Detection of submaximal effort by use of the rapid exchange grip

To assist in distinguishing patients with truly decreased hand grip strength from those deliberately not gripping the dynamometer at maximal capacity, a rapid exchange grip strength test was devised and tested under four conditions. Part I, 100 normal subjects undergoing static grip testing and the rapid exchange grip test. Part II, 45 patients chosen at random from physical therapy with various hand injuries tested using only the static grip test. Part III, a blind control study on 15 normal subjects instructed to fake an injury to either the right or left hand. This group was given both the static and rapid exchange grip test. Part IV, a retrospective evaluation of 45 patients seen in a private hand practice who had both the static and rapid exchange grip test. After the dynamometer had been set to the position at which the patient had previously achieved maximal grip strength, the patient was instructed to rapidly alternate hands while gripping the dynamometer. Uninjured subjects had consistently lower rapid exchange grip test scores than previous scores at the same setting (negative rapid exchange grip). Average rapid exchange grip test scores were higher than previous scores (positive rapid exchange grip) when subjects were instructed to fake an injury with one hand. We conclude that if maximal performance has not been achieved on the static test, the rapid exchange grip shows a significant increase in grip strength on the affected side. More patients claiming worker's compensation had positive rapid exchange grips and the average score was higher than that of patients not claiming worker's compensation. This test may help differentiate the patient whose decreased performance is secondary to pain from those who voluntarily perform submaximally. (J HAND SURG 1989;14A:742-5.)

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Although grip strength is not a true measure of hand function, it often aids in gauging impairment. Whether for psychologic or economic reasons, however, some patients deliberately perform submaximally to seem more impaired than they actually are. Since the static test using the hydraulic-grip dynamometer[1] has become the standard instrument of measuring grip strength, an objective means for distinguishing between maximal and submaximal performance is necessary to make grip strength measurements truly meaningful.

Attempts to provide such objective evaluation have been made in the past. Stokes[2] reported that a static test, in which a patient grips the dynamometer with maximum effort at all five settings, produces a bell-shaped curve even if the patient's hand is injured (Fig. 1). Conversely, when a patient does not perform maximally, the test produces a straight line. Theoretically, this difference could be used to distinguish between these two populations. Unfortunately, the bell-shaped curve produced by a maximally performing injured hand may be quite flat, while the uncooperative patient's hand occasionally produces a small curve. This makes consistently distinguishing between the two populations difficult.

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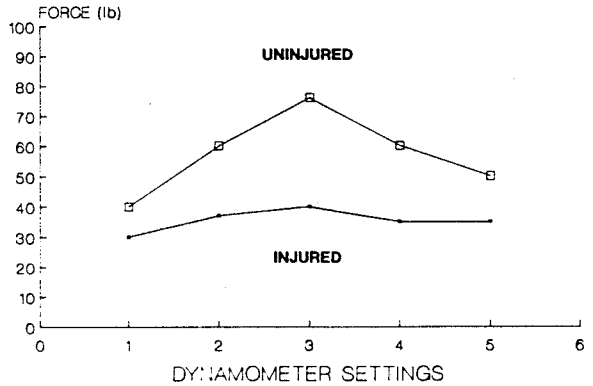

Fig. 1. Bell-shaped curve as described by Stokes.

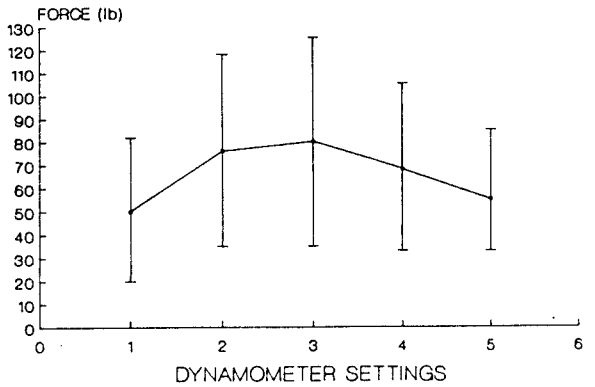

Fig. 2. The results of 100 uninjured subjects at each of the five settings on the dynamometer (static test) were averaged and plotted. Note that the results produced a skewed bell-shaped curve. Vertical lines show the range of scores at each setting.

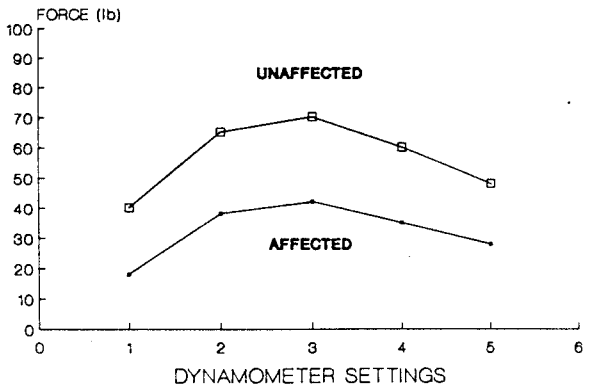

Fig. 3. The results of static tests from injured (affected) hands of 45 patients were averaged and plotted. The uninjured (unaffected) hands were also tested, and the results were averaged and plotted. Both sets of results produced skewed bell-shaped curves.

To overcome this problem, the rapid exchange grip (REG) test was devised.[3] The REG test enables the person administering it to detect the voluntary decrease in grip found in patients who have a psychologic problem rather than an organic hand problem. The purpose of this study was to evaluate, both prospectively and retrospectively, the ability of a REG test to differentiate those patients with decreased grip performance due to injury from patients not performing maximally for whatever reason.

Methods

The static test is performed by having the patient maximally grip the dynamometer (Jamar) at each of the five settings. Both hands are tested at each setting, but timed at intervals to prevent fatigue. Grip strength is a function of the size of the object being gripped and the ability of the thumb and thenar muscles to oppose the four fingers.[1] Therefore, at some point, usually between the second and fourth settings on the dynamometer, the patient reaches a maximum mechanical advantage. The REG test is then administered at this setting. To execute the REG test, the patient is instructed to switch hands rapidly on the dynamometer, maximally gripping each time. The dynamometer is held in place by the physician. The patient is encouraged to maximally grip the dynamometer alternating hands as rapidly as possible. Although there is no set number of rapid exchanges, routinely, each hand grips the dynamometer 5 to 10 times. The test terminates once the examiner has determined if the results of the test are positive or negative.

The study was divided into four parts. In part I, 100 normal subjects (52 men, 48 women) underwent static grip testing using all five settings on the dynamometer. The subjects also took the REG test.

In part II, 45 randomly chosen hand injury patients who were enrolled in a physical-therapy program were tested using only the static test.

In part III, a blind controlled study was performed using 15 normal subjects instructed to fake an injury to the right or left hand. This group was given both the static and REG test. The volunteers were unaware of any hypothesis we might hold concerning malingering and trends in REG values.

In part IV, data were evaluated for all 45 patients who had been seen in a private hand practice over the past 4 years and who had taken both the static and the REG tests. The test results from patients who did and who did not receive worker's compensation were then compared.

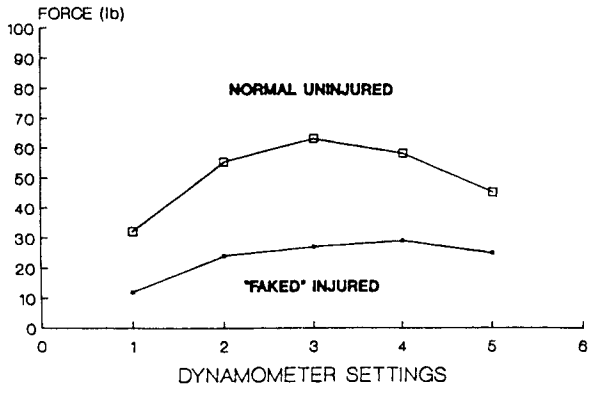

Fig. 4. Fifteen uninjured subjects faked an injury with one hand while undergoing the static test. These results, when averaged, produced a flattened, skewed bell-shaped curve. The same subjects then underwent the static test using their other hands without attempting to fake an injury. These results produced a more rounded, skewed bell-shaped curve.

Table I. Comparison of REG test scores (% static test score) by worker's compensation classification

	Group claiming worker's compensation	*Group not claiming worker's compensation*	*p values**
Affected hand	215 + 127%†	151 + 76%‡	0.05§
Unaffected hand	107 + 20%	81 +22%	0.0003§
N	25	20	

*Two tailed t-test.
†Increase in REG score over static test score was significant (p = 0.0002).
‡Increase in REG score over static test score is significant (p) = 0.0003).
§Statistical significance of the difference between the two groups.

Results

In part I, results of the 100 normal subjects who took the static test showed a skewed bell-shaped curve (Fig. 2). When the REG test was administered to this group, the grip strength during REG testing was 85.6 ± 1% of the statistically determined grip strength for the results obtained from the same setting in the static test. The decrease was significantly less than control values ($p < 0.001$), suggesting that strength falls approximately 15% in normal subjects during REG testing. A REG score less than the matched static test is considered a negative REG.

The data from patients having physical therapy for various hand injuries (part II) produced a skewed bell-shaped curve regardless of injury pattern (Fig. 3).

In part III (normal individuals who had faked an injury to one hand), the resultant REG test scores from the side with the faked injury increased in 100% (15 of 15) of the subjects (Fig. 4). This increase in s was 179 ± 67% above static grip strength. A REG score greater than or equal to the static test score positive REG. The REG test score from the non-f side decreased in 14 out of 15 cases (negative test). The difference between the two sides was st tically significant ($p < 0.001$).

Table II. Comparison of workers compensation status by REG test scores

	Patients claiming worker's compensation	*Patients not claiming worker's compensation*	*p valu*
Affected hand			
Positive REG	25	16	0.03†
Negative REG	0	4	
N	25	20	
Unaffected hand			
Positive REG	16	5	0.00
Negative REG	7	15	
N	23‡	20	

*Two-tailed Fisher exact.
†Statistical significance of difference between those who claimed wor compensation and those who did not.
‡Unaffected-hand data were not recorded for two patients.

Part IV showed significant differences between t patients claiming and not claiming worker's com sation (Tables I and II).

Discussion

Although this study alone does not prove tha REG test can consistently distinguish between max and submaximal performance, test results can aler physician to those situations in which submaximal formance should be suspected.

The following theoretical mode as describe Milner-Brown and colleagues[4, 5] and Ramos associates[6] explains our findings. Precise activitie mand concerted and constant cortical monitoring o sired muscles. The more precise or unfamiliar th tivity, the more time required for cortical monit of the two major patterns of neural muscles activ coding: rate coding and recruitment coding.[7] Rate ing controls frequency of neuronal firing and re ment coding regulates the number and type of m units involved. Maximal muscle exertion fully uses recruitment and rate coding. Submaximal exer however, requires a carefully controlled mixture o and recruitment coding. The exact mixture depen a complex feedback pattern of signals to the ce nervous system, which the patient may not be ca of accomplishing in a short period of time.

In part I of our experiment, we evaluated grip str

in normal subjects. When these subjects took the REG test, maximum grip values fell approximately 15% compared to the static test. We postulate that the time available for the intense cerebral attention associated with orderly recruitment of motor units decreases during the REG test resulting in weaker grip than that found during the static test.

In part III, the REG was evaluated in known submaximal performers. This increase in score was 179 ± 67% above static grip strength, i.e., it is not uncommon to see grip strength more than double on the positive side. The REG was positive on the faked side 100% of the time. Again, this increase in score can be explained by the above model. Regulation of muscular effort to perform submaximally in the static test requires a careful mixture of rate and recruitment coding and extensive feedback along pathways to the central nervous system. The REG decreases the time frame for comparison of a given contraction state with the contraction state used during submaximal performance. Unable to reproduce the limited muscle contraction (grip strength), the subject instead produces results closer to true maximum grip.

In part IV, we retrospectively reviewed patients claiming and not claiming worker's compensation who had been given both static and REG tests. We assumed that, while submaximal performers may be found in both groups, the group of patients claiming worker's compensation would have more economic incentives to perform submaximally. Indeed, while positive REGs were found in both groups of patients, the differences between the two groups were significant both in the extent to which the REGs were positive (Table I) and the number of patients with positive REGs (Table II).

The REG test results from the unaffected hands were surprising. A regression analysis comparing unaffected-side REG percentage with affected-side REG percentage demonstrated a significant correlation for patients claiming worker's compensation ($r = 0.63$, $p = 0.001$). No such correlation appeared in the group of nonclaimers ($r = 0.20$), ($r = 0.4$). Given that the group of patients claiming worker's compensation had more malingerers, we speculate that the same psychologic factor that inhibits performance on the side affected by injury also inhibits performance on the unaffected side. In other words, these patients may have been adjusting their overall performance to accentuate their total disability. Given the rapid exchange of hands required by the REG test, submaximal performers may not have had time to grip differently with both hands, thus resulting in submaximal performance for both.

As recorded in numerous other studies,[8-13] however, an individual's grip strength is variable. Furthermore, given the assumptions and methods of our study, we cannot generalize from our results to say that a positive REG for a specific individual indicates malingering. Our test does reveal, however, trends that can sensitize the physician to the performance of different types of patients. If a patient's REG is negative, the physician may have more confidence that the patient is performing maximally. If both the patient's affected and unaffected hands demonstrate positive REGs, however, the physician may wish to investigate further to determine whether malingering is present.

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