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INFLUENCE OF MAXIMUM OR SUBMAXIMUM EFFORT ON THE LOAD DISTRIBUTION OF THE HAND

M. Mühldorfer-Fodor, E. Cenik, KJ Prommersberger, Klinik für Handchirurgie, Bad Neustadt /Saale, Germany

T. Mittlmeier, Universitätsklinik Rostock, Germany, P. Hahn, Vulpius Klinik, Bad Rappenau, Germany

Introduction:

Grip force testing is an important parameter to assess hand function. Numerous clinical tests exist to recognize feigned grip force loss. Most of them base on using the Jamar dynamometer, like e.g. the rapid exchange grip test or the 5-rung test. In the literature, a sensitivity of 55-70% and a specificity of 66-92% for those tests were reported. Digital evaluation of grip force testing seems to be a promising approach; for those, clinical results are still missing.

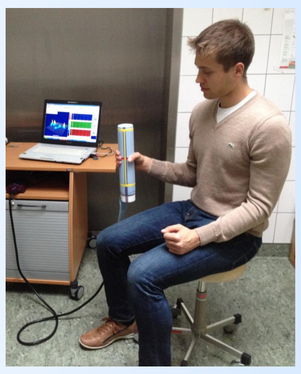
The Manugraphy system analyzes the load distribution of the hand during cylinder grip. The question arose if the individual load distribution pattern of the hand might be a criterion to distinguish sincere from insincere effort during grip force testing.

This study investigated the question: Does a simulated force loss during grip force measurement influence the load distribution pattern of the hand?

Methods:

Fifty-four healthy subjects, all right handed, half men and half women, had grip force measurement on two different days. The 20cm cylinder of the manugraphy system was used, which is coated with a pliance sensor matrix (Fig. 1). The subjects were instructed to perform grip force measurement using one hand with maximum force, the opposite hand with 2/3-3/4 of the maximum force to pretend weakness. The side, which had to perform submaximal effort at the first session, was randomized; sides changed at the second visit. (Fig. 2)

Fig. 1:
Grip force measurement with the Manugraphy system.



The total grip force as well as the loading pattern within thumb, fingers, thenar and hypothenar was analyzed. Further, the percent contribution of these 7 areas to the total load was calculated. Using the Wilcoxon test, the corresponding areas were compared with regard to maximum force of both hands, maximum /submaximum force of the same hand and maximum force on one hand compared to the submaximum force of the opposite hand. The latter comparison corresponds to the clinical situation, when a person feigns grip loss. Additionally, the grip force values were analyzed by machine learning to establish a predictive model that can distinguish between maximum and submaximal effort by the load distribution pattern of the hand.

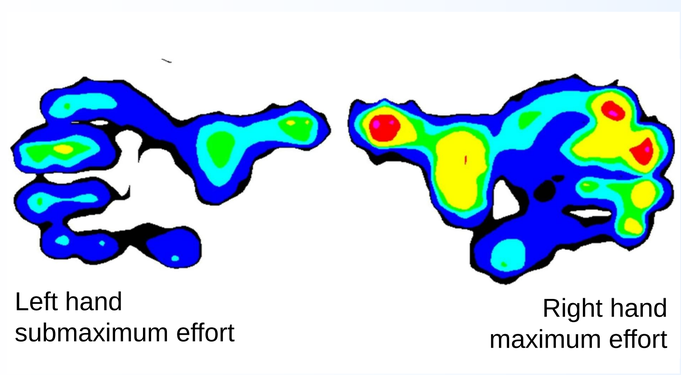
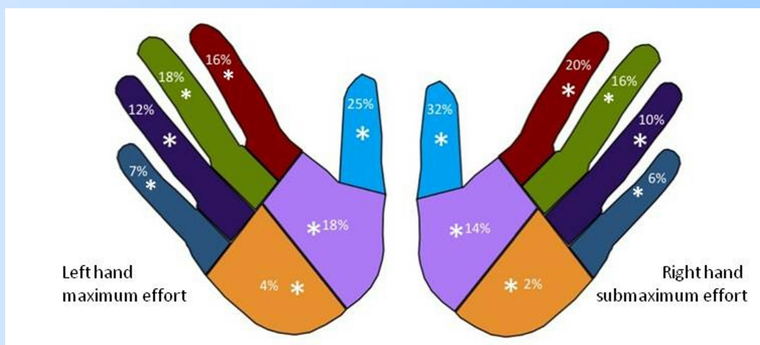


Fig. 2: Manugraphy diagram: With maximum effort, index and middle finger tips apply a similar, high load; with submaximum effort, the index finger tip contributes less than the middle finger, the maximum of the middle finger shifts from the finger tip to the middle phalanx.

Results:

For the submaximum measurement, the subjects exerted much less force than intended, with was 30-41% of the maximum force on average. Comparing both hands using maximum force, the load distribution was similar. The load distribution of the hands differed significantly comparing the maximum and submaximum effort: 5/7 areas were different for the right hand, 4/7 areas for the left hand.
Comparing a sub-maximum effort of the right hand to the maximum force of the left hand, all seven areas were different (Fig. 3). Vice versa, using the left hand submaximally and the right hand with maximum force, 5/7 areas were different.
Despite of these differences, predicting maximum versus submaximum effort by only statistical methods was not possible.



200 mm cylinder	P	Left max %	Right submax %	Ø Difference between areas	SD of difference
Thumb	**<0,01**	25	32	8,4%	7,4
Index	**<0,01**	16	20	4,9%	4,0
Middle	**0,01**	18	16	3,9%	3,2
Ring	**<0,01**	12	10	2,9%	2,1
Small	**0,04**	7	6	2,5%	1,9
Thenar	**<0,01**	18	14	5,4%	3,5
Hypothenar	**<0,01**	4	2	2,6%	2,1

Fig. 3:
Left hand maximum effort, right hand submaximum effort:

The percent contribution of seven anatomical areas to the total load of the hand are compared, significant differences are marked with *.

In the table, differences of percent contribution are shown after correction of positive and negative signs.

Using machine learning, a sensitivity of 98% and a specificity of 90% identifying submaximum effort was achieved. Assuming a prevalence of 10% of people who will perform the test with submaximal effort, the positive predictive value was 54 % and the negative predictive value was 99,7 % calculated with Bayes Theorem.

Conclusion:

This study asserted that load distribution of the hand during cylinder grip differs in sincere and insincere effort. Common statistical methods are appropriate to compare the results of a larger study group. To distinguish a sincere grip force effort from a faked grip force loss was achieved by using an computed algorhythm, which was created by machine learning.

Contact:
Dr. Marion Mühldorfer-Fodor, Klinik für Handchirurgie
Salzburger Leite 1, 97651 Bad Neustadt/Saale, Germany
muehldorfer3@gmx.de