ELECTROMYOGRAPHY OF CERTAIN HIP MUSCLES

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INTRODUCTION

Investigations into symmetrical easy standing have led to the expression of divergent views concerning the relation of the thigh to the pelvis at the hip joints, and the precise role of the hip musculature in the maintenance of such a posture. Åkerblom (1948) reviewed the literature and pointed out that a number of investigators considered that during 'comfortable standing' the hip joints were fully extended, the iliofemoral ligaments tense and the posture maintained with a minimum of muscular activity. On the other hand others, including more recently Steindler (1955), believed that in this posture the body was in a state of unstable equilbrium at the hip joints and that the erect position was maintained by contraction of the appropriate muscle groups. Åkerblom himself subscribed to the latter view, and pointed out that in previous investigations there had been a lack of uniformity and accurate definition of the posture investigated. Recently, Smith (1956), following investigations on the knee joint, has shown that the concept of the fully extended position of a synovial joint as being an absolute and limiting position is untenable, and that the actual position occupied by the joint is variable and directly related to the extending torque that is being applied to the joint.

Investigation of this problem using electromyography does not appear to have been carried out. If a very high amplification is used, this technique makes it possible to determine whether a muscle is active or not and it was decided therefore to employ this method in an investigation of the hip musculature during standing and during the performance of certain simple movements.

MATERIAL AND METHOD

A double-channel amplifier was used, together with a double-beam oscilloscope. The most important features of the apparatus were the low noise level of 2μV. and its high amplification ($\times 5 \times 10^6$) so that the minimum detectable potentials were of the order of 3μV. peak to peak. In order to reduce interference, the apparatus was surrounded by a screening cage. The amplifier had constant gain between 20 and 200 c./s. the response being reduced by one-half at 4 and 700 c./s. The potentials from the muscles were observed on the oscilloscope screen, and records were obtained by means of photographing the screen. Surface electrodes consisting of small silver cups were used and contact was maintained by suction. The electrode site was shaved, cleansed with spirit and scraped gently ten times with fine sandpaper. Cambridge electrode jelly was applied and gently rubbed into the skin.

The subjects used were eighteen males aged 18–42 years. The muscles investigated were (1) the iliopsoas, (2) the gluteus medius and minimus, and (3) the gluteus maximus. The sites for the attachment of the electrodes were chosen after preliminary investigation. For the iliopsoas they were placed 4 cm. apart, parallel to and below the inguinal ligament, with the mid-point between the electrodes about 4 cm. below and medial to the anterior superior iliac spine. With the electrodes in this position the subject was asked to flex the thigh at the hip joint with the leg hanging vertically at the knee joint. Large potentials (0·5–1·0 mV.) were recorded during this movement. With the electrodes over the sartorius or rectus femoris no potentials were obtained during this movement.

When investigating gluteus maximus, the two electrodes were placed vertically about 4 cm. apart near the centre of the muscle mass. With the electrodes arranged in this way, large potentials (0·5–1·0 mV.) were recorded when the subject stepped on to a low stool. The muscle was felt to be contracted during this movement. The vertical disposition of the electrodes was used routinely, but in any individual the potentials obtained were similar with regard to their amplitude and number of peaks per second, however the electrodes were placed with respect to the main direction of the underlying muscle bundles.

With the subject abducting his thigh against resistance the site of the contracted gluteus medius and minimus muscles was determined by inspection and palpation. The electrodes were placed transversely 4 cm. apart over the area, about 7 cm. vertically above the tip of the greater trochanter. Large potentials (0·5–1·0 mV.) were recorded from this site during resisted abduction of the thigh and while standing on the recording limb.

The subject was asked to lie on a bed and recordings were taken from each site with the muscles relaxed. He was then asked to assume the symmetrical standing at ease position and, using the two channels simultaneously, recordings were taken from (1) iliopsoas and gluteus maximus, (2) iliopsoas and gluteus medius and minimus. In this posture the subject stood comfortably with the shod feet about 30 cm. apart, the feet turned outwards between 30° and 45° from the sagittal plane, the head erect and the hands lightly clasped behind the back.

The extensors of the thigh at the hip joint were investigated more fully, and simultaneous recordings were taken from the gluteus maximus and from the hamstrings during certain movements. When investigating the hamstrings one electrode was placed over the biceps femoris and one over the semitendinosus and semimembranosus 15–20 cm. above the level of the head of the fibula. At the beginning of each movement the subject was in the symmetrical standing at ease position and he returned to this position when the movement was completed. The movements investigated were (*a*) forward arm raising to 90°, (*b*) forward swaying at the ankle joints with the knees straight for approximately 5°, (*c*) slow bending at the hips to touch the toes with the knees straight. In order to illustrate the results obtained, two of the subjects repeated the movements on a number of occasions in time to a metronome, and subsequently synchronized cinematographic recordings of the movements were taken. The subjects were photographed against a background with vertical lines so that the position of the body relative to the vertical plane could be easily seen. Individual frames at intervals of 1 sec. were then taken from these films and matched with the appropriate part of the oscilloscope record. This method of recording was used since the screening cage made it impossible to film the subject and the oscilloscope screen simultaneously.

Records of amplifier noise and of calibration signals were taken at the beginning and end of the recording session for each individual in order to ensure that there was no variation in the amplifier throughout the experiment.

RESULTS

Relaxed muscle. Using the highest amplification available, the recordings over all the relaxed muscles studied were similar to those obtained in a previous investigation involving some relaxed leg and thigh muscles (Joseph, Nightingale & Williams, 1955). These records showed (*a*) a 'background' due to amplifier noise consisting of deflexions of 1·5–2 μV. amplitude occurring at 300–350 peaks/sec., (*b*) larger potentials of 3–7 μV. at 40–50 peaks/sec., and (*c*) deflexions of much longer duration, varying considerably in amplitude from the smallest detectable to 20 μV.

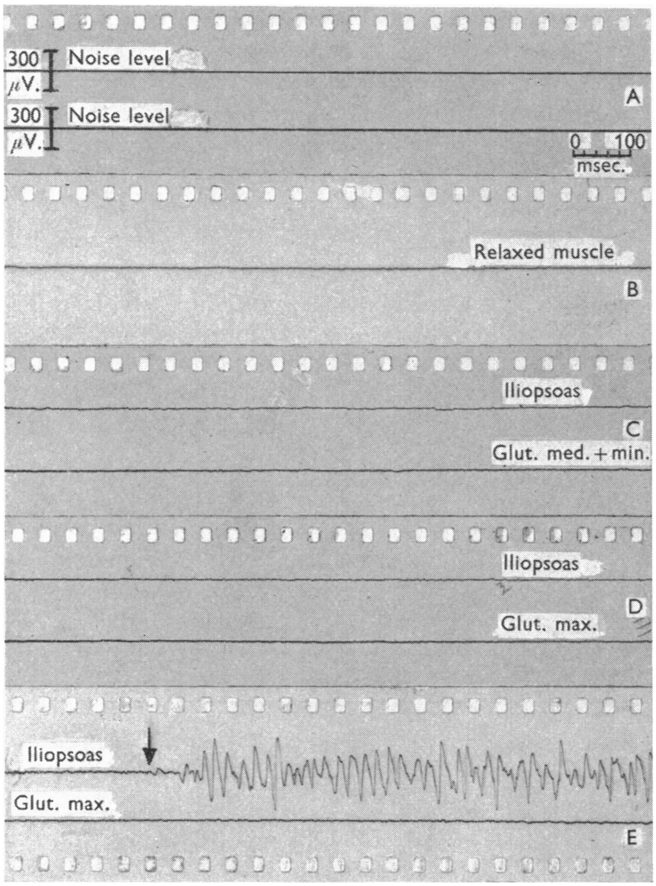

Fig. 1. A: Noise level, both channels; B: relaxed muscle; C: simultaneous recordings from iliopsoas (upper trace) and gluteus medius and minimus (lower trace) while standing at ease; D, E: simultaneous recording from iliopsoas (upper trace) and gluteus maximus (lower trace) while standing at ease. At arrow, subject flexed recording limb at hip.

Standing at ease. In all eighteen subjects the recordings from gluteus maximus and from gluteus medius and minimus, and in thirteen out of eighteen subjects the recordings from iliopsoas were similar to those obtained from the muscles when relaxed (Fig. 1). With the high amplification used, potentials from contracted

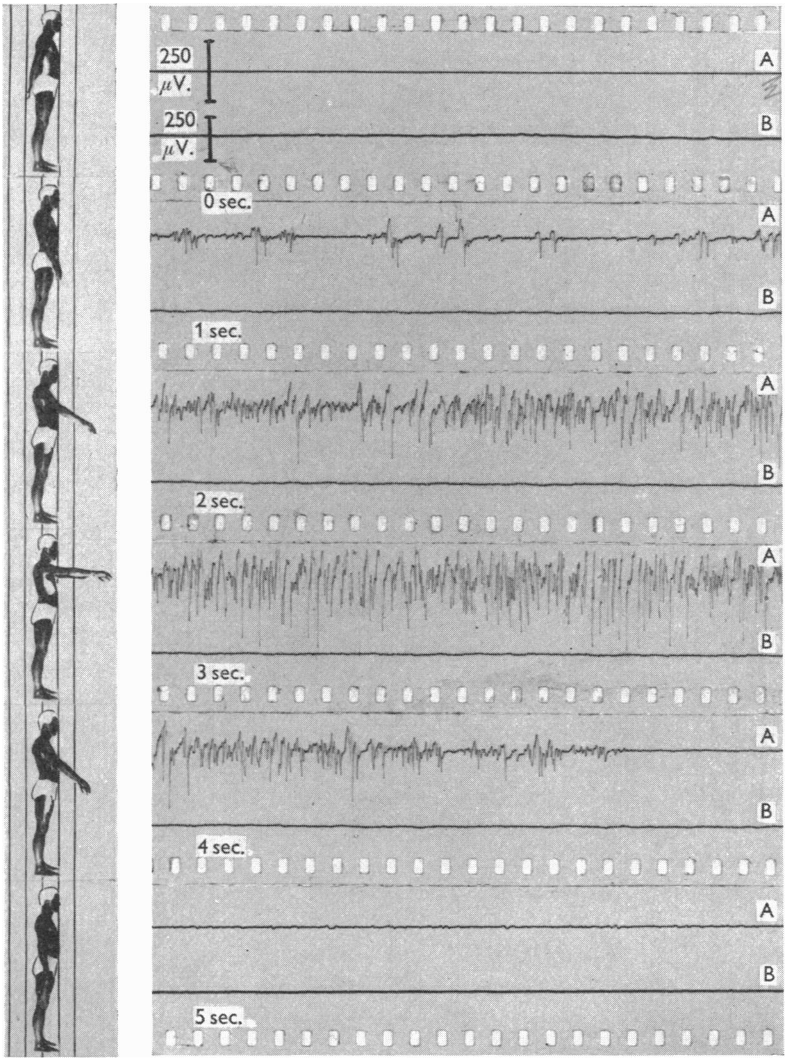

Fig. 2. Simultaneous recordings from (A), hamstrings, and (B), gluteus maximus during forward arm raising.

adjacent muscles, e.g. the pectineus in the case of the iliopsoas and the tensor fasciae latae in the case of the gluteus medius and minimus, could easily be picked up and it can be assumed that absence of potentials indicated absence of detectable activity in these muscles. In the remaining five subjects with the electrodes over iliopsoas, presistent potentials of approximately 100 μV. were obtained. When these subjects were asked to relax their abdominal muscles these potentials disappeared and a relaxed muscle picture was obtained. The thirteen subjects showing a relaxed muscle picture over iliopsoas during symmetrical standing at ease showed persistent potentials of about 100 μV. when asked to contract their abdominal muscles.

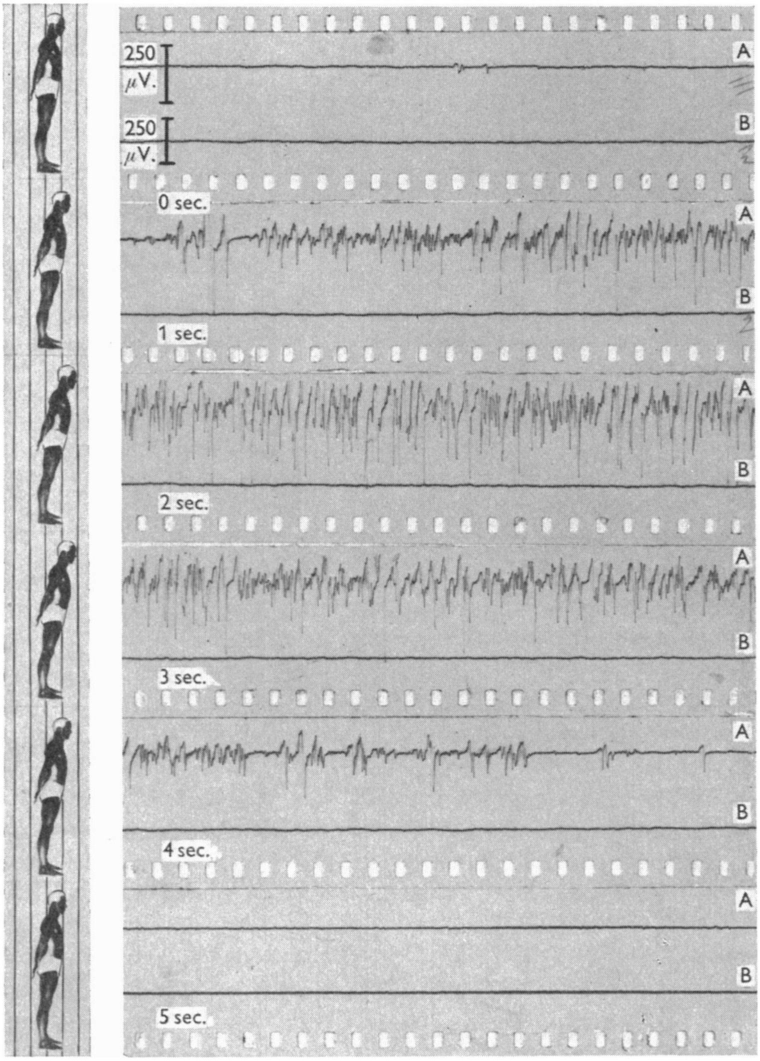

Fig. 3. Simultaneous recording from (A), hamstrings, and (B), gluteus maximus during forward swaying at the ankle joints.

Extensor activity at the hip joints. Simultaneous recordings were taken from the hamstrings and gluteus maximus throughout this part of the investigation, and the amplification was reduced considerably to facilitate recording of the relatively large potentials produced. During forward arm raising from the symmetrical standing at ease position, large potentials (about 500 μV.) were recorded from the hamstrings when the arms were 5–10° from the vertical and were present throughout the rest of the movement. The gluteus maximus showed no evidence of electric activity (Fig. 2).

During forward swaying at the ankle joints, large potentials (about 500 μV.) appeared almost immediately from the hamstring group and persisted until the standing at ease position was regained. The recording from gluteus maximus again showed no evidence of electric activity (Fig. 3).

During toe touching with the knees straight, large potentials (about 500 μV.) were detected from the hamstrings almost immediately the movement commenced. These persisted throughout the downward and upward phases of the movement and disappeared only when the standing at ease position was regained. There was no demonstrable activity in gluteus maximus until the final stage of the downward phase of the movement when large potentials (about 400 μV.) were recorded. These persisted throughout the upward phase, and finally disappeared a little before the standing at ease position was again reached (Fig. 4).

DISCUSSION

The recordings over the relaxed muscles studied in this investigation were similar to those obtained over certain relaxed muscles of the leg and thigh studied previously. A detailed analysis of such records, and evidence suggesting that the deflexions recorded were not due to motor unit activity, were presented elsewhere (Joseph *et al.* 1955).

The present investigation has shown that in the eighteen subjects studied there was no postural activity in the iliopsoas, gluteus maximus, and gluteus medius and minimus during easy standing, and although the records were necessarily limited in length, they were representative of what was observed on the oscilloscope screen for periods of approximately 5 min. This is at variance with the commonly held view that a subject standing in the posture described is in a state of unstable equilibrium at the hip joints, and that accompanying the slight continual variations in posture that have been shown to occur (Hellebrandt, 1938), the upright position is maintained by activity in the appropriate muscle group. The intermittent type of activity, which is implied in this view, was not observed in any of the subjects studied during the present investigation.

In a careful radiological study of twenty-five subjects, it was shown (Åkerblom, 1948) that if an increased extending torque is applied experimentally, the hip joint could be extended 0–15° (mean 6°) beyond the position it occupied during symmetrical standing at ease. Furthermore, in ten subjects using simultaneous statography and radiography he showed that in the posture described, the line of body weight passed posterior to the hip joints (0–4 cm., mean 1·8 cm.). In view of these observations and the absence of postural activity demonstrated in the present investigation, it is thought that in the symmetrical standing posture, further extension at the hip is opposed by a passive mechanism. Smith (1956) has described the passive resistance to extension that occurs during the final stages of this movement at the knee joint, has analysed the factors contributing to the articular and non-articular components of the mechanism, and is of the opinion that such factors

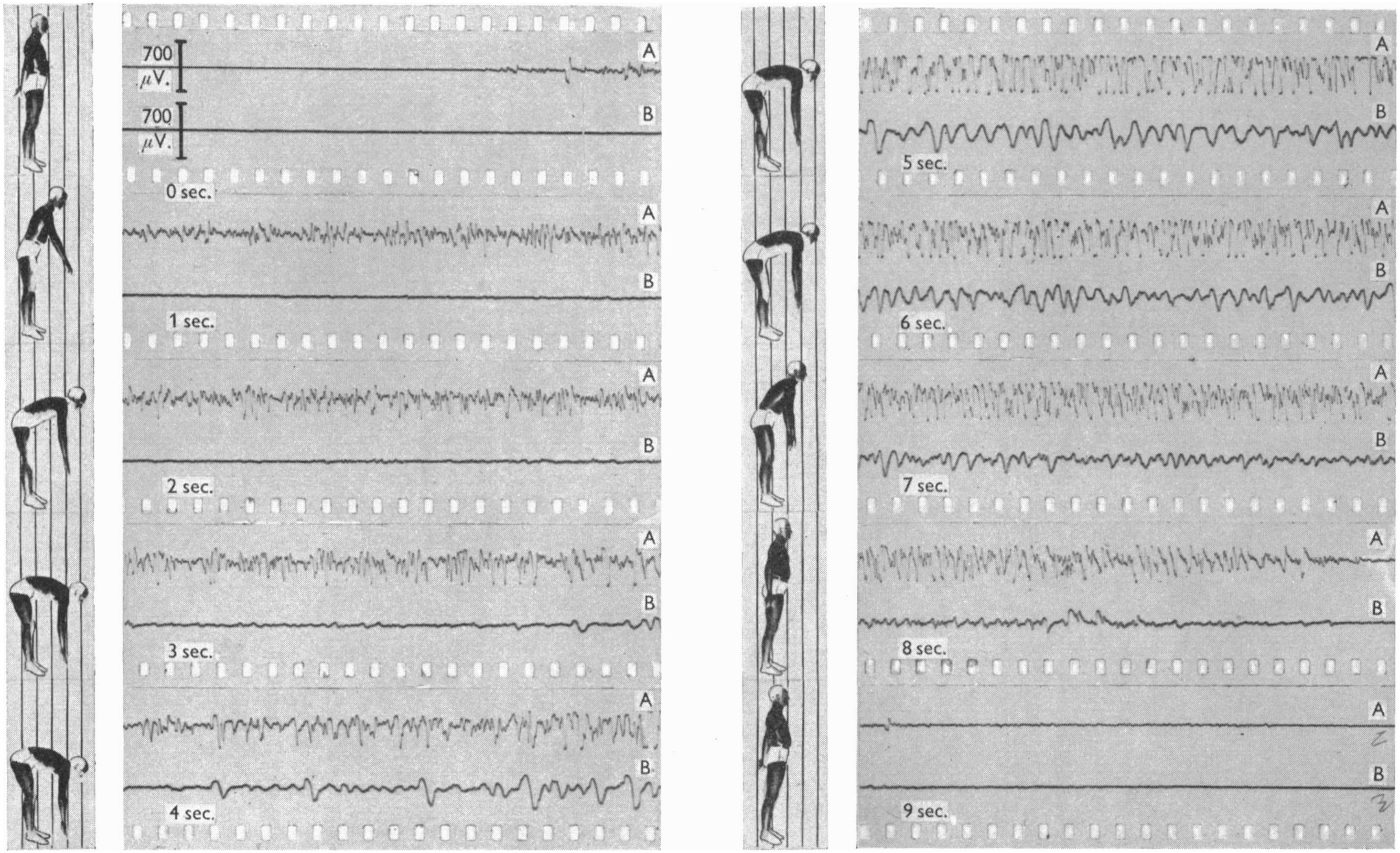

Fig. 4. Simultaneous recordings from (A), hamstrings, and (B), gluteus maximus during touching the toes with the knees straight.

must be operative to a varying extent in all synovial joints. In the symmetrical standing at ease position electromyographic studies have demonstrated absence of postural activity in the hip muscles studied in the present investigation, and also in the anterior and posterior thigh muscles in most subjects (Joseph & Nightingale, 1954). It is interesting to compare these observations with those of Hellebrandt, Brogdon & Tepper (1940), who used the method of closed circuit indirect calorimetry to determine the total energy expenditure of the body exposed to graded gravitational stress. It is stated that the increase in total energy expenditure during standing compared with that during recumbency is extremely small.

The experiments involving simple movements demonstrate the differential activity of the gluteus maximus and the hamstrings. The forward displacement of the line of body weight that occurs during forward arm raising, forward swaying and during the downward phase of toe touching, is accompanied by contraction of the hamstring muscles, and not gluteus maximus as suggested by Steindler (1955). It appears that during straightening up after touching the toes, more powerful extensor activity is required and simultaneous contraction of the gluteus maximus and hamstrings occurs during this movement. In order to explain the differences in the activity of the hamstrings and gluteus maximus in the upward and downward phases of the toe touching movement, these movements may be regarded as examples of positive and negative work respectively, as described by Abbot, Bigland & Ritchie (1952). They investigated the comparative cost in terms of oxygen consumption of positive and negative work and stated that positive work always costs more than negative work. The recordings obtained from the gluteus maximus and hamstrings during the present investigation support this finding and fit in with the concept of negative work as described by Hill (1951), who stated 'if the forces for lengthening and for shortening are to be made the same—as they must be if the external load is the same—the stimulus for the case of lengthening must be reduced either by exciting fewer fibres to activity or by reducing the frequency of the stimulation'.

SUMMARY

1. An electromyographic study has been made of the iliopsoas, gluteus medius and minimus, and gluteus maximus muscles whilst relaxed and during symmetrical easy standing in eighteen males aged 18–42 years.

2. The recordings obtained from the relaxed muscles were similar to those obtained in a previous investigation on certain relaxed muscles of the leg and thigh.

3. In the eighteen subjects studied there was no demonstrable postural activity in the iliopsoas, gluteus medius and minimus, and the gluteus maximus muscles during symmetrical standing at ease.

4. The differential activity of the hamstrings and the gluteus maximus during the performance of certain movements involving extensor activity at the hip joint has been investigated, and the significance of the results discussed.

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