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ELECTROMYOGRAPHY OF MUSCLES OF POSTURE: THIGH MUSCLES IN MALES

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Previous workers have investigated the activity of the thigh muscles in maintaining the upright position in humans, but there are some criticisms of their observations. Often the number of subjects investigated is not stated or appears to be inadequate, and frequently the posture is not fully defined. Åkerblom (1948) stated that he studied twenty-three subjects, but he did not define accurately the posture used and omitted to investigate the muscles of the back of the thigh with the electromyograph. He found that the quadriceps extensor was usually inactive and suggested that the hamstrings actively resist the effect of the body weight unless the knee joints are fixed in maximum extension, in which case the ligaments of the knee joint passively limit extension. Kelton & Wright (1949) defined the posture studied, but investigated only two subjects in both of whom they found no activity in the thigh muscles. Floyd & Silver (1950) neither defined their 'standing position' nor stated the number of subjects investigated. They referred to 'a certain position of comfortable stance' in which activity in the thigh muscles is 'practically zero' and to 'bursts of flexor and extensor muscle activity' which corrected deviations from this comfortable position. Goff (1952) found that the hamstrings showed activity if the subjects were 'standing at ease' with the feet close together, but that this activity ceased if the feet were placed 14 in. apart. He gave no indication of the number of subjects investigated.

MATERIAL AND METHOD

The amplifier used was similar to that already described (Joseph & Nightingale, 1952), except that the noise level was reduced to approximately 15 μV peak to peak, the minimum detectable amplitude being about 25 μV peak to peak. Brass suction electrodes 12 mm in diameter were used, and a large earthed pad was strapped to the ankle of the limb studied. The site of attachment of each electrode was prepared by rubbing with Cambridge Jelly.

Fourteen males aged 19–24 years were investigated and three standard postures, as described in a previous paper (Joseph & Nightingale, 1952) were used: (1) standing at ease, (2) standing with weight mainly on right limb, and (3) standing with weight mainly on left limb. In some subjects additional investigations were made in order to study the effects of shifting the line of weight in relation to the knee joints. These subjects were asked (1) to raise their arms forwards at the shoulders, and (2) to sway at the ankle joints from the stand at ease position forwards, backwards and forwards again to the original position. The extensor quadriceps muscle was investigated by attaching one electrode over the vastus lateralis and the other over the vastus medialis about 3 cm above their lower muscular borders, which were defined by actively pulling the patella upwards. This arrangement made it possible to pick up the activity from either or both muscles simultaneously. The hamstring muscles were investigated by attaching one electrode over the medial hamstrings (semimembranosus and semitendinosus) and the other over the lateral hamstring (biceps femoris) about 3 cm above the beginning of their tendons. When studying the effect of raising the arms the electrodes were attached to the medial and lateral hamstrings and when studying the effects of swaying, to the lateral hamstring and vastus lateralis.

A calibration signal of 120 μV peak to peak, 300 c/s and the noise level of the amplifier with input grids earthed were recorded. Recordings were obtained from the front and back muscles of the right thigh in the three postures described above and also with the muscles relaxed. Recordings were also made of the effect of raising the arms forwards and of swaying at the ankle joints.

RESULTS

Table 1 shows the number of subjects from whom detectable potentials were recorded. Even in these subjects the potentials were usually small and infrequent. In the case of the quadriceps, marked potentials were found in all positions in one subject and in the non-weight-bearing limb in another. In the case of the hamstrings, two subjects showed marked potentials in the weight-bearing limb and one in the non-weight-bearing limb. Representative records of apparent absence of activity in the muscles investigated are shown in Fig. 1 B, C. The oscillations on these records are not regarded as potentials due to contraction of the underlying muscles, since their contraction for weight bearing would produce easily detectable potentials (see beginning and end of records in Fig. 3). It may be suggested that since only one site for the electrodes was used, potentials could have been picked up from other sites over the muscles investigated. In some of the subjects many positions for the electrodes were used and no detectable potentials were found. Another possible criticism is that activity in a deep part of the muscle was missed. This is regarded as unlikely since in a further series of twelve subjects in which a much greater amplification was used (to be published), no muscle potentials were detected.

TABLE 1. Number of subjects (out of fourteen) showing potentials in right quadriceps (RQ) and right hamstrings (RH) in three standard postures (see text)

Muscle	Standing at ease	Weight on right limb	Weight on left limb	Total investigated
RQ	2	4	4	14
RH	3	5	4	14

In seven subjects, raising the upper limbs forwards at the shoulder without altering the posture of the rest of the body, produced, in all cases, marked potentials from the hamstrings at about 15° of flexion (see Fig. 2). Apparently the movement of the upper limbs produces a shift forwards of the centre of gravity, and this causes a detectable contraction of the hamstrings. These potentials were present while the arms were held forwards for a continuous period of 2 min and only decreased and disappeared if the subject readjusted his line of body weight by swaying backwards.

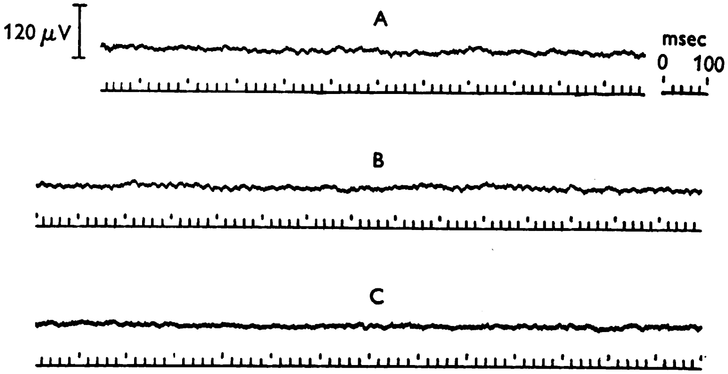

Fig. 1. A (base-line), recording from relaxed quadriceps extensor; B, quadriceps, stand at ease; C, hamstrings, stand at ease.

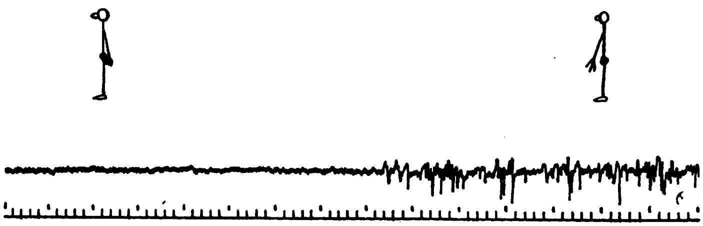

Fig. 2. Recording from hamstrings; effect of raising upper limbs forwards at shoulders without altering position of the rest of body.

In seven subjects, the effect of swaying at the ankles without altering the posture of the rest of the body showed that, as the body swayed forwards, the hamstrings became active. As the body swayed backwards, the potentials disappeared and beyond a certain point, the quadriceps contracted (see Fig. 3).

DISCUSSION

Since ten out of fourteen subjects studied showed no potentials from the quadriceps and hamstring muscles, it is apparent that most subjects stand at ease without any detectable activity in these muscles. The explanation for this is that in this position of the body the line of weight usually falls in front of the centre of the knee joints. The weight of the body above the knee is supported by structures other than the hamstrings and these structures may be the ligaments of the knee joint or the gastrocnemius, in those subjects in whom that muscle can be shown to be active (Joseph & Nightingale, 1952), or both. The popliteus appears to be excluded by the investigations of Barnet & Richardson (1953). If, however, the line of weight falls behind the centre of the knee joints the quadriceps contracts to prevent flexion at the knee and this explains why some subjects show potentials from this muscle. The subject who showed marked potentials from the quadriceps when non-weight bearing, was seen to hold the non-weight bearing limb in a position of flexion at the knee with the quadriceps contracted.

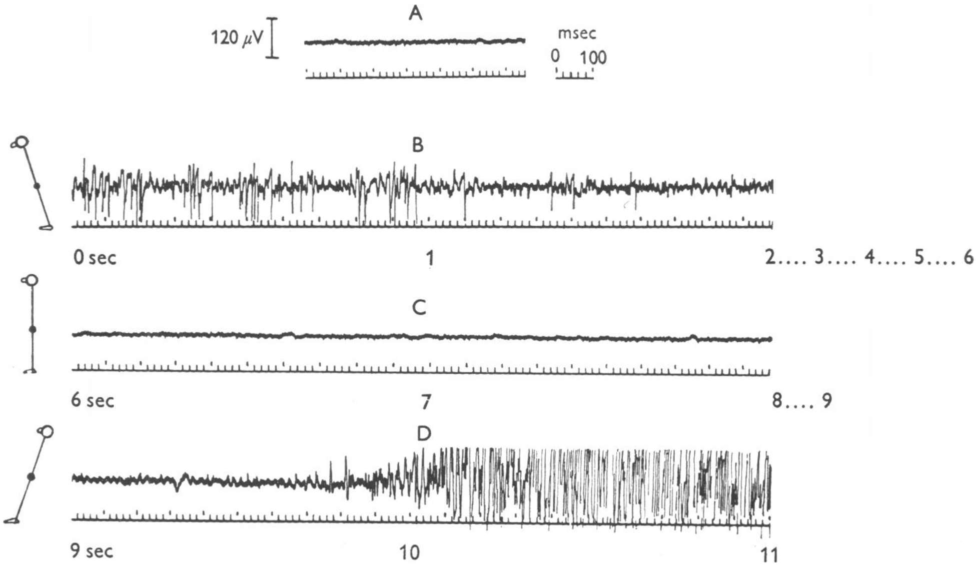

Fig. 3. Sections of recording of 11 sec duration from vastus lateralis and biceps femoris simultaneously, showing effect of swaying at ankle joints from stand at ease position. A, recording from relaxed quadriceps extensor (base-line); B, secs 1 and 2, swaying forwards, showing marked potentials from biceps femoris; C, secs 7 and 8, while swaying backwards, no muscle potentials (this absence of potentials lasted 5 sec); D, secs 10 and 11 after swaying backwards beyond a certain point, marked potentials from vastus lateralis.

That some subjects showed marked potentials from the hamstrings while standing on the recording limb is due to the fact that in changing from the stand at ease position to standing with the weight mainly on the recording limb, the line of weight can be shifted forwards sufficiently to cause the hamstrings to contract. This shift of weight forwards is similar to the effect produced by raising the arms forwards and by swaying forwards, both of which activities are associated with marked potentials from the hamstrings. Probably this is due to the shifting forwards of the line of weight in relation to the hip joints. When the line of weight falls in front of the hip joints, the hamstrings contract to prevent flexion at the hips. This contraction of the hamstrings will, of course, assist the ligaments of the knee joints to support the body weight at the knees.

It is possible that the contraction of these muscles is primarily for the latter purpose, but this is unlikely.

Åkerblom's (1948) work confirms this explanation. He found that in twenty-three subjects standing comfortably and symmetrically the gravity line was in front of the centre of the knee joints, the mean value being $1{\cdot}6 \pm 0{\cdot}2$ cm. Only in one subject did the gravity line fall consistently behind the centre of the knee joint. In ten subjects, he found that the gravity line fell behind the centre of the hip joints except in one case in whom it passed through the centre of the hip joints.

SUMMARY

1. Using the electromyograph, it can be shown that in standing at ease or in a limb which is mainly bearing the weight of the body, the thigh muscles, both front and back, do not produce detectable potentials. In these postures some of the ligaments of the knee joint support the body weight.

2. Shifting the line of the body weight forwards causes the hamstrings to contract in order to prevent flexion at the hip joints and shifting it backwards causes the quadriceps to contract to prevent flexion at the knees.

REFERENCES

ÅKERBLOM, B. (1948). *Standing and Sitting Posture*, pp. 102–126. Stockholm: A.-B. Nordiska Bokhandeln.

BARNET, C. H. & RICHARDSON, A. T. (1953). The postural function of the popliteus muscle. *Ann. phys. Med.* **1**, 177–179.

FLOYD, W. F. & SILVER, P. H. S. (1950). Electromyographic study of standing in man; thigh and leg muscles. *J. Physiol.* **111**, 22*P*.

GOFF, C. W. (1952). Orthograms of posture. *J. Bone Jt. Surg.* **34**A, 115–122.

JOSEPH, J. & NIGHTINGALE, A. (1952). Electromyography of muscles of posture: leg muscles in males. *J. Physiol.* **117**, 484–491.

KELTON, I. W. & WRIGHT, R. D. (1949). The mechanism of easy standing by man. *Aust. J. exp. Biol. med. Sci.* **27**, 505–515.