

Construction of a Simple Test for Assessment of Hand Function in Primary Care

Theories and experimental trials for the test situation

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This paper describes a hand test consisting of three steps to test the subject's ability

- to grasp firmly another person's hand
 - to hold a pencil firmly with fingers II-V with straight knuckles and maximally flexed finger joints, while the investigator pulls the pencil
 - to hold on to a piece of paper with a rounded pinch grip between thumb and index finger while the investigator pulls the paper with a rounded pinch grip with submaximal strength.
- All three steps must be performed with each hand without causing pain.

The test was an adequate parameter for the grip function, and at the same time could register work-load elicited pain, strength, and mobility. The test can be carried out by healthy subjects, but not by patients with rheumatoid arthritis. The test is logically constructed and has a high validity and reliability.

Key words: hand test, hand handicap, inflammatory hand disease.

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The grip function of the hand is of great importance in professional and daily-life activities (1,2). Good strength and mobility and lack of work-load elicited pain are three essential requirements for a well-functioning grip function (3,4). Consequently, every hand disease which entails impaired strength and mobility or work-load elicited pain will have a negative effect on grip function. In early inflammatory joint disease, these three variables constitute the main symptoms (5).

Rheumatoid arthritis is the most prevalent (1%) of the chronic inflammatory joint diseases (6). It often starts in the hands (7,8) and can cause hand deformity with severe invalidism (9). In the recently accepted new ARA criteria, a mandatory involvement of the hand has been included (10).

Previous studies (11) have shown that grip function is impaired in subjects with rheumatoid arthritis (RA). Early diagnosis and treatment of RA may have a favourable effect on the prognosis (12,13).

Preventive measures give best results when started at an early stage of the disease (14).

As diagnosis can be difficult at an early stage of RA, a simple qualitative hand test would be a valuable diagnostic tool. This is especially important in primary health care, which is where patients with hand symptoms often seek treatment first.

HYPOTHESIS

Normal strength, normal mobility, and absence of pain are essential requirements for normal grip function. Reduced mobility, reduced strength, and the presence of pain are the cardinal symptoms of inflammatory hand disease (RA in particular) at an early stage. One could, therefore, pose the hypothesis that it would be possible to apply a test of grip function in screening for RA.

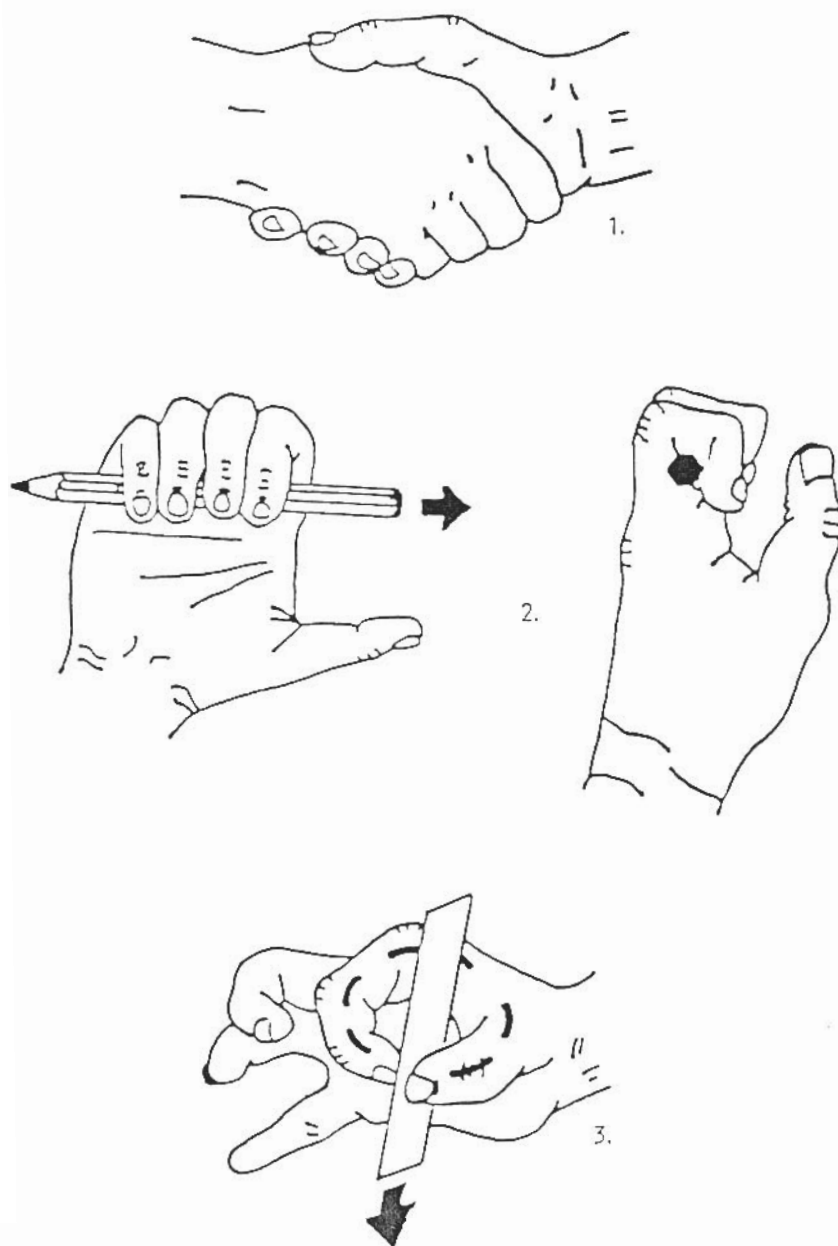


Figure 1. The three parts of the test.

CONSTRUCTION OF THE TEST

Background

Helin & Rasmussen (15) have constructed a clinical test for the assessment of different degrees of impaired joint function in patients with definite RA. The "zero stage" defined for hand- and arm function and for 14 other joints corresponds to good function in these joints. This comprehensive test is, however, too complicated for use in clinical routines in primary health care. Moreover, the hand test does not

differentiate a completely normal hand function from a slightly impaired one, since it does not require full mobility of the joints of the fingers. It seems reasonable, however, that the hand test could be modified in this respect so that it could discriminate the normal hand from the abnormal.

It was against this background that the new hand test was constructed, as illustrated in Fig. 1. It included:

Part 1

A test of the ability to grasp the observer's hand firmly, with all distal phalanges in contact with the observer's hand. The observer should be passive during this part of the test.

Part 2

A test of the ability to hold a pencil firmly with all four fingers, with extended metacarpophalangeal joints (MCP) and maximum flexion of proximal and distal interphalangeal joints (PIP, DIP) when the observer tries to pull the pencil out with a flat pinch grip.

Part 3

A test of the ability to hold firmly on to a piece of paper with a round pinch grip when the observer tries to pull the paper out with a round pinch grip with submaximal strength.

Hand function should be regarded as normal if all three parts of the test can be performed with each hand without causing pain.

Requirements on the validity of the test

The test should be a tool for evaluating the grip function of the hand and should register pain, mobility, and strength.

The test is based on the accepted types of grip: hand pressure, 4-finger grip, and the pinch grip (4, 16). Sollerman (4) has demonstrated that these three grips or a combination of them are used in 97% of all activity of daily life tasks.

The normal hand should tolerate a work load without pain being caused (4). Inflamed joints exposed to pressure cause pain (17). In order to discriminate healthy hands from abnormal hands the test must discover impaired mobility. Maximum extension of MCP joints and maximum flexion of PIP and DIP joints are therefore required. These requirements also make it possible to exclude contractures of the interosseous muscles and the long flexor tendons. The round pinch grip requires good mobility of the thumb. The three recommended grips register strength (3).

It should not be possible for subjects with inflammatory hand disease to pass the test.

It should be possible for subjects with healthy hands to pass the test.

Theory behind the construction of the test

Part 1

The normal hand should be able to accomplish this action without pain. The observer has only to register the subject's active hand pressure, and is therefore passive during this part of the test. The observer asks if the subject experiences pain.

Parts 2 and 3

The test must be logically constructed in view of the maximum strength developed in the various grips. In normal hand function, the strength accomplished in the subject's 4-finger and pinch grips must be stronger than the strength allowed in the observer's grip. The 4-finger grip must therefore be tested with a flat pinch grip (which is weaker than the 4-finger grip) and the round pinch grip with the same round pinch grip by the observer, but with submaximal strength.

METHODS

*Experiments**Test of strength in the different grips*

In order to analyse the maximum strength developed in the grips, 15 subjects with healthy hands and the ability to pass the hand test were studied (4 men, 11 women, aged from 23–64 years). Thirteen were right-handed and two left-handed. The maximum strength developed in the various grips was studied with a spring-balance.

The 4-finger grip was tried first with extended and then flexed MCP joints and with the pencil being pulled in both the ulnar and the radial directions. Each hand was studied. The flat pinch grip was investigated from the point of view of maximum strength in both hands.

Three ways of gripping a piece of paper were used: the round, flat and lateral pinch grips ("key grip").

Studies of normal and abnormal hands

Five physicians and five physiotherapists investigated 327 patients (130 men and 197 women) aged 40–70 years at the Skurup Health Centre, Sweden. The subjects were required to be free from subjective hand problems and to have no signs of hand disease or sequelae of such (swelling, tenderness, contracture, Heberden's nodes, injury or lesion, etc.) on inspection and palpation.

Sixty-eight consecutive patients with inflamma-

Table I. Mean difference of maximum strength (in kp) developed in different hand grips tested by a spring balance when the observer tried to pull a pencil and a paper from the subject ($N = 15$).

Standard errors within parenthesis.

Grips	Right hand			Left hand		
	M_d	(SE_d)	p	M_d	(SE_d)	p
Pencil test						
4-finger grip with MCP extended; radial versus ulnar experiment	0.19	(0.16)	NS	0.11	(0.09)	NS
4-finger grip with MCP flexed versus MCP extended	3.00	(0.26)	$p < 0.001$	2.85	(0.28)	$p < 0.001$
4-finger grip with MCP extended (ulnar) versus flat pinch grip	2.81	(0.29)	$p < 0.001$	2.81	(0.35)	$p < 0.001$
Paper test						
Flat pinch grip versus round pinch grip	1.07	(0.16)	$p < 0.001$	1.31	(0.26)	$p < 0.001$
Lateral pinch grip versus flat pinch grip	2.64	(0.26)	$p < 0.001$	2.22	(0.28)	$p < 0.001$

tory joint disease, aged 40–70 years and attending the Skurup Health Centre over a two-month-period, were studied for hand abnormality. Five patients, three with chondrocalcinosis and two with Mb Bechterew, were excluded because they had no hand complaints. The remaining 63 patients were suffering from varying degrees of disease activity. All three parts of the test were performed by all patients.

Studies of reliability

Six subjects (all women) and six investigators (all physiotherapists) were included in the study. Two of the subjects had healthy hands, two had RA, one had osteoarthritis, and one had cervical spondylosis.

During the test only the hands of the subjects were visible. All hands were without deformity. The subjects were seated in fixed positions, while the observers circulated. When all the subjects had been examined by each observer the subjects changed positions according to a pattern unknown to the observers. There were three test rounds.

Calculations and statistics

In the investigation of strength of different grips, two-sided Student's t-test for paired data were used to assess the differences. The results are shown in Table I as M_d (mean deviation) and SE_d (standard error of mean deviation).

Intraobserver reliability is defined as the probability of having the same result if one observer investigates the same hand twice. In this study, each observer could have either three identical results (yes or no) or two identical and one different result. When there were three identical results the reliability estimate was 1.00 and when there were two identical and one different result the estimate was 1/3. For each hand, the mean value of these estimates for the six observers was calculated.

Interobserver reliability is defined as the probability of having the same result if each of two different observers investigates the same hand once. This was estimated for each hand separately by means of the formula

$$\frac{1}{\binom{6}{2} \cdot 3 \cdot 3} \sum_{i < j} [x_i \cdot x_j + (3 - x_i)(3 - x_j)]$$

where $\binom{6}{2}$ is the number of different combinations of two observers out of six and $3 \cdot 3$ is the number of ways of choosing one result for each of the two observers.

RESULTS

Tests of strength in the different grips (Table I)

The pencil experiment showed no difference ($p > 0.05$), whether one pulled the pencil in a radial or ulnar direction, when the "4-finger test" (ulnar or

Table II. Intra- and interobserver reliability (p_{intra}/p_{inter}) for 12 different hands.

	Hand								Healthy hands (mean values)
	RA	RA	Cervical spondylosis	Osteoarthritis		RA	RA		
Handshake									
Movement	1.00	1.00	1.00	1.00	1.00	0.89/0.89	1.00	1.00	1.00
Power	0.89/0.89	1.00	0.67/0.63	0.67/0.63	1.00	0.89/0.89	0.89/0.89	1.00	0.97/0.94
Pain	1.00	1.00	1.00	0.89/0.89	1.00	1.00	1.00	1.00	1.00
Pencil									
Movement	1.00	0.78/0.79	0.89/0.89	0.56/0.64	1.00	1.00	0.78/0.79	1.00	1.00
Power	1.00	1.00	0.78/0.55	0.69/0.45	1.00	1.00	0.89/0.89	1.00	1.00
Pain	1.00/0.47	1.00/0.47	1.00	1.00	1.00/0.47	1.00/0.47	0.89/0.44	1.00	1.00
Paper									
Movement	0.89/0.42	0.89/0.42	1.00	1.00	1.00	0.89/0.89	0.89/0.89	1.00	1.00
Power	1.00	1.00	0.44/0.54	0.44/0.49	1.00	0.89/0.78	0.89/0.89	0.89/0.89	1.00
Pain	0.89/0.89	0.89/0.89	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Total	1.00	1.00	0.67/0.71	0.78/0.79	1.00	1.00	1.00	0.89/0.89	0.97/0.95

Remark: When only 1.00 is shown this means that both p_{intra} and p_{inter} are 1.00. RA: rheumatoid arthritis.

radial) was performed with extended MCP joints, and again with flexed MCP joints, the flexed joints gave a stronger grip for both hands ($p < 0.001$).

The "4-finger grip" was stronger ($p < 0.001$) than the flat pinch grip for both hands.

The experiment with paper showed that for both right and left hands the flat pinch grip was stronger ($p < 0.001$) than the round pinch grip, and that the lateral pinch grip was stronger ($p < 0.001$) than the flat pinch grip.

Studies of normal and abnormal hands

Of the 327 subjects with healthy hands, 325 accomplished the test without difficulty, while two persons reported minor trouble. None of the 63 patients at the Skurup Health Centre with inflammatory hand disease were able to accomplish the hand test.

Studies of reliability

For each of the twelve hands studied, we estimated intraobserver reliability for each of the nine parts of the test separately and also for the combined test, for each observer and for each test round separately, i.e. for the result obtained by scoring zero if all partial tests gave zero and scoring one otherwise. The averages for all six observers are shown in Table II.

All parts of the test showed high intra-observer reliability for persons with healthy hands. For the

other hands the intra-observer reliability was high or acceptable.

Intraobserver reliability estimates are also shown in Table II. All parts of the test showed high or acceptable results with the exception of "pencil pain", which showed a less good result for five of the hands.

The calculations of having a positive result in one of the nine parameters revealed high-intra- and interobserver reliability, with the exception of one hand.

DISCUSSION

When screening for inflammatory joint disease the hand is the appropriate part to examine. This is evident from the new ARA criteria (10) which require involvement of the hands. In addition, since previous studies have shown that grip function is impaired in RA patients (11), it would be natural to start with this function for the theoretical construction of a test.

In order to obtain quantitative assessment of hand function which allows a comparison of the same hand on different occasions, clinical judgement is required as well as an analysis of function (16). As far as grip is concerned, earlier interest primarily concerned strength, which was assessed with different types of dynamometer (3, 11, 18). Walker et al.

(19) have constructed an apparatus which registers both strength and mobility. However, this apparatus is fairly complicated. A simple qualitative test which assesses several grip function parameters simultaneously has not existed previously. A hand test for three types of grip with the requirement that they can be accomplished without inflicting pain on patients with rheumatoid arthritis has been developed by Helin and Rasmussen (15). However, this test cannot reliably discriminate healthy hands from diseased, since it does not require a maximum mobility of finger joints. In order to develop a screening test, therefore, the above test had to be modified.

An important requirement of the new test was a logical construction concerning the maximum strength developed in the different grips. The strength being developed by the tested subject must always be stronger than the strength developed in the observer's grip. The study has shown that the 4-finger grip was stronger than the flat pinch grip. With regard to the three types of pinch grip, the round one was weaker than the other two. Other investigators have used various types of apparatus to evaluate the strength of different hand grips and have reported the same result (3, 11). It is therefore correct to use the 4-finger grip and the flat pinch grip in the second part of the test. In the third part of the test the objective is to investigate the round pinch grip as the major requirement of the mobility of the thumb. The investigator is at this stage allowed to pull the paper with submaximal strength in the round pinch grip.

The validity of the test was examined. It was demonstrated that healthy subjects were able to accomplish the test while patients with inflammatory hand disease were not. It has been shown experimentally that the validity requirement was satisfactory for 327 subjects with healthy hands and 63 patients with inflammatory hand disease.

The conclusion of the experiment with the spring-balance was two-fold as follows: if the pencil can be pulled out from a 4-finger grip with a flat pinch grip, this 4-finger grip has impaired strength. If the paper can be pulled out of the subject's round pinch grip by the observer with a submaximal round pinch grip, the grip strength of the subject is impaired.

The reliability was high or acceptable for all parts of the test. The most important finding is however that the combined test showed high ability in discriminating healthy hands from sick hands.

A new simple and inexpensive test for assessment

of grip function has been constructed. The test can discriminate between normal and sick hands and at the same time register pain, reduced mobility, and reduced strength, which are the three cardinal symptoms in early rheumatoid arthritis.

Studies with the test as an epidemiological instrument in primary health care have started.

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