Injuries to the ankle are common in children. We investigated whether decreased dorsiflexion predisposes to such fractures and sprains. Passive dorsiflexion in children with ankle injuries was compared with that in a control group of patients with a normal ankle. The uninjured side was examined to determine flexibility in those patients with ankle injuries. In 82, the mean dorsiflexion was 5.7° with the knee extended and 11.2° with the knee flexed. In 85 controls, the mean dorsiflexion was 12.8° with the knee extended and 21.5° with the knee flexed (p < 0.001, Student’s t-test). There was a strong association between decreased ankle dorsiflexion and injury in children. A flexible triceps surae appeared to absorb energy and protect the bone and ligaments, while stiffness predisposed to injury. We suggest that children with tight calf muscles should undergo a regimen of stretching exercises to improve their flexibility.

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Patients and Methods

Injuries to the ankle are common in children, with 7% of paediatric fractures occurring around this joint. Despite the frequency of such injuries, little is known about prevention. Reports by Quirk3 and Wiesler et al4 suggest that a decreased range of ankle movement may predispose to these injuries.

In the normal ankle, the range of dorsiflexion is 8° to 26° past the anatomical position, i.e., with the foot at right angles to the linear axis of the leg. During normal gait, about 10° of dorsiflexion is needed during the stance phase and toe-off.6-8 Dorsiflexion of more than 10° is used when going downstairs, kneeling, and in many sports activities. For example, in athletes, Lindsojo et al6 believe that a loaded range of dorsiflexion of 20° to 30° is necessary. In infants and children, greater mobility and flexibility may be present than in adults, and in the newborn the foot can sometimes be dorsiflexed so that the toes and dorsum of the foot touch the skin over the tibia.

We have frequently noted diminished ankle dorsiflexion secondary to tightness of the triceps surae in growing children. Our hypothesis is that flexibility of the triceps surae has a protective effect against injuries to the ankle. When subjected to loading, energy is dissipated gradually by a prolonged, eccentric muscle contraction, preventing injury. In a computerised search of the medical literature, we were unable to find any research which has tested this hypothesis. Therefore, we have attempted to ascertain if decreased dorsiflexion of the ankle secondary to tight musculature of the calf is associated with an increased incidence of injury to the ankle.

We measured dorsiflexion of the ankle in a consecutive series of 82 patients with fractures or sprains at this joint seen at a children’s hospital. A control group consisted of patients seen in the orthopaedic clinic and plaster room mostly with injuries to the upper limbs. In the control group patients were excluded if they had had a previous injury to the lower limb which required medical attention or had other confounding conditions, such as a deformity of or surgery on the lower limb, or a neuromuscular disorder.

In the patients with fractures and sprains of the ankle, pain and inaccessibility of the ankle because of a cast or splint, limited our examination to the uninjured ankle. In the control group, both ankles were measured. In each group, the patient’s range of passive dorsiflexion was determined, first with the knee extended and then with the knee flexed to 90°.9,10

There were 82 patients in the injured group and 85 in the control group. In the injured group, 18 patients had sprains (22%) and 64 fractures of the ankle. Using the Salter-Harris...
classification, the most common type of injury was type-I fracture of the fibula. Of the fractures, 23% did not involve the physis. There was also one pathological fracture occurring through a site of fibrous dysplasia in the distal tibial metaphysis. This was classified separately. The mean time from injury to measurement was 7.2 days (0 to 26). The most common presenting problem in the control group was a fracture of the wrist, followed by an injury to the hand. Details of both groups are given in Table I.

Arcs of passive movement were measured with a goniometer according to the recommendations of the American Academy of Orthopaedic Surgeons. All subjects were positioned supine on a padded treatment table. The tip of the lateral malleolus was used as the axis. The stationary arm was vertical and parallel to the midshaft of the fibula. The movement arm was brought down so that it was parallel to the fifth metatarsal. We ensured that the patient did not actively dorsiflex the ankle during the measurement.

When dorsiflexing the ankle, the heel was held, the hindfoot pulled distally and the ankle gently dorsiflexed with a magnitude of torque which caused a slight stiffening of tendo Achillis. A slight varus force was applied to the hindfoot to align the calcaneus underneath the talus. No dorsiflexion force was applied directly on the forefoot.

A single observer carried out all the measurements using a standard technique. Interobserver reliability was assessed by independent blinded measurements carried out by a second observer on the same day in a group of 24 patients (35 ankles).

Ankle fractures were classified according to the Salter-Harris classification. We used Student’s t-test to compare the mean range of movement for the injured group with that for the control group. Statistical significance was determined at a level of p < 0.05. A linear regression model was also used to adjust for slight age and gender differences between the groups. SPSS 7.5 for Windows (SPSS Inc, Chicago) was used for analysis.

Results

There was a marked difference in measurements of ankle dorsiflexion between the control and the injured groups. Measured with an extended knee, the injured group had a mean dorsiflexion of 5.7° compared with 12.8° for both the left and right ankles of the uninjured group. Measured in knee flexion, the mean dorsiflexion was 11.2° for the injured group and 21.5° for the left ankle and 21.4° for the right in the control group. The dorsiflexion in the injured group was less than that in the control group by 7.1° in extension and 10.3° in flexion. These results were statistically significant (p < 0.01) (Fig. 1).

There was a small difference between the groups in terms of gender and age. Using a linear regression model to adjust for these two parameters, there was still a large and statistically significant difference (p < 0.01) in dorsiflexion between the groups. The injury group had 6.4° less dorsiflexion than the control group when tested with the knee extended and 9.4° less ankle dorsiflexion when tested with the knee flexed. Girls were more flexible than boys.

We found no differences in our control group between left and right ankles and therefore felt justified in measuring the uninjured side to estimate flexibility of the ankle in the injured group.

The mean absolute difference in ankle dorsiflexion measured by two blinded observers was 2.3° in extension and 2.6° in flexion of the knee. There was no tendency for one observer consistently to produce higher or lower readings. Interobserver reliability was higher, but subject to bias since it was not blinded.

Discussion

Stiffness of the ankle is a common problem after injury. Patients are frequently advised to stretch the calf muscles to counteract the effects of injury, scarring and immobilisation. Our observations suggest that children with injuries to the ankle have less inherent flexibility before the injury. We believe that this contributes to the cause of the injury. Our practice for less flexible children is to recommend stretching of the calf muscle in a loaded position by placing the leg behind them while leaning against a wall. We emphasise that the foot should be placed perpendicular to the wall, with the hindfoot in slight varus, and that the heel should remain on the ground. We find that this is facilitated in children by dorsiflexion of the first toe. Controversy remains as to the long- and short-term effects of stretching in the prevention of injury, but we believe that this is appropriate treatment. Despite the widespread clinical use of stretching for decreased ankle dorsiflexion in patients and healthy subjects few studies have determined...
the optimal duration and frequency of stretching required to achieve a lasting effect. No studies have documented a stretching protocol in healthy children.

Our observation that ankle dorsiflexion was significantly less in the injured group may have other explanations. One possibility is an error in measurement. We have attempted to minimise this by having a single observer use a standardised technique with the same goniometer. Previous studies on the measurement of ankle dorsiflexion suggest that intraobserver reliability tends to be greater than interobserver assessment.\textsuperscript{18-23} Our measured interobserver error of 2.3° to 2.6° suggests that the measurement error is small compared with the effect seen. The effect of measurement error alone should have been to obscure differences between groups. We do not feel that measurement error was an important factor in our study.

Expectation may be a significant source of bias since the observer was not blinded to the injury status of the patient. Most children with ankle injuries have evidence of injury, whether it be crutches, a cast or even a surgical scar. To blind the examiner completely, we would have had to hire and train an outside observer, such as a physiotherapist, to undertake the measurements, and somehow blind them to the patient’s injury status. We felt that this would be impractical and that an objective measurement made in a standardised way should help to remove observer bias.

Since we were unable to assess the range of movement of the injured ankle, we used the uninjured side as a surrogate. We measured dorsiflexion of both right and left ankles in the control group and found that they did not differ significantly, which lends support to the practice of measuring the uninjured ankle. The findings of previous studies support our observation that ankle dorsiflexion is equal bilaterally.\textsuperscript{18,24-25} It is possible that contracture may develop in the contralateral ankle as a result of walking on crutches. However, the mean time from injury to measurement was seven days and we do not think that a significant contracture would develop in a previously normal ankle over that time.

Our findings show that limited ankle dorsiflexion predisposes to ankle injury. A twisting fall produces a torsional and dorsiflexion moment on the foot. Gradual absorption of energy by controlled dorsiflexion through a flexible gastrosoleus complex may prevent injury, whereas sudden loading in the presence of a tight calf muscle may result in a sprain or fracture.

We therefore recommend stretching with the aim of preventing ankle injuries. Our protocol is stretches for 30 seconds at least twice daily, with the foot positioned in slight inversion, the heel firmly planted, and the great toe dorsiflexed. There is evidence that stretching increases the range of ankle movement.\textsuperscript{12,17} Whether this actually reduces the risk of injury is unknown. Our finding of an association between decreased flexibility and increased risk of injury does, however, support this hypothesis.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


