0,09	0,04
The widest measurement of arm	0,25	0,29	0,36	0,54	0,16	0,46	0,24	0,43
The widest measurement of forearm	0,45	0,60	0,44	0,68	0,30	0,66	0,46	0,61
Hand's breadth	0,50	0,55	0,63	0,56	0,34	0,62	0,60	0,64
WKP	0,54	0,45	0,50	0,46	0,34	0,53	0,50	0,44
WKR	0,27	0,16	0,37	0,10	0,05	0,10	0,36	0,15

Table 6. Values of correlation coefficient for mean values of morphological features and handgrip strength for II group tested.

Morphological features	Male							
	R (S 0˚)		L (S 0˚)		R (S 90˚)		L (S 90˚)	
	Dynamometer level				Dynamometer level			
	II	III	II	III	II	III	II	III
Absolute length of upper limb	- 0,45	- 0,16	- 0,34	- 0,21	- 0,32	- 0,31	- 0,41	- 0,12
Relative length of upper limb	- 0,28	- 0,02	- 0,06	0,00	- 0,14	- 0,24	- 0,30	- 0,07
Segment length of arm	- 0,31	- 0,18	- 0,19	- 0,13	0,08	- 0,18	- 0,22	- 0,29
Segment length of forearm	- 0,06	0,27	- 0,27	0,09	0,03	0,24	0,06	0,16
Segment length of hand	- 0,13	0,18	0,09	0,08	0,00	0,04	- 0,34	0,05
Axillary measurement	- 0,06	0,10	- 0,26	0,01	- 0,40	0,09	- 0,37	- 0,05
The widest measurement of arm	0,14	0,13	0,09	0,19	- 0,09	0,23	- 0,12	0,21
The widest measurement of forearm	0,16	0,13	0,07	0,16	- 0,17	0,12	- 0,19	0,19
Hand's breadth	0,52	0,22	0,63	0,40	0,63	0,42	0,43	0,33
WKP	0,17	- 0,11	0,20	- 0,09	- 0,19	- 0,10	- 0,21	0,01
WKR	0,49	0,13	0,39	0,23	0,50	0,34	0,42	0,18

Morphological features	Female							
	R (S 0˚)		L (S 0˚)		R (S 90˚)		L (S 90˚)	
	Dynamometer level				Dynamometer level			
	II	III	II	III	II	III	II	III
Absolute length of upper limb	- 0,26	- 0,22	- 0,30	- 0,09	- 0,29	- 0,09	- 0,27	- 0,14
Relative length of upper limb	- 0,21	- 0,21	- 0,33	- 0,13	- 0,35	- 0,08	- 0,28	- 0,16
Segment length of arm	- 0,16	- 0,19	- 0,23	- 0,16	- 0,16	- 0,09	- 0,32	- 0,27
Segment length of forearm	0,01	- 0,01	- 0,15	- 0,06	- 0,06	0,03	0,08	0,02
Segment length of hand	0,13	0,36	- 0,17	0,35	0,12	0,29	- 0,03	0,13
Axillary measurement	0,26	0,19	0,23	0,27	0,32	0,23	0,25	0,10
The widest measurement of arm	0,17	0,31	0,14	0,12	0,27	0,18	0,24	0,14
The widest measurement of forearm	0,12	0,26	0,08	0,19	0,52	0,25	0,25	0,08
Hand's breadth	- 0,15	- 0,03	- 0,30	0,08	- 0,06	0,02	- 0,07	0,03
WKP	0,07	0,18	0,18	0,18	0,43	0,16	0,14	0,05
WKR	- 0,21	- 0,27	- 0,13	- 0,12	- 0,11	- 0,16	- 0,01	- 0,02

S – sagital plane
R – right
L – left

Comparing results between groups tested we must state that the same features, i.e.the broadest forearm's measurement and WKP have influence on the value of female grip strength (in group I as well as in group II). In the male group we noticed opposite situation, the broadest forearm's measurement and WKP had the greatest influence on their results in group I while in group II - hand breadth and WKR.

Discussion

Standard, clinical measurements of grip strength most often includes 1, 2 or 3 trials without any previous warming up and is treated as the measurement of maximum strength of a hand [Marion and Niebuhr 1992]. Patterson and Baxter [after Mathiowetz 1990] showed that the maximum strength is acquired during the first trial, then during the third and second trials which is accordingly 35%, 34% and 31% of total number of tests but above values were gained with a 1-minute break. With a 5-seconds, the maximum strength was also observed in trials 1 and 2 and then trial 3 (accordingly 66%, 21% and 13%). These results prove the influence of fatigue on grip strength. Mathiowetz [1990] points out that the usage of 3 trials gives better results than double trials but he also emphasises that reliability of both trials is comparable. Knowing these results we adopted in our study the procedure of measurement in two trials, like Josty and others [1997].

In many studies, the problem of fatigue influence on acquired strength values is often raised in spite of keeping some procedures eliminating the above phenomenon. According to Mathiowetz [1990], from the analysis of nowadays literature it is not clearly evident whether the therapist should be afraid of the fatigue influence on grip strength measurement using the recommended standard procedure, i.e. 3 grip trials with 15-seconds breaks between each of them or maybe 5-seconds break, as in the Beaton's measurement procedure [Beaton and others 1995].

In our study we compared results of global grip in 2 trials at all dynamometer levels for both groups tested. Values acquired univocally show higher results in the first grip trial with the procedure of 15-seconds breaks between successive squeezes and 2-minutes breaks between next dynamometers levels. The length of breaks although sometimes bigger than in the case of other authors [Beaton and others 1995, Trossman and Li, after Lusardi and Bohannon 1991] seems to be not sufficient after all. It might suggest, which is mentioned by Mathiowetz [1990]. Comparison of the study results confirm that time between successive trials is a very important factor for the grip strength and fatigue effect can be especially observed in the male group with grips performed at first with the elbow straight.

Many of the authors testing the grip strength limit their studies only to the second level of the dynamometer, for women as well as for men [Beaton and others 1995, Cederlund and others 1999, Johnson 1991]. Nitschke and others tested the grip strength at the third level of dynamometer although they cite other scientific studies in which the greatest grip strength was observed at the second level of dynamometer. Acquired by us results of grip strength for women and men univocally confirm that the value of strength measured at the second level of dynamometer is greater than the one measured at the level III. It is difficult for us to explain the reason why the highest grip strength values are developed first of all at the levels II and III. of the dynamometer resistance beam. Still our results are unanimous with the results of the other authors and concurrence of these give basis to choose the level II of the dynamometer in routine studies on grip strength.

Another aim of our study was to answer the question if the position of elbow joint significantly influences the grip strength. Woody and Mathiowetz [1988] tested the influence of elbow joint position on the value of global handgrip and stated - with 20 women in good health tested - a greater grip strength with the elbow bended at 90° than in the position of 0°. Results acquired by us confirm Mathiowetz's results but only for the second group of women, where medium values of grip strength are higher with the elbow joint bended. It refers both the II and the III positions of the dynamometer. Beaton and others [1995] in their studies point out a very significant difference in the grip strength between elbow joint positions of 45° and 90°. Our studies which were concentrated on testing differences between elbow joint positions of 0 and 90, confirm this differentiation and indicate essential influence of elbow joint positions on achieved values of grip strength. Minimum, maximum and medium values of grip strength univocally show that higher values are acquired with the elbow joint straight in the first groups of males and females, both at the dynamometer levels II and III, which means that it is better to measure grip strength with the elbow joint straight. Results of studies in group I in relation to diverging results of group II, studied at first with the bended position and then with the elbow joint straight, might suggest fatigue influence on results acquired which is mentioned further on our discussion. Gaining the answer to our question asked in the aim of this study, does not explain why it happens so and why results acquired differ in studied groups. In the author's opinion, higher values achieved in the straight elbow joint position arise from the distance insertions of muscles, mainly fingers' flexors.

Results comparison of grip strength of dominant and non-dominant hands is a commonly known criterion of division and analysis. Such comparisons can be found among others in Bechtol's publications (1954) [Josty and others 1997]. Those who test the value of grip strength between the dominant and non-dominant hands confirm in their studies the superiority of dominant hand's strength over non-dominant hand's strength [Crosby and others 1994] though Cosby and others observed that the maximum nondominant handgrip strength was often greater than the maximum dominant handgrip strength. In our studies this dissimilarity of results was the least observed in the tests at level II on which only 1/3 of subjects did not show the maximum muscle strength. Jarits studies [1991] in the field of comparing dominant and non-dominant handgrip strength proved that there is no significant difference in values discussed. Generalising we can state that our studies confirmed a distinct supremacy of dominant hand over the non-dominant one for female group as well as for male group at various dynamometer levels and with different elbow joint positions.

According to the suggestions of the American Society of Hand Therapists, the body mass as well as the body height should be considered during tests as factors significantly influencing the value of grip strength. All the more, that the most of reference books devoted to the muscular strength of a man, underline existence of a strong relationship between muscular strength and body build, especially body mass. It also refers to the strength of muscles responsible for "gripping" the dynamometer. Acquired by us results do not confirm this to the end. The lack of strong relationship between the body mass and the value of being developed grip strength may possibly point to influence of other factors such as: hobby or occupation, on values achieved. Only the body height in the second male group point to a strong relationship with muscular strength of fingers' flexors.

In the field of some morphological features (for instance: hand's breadth) our studies confirmed rightness of these suggestions in a very limited area, i.e. in the first female group and the second male group, although the whole of our studies results clearly confirmed sexual dimorphism which was also proved by other authors [Cosby and others 1994, Ford and others 1990, Hai and others 1999]. Achieved results of correlations of medium values of morphological features and grip strength are recurrently so different and vast that, according to the authors, they deserve a separate study.

Results

1. There exists a distinct domination of the dominant hand over the non-dominant one in the value of grip strength.
2. The value of global grip strength depends on the dynamometer level - is the highest at the level II position of the resistance beam and this fact should decide about the choice of this level in studies on grip strength.
3. Maximum values of global grip are mostly acquired during the first trial.
4. There exists a dependence of global grip value on some morphological parameters (mainly the widest forearm's measurement and hand's breadth).
5. Elbow joint position essentially conditions the value of tested strength.
6. The highest values of strength are observed at the straight elbow position.

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