

## MORNING STIFFNESS IN RHEUMATOID ARTHRITIS\*

BY

J. T. SCOTT

*Department of Medicine, Postgraduate Medical School, London*

Morning stiffness is a common complaint in rheumatoid arthritis. It varies from a scarcely perceptible stiffening of the fingers, sometimes the earliest premonition of disease, to the torpid, turgid immobility which in advanced arthritis is the waking despair of the unhappy patient. The symptom is not specific, occurring also in other forms of arthritis including osteo-arthritis, but it is sufficiently characteristic to head the diagnostic criteria for rheumatoid arthritis proposed by the American Rheumatism Association (Ropes, 1959).

While in severe cases the whole body is involved, it is the hands which are mainly affected. Little attention has been paid to the assessment of objective morning stiffness, and its cause is unknown. A diurnal variation of grip strength in both rheumatoid and normal individuals has been noted by several observers (Bywaters, 1940; Bechtol, 1954; Wright, 1959), who have pointed out the importance of testing grip strength at a constant hour of the day when assessing progress; this variation has been found to diminish during treatment with corticotrophin. Grip testing, while no doubt expressing to some extent the subjective symptom of morning stiffness, is also of course a measure of muscle power unrelated to this symptom, and impaired morning grip strength found in normal subjects must be considered in terms of weakness as well as of stiffness. In rheumatoid patients grip strength is also limited by pain and supervening psychological factors. It therefore seemed desirable to attempt to measure the passive stiffness of a joint, though it is appreciated that this will be affected by the state of extra-articular structures and muscle tone. Moreover, the hands of patients with rheumatoid arthritis sometimes appear more swollen in the early morning than at other times, and the

possibility presents itself that this tissue swelling is the cause of morning stiffness.

This paper describes a study of patients with rheumatoid arthritis and morning stiffness and of non-arthritic control subjects, in whom objective measurements were made of joint stiffness and hand volume, as well as of grip strength.

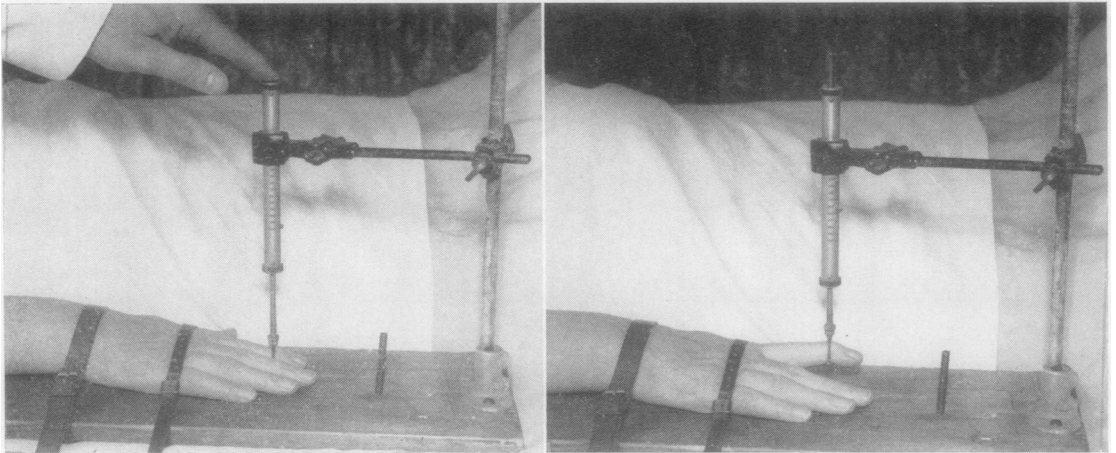
### Methods

Passive stiffness of one or other second metacarpophalangeal joint was estimated by elevation of the relaxed finger from the neutral position by an extension spring. The spring was held by a clamp in a vertical position over a wooden platform. The upper end was fixed and the position of the lower end was indicated by a pointer which moved along a vertical scale. Attached to the lower end was a short horizontal bar lying 4.25 cm. above the platform, which would come to rest on the platform when the spring was extended by this distance (Fig. 1, overleaf).

The patient's hand and forearm were strapped to the platform, the hand being secured by a strap which was placed across the metacarpal heads and drawn to the same tightness at each measurement. The hand was placed in such a position that the skin crease opposite the distal interphalangeal joint lay on the horizontal bar of the extended spring. The patient was told to relax the hand completely (easily accomplished after a short demonstration) and the spring was then released, lifting the finger (Fig. 2, overleaf).

The force required to extend the spring was 40 G./cm. Since the spring was extended 4.25 cm. before release, the initial force acting on the relaxed finger was 170 G. As the finger was raised by the spring so the force diminished, the final force

\* Presented at a meeting of the Heberden Society, July 2, 1960



Figs 1 and 2.—Measurement of finger displacement, showing position of finger before and after releasing spring.

depending on the position in which the finger came to rest. In practice the distance through which the most supple finger was elevated was never more than 2.5 cm., at which point there was still a force of 70 G. Joint stiffness has been expressed simply in terms of the distance through which the finger was displaced, an adequate expression for the comparative purposes of this study.

Multiple readings undertaken within a short period to test the reproducibility of the method were

unacceptable because it was soon clear that repeated extension of the joint not unnaturally decreased its stiffness. Fig. 3 shows fifty successive readings in a normal subject during an afternoon session of an hour and a half, during which time finger displacement is seen gradually to increase; this situation is perhaps analogous to the rheumatoid patient working off his stiffness, or the pianist increasing the suppleness of his fingers by repeatedly clenching and unclenching the hands.

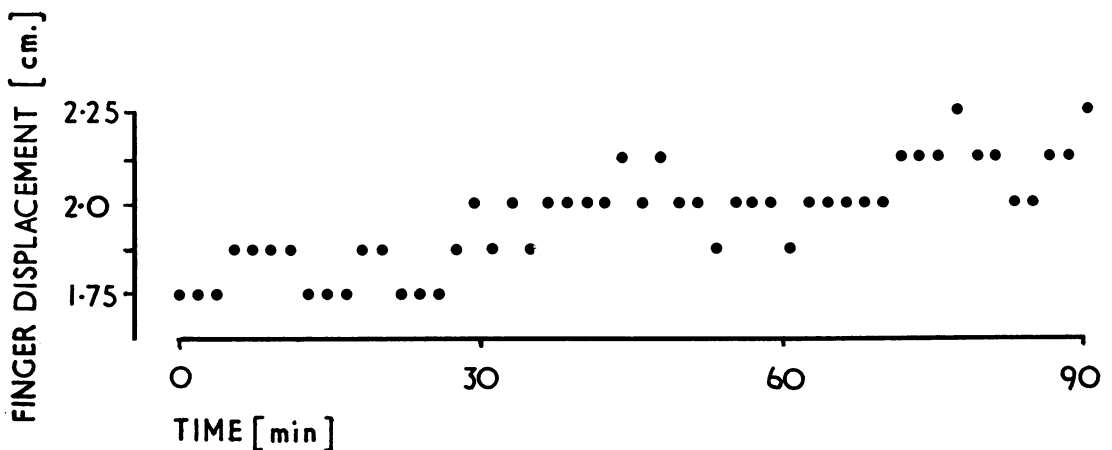


Fig. 3.—Fifty successive estimations of finger displacement in a normal subject in a period of 90 minutes, showing gradual increase in displacement.

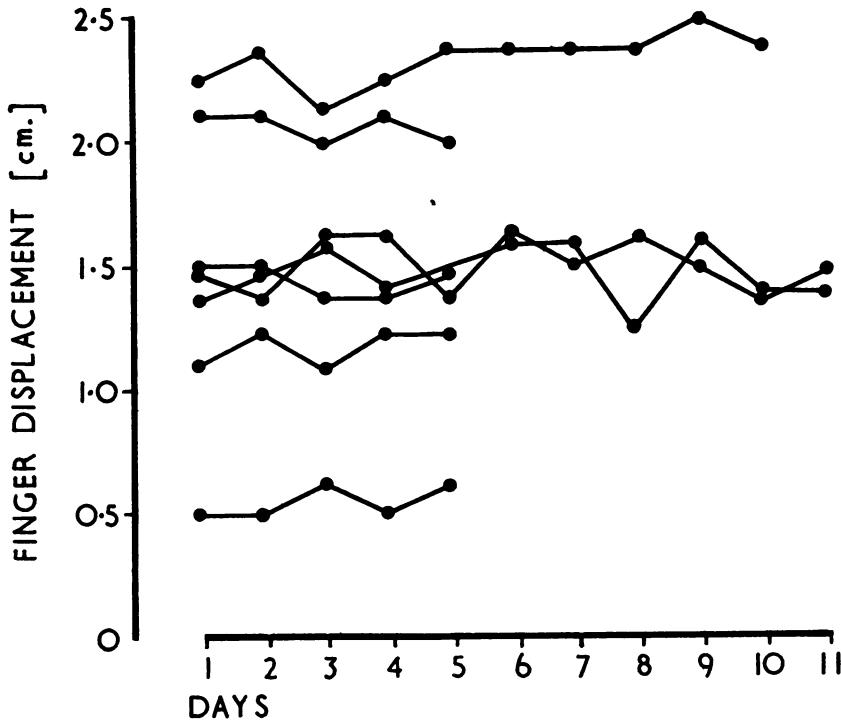


Fig. 4.—Daily measurements of finger displacement on one hand in seven normal subjects.

Fig. 4, however, shows readings (on one hand) of seven normal subjects during periods of from 5 to 11 days at the same time of day. Variability in individual subjects is not excessive, though there are marked differences in finger displacement among this group of people.

To measure hand volume a perspex tank was filled with water at body temperature to the level of an overflow pipe (Fig. 5, overleaf). The hand was immersed to an ink line drawn round the wrist at the level of the ulnar and radial styloid processes and the volume of displaced water was measured. As a test of the accuracy and reproducibility of this method, fifty consecutive readings were taken on a normal subject during a period of 2 hours in the middle of the day. The coefficient of variation was 0.63 per cent. (mean 411.4 ml.; standard deviation 2.6 ml.). In the study the mean of three readings was taken as the hand volume.

Strength of grip was tested with a standardized rubber bag cased in silk attached to a mercury

sphygmomanometer, filled with air to an initial pressure of 20 mm. Hg. A mean of three readings was taken. In normal subjects, in whom grip strength exceeded 300 mm. Hg, the bag was attached to an aneroid spring meter.

Morning and evening measurements by these three methods were made in five adult in-patients (four females and one male) who had chronic, active rheumatoid arthritis with a positive sheep cell agglutination test. All complained of subjective morning stiffness.

Measurements were also made in four non-arthritic adult control subjects (three females and one male) with no morning stiffness.

The subjects were tested for between 10 and 20 days as nearly consecutive as possible. The morning measurements were taken soon after waking and before the patient rose from bed: this was usually between 6 and 6.30 a.m. and always before 7 a.m. The evening readings were made in the late afternoon or early evening, usually about 6 p.m. Additional readings were made on several patients at intervals throughout the day.

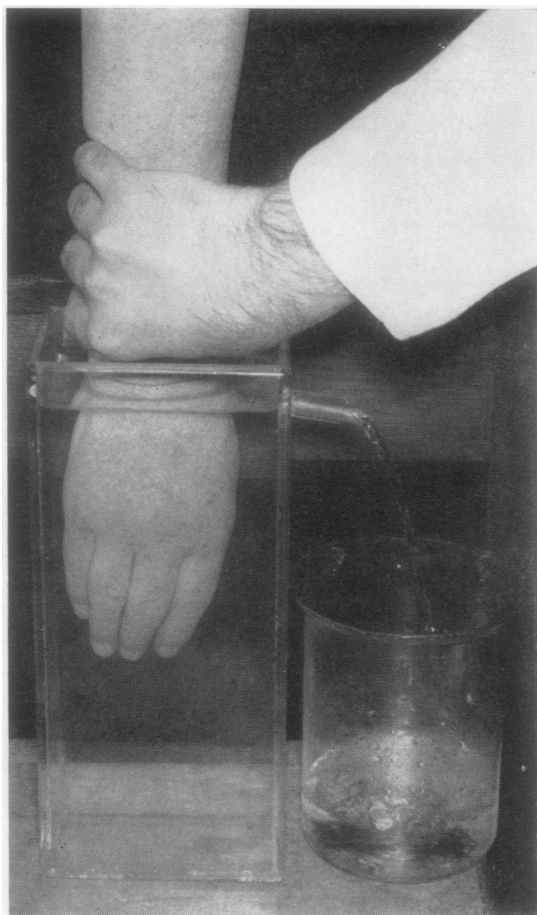


Fig. 5.—Measurement of hand volume.

### Results

Morning stiffness in the rheumatoid arthritis patients was usually demonstrable by decreased finger displacement in the morning compared with the evening. The ordinate in Fig. 6 indicates the distance by which evening displacement exceeded morning displacement. In the rheumatoid subjects the finger was elevated on an average between 0.175 and 0.256 cm. further in the evening than in the morning, though as might be expected there was considerable variation shown by the large standard deviation. In the normal subjects the mean difference between morning and evening displacement was close to zero.

The difference between morning and evening hand volumes is similarly shown in Fig. 7 (opposite). In the rheumatoid patients the morning volume usually

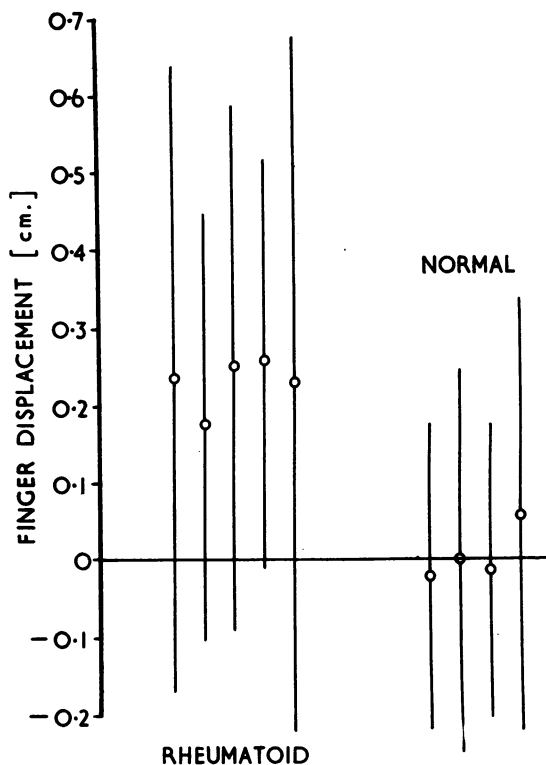


Fig. 6.—Distance by which evening finger displacement exceeded morning displacement in rheumatoid and normal subjects. Circles indicate mean differences, vertical lines two standard deviations above and below the mean.

exceeded that of the evening, the mean differences in the five patients ranging from 6.5 to 17.5 ml. There was again a large variation from day to day. The normal subjects, however, also showed a greater volume in the morning, the mean differences ranging from 5.5 to 7.5 ml.

Evening grip strength usually exceeded that of the morning in both rheumatoid and normal subjects. These findings accord with the previous work mentioned, but Fig. 8 (opposite) shows the variability of the diurnal difference, particularly it seems in normal subjects; it should be pointed out, however, that the absolute grip strength in the rheumatoid patients was less than 200 mm. Hg, whereas in the normal subjects it lay mostly between 300 and 600 mm. Hg, so that relative to the actual grip strength the variability in the two groups is not so dissimilar as this graph suggests.

Most of the change in finger displacement, hand volume, and grip strength took place in the first few hours after waking, coinciding with the disappearance

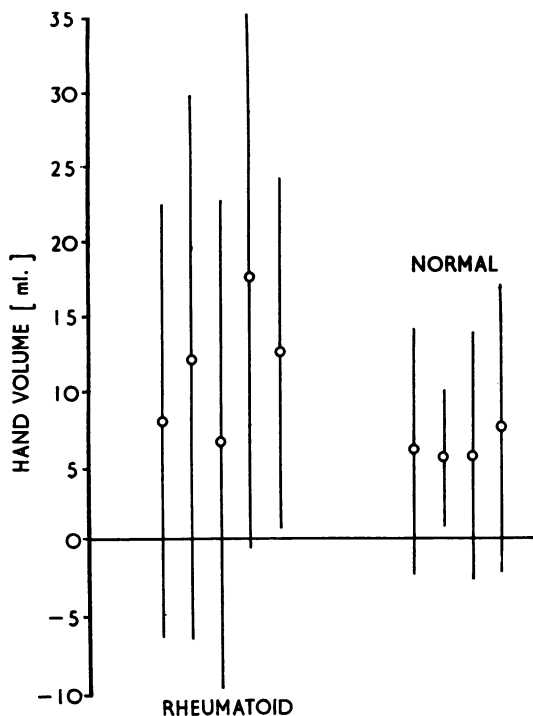


Fig. 7.—Amount by which morning hand volume exceeded evening hand volume in rheumatoid and normal subjects.

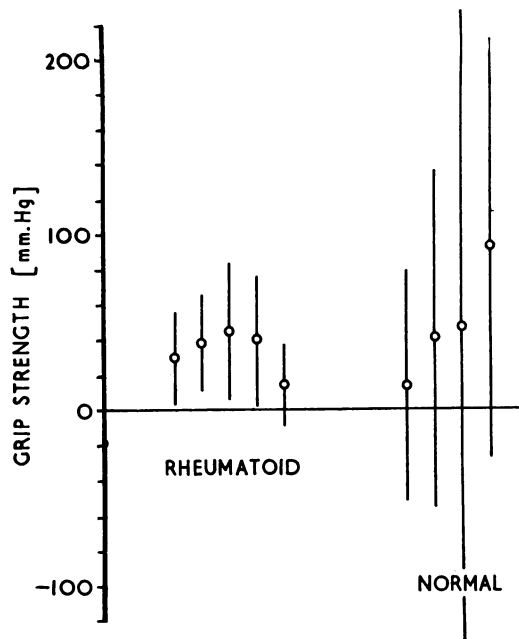


Fig. 8.—Amount by which evening grip strength exceeded morning grip strength in rheumatoid and normal subjects.

of subjective morning stiffness. Fig. 9 (overleaf) shows hourly changes during a day in a patient with rheumatoid arthritis.

All these observations were made while the patients with rheumatoid arthritis were receiving treatment with salicylates. The opportunity was taken in three patients, one of whom is illustrated in Fig. 10 (overleaf), to observe the effect of corticosteroid therapy. Corticosteroids produced an improvement in subjective stiffness, an increase in grip strength and finger displacement, and a decrease in hand volume, together with a reduction in the diurnal variation in all of them. The effects in this case occurred soon after oral prednisolone, 20 mg. daily in four divided doses, was started. The drug was discontinued after 6 days and there was a subsequent return to the pre-treatment state though some improvement in grip strength was maintained. Prednisolone was again started, this time in a dosage of 5 mg. each night only, and a repetition of the effect was seen, though it later became necessary to increase the dose to 5 mg. twice daily, on which the patient has remained very well.

### Discussion

Pain and stiffness are two symptoms not always easily distinguishable from each other, since the range of movement in a painful joint is impaired by voluntary or involuntary muscle action. In these investigations, however, finger displacement was never sufficient to be painful in the subjects tested, so that the observed differences between morning and evening displacement could hardly be due to a diurnal variation in the pain sensitivity of articular structures, though the existence of such a variation remains an interesting possibility. Grip strength, on the other hand, is certainly influenced by pain in rheumatoid patients.

The demonstration of objective morning stiffness together with an increase in morning hand volume suggests that the stiffness may be due to an increase in inflammatory oedema in the early morning, perhaps related to a diurnal variation in adrenal corticosteroid production (Perkoff, Eik-Nes, Nugent, Fred, Nimer, Rush, Samuels, and Tyler, 1959). This concept is supported by the diminution or abolition of such variation when corticosteroid treatment is given. It was, however, seen that normal subjects also had a greater hand volume in the morning than in the evening, the difference being as great as in some, but not all, of the rheumatoid arthritis

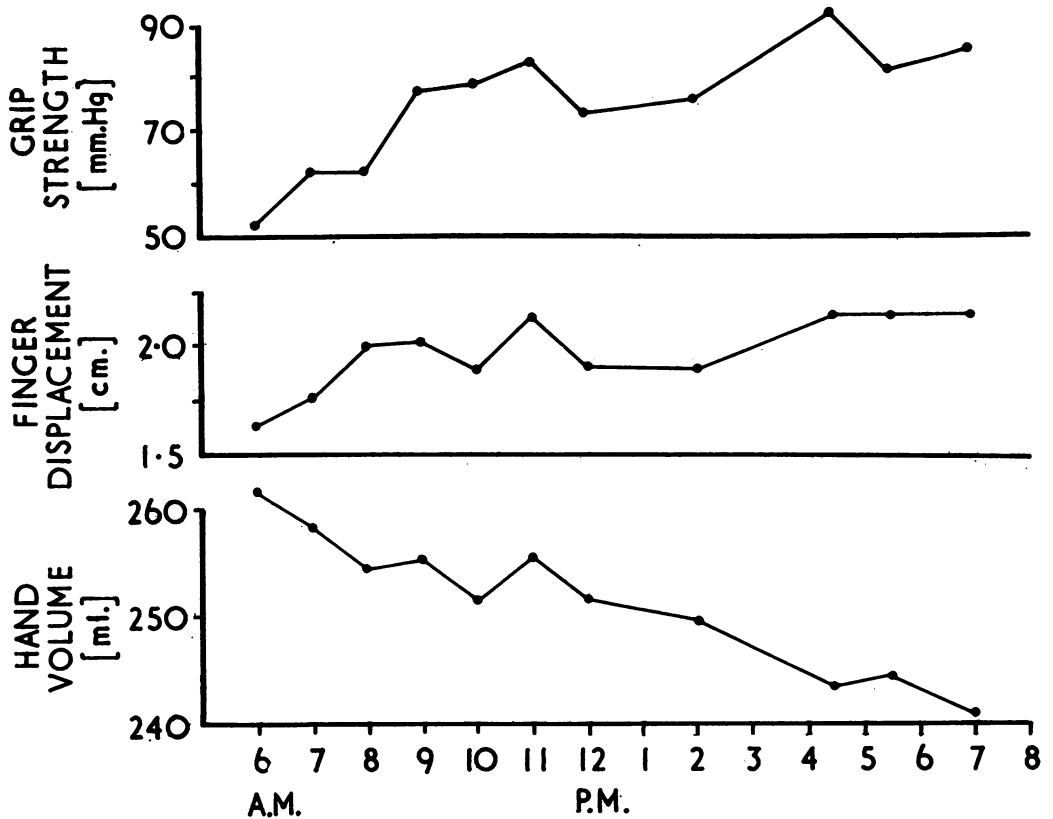


Fig. 9.—Hourly changes in grip strength, finger displacement, and hand volume in a patient with rheumatoid arthritis.

patients. None of the normal subjects complained of morning stiffness, nor did they show any diurnal variation in finger displacement, from which it follows that an increase in hand volume cannot be the entire cause of morning stiffness, though this may be a contributory factor and indeed must be so when gross. It is further conceivable that local periarticular oedema could cause morning joint stiffness with little increase in total hand volume beyond that found in normal subjects. Nevertheless, there probably exists a further mechanism underlying rheumatoid morning stiffness, such as perhaps a diurnal variation in the elasticity of connective tissue.

The morning increase in hand volume seen in normal subjects is probably largely attributable to the local factor of immobility during sleep and to the diminished venous return which is due to lack of muscular pumping action. A further general factor may be involved: there is a diurnal rhythm in the excretion of water and electrolytes, the output being greater by day than by night (Borst and de

Vries, 1950; Stanbury and Thomson, 1951). This implies nocturnal tissue fluid retention, of which increased morning hand volume may be a manifestation.

#### Summary

The subjective complaint of morning stiffness in patients with rheumatoid arthritis has been demonstrated by a matutinal increase in objective joint stiffness and hand volume, and a decrease in grip strength. A similar variation in hand volume and grip strength, but not in joint stiffness, is seen in normal subjects, and it is evident that increased total hand volume is not the entire cause of morning stiffness.

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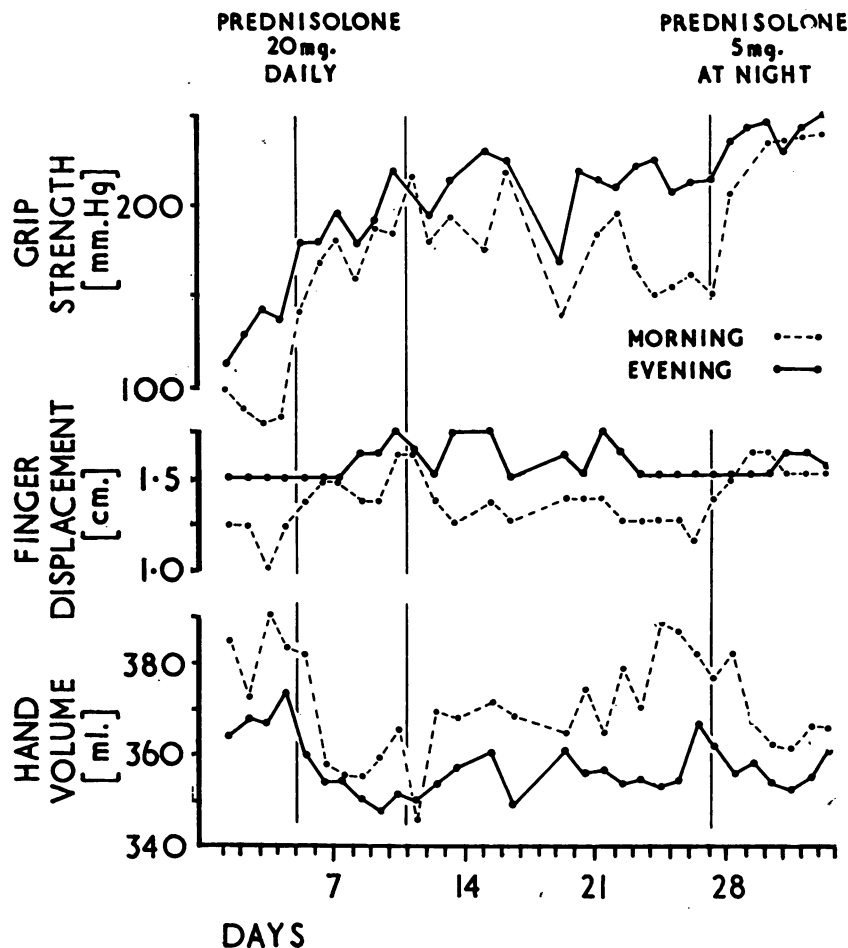


Fig. 10.—Daily measurements of morning and evening grip strength, finger displacement, and hand volume in a patient with rheumatoid arthritis, showing the effect of treatment with prednisolone.

**Discussion.**—DR. O. SAVAGE (*London*) commented that morning stiffness was one factor in the complicated empirical formulae that had been designed to diagnose and assess rheumatoid arthritis. Until now it had not been possible to measure it accurately and objective methods of assessment were welcome.

PROF. E. G. L. BYWATERS (*London*) said that 20 years before he had found, on measuring the diurnal variation of grips and of finger-joint circumference in normal and rheumatoid subjects, that there was much individual variation in both categories in regard to grip and swelling: some showed large diurnal variation, others none. The circumference of the finger between joints showed similar variations. There appeared to be a relationship between finger swelling and grip variation, especially as shown by immobilization, and it seemed possible that swelling of the fingers might not be shown by measurements of whole hand volume.

DR. V. WRIGHT (*Leeds*) asked Dr. Scott whether he had allowed for variation in finger length in his measurements

of joint stiffness, since he would be aware that the force exerted was a product of the tension in the spring and the length of the finger. What was the standard deviation of measurements with the hand left in the apparatus, and with it removed between readings? This was of great importance if conclusions were to be drawn about changes related to morning stiffness.

DR. SCOTT replied that no account had been taken of finger length because comparisons of joint stiffness were made only in respect of the same patient in the morning and the evening. There was a great deal of variation in objective stiffness among normal and rheumatoid subjects, with a considerable overlap between the two groups. The hand had been removed from the apparatus between measurements when multiple readings were undertaken to test the reproducibility of the method, but stiffness had been found to diminish with repeated extension of the joint.

In a reply to a question from Prof. Bywaters, he said that no patients had been investigated under anaesthesia.

**Enraidissement matinal dans l'arthrite rhumatismale****RÉSUMÉ**

Le symptôme d'enraidissement matinal chez des malades atteints d'arthrite rhumatismale fut expliqué par une augmentation matinale de l'enraidissement articulaire objectif et du volume de la main et par une diminution de la force de la poigne. Une variation similaire dans le volume de la main et dans la force de la poigne, mais non pas dans l'enraidissement articulaire, survient chez des sujets normaux; il est donc évident que l'augmentation du volume total de la main n'est pas la seule cause de l'enraidissement matinal.

**Rigidez matutina en artritis reumatoide****SUMARIO**

El síntoma de rigidez matutina en enfermos con artritis reumatoide fué demostrado por un incremento matutino de la rigidez articular objetiva y del volumen de la mano y por una disminución de la fuerza al asir. Una variación similar en el volumen de la mano y la fuerza al asir, pero no en la rigidez articular, aparece en sujetos normales; es, pués, evidente que el aumento del volumen total de la mano no es la única causa de la rigidez matutina.