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THE HIP JOINT: FORCES NEEDED FOR DISTRACTION AND APPEARANCE OF THE VACUUM PHENOMENON

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ABSTRACT. **Joint traction and other mobilization techniques are commonly used in physical therapy for patients with osteoarthrosis. The aim of this study has been to: (*a*) measure the separation of the joint surfaces in the normal hip joint during application of different forces; (*b*) investigate whether or not the degree of separation was influenced by the position of the joint; (*c*) compare hip joint laxity in men and women; (*d*) find the traction force needed to cause the appearance of vacuum phenomena. To achieve a separation in the hip joint, a traction force of at least 400 N must be applied. The distraction was greater in the loose packed position than in the close packed position at equal force and in both males and females. Vacuum phenomena appeared at between 400 and 600 N of traction, varying with joint position.**

Key-words: hip joint, separation, traction, vacuum phenomenon.

Passive mobilization techniques are primarily indicated for the treatment of reversible joint hypomobility, but can also be used to maintain mobility, delay progressive stiffness and relieve pain (1, 6). They can be carried out either as a translatory gliding (movement parallel to the articular surfaces), or as traction or separation (movement perpendicular to the articular surfaces). For pain relief, the translatory movement is performed with the joint in a maximal loose packed position or resting position (6), while in cases of restricted mobility, the translatory movement is carried out with the joint positioned inside the current limit.

Scientific documentation on the effect of traction and other mobilization techniques on extremity joint problems is sparse. Insulander (5) showed that it is possible to separate the hip joint components by manual traction. Radiological examination showed a distraction of 10–20 mm at a traction force of 400 N. Olson (12) noticed positive results in his experimental study of the treatment of the carpal joint in dogs. The animals receiving mobilization therapy gained a greater range of mobility than that of the control group.

Three investigations have dealt with the therapeutic effect of traction in patients with osteoarthrosis of the hip joint (2, 9, 11). All three papers report a decrease in subjective pain score shortly after treatment, but objective parameters, such as joint mobility and walking speed were unaffected. The traction force applied varied between 50 and 400 N, usually around 250 N. In a large socket-and-ball joint considerable adhesive forces prevent distraction of the joint components. Distraction, however, can be achieved by the application of sufficient external force, resulting in a temporary vacuum phenomenon (13, 14). As joint space increases during traction, a negative pressure develops within the joint, which in turn causes gas evaporation from surrounding extracellular spaces (7, 8, 13, 14). The gas, principally nitrogen, is observed on the radiogram as a dark crescent shape between the joint cartilages. In spite of the fact that passive motion techniques are used all over the world, we have found no studies pertinent to determine what happens inside the joint; i.e. whether there is a measurable separation during the procedure and, if so, which force is needed to achieve this.

The aim of the present study has been: 1) to measure any separation of the joint surfaces in the normal hip during application of different forces; 2) to find out if the position of the hip joint has any influence on the degree of separation; 3) to compare hip joint laxity in men and women; 4) to establish the traction force needed to produce a vacuum phenomenon. A further study is planned of a comparison between findings in patients with normal joints and patients with hip arthrosis.

MATERIAL AND METHODS

Eight healthy volunteers, four men and four women, agreed to participate in the investigation. Their age were from 20 to

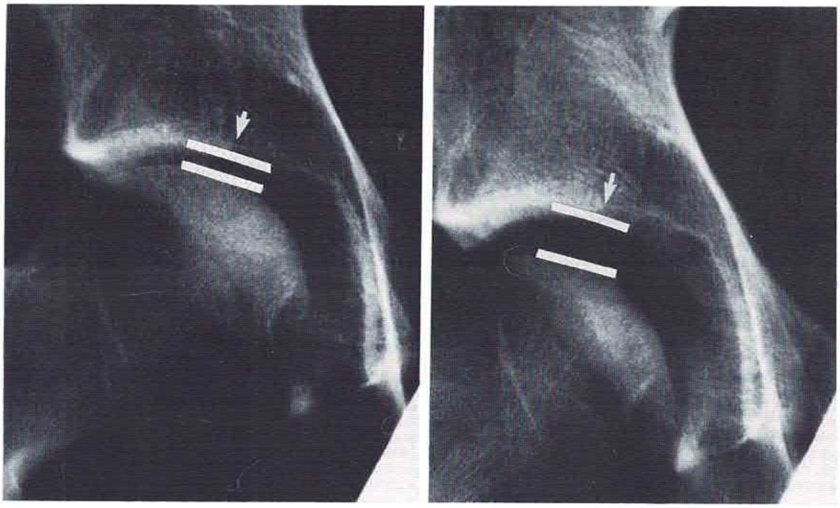

Fig. 1. Measurement of joint space in the hip joint during rest (left) and traction (right).

46 years (mean 29), height 162–190 cm (mean 173) and weight 49–81 kg (mean 63).

We used a radiological apparatus (Exponent 1001 ST, CGR), equipped with fluoroscopy, so that the central ray of the roentgen beam could be properly centered on the hip joint. The gonads of the volunteers were protected by lead during the procedure. The forces applied were measured with a strain gauge dynamometer (Chatillon, model DPPH-1000N).

Experimental procedure

Each subject was supine on the roentgen table, securely fastened to the table with a belt over the pelvis to prevent tilting, and with a stirrup applied to the groin, to prevent gliding downwards during traction. The free leg was supported by a foot-plate. A traction belt was applied around the ankle. The traction belt was connected to the dynamometer, held by the therapeut performing the traction.

Traction was carried out on the right hip in two different positions: (*a*) with the hip joint in the loose packed position, i.e. flexion and abduction, 30° respectively, and with some outward rotation; (*b*) with the joint near the close packed position, i.e. extension, abduction and inward rotation. In all cases the knee joint was extended. The volunteers were asked to relax as much as possible. An initial radiogram was taken to document the position of the joint prior to traction. Subsequently, traction force was applied, increasing gradually from 200 to 400 and 600 N. At each increase in force a radiogram was taken. In the men, an additional traction force of 800 N was applied in the close packed position. Since we considered the women to have less muscle protection, we did not want to expose them to such a high traction force. At the start of every second experiment, the hip joint was in the loose packed position. At the start of all other experiments, the hip joint was in the close packed position.

Measurements

The joint space was measured on the radiogram with a calliper. An easily identifiable point on the subcartilaginar cortex line of acetabulum was used as the starting point (Fig. 1. "arrow"). A line was drawn from the starting point parallel to the direction of the traction. The intersection of this line and the cortex of caput femoris was marked as the "end point". The distance between the two points was defined as the "joint space" (Fig. 1). To compensate for the cartilage thickness, the joint space on the first film was subtracted from the distances on the subsequent films to obtain the "real" distraction. No correction was made for geometrical distorsion (approx. 20% magnification). All measurements were made by an experienced radiologist.

RESULTS

To achieve an obvious separation in the hip joint, a traction force of more than 400 N had to be used. There was a difference in the effect of the traction, depending on the position of the joint. In most individuals the separation was greater when the joint was in the loose packed position than in the close packed position. This difference was observed at all traction forces.

The loose packed position

With a traction force of 200 N, the separation was very small and varied between 0.1 mm and 1.4 mm. It increased some what at 400 N, varying from 0.8 to 3.0 mm. With a traction of 600 N there was considerable variation, from 1.2 mm to 10.4 mm (Fig. 2 and 3).

The close packed position

In almost all individuals, the separation was less in the close packed position than in the loose packed position. At 200 N it varied from 0 to 1.4 mm; at 400 N from 0.6 to 1.5 and at 600 N from 0.9 to 6.0 mm. The four men, exposed to a traction force of 800 N,

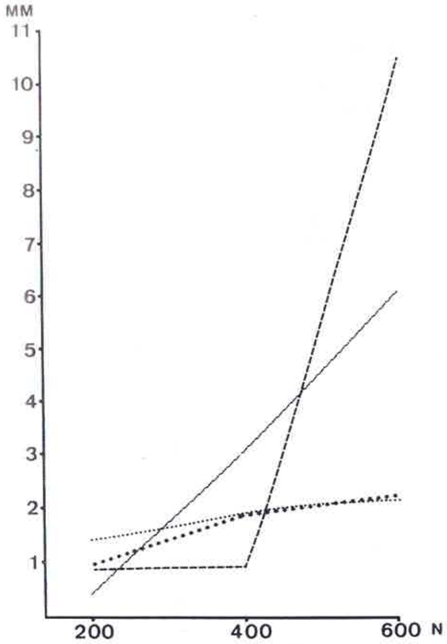

Fig. 2. Separation of the hip joint in the "loose packed position" in four male individuals during traction of 200, 400 and 600 N.

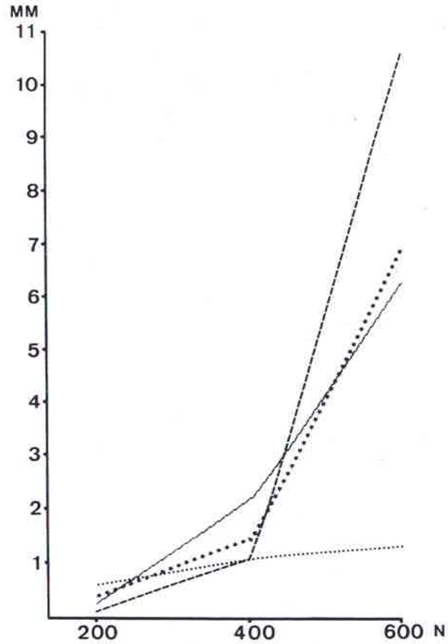

Fig. 3. Separation of the hip joint in the "loose packed position" in four female individuals during traction of 200, 400 and 600 N.

exhibited a separation varying from 1.3 mm up to 8.6 mm (Figs. 4 and 5).

Men–women

No significant difference was noted; when less traction force was applied (200–400 N) the separation was generally somewhat greater in women than in men, while the opposite was found at a traction of 600 N.

The vacuum phenomenon

The force needed to overcome the adhesive forces varied with the position of the joint. In the loose packed position (when the capsule tension was minimal) the vacuum phenomenon appeared with a traction of 400 N in four individuals and with 600 N in two. In two subjects, the vacuum phenomenon did not occur at all. In the close packed position (when the capsule is tight) the vacuum phenomenon was observed in one person at 400 N, in three at 600 N and in four persons did not occur.

DISCUSSION

Clearly, it is possible to separate the joint surfaces in the hip joint using manual traction, although the distension differs very much between individuals. According to our series, it was possible to achieve a separation of more than 10 millimetres in two individuals with a traction of 600 N, in three individuals 6 to 7 millimetres and in three only between 1 to 2 millimetres. The joint space increased more between 400 to 600 N than between 200 and 400 N in both men and women, but was most pronounced in men when the hip joint was in the loose packed position. In the close packed position, when the men were subjected to a force of up to 800 N, the increase in joint separation was almost linear from 400 to 600 and 800 N of traction.

The great difference in distraction might be due to a different joint laxity varying with age, sex and body constitution; however the main reason for the differences noted is probably the individual ability to relax the muscles around the hip joint. The volunteers were asked to relax as much as possible, and never reported pain during the procedure; it can still not be excluded that muscles, not sufficiently relaxed, restrained the joint from being distracted. In a previous study (3) we measured the degree of traction needed to distract the hip joint to obtain good visibility during hip arthroscopy. Some of the patients were under general anaes-

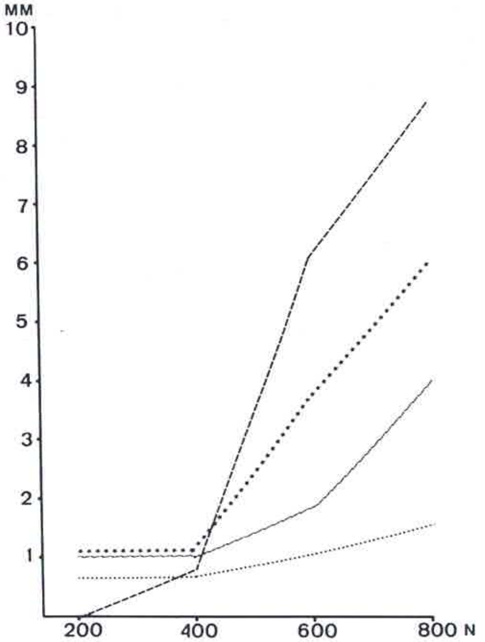

Fig. 4. Separation of the hip joint in the "close packed position" in four male individuals during traction of 200, 400, 600 and 800 N.

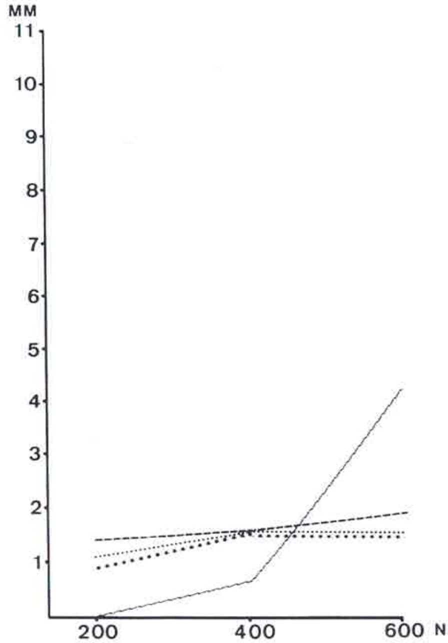

Fig. 5. Separation of the hip joint in the "close packed position" in four female individuals during traction of 200, 400 and 600 N.

thesia, some were not. It was then possible to separate the hip joint as much as 15 mm in a young anaesthetized female using a force of 500 N, while 900 N was needed to reach 8 mm extension in a 55-year-old unanaesthetized man. It was easy to feel the difference in relaxation between anaesthetized and unanaesthetized patients. When traction is used as physical therapy treatment, however, the patients are never anaesthetized, and the aim of this study was to see what happens during simulated treatment in healthy subjects. To achieve a significant separation in the joint, a force beyond 400 N must usually be applied, depending of course on the individual being treated. In our study fairly young volunteers with normal hip joints participated. It is plausible that older persons and patients with some hip joint affection, like osteoarthrosis, will have stiffer joints, i.e. a thicker and more tense capsule and rougher cartilage. Consequently, more force may be needed for separation. These patients probably also have a more pronounced muscle defence due to already existing pain. In the earlier mentioned studies (2, 9, 11), forces below 400 N were used. The therapeutic effect, consequently, cannot be due to the separation per se, but to some other mechanism connected with the traction procedure, like stretching of the surrounding soft tissue. Passive manipulation or traction applied to a joint has many reflexogenic and perceptual consequences. Through stimulation of mechanoreceptors, a presynaptic inhibition of the nociceptive afferent transmission through the synapses in the basal spinal nucleus is inhibited (10, 15). Afferent discharges from the receptors in the joint tissue exert potent reflex influences on the activity of the muscles surrounding the joint. It is plausible that a degenerated and painful hip joint gives rise to a strong contraction of the muscles around the joint, which in turn, by the resulting impaired circulation, might lead to more pain. The traction applied could in this manner affect both the joint capsule, the ligaments and the surrounding muscles, leading to pain inhibition and muscle relaxation.

To some extent the pain relief could emanate also from the placebo effect. It is known that when treating patients in pain, about 30% of the effect is due to placebo (4). Joint separation differed little between men and women. When traction forces of 200 and 400 N were used, the separation in the female hip joints was somewhat, but not significantly, greater than in the males. When greater force was used, 600

N, it was possible to achieve more separation in the men, but since our material consists of such small groups, no clear conclusion can be drawn. In this study there seems to be larger differences between individuals than between men and women. The age of the volunteers seemed to be of little significance. The youngest (20 years) and the oldest (46 years) had almost identical values both in the loose and in the close packed position.

The tractions were performed in the caudal direction, i.e. the weight-bearing surfaces were separated. Some physical therapists prefer to carry out the traction in a more lateral direction, but in that case, surfaces without cartilage are being separated since the medial part of acetabulum is not covered by cartilage. This mode of traction probably produces a similar stretching of the joint capsule, so if the pain reducing effect is achieved by activation of mechanoreceptors (15), this position could be comparable to the position we used in the present study. If the effect, however, is due to temporary reduction of joint pressure on the weightbearing surfaces, our more functional position is probably to be preferred.

CONCLUSIONS

To achieve a separation in a normal hip joint, a traction force of at least 400 N must be applied. The distraction was greater in the loose packed position than in the close packed position with comparable forces. No difference was found between men and women. Vacuum phenomena appeared between 400–600 N of traction, varying with joint position.

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