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A NEW DYNAMOMETER FOR MEASURING THE ISOMETRIC STRENGTH IN HUMAN FINGER FLEXORS

By

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Routine estimation of strength in the finger flexors is a clinical procedure the result of which is recorded according to *Seddon* (1953) in values ranging from zero (no strength) to five (Full strength). This grading, of course, is somewhat arbitrary and the reproductibility even in the hands of a well-trained examiner is somewhat dubious. The shortcomings of the method are intensified if the patient is subsequently tested by different examiners.

An objective estimation of strength in the flexor digitorum sublimis and profundus muscles is useful or indispensable in a number of situations viz. in postparalytic conditions, in training, after nerve and tendon repair, and in cases where a sublimis tendon is wanted for reactivation of thumb or finger function other than the original one.

In an attempt to obtain a more objective estimation than the above mentioned, the authors have designed a finger-flexor dynamometer, to be described in the following.

THE APPARATUS

The dynamometer registers the isometric muscle strength as a torque by means of strain-gauges glued to a steel spring. This is the fundamental principle in various recent test-methods. (*Darcus* (1951), *Asmussen et al.* (1959)).

The dynamometer here described is designed for testing the strength of the proximal and distal interphalangeal (IP–) joints of the right third finger exclusively. However, it can easily be modified for testing of these joints on any finger.

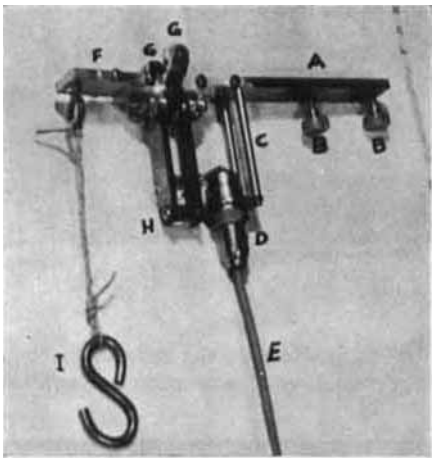

Fig. 1.
The Dynamometer. A: brass bar, 150 × 25 × 5 mm. F: brass bar 50 × 25 × 5 mm. G: ball-bearings, connecting A with F. H: U-shaped steel spring, the left leg of which is furnished with two strain-gauges, one on either side. B: nuts for screwing the dynamometer to the plate, shown in Fig. 2.

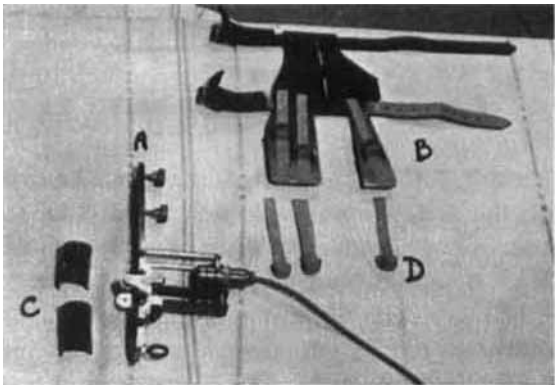

Fig. 2.
A: the dynamometer. B: the handplate. C: the semi-cylindroid splints for fixing the fingers not tested. D: the wedges used to obtain hyperextension in the distal phalanges.

The dynamometer (Fig. 1) consists of a 150 × 25 mm. brass-bar hinged to a 60 × 25 mm. brass-bar with ball-bearings. The axis of rotation between these bars is located 11 mm. above the bar level. The free rotation on the axis is prevented by a U-shaped steel spring upon which the strain-gauges are fastened. The dynamometer is screwed on a plate

Fig. 3.
Hand of person to be tested, mounted in the apparatus. The non-tested fingers can be seen hyperextended. The amplifier is seen to the left.

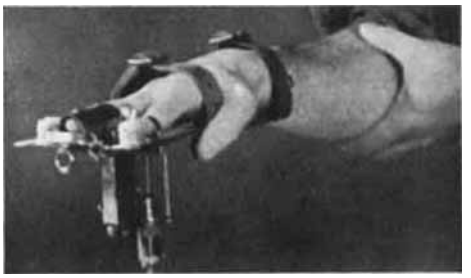

Fig. 4.
A closer view of the hand, seen in Fig. 3.

to which the second, fourth and fifth fingers can be immovably fixed, eventually with the distal IP-joints hyperextended (Fig. 2). A Philips' direct reading measuring bridge PR 9300 (Fig. 3) was used for registering the results. The calibration was carried out with known torques and registered in kg. × cm. Thus it was possible to record a virtually rectilinear calibration-curve, which was utilized in judging the test results. Maximal deflection on loading corresponded to approximately 19 kg. × cm. in largest amplification, and in the second largest amplification to approximately 63 kg. × cm. The inaccuracy of the individual reading was estimated to between one and three per cent.

TEST METHOD

It was our purpose to obtain an impression of the isometric strength in m. flexor digitorum sublimis and profundus.

Flexion of the distal IP-joint is an exclusive profundus muscle effect, whereas flexion of the proximal IP-joint is brought about by profundus,

as well as sublimis action. However, it is usually possible to eliminate the profundus action on the proximal IP-joint, if the distal IP-joints of the non-tested fingers are fixed in hyperextension.(*Apley* (1956)). In testing of the proximal IP-joint of the third finger this phenomenon was utilized by interposing wedges under the distal phalanges of the remaining fingers. These were immobilized under semi-cylindroid splints (Fig. 4), which could be mounted on the dynamometer. During testing of the distal IP-joint the proximal phalanx was immobilized in a similar manner. During the tests the third finger was strapped to the dynamometer in a position where the axis of the latter and that of the IP-joint were coincident. Thus is was ensured that only the forces acting upon the joint were registered.

Each person tested was urged to exert his maximal isometric strength in three consecutive periods of 2 to 4 seconds' duration each.

RESULTS

Five females (age 19–26) and five males (age 23–30) were tested. Table 1 shows the results of the testings on the IP-joints of the right third finger, and the mean values of maximal in the two sexes.

TABLE 1

Isometric strength is kg. × cm. of the right third finger during flexion of the proximal and distal IP-joints. The means of the maximae and their standard error are indicated for the two sexes.

Subject	Age	Sex	Proximal IP-joint				Distal IP-joint			
			Results of 3 tests			Max.	Results of 3 tests			Max.
BR	19	F	18.1	18.1	16.5	18.1	5.7	6.4	5.3	6.4
HA	24	F	15.9	17.3	17.3	17.3	6.0	6.4	5.3	6.4
KI	21	F	15.4	15.1	15.8	15.8	5.4	5.0	5.4	5.4
UK	26	F	16.4	15.8	15.1	16.4	5.8	6.0	6.4	6.4
EJ	23	F	10.1	10.1	10.1	10.1	5.8	5.8	6.0	6.0
					Mean: 15.5 ± 1.2				Mean: 6.1 ± 0.2	
FBM	27	M	31.1	29.0	29.0	31.1	9.8	10.9	11.2	11.2
KA	26	M	26.5	29.6	25.8	29.6	9.6	9.8	9.6	9.8
HN	23	M	25.6	25.6	19.3	25.6	6.9	6.9	6.6	6.9
FBP	30	M	25.5	25.0	25.8	25.8	10.9	12.7	10.8	12.7
JL	30	M	28.1	24.0	19.9	28.1	9.6	9.6	9.0	9.6
					Mean: 28.0 ± 1.1				Mean: 10.1 ± 1.0	

DISCUSSION

As shown in table 1, there was only a slight variation between the individual measurings, which was considered to reflect the quality of the dynamometer inasmuch as it did thus fulfil the indispensable conditions of a test-method, namely 1) objectivity, 2) slight inaccuracy, 3) reproductibility and 4) low dispersal on repeated readings.

It was not quite certain that hyperextension of the distal phalanges of the second, fourth and fifth fingers always totally eliminated the profundus action on the proximal IP-joint of the third finger during the sublimis testing here. At least it was our impression that considerable individual variations did exist, but no attempt was made to investigate this problem.

An interesting additional finding should be mentioned. It was found that dorsiflexion from a neutral position of the radio-carpal joint (180°) did not measurably augment the strength of the finger flexors. This was contrary to the prevalent conception that within certain limits the strength of a muscle—ceteris paribus—is augmented during stretching. On the other hand the flexor strength was decreased during volar flexion of the radio-carpal joint from the neutral position. This is in accordance with the above mentioned observations. However, this problem was not within the scope of the present work, so no attempt was made to investigate it under systemically varied circumstances.

SUMMARY

A new finger-flexor dynamometer is described which registers the isometric torques developed about the interphalangeal (IP)-joints. The present specimen was constructed for testing of the IP-joint of the third finger, but the apparatus could easily be modified for testing of the second, fourth and fifth fingers. The torques were registered by means of strain-gauges and a direct reading measuring bridge. The inaccuracy of the individual readings was estimated to 1–3 per cent. Five females (age 19–26) and five males (age 23–30) were tested. The isometric torque of the proximal IP-joint of the third right finger was 15.5 ± 1.2 kg. × cm and 28.0 ± 1.1 kg. × cm. for females and males respectively, and the corresponding values for the distal IP-joint were 6.1 ± 0.2 kg. × cm. and 10.1 ± 1.0 kg. × cm. respectively.

RESUME

Il est donné la description d'un nouveau dynamomètre de flexion des doigts qui enregistre le moment de force isométrique autour des arti-

culations interphalangiennes. Le présent spécimen a été construit pour contrôler l'articulation interphalangienne du majeur, mais l'appareil peut facilement être modifié pour contrôler l'index, l'annulaire ou l'auriculaire. Les moments de flexion sont enregistrés au moyen de jauges d'effort et d'un pont sur lequel on peut relever directement la mesure. Les erreurs individuelles de lecture sont évaluées entre 1 et 3 %. Cinq femmes (âgées de 19 à 26 ans) et cinq hommes (âgés de 23 à 30 ans) ont subi le test. Pour l'articulation interphalangienne proximale du majeur droit, le résultat a été de 15,5 ± 1,2 kg × cm et de 28,0 ± 1,1 kg × cm respectivement chez les femmes et chez les hommes et les valeurs correspondantes pour l'articulation interphalangienne distale furent de 6,1 ± 0,2 kg × cm et de 10,1 ± 1,0 kg × cm, respectivement.

ZUSAMMENFASSUNG

Ein neues Fingerbeuger-Dynamometer wird beschrieben, das die isometrischen Drehmomente verzeichnet, die sich an den interphalangeal (IP-) Gelenken entwickeln. Das vorliegende Exemplar wurde konstruiert um das IP Gelenk des dritten Fingers zu prüfen, aber der Apparat kann ohne weiteres zur Prüfung des zweiten, vierten und fünften Fingers eingerichtet werden. Die Drehmomente wurden mittels Belastungsmessungen und einer Messungsbrücke mit direkter Ablesungen registriert. Die Ungenauigkeit der einzelnen Ablesungen wurde auf 1–3 % geschätzt. Fünf Frauen im Alter von 19–26 Jahren und fünf Männer (23–30 alt) wurden geprüft. Das isometrische Drehmoment des proximalen IP Gelenk des dritten rechten Fingers war 15,5 ± 1,2 kg × cm und 28,0 ± 1,1 kg × cm für Frauen beziehungsweise für Männer und die entsprechenden Werte für das distale IP Gelenk waren 6,1 ± 0,2 kg × cm und 10,1 ± 1,0 kg × cm beziehungsweise.

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